FACTORS INFLUENCING THE USE OF MOBILE PHONE BASED SERVICES AMONG SMALLHOLDER FARMERS IN AGRICULTURAL SUPPLY CHAIN: A PESPECTIVE OF BUNGOMA COUNTY, KENYA

by

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I dedicate this dissertation to my loving parents, Festus Shikutwa and Anne Shikutwa, and my siblings. My late sisters, Mary Hilda Shikutwa and Muddy Shikutwa will always remain special.

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LIST OF ABBREVIATIONS

AM	Agricultural markets
AMI	Agricultural market information
ARD	Agricultural Rural Development
CAK	Communication Association Kenya
DOI	Diffusion of Innovation
GDP	Gross Domestic Product
FAO	Food Agriculture Organization
ICT	Information Communication Technology
ICTD	Information Communication Technology Development
InfoDev	Information Development
IS	Information Systems
MAIS	Market Agricultural Information System
MARD	Mobile Agricultural Rural Development
MIS	Market Information System
SCU	Supply Chain Integration
SCM	Supply Chain Management
SMEs	Small Medium Enterprises
SMS	Short Message Service
TAM	Technology acceptance model

ABSTRACT

Over the past decades, adoption and use of information and communication technologies (ICT) has become an area of interest. The advancement of information and communication technologies in rural areas of developing countries offered opportunities to disseminate timely and accurate for rural development. However, the adoption and use of agricultural market information services (AMIS) remained insignificant among smallholder farmers in the rural areas of developing countries. Therefore, a sound understanding on possible factors associated with the use of mobile phone-based services in support of agricultural supply chain is necessary. This study applied an extended diffusion of innovation model (DOI). The study relied on a convenient sample of 200 smallholder farmers in Bungoma County, Kenya. Data was analyzed using descriptive and multinomial logistic regression (MLR) statistics to identify possible factors associated with the adoption and use of mobile phone-based services in Bungoma County, Kenya. The backward selection analysis confirmed that innovativeness, social influence, and compatibility were statistically significant on the use of mobile phone-based services in the study context. Overall, the results confirmed a positive relationship between the final model and the use of mobile phone-based services (M-services). Therefore, the results of this study may contribute knowledge to the domain of ICT4D in the rural context of developing countries. Further, the findings of this study established knowledge that may be useful for practical implications among smallholder farmers and policy makers in the field of ICT4D.

CHAPTER 1: INTRODUCTION

Nature of the Problem

The advent of modern information communication technologies (ICT) has revolutionized the dissemination of information in rural parts of developing countries (Marinagi, Trivellas & Sakas, 2014; Celik, Sahin, & Aydin, 2014; Duncombe, 2014; Mazzarol, 2015; Wyche & Steinfield, 2016; Aker, Ghosh & Burrell., 2016; Akter et al., 2021; Xie, Luo, & Zhong, 2021). However, smallholder farmers in rural parts of developing are yet to benefit from this transformation (Baumüller, 2015; Wyche & Steinfield, 2016; Gereffi & Lee, 2016; Kabbiri, Dora, Kumar, Elepu & Gellynck, 2018; Tefera, Goeman, Elen, Petegem & Hunde, 2021; Marwa, Mburu, Oburu, Mwai & Kahumbu, 2020; Akter et al., 2021). Despite the wide spread of mobile phone-based services in rural parts of developing countries, the adoption and use of ICT based services remains low. For instance, according to Kante et al. (2019) by the year 2015, over 140 ICT agricultural initiatives had been set up in rural parts of developing countries (e.g, MyAgro in Mali, Esoko, icow, Mfarm in Kenya (Katengeza, Okello & Jambo, 2011 & Crandall, 2012). In Kenya it was estimated only 5% of small holder farmers used mobile phone services to access agricultural market information (infoDev, 2013; Wyche, Densmore & Geyer, 2015; Wyche & Steinfield, 2016). Similarly, Kante et al. (2019) observed that in Mali, Senegal, and Tanzania approximately 6% of smallholder farmers used mobile phone-based services to access agricultural market information.

Several studies undertaken to investigate the adoption and use of ICT based market information services in developing countries, postulated that this disparity is largely attributed to low uptake of existing ICTs among smallholder farmers in rural parts of developing countries (Kante, Oboko, & Chepken, 2019; Krell, Giroux, Guido & Hannah, 2021). Some scholars (e.g.,

Jain, Kumar, Singla, 2015; Kabbiri et al., 2018; Khan Tithi, Chakraborty, Akter, Islam & Sabah, 2021) supported that a well – designed for information and communication technologies for development (ICT4D) initiative should be tailored towards the needs of potential users of the innovation. Therefore, it is imperative to gain knowledge of the needs of smallholder farmers in developing countries like, Kenya.

However, evidence indicated numerous information communication technologies for development (ICT4D) projects aimed at disseminating agricultural market information remained insignificant among smallholder farmers in rural parts of Africa (Aker & Mbiti, 2010; Ochieng, Okello & Otieno, 2013; Donner & Escobari, 2010; Ogbeide & Ele, 2015; Wyche & Steinfield, 2016; ChelangatRono, 2018; Abebe & Cherinet, 2019; Emeana, Trenchard & Dehnen-Schmutz, 2020; Kante et al., 2019; Okello, Kirui & Gitonga, 2020; Krell et., 2021).

Similarly, an increasing number of economic studies concluded the impact of ICT4D initiatives are still considered insignificant in rural parts of developing countries (Aker, Ghosh, & Burrell, 2016; Kante et al., 2019), despite of the potential benefits of mobile phone-based services provision of complete and timely agricultural market information among smallholder farmers in remote parts of Africa (Kante, Oboko, & Chepken, 2017; Kante et al., 2019, Wyche & Steinfield, 2016; Hoang, 2020).

The current trends for adoption and use of agricultural market information in rural parts of developing countries is understood to be gradual and still below expectations (Wyche & steinfield 2016; Kante, Oboko & Chepken, 2017; Kante et al., 2019). Agricultural supply chain in rural parts of developing countries is traditionally characterized by information asymmetry, poor access to agricultural markets, fragmented agricultural markets, low profit margins, high transactions costs, intermediaries, and therefore smallholder farmers are unable to effectively

collaborate with other buyers (Poole & Lynch, 2003; Wyche & Steinfield, 2016, Kante et al., 2019; Krell et al., 2021). Access to agricultural market information is regarded as critical for an effective distribution chain in the study context (Ogbeide & Ele, 2015; Kante et al., 2019).

The proliferation of mobile phone-based services in rural parts of developing countries offered an opportunity to resolve tenacious agricultural market failures linked to information asymmetry among smallholder farmers in rural Africa (Wyche & Steinfield, 2016; Kante et al., 2019). Numerous scholars argued the adoption of a new technology is largely influenced by a combination of numerous factors, including perceptions (Richardson, 2009; Baumüller, 2015); Kabbiri et al., 2018; Kante et al., 2019; Krell et al., 2021; Hoang, 2020).

Consequently, there are limited empirical studies on factors influencing the adoption and use and use of mobile phone-based services regarding agricultural market information in Bungoma County, Kenya (Ogutu, Okello, & Otieno, 2014; Kante et al., 2017; Kante et al., 2019). To date, no study has empirically examined the perceived factors associated with the adoption and use of mobile phone-based services among smallholder farmers regarding agricultural market information in Bungoma County, Kenya.

The rationale to focus on use of mobile phone-based services stems from the fact that the mobile phone remained the first modern telecommunication technology of any kind in most parts of rural Africa, due to its flexibility to bypass infrastructure constraints (Aker & Mbiti, 2010; Qureshi, 2013; Baumüller, 2015; Wyche, 2015; Wyche & Steinfield 2016). In such physical terrains, mobile phone enabled services have the potential to establish a synergistic link to market information, for instance, in rural parts of Kenya, mobile phone networks have higher penetration rate than the internet (Oteri, Kibet & Ndung'u, 2015). As such, (Counted & Arawole, 2016) argued the rise of the mobile phone-based services in Africa has enabled the continent to

skip the landline development gap and move directly to the mobile phone based enabled services.

The inclusion of mobile phone-based services in ICTD projects is emphasized due to the potential benefits of such services on provision of timely and complete agricultural market information among smallholder farmers in rural parts of developing countries. This information has led to lower operational costs, access to agricultural markets and market linkages to farmers, access to credit from financial institutions, and positions smallholder farmers to negotiate for better market prices (Ogbeide & Ele, 2015; Baumüller, 2015; Okello, Adera, Mbatia & Okello, 2010; Aker, et al., 2016; Wawire, Wangia & Okello, 2017; Kante et al., 2017; Kante et al., 2019; Okello, Kirui & Gitonga, 2020).

Reliance on the traditional methods to disseminate agricultural market information among smallholder farmers often led to inefficient marketing activities in already fragmented markets with poor ICT infrastructure. This approach exacerbated smallholder farmers' exploitation by middlemen (Duncombe, 2012; Magesa, Michael & Ko, 2014; Okello, et al., 2020). For example, farmers have been occasionally forced to travel long distances with lack of complete information on pricing, and demand of the product leading to uncompetitive markets (Okello et al., 2020). According to Chikuni and Kilima (2018) farmers with no alterative markets, often fail to improve their marketing choices. In Kenya, the traditional methods of disseminating agricultural market information include face to face or interpersonal relationships using extension agricultural officers, middlemen, and radio programs (Magesa et al., 2014; Wyche & Steinfield, 2015; Baumüller, 2015, Aker, 2011; Kante et al., 2017; Kante et al., 2019). Nevertheless, the increased proliferation of mobile phone-based services has the potential to overcome some of the major challenges experienced by smallholder farmers along the rural

agricultural value chain. Dissemination of market information, lowering transaction costs, and linking farmers to markets (Baumüller, 2015; Kante, et al., 2019). However, few studies have paid attention on understanding possible factors associated with the adoption and use of mobile phone-based services, how farmers access mobile phone-based services, and types of information communicated via mobile phone services (Krell et al., 2021).

Mobile Phone Technology Uptake

The wide ownership of mobile phone in rural parts of developing countries flashed the idea to make use of mobile phone-based information and services for socio-economic development in rural Africa (Ahmad, 2016). For instance, as of 2015, 83% of Africa's adult population owned mobile phone handsets (Thothela, Markus, Masinde & Mahfouz, 2021). The proliferation of mobile phone handsets across Africa presents an opportunity for innovation in developing countries to connect smallholder farmers within the agricultural supply chain in rural parts of Africa (Wyche, 2015). As the cost of mobile phones tumbled, mobile phone ownership and internet access have become possible for populations in the continent's lowest-income areas (Wyche & Olson, 2018; Baumüller, 2015; Wyche & Steinfield, 2016). To this end, mobile based information services are touted as digital platforms with transformative potential for smallholder farming across rural Africa (Santosham & Lindsey, 2015; Krell et al., 2021). According to Misaki, Apiola, Gaiani and Tedre (2018) the use mobile phone-based services has potential benefits to provide access to agricultural markets, market information and financial facilities among smallholder farmers in developing countries.

Mobile Phone -Based Services

In the last decade, the development of agricultural market information technologies has increased considerably (Magesa, 2014; Kante et al., 2019; Okello, Kirui & Gitonga, 2020). Providing smallholder farmers with agricultural market information could improve economic development in rural parts of developing countries (Wyche & Steinfield, 2016). The motivation to use phone technology offers the potential to resolve market information asymmetry and increase agricultural market participation among smallholder farmers (Katengeza et al., 2011; Crandall, 2012; Kante, et al., 2019). Additionally, increased use of agricultural market information by smallholder farmers can shift their position from traditional subsistence producers to considering farming as an economic activity. Mobile phone-based services offer price information and market information which could enable smallholder farmers increased participation in the agricultural markets in rural parts of Kenya (Ogutu et al., 2014 & Baumüller, 2015).

Efforts to develop mobile based services were pioneered by non-governmental organizations (NGOs), technology companies, and private developers (Wyche & Steinfield, 2016). Approximately over 140 ICTs services were launched as of 2015 in developing countries, including Africa. Mobile phone-based technologies provided services in the form of: SMS based, voice based, and integrated SMS and voice-based services (Donovan, 2012). However, low adoption and use of mobile phone-based services is directly associated with underuse of existing agricultural market information services by smallholder farmers in rural Africa (Kante et al., 2019).

While there are potential benefits of M-Agri service initiatives to provide smallholder farmers with pricing information, access to variety of markets, and access to financial facilities within the agricultural supply chain in the rural parts of developing countries (Duncombe,

2012a; Fisher & Abbot, 2011; Fafchamps & Minten, 2012; Nakasone, Torero & Minten, 2014). The adoption and use of such services are still in question (Wyche & Steinfield, 2016; Kante at al., 2019). For example, MFarm that offered market price information and connected farmers within the agricultural supply chain was termed as "transformative" and "revolutionary" for rural development challenges such as alleviating rural poverty and increasing food security (as cited by Solon 2013; Tran 2013). Despite the wide spread of mobile phone-based services, several scholars argued there is limited information on the impact and sustainability of the existing ICTs among smallholder farmers in rural parts of developing countries (Wyche & Steinfield, 2016; Baumüller, 2015; Magesa, Michael, Ko, 2014; Kante et al., 2019; Okello et al., 2020). Notably, Donovan (2011) consequence of limited knowledge and interventions on sustainability led to failure, because the adoption and use of existing ICTs among smallholder farmers are still surprisingly low. In another study, Emeana et al. (2020) argued that improving the adoption and sustainability of existing ICTs requires an understanding of both human – computer interactions and information communication technologies for development in the rural context. In Kenya, for example, a recent study finding reported that MFarm app in western Kenya, a mobile phone-based service that was labelled as revolutionary, proved to be defunct. During the data collection period in 2016, it was almost impossible to come across active MFarm users in western Kenya (Wyche et al., 2019).

Local Agricultural Markets

Local agricultural markets remain the lifeline of smallholder farmers in rural parts of developing countries (Yankson, Owusu, & Frimpong, 2016; Mahmoud, Blankson, Owusu – Frimpong, Nwankwo & Trang, 2016). Nonetheless, marketing farm produce within the agricultural supply chain in rural areas in Africa is beset with several challenges, including (a)

lack of market information to facilitate agricultural supply chain in rural parts of Africa (Yankson et al., 2016), (b) lack of different market platforms, and (c) access to complete timely market information. These challenges present major constraints impeding smallholder farmers' participation within the agricultural supply chain. Researchers attributed this to insignificant use of existing mobile phone technology-based services to disseminate agricultural market information (Nakasone et al., 2014; Duncombe, 2016: Wyche, Simiyu & Othieno, 2019). Yet, participation of smallholder farmers within the agricultural supply chain in rural parts of Kenya is inconceivable without market participation (Ogutu et al., 2014).

Agricultural markets in rural parts of developing countries are characterized by endemic information asymmetry between producers and buyers within the agricultural supply chain (Katengeza, 2012; Ogbeide & Ele, 2015). This implies smallholder farmers in rural parts of developing countries Kenya included lack complete market information, updated market prices, customer relationship feedback, the disparity between supply and demand, inefficient predictions, quality and access to diverse open markets, forcing majority of smallholder farmers in rural Africa to sell their produce to low paying markets or at the farm gate as opposed to local competitive or regional markets with better returns (Fafchamps & Hill, 2005; Katengeza & Okello, 2011). Therefore, smallholder farming in rural Kenya is characterized by erratic price variations at every stage of the chain (Mukhebi, 2004; Akter et al., 2021). According to (Magesa et al., 2014; Ganesh kumar, Murugaiyan & Madanmohan, 2017) farmers would be exposed to less market exploitation and more bargaining power if they had complete market information at the point of transaction.

Supply Chain Management

Supply chain management (SCM) originated from the idea of optimizing the value chain: through cost reduction and maximized returns, value chain analysis took a wider perspective, including the socio-economic impact of smallholder farmers in rural communities (Gereffi & Lee, 2016; Tefera et al., 2021). A growing number of studies showed that potential benefits of smallholder farmers use of mobile technology to connect with diverse suppliers cannot be underestimated (Martin & Abbott, 2011; Ogbeide & Ele, 2015). Bringing smallholder farmers at level with the digital revolution is not only a matter of improving monthly profits, but sustainable socio- economic development (Ardjouman, 2014). Prior studies (i.e., Kamunge, Njeru & Tirimba, 2014; Ogbeide & Ele, 2015; Steinfield, Wyche, Cai & Chiwasa, 2015; ChelangatRono, 2018; Wyche et al., 2019) have reported the use of mobile phone technology is essential for sharing agricultural market information in the rural context. Agricultural supply chain in rural parts of Kenya like other developing countries is often characterized by high procurement costs due to poor infrastructure which limits their access to broader markets (Akter et al., 2021). In Kenya, like other developing countries participation of smallholder farmers within the agricultural supply chain is inconceivable without complete and timely market information (Ogutu et al., 2014 & Aker et al., 2016).

Agricultural Supply Chain

Creating a more efficient agricultural value chain involves inclusion of mobile phone technology in daily operations (Halewood & Surya, 2012; Ogbeide & Ele, 2015). This could be achieved by linking farmers to better markets with the aim of value creation among actors within the rural agricultural distribution network (Okello, Ofwona-Adera, Mbatia, & Okello, 2010; Georgise, Thoben & Seifert, 2014). Despite the fragmented nature of poor smallholder farmers'

holdings in rural parts of developing countries and poor infrastructure, their increased participation within the agricultural chain is paramount to sustainable agricultural supply chain in rural parts of developing countries (Jia, Zuluaga- Cardona, Bailey & Rueda, 2018). This approach is in tandem with the design of mobile phone services to disseminate agricultural market information, and link farmers with other buyers within the network (Crandall, 2012 & Baumüller, 2015).

However, to date the agricultural supply chain in rural parts of Africa is characterized by low productivity, coupled with information asymmetry (Aker & Mbiti, 2010; Duncombe, 2012b; Magesa et al., 2014; Kante, Oboko, & Chepken, 2017; Kante et al., 2019). The low adoption and underuse of mobile phone-based services in accessing agricultural market information (Trienekens, 2011; Katengeza et al., 2011; Ole & Ogbeide, 2015; Baumüller, 2015; Yankson et al., 2016; Kante, et al., 2019; Okello et al., 2020) has left farmers to rely on traditional methods of communication, and farmers commonly depend on middlemen for market information (Magesa, et al., 2014). Therefore, there is need for adoption and use of mobile phone-based services among smallholder farmers within the agricultural supply chain in the rural context of development countries (see Figure 1).

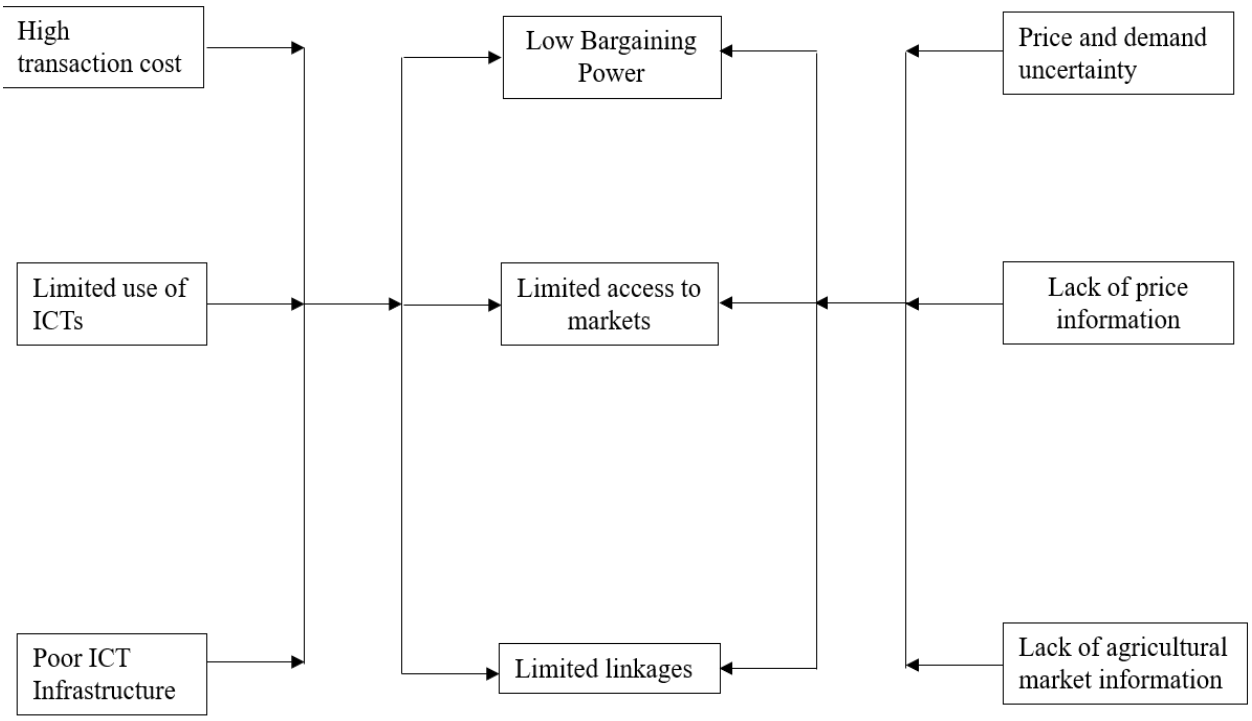

Figure 1. *Need for inclusion of mobile phone-based services among smallholder farmers in the rural context of development countries*

Informed by (Trienekens, 2011)

Role of Agriculture in Africa and Kenya

Approximately 70 per cent of Africa's population resides in rural areas and depends on agriculture for their livelihoods (Thothela, Markus, Masinde & Masinde, 2021; The World Bank annual report 2008 cited by World Bank, 2008). Agriculture has remained vital to Kenya's economic growth, owing to its contribution to key economic indicators: GDP, job creation and poverty alleviation (Muriithi, 2017; ChelangatRono, 2018; Kante et al., 2017; Ayim, Kassahun, Tekinerdogan & Addison, 2020). Empirical studies have reported, that more than 80% of food consumed in developing countries is produced by rural smallholder farmers (Ogbeide & Ele, 2015). In Kenya, smallholder farmers account for approximately 75% of the overall agricultural produce (Ogutu et al., 2014; Wyche, Densmore & Geyer, 2015).

Despite most of the developing countries dependence on smallholder agriculture, the agricultural supply chain in Africa, Kenya included continues to be characterized by inefficiency: low productivity, post-harvest losses, unreliable market information, and low returns leaving little for smallholder farmers to reinvest (Magesa et al., 2014; Okello, Kirui, Gitonga, Njiraini & Nzuma, 2014; Ogbeide & Ele, 2015). Numerous studies concluded smallholder farmers in rural parts of developing countries, Kenya included, face considerable urban rural digital divide. Consequently, smallholder farmers in these environments remained isolated from the global supply chain (Ogbeide & Ele, 2015; Wyche & Steinfield, 2016; Ogbeide & Ele, 2015; Owusu et al., 2017). According to (Mwambi, Oduol, Mshenga, & Saidi, 2016) approximately 2% of avocado smallholder farmers in Kenya are connected to the global supply chain. Thus, the agricultural segment has been severely underperforming for several decades (Ayim et al., 2020).

Considering this challenge, the ICTs offer the best chance to change this trend. One of the key reasons is that information fuels innovations and competitiveness, which in turn can lead to improved production (Manfree & Nordehn 2013; Aker et al., 2016). Similarly, Ogutu et al. (2014) shared that access to agricultural market information and markets are critical to enhancing smallholder farmers' participation within the agricultural supply chain in the rural context of developing countries. The intention of this research was to examine factors influencing use of ICTs among smallholder farmers in developing countries as recommended by Kante et al. 2019. According to Wyche and Steinfield (2016) smallholder farmers in Bungoma county are aware of the benefits and have been exposed to the existing mobile phone-based services. The research site was Bungoma county in Kenya, as illustrated in Figure 2.

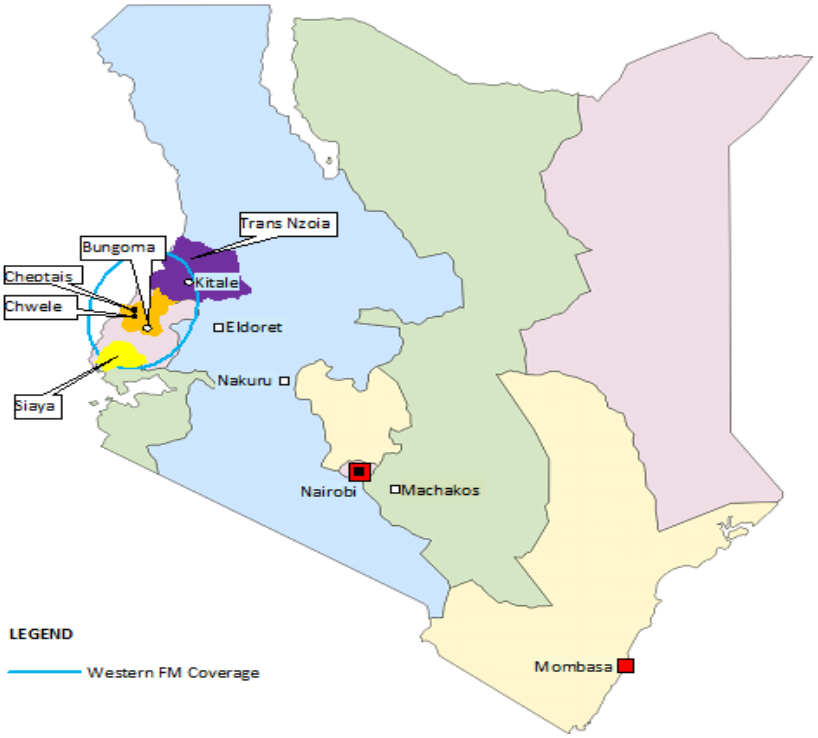

Figure 2. Research Location Site in Kenya -Bungoma County
Source: Bungoma DDP, 2005-2010, Oloo, Ngigi, Mshenga, (2013).

Decisions to Adopt to Agricultural Market Information

The use of mobile phone technology in the rural context of developing countries is largely attributed to a combination of factors among the potential users (Aker & Mbiti, 2010). Therefore, it is important for Information Communication Technology Development (ICTD) community and supply chains professionals to be aware of the perspectives of smallholder farmers on adoption and use of mobile phone technology (Ogbeide & Ele, 2015; Kabbiri et al., 2018). Similarly, Kante et al. (2019) argued the adoption of new technology is largely influenced by a combination of perceptions of the potential user on the technology. Additionally, others have claimed that the adoption of a new technology is embedded in the social systems of a given community (Avgerou, 2010; Walsham, 2017; Lwoga & Sangeda, 2019). Therefore, this study will examine factors influencing use of mobile phone-based services among smallholder farmers in Bungoma county in Kenya (Kante et al., 2019).

Statement of the Problem

Smallholder farmers in rural parts of developing countries have been constrained by limited access to agricultural market information (Aker et al., 2016). The low adoption and underuse of mobile phone services in supply chain markets is attributed to low uptake of existing mobile based technologies services in the rural context of developing countries (Nakasone et al., 2014; Misaki et al., 2018, Duncombe, 2016: Wyche et al., 2019; Kante et al., 2019). There is limited literature that expounds on factors associated with the adoption and use mobile phone services on agricultural market information among smallholder farmers in rural parts of developing countries.

To date, markets in rural parts of developing countries are characterized by low productivity dominated by asymmetry market information between producers and buyers within the agricultural supply chain (Katengeza, 2012; Ogbeide & Ele, 2015: Kante, Oboko, & Chepken, 2018). This implies smallholder farmers in rural parts of developing countries, Kenya included, lack complete and timely information on product pricing, high procurement costs, customer relationship, information on disparity between supply and demand, inefficient predictions, and access to diverse open markets (Aker et al., 2016; ChelangatRono, 2018; Ogbeide & Ele, 2015; Kante et al., 2019; Ayim et al., 2020; Akter et al., 2021). Therefore, lack of complete and timely market information often isolates smallholder farmers from agricultural supply chain in rural parts of Kenya (Okello, et al., 2014; Hoang, 2020).

This study was motivated by the idea that use of ICTs is influenced by a combination of perceived factors embedded in a social system (Rogers, 2003; Islam & Islam, 2006; Avgerou, 2008) scholars have argued that perceptions are likely to influence the adoption and use of mobile phone based services which are embedded in the social system (Aker & Mbiti, 2010; Ogbeide & Ele, 2015; Duncombe 2012; Kante et al., 2017 & Kante et al., 2019; Hoang, 2020). In

contrast, Baumüller (2015) argued against relying on farmers' perceptions on the adoption and use of a new technology, instead recommended implementation of participatory action. However, proponents of Diffusion of Innovation (DOI) model (Roger's 2003; Richardson, 2009) acknowledged that the adoption of a new technology is gradual and largely influenced by the characteristics of the innovation. Therefore, it is critical to understand factors associated with the adoption and use of mobile phone – based services in the rural context of developing countries (Kante et al., 2019; Krell et al., 2021).

This study is founded on the idea that researchers (e.g., Duncombe, 2012; Kante et al., 2017; Wyche & Steinfield, 2016; Baumüller, 2015; Kante et al., 2019; Okelo et al., 2020; Ayim et al., 2020; & Krell et al., 2021) have acknowledged there are limited studies that report on (a) possible factors affecting adoption and use of mobile phone based services, (b) types of mobile phone based services available for smallholder farmers, (c) how smallholder farmers access agricultural market information, (d) types of mobile phone based services available for use by farmers, and (e) how farmers access mobile phone based information in the rural parts of developing countries. In line with one of the identified research gaps. This study will investigate factors associated with the use of mobile phone-based services regarding agricultural market information in Bungoma County (Kante et al., 2019; Krell et al., 2021).

Purpose of the study

The purpose of this study was to identify and examine factors that are likely to influence the use of mobile phone-based services among smallholder farmers in Bungoma County, Kenya, regarding agricultural. The original Rogers' diffusion of innovation (DOI) model focused on the five attributes of innovation: compatibility, complexity, relative advantage, observability and

trialability. Additionally, Rogers claimed the five traits of innovation accounted for 49-87% of adoption variance of a new technology (Rogers, 2003).

To capture familiar data points for this study based on the literature reviewed, the following demographic factors, age, education, gender, income, and innovativeness were included in the study. Other researchers used similar demographic factors in their studies (e.g., Krell et al., 2021; Katunyo, Otieno, Kosura & Okello, 2018) who have conducted studies in Kenya. Apart from the demographic information, this study adapted the DOI model applied by (Kante et al., 2019) and added the construct of innovativeness.

The independent variables included: relative advantage, observability, perceived costs, compatibility, social influence, information quality, gender, education, income, innovativeness and compatibility. This study used multinomial logistic regression method to identify independent variables that were likely to influence the adoption and use of mobile phone-based services among smallholder farmers, in addition to exploring if there were significant relationships among these independent variables in relation to adoption and use of mobile phone-based services in Bungoma County, Kenya.

Research Questions

The following research questions were applied to achieve the objective of the study:

1. What factors influence the use mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County, Kenya?
2. What is the relationship between use of mobile phone-based services and the perceived characteristics of innovation among smallholder farmers in Bungoma County, Kenya?
3. What demographic characteristics influence the use of mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County?

Theoretical Background

Numerous theories and models have aided in understanding the adoption and use of technology. The common theories include diffusion of innovation theory, technology of acceptancy model, affordance theory, theory of reasoned action theory, planned behavior, and motivational (Heeks & Molla, 2009; Ogbeide & Ele, 2015; Duncombe, 2016; Lwoga & Sangeda, 2019; Kabbiri et al., 2018; Wyche & Steinfield, 2016: Kante et al., 2019).

According to technology of acceptancy model (TAM) model, one's authentic use of a new technology is inspired by user's behavioral intentions. TAM model was developed to provide information to the technology developers whether the targeted population will accept the new technology or reject the technology (Kabbiri et al., 2018; Davis, 1989). Nevertheless, numerous scholars have emphasized the two TAM constructs do not adequately reflect the use technology from a social context perspective (Luarn & Lin, 2005; Kabbiri et al., 2018). The adoption and use of an innovation do not happen instantly, rather a process where some individuals adopt the innovation ahead of others (Richardson, 2009). Moreover, Roger, (2003) claimed that while an innovation might have been created a long time ago, the newness of the innovation depends on the individuals' perceptions. Therefore, this study applied diffusion of innovation model (DOI) in understanding factors associated with adoption and use of mobile phone-based services for agricultural market information and examine relationships between adoption and independent variables in Bungoma County, Kenya

Theoretical Framework

The conceptual framework for this study is based on Rogers' diffusion of innovation (DOI) theory. DOI is considered one of the commonly used theoretical framework used in the field of technology adoption (Sarif & Ismail, 2006). In addition, (Rogers, 2003) claimed DOI

perceived attributes of innovation accounted for 48 -87% innovation gap and explained why and how new technology or ideas spreads through a specific social system. These DOI attributes included: (a) relative advantage, (b) compatibility, (c) complexity, (d) trialability, and (e) observability (Rogers, 2003).

The adoption of DOI as a framework is well fitted for this study. For instance, the application of the DOI was originally applied in the field of agriculture by Ryan and Gross (1943) who examined farmers adoption on ICT- based farm information, and later applied in other fields of technology adoption (Kante et al., 2019). And secondly, DOI theory fits better with the identified constructs relevant to this study to gain accurate knowledge and understanding on the factors influencing the rate of adoption in the study context (Richardson, 2009; Kante et al., 2019). Specifically, the DOI framework describes how characteristics of an innovation influenced the rate of adoption and use of a new technology in a social system (Rogers, 2003).

However, the original DOI theory lacks following constructs: cost, social influence, and information quality that have been supported in previous studies to have influenced the use of mobile phone-based services among farmers, (Kante et al., 2017; Kante et al., 2019). To understand factors that impact smallholder farmers' decision to adopt and use mobile phone technology. Based on (Ventkatesh, Morris, Davis & Davis 2003; Kante et al., 2019; Heeks & Molla, 2009; Richarsdon) this study adopted an extended DOI ICT model to extract information quality and cost, social influence from related literature. The conceptual framework provided a powerful lens to examine what factors influenced adoption and use of mobile phone-based services among smallholder farmers in Bungoma County in Kenya. This framework was guided by the following seven constructs that are attributes of innovation: relative advantage,

observability, perceived costs, compatibility, social influence, simplicity, and information quality.

Significance of Study

It is anticipated the research findings will, (a) add to the existing literature and knowledge to the field of adoption and use of mobile phone technology in rural context in developing countries, (b) provide knowledge to various institutions including ICTD community interested in development new technologies within the agricultural supply chain in Africa, (c) provide new findings that may contribute knowledge on the development of ICT models aimed at increased adoption and use of modern technologies, and (d) contribution to GDP, alleviation of poverty, reduce inefficiencies within the agricultural food chain in Africa (Ogbeide & Ele, 2015). This study is aligned to the global food challenge and reduction of global poverty levels, considering approximately 75% of the world poorest population reside in developing countries, and are dependent on small scale agriculture (Aker et al., 2016; Yankson et al., 2016; Okello et al., 2010).

Assumptions of the Study

- Each participant owns a smart mobile phone to enable them access agricultural market information.
- In this study, mobile phone-based services are labelled as new or modern form of technology available in the rural parts of developing countries.
- Smallholder farmers in Bungoma County are aware of the benefits of adoption and use of mobile phone technology, scholars have conducted empirical studies in the region on use

of mobile technology-based services, like“MFARM” (Wyche et al., 2019, Okello et al., 2020).

- The speed at which mobile phone technology is adopted by smallholder farmers may vary with combined perpetual attributes.
- This researcher perceives mobile phone-based services technology to be more relevant for smallholder farmers in Bungoma County in Kenya than other traditional ICT-services such as radio, television broadcasts and newspapers
- In this study the word adoption and use of mobile phone-based services are used interchangeably, as in other studies such as Munyegera and Matsumoto (2016).

Limitations of the Study

Results from Bungoma county in Kenya limits generalization of the study findings to other rural parts of developing countries. The study population included smallholder farmers who had active email addresses, which means the findings may not apply to majority of farmers in typical rural parts of developing countries who have no access to bundles or the internet.

Delimitations of the Study

The findings might be limited due to external validity threat. The participants needed to have an active email to participate in the study, this criterion excluded a population of farmers with no email addresses. However, the study managed to have a reasonable sample frame of 200 participants, which necessitated the application of non-probability convenient sampling.

The demographic characteristics of smallholder farmers in rural parts of developing countries which often included high literacy levels, low level of technical skills, and unaware of existing technologies (Aker, 2011; Chisama, 2016; Kante et al., 2019) may affect the topic under

investigation. On awareness of existing technologies, the study site Bungoma County was purposefully selected because the region was previously targeted for numerous ICT initiatives like DrumNet and KACE development projects (Okello et al., 2010; Wawire, 2013; Wyche & Steinfield, 2016). Participants of this study had to meet the following two-point criteria, (a) over 18 years, and (b) had active email addresses, which may exclude other participants.

Summary

Although agriculture is an important sector to the Kenyan economy with more than 80 percent of the rural population reliant on subsistence farming (Wyche & Steinfield, 2016), numerous researchers revealed increased adoption and use of mobile phone-based services among smallholder farmers. This has potential to overcome the inadequacies of the agricultural supply chain in rural parts of developing countries by enabling effective dissemination of agricultural markets by linking more smallholder farmers to better markets at a reduced transaction costs (Kamunge et al., 2014; Ogbeide & Ele, 2015; Steinfield, 2015; ChelangatRono, 2018; Wyche et al., 2019). More obvious, there is limited literature on empirical factors associated with low adoption and use of mobile phone-based services. Therefore, this study focused on examining significant factors influencing the use of mobile phone-based services and identifying any possible relationship between the dependent variable and independent variables in the study context.

Definition of Terms

Adoption: is the decision of full use of a new technology or an innovation, and rejection is a decision not to adopt the innovation or technology (Rogers, 2003).

Agricultural market information: Agricultural market information designed to gather process and disseminate information on situations and dynamics of agricultural markets for decision making (Baumüller, 2015; Hoang, 2020; Kante et al., 2019; Krell, et al., 2021).

Agricultural input information: compromise of input prices, weather forecasts, agronomy advice on farm inputs (Hoang, 2020).

Agricultural supply chain: Agricultural supply chain covers the whole chain of actions from production and distribution (Naik & Suresh, 2018). In the rural context of developing countries, majority of smallholder farmers sell their produce at the farm gate or localized markets rather than better paying regional markets (Fafchamps & Hill, 2005; Katengeza, et al., 2011).

Compatibility: The rate to which an innovation is deemed to be consistent with the existing values, prior experiences, and needs of possible adopters (Rogers, 2003).

Complexity/Simplicity: The degree to which an innovation is deemed as difficult or simple to adopt and use (Rogers, 2003).

Diffusion of Innovation (DOI): is a process by which an innovation is communicated through channels over time among individuals of a social system, in this case agricultural supply chain among smallholder farmers in Bungoma County (Rogers, 2003 p. 3)

Innovation: refers to the idea or process, that technology is considered new or unaccustomed to potential users within a social system (Rogers, 2003; Skryabin, Zhang, Liu, & Zhang, 2015). Certain attributes of innovations are likely related to the rate of their adoption and use. Individuals are more likely to adopt and use an innovation that (a) is perceived as

having some relative advantage over existing practices, (b) that is compatible with current values and needs, (c) that is not too complex to operate, (d) that could be tested prior to adoption, and (e) that has observable results (Rogers, 2003).

Innovativeness: According to (Rogers, 2003) the degree to which one adopts an innovation earlier than other individuals in a social system. Mobile phone-based services mobile apps are software programs designed to run mostly on devices. In this study context mobile phone-based services are designed to cover spectrum of information, including agricultural market information, in different forms including SMS, quick codes, helplines etc. (Costopoulou, Karetsos & Ntaliani, 2016; Krell et al., 2021).

Observability: The degree to which the results of an innovation are noticeable to others (Rogers, 2003). The visibility of positive outcome of the innovation increases the likelihood to be adopted.

Relative Advantage (RA): The rate of which an innovation is considered better than the idea it supersedes (Rogers, 2003).

Perceptions: According to (Bruner, 1990), an individual's way of life revolved upon shared meanings and ideas as well as shared modes of discourse for negotiating differences in meaning and interpretation. Thus, experiences and situations affect the way we perceive respond and construct meaning from our environments.

Perceived attributes of innovation: Original DOI Rogers' model identified five attributes of innovations that help to explain different rates of adoption: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003).

Smallholder farmers*:* In Kenyan context smallholder farmers are defined as entities that own land from 0.1 to 10 ha (MSE) Act of Kenya (Njoki, 2020).

Social system*:* is a set of interrelated units with a common goal (Rogers, 2003, p.23). In this study, it refers to cereal smallholder farmers in Bungoma County.

CHAPTER 2: REVIEW OF LITERATURE

Introduction

In summary, this chapter provided an overview of literature on ICTs by smallholder farmers in rural context of developing countries (Mittal & Mehar, 2012; Ogutu et al., 2014; Misaki et al., 2018; Kante et al., 2019; Krell et al., 2021). The literature review focused on the following areas: The first section addressed the role of mobile phone technology in African context. The second section described the local agricultural markets and smallholder farmers' information needs in the study context. The last section provided information methods and theoretical foundations applied in similar in developing countries context.

The development of ICT initiatives has been cited as an area of interest for rural economic development (Aker & Mbithi, 2010; Wyche & Steinfield, 2016; Baumüller, 2013; Ogutu et al., 2014; Chikuni & Kilima, 2019, Okello et al., 2020; Hoang, 2020). Consequently, the rural parts of developing countries, including Kenya have experienced wide spread of mobile phone-based services (Baumüller, 2013; Wyche & Steinfield, 2016; Kante et al., 2017; Kante et al., 2019; Wyche et al., 2019; Ayim et al., 2020; Krell et al., 2021; Diaz, Sasaki, Tausaka & Szabo, 2021). In contrast, existing study findings concluded, the adoption and use of ICT services regarding agricultural market information among smallholder farmers in rural parts of developing counties remains insignificant (Kante et al., 2019; Krell et al., 2021).

Despite the substantial potential benefits of the existing mobile phone-based services regarding agricultural market information among smallholder farmers in rural parts of developing countries (Ogbeide & Ele; 2015; Mittal & Mehar, 2012; Kante et al., 2017 & Kante et al., 2019; Krell et al., 2021). To date, literature on ICTs in developing countries have placed little attention on understanding the possible factors affecting use of mobile phone-based

services, how smallholder farmers' access mobile phone-based services, and types of mobile phone-based services in most developing countries, Kenya included (Baummuller, 2013; Wyche & Steinfield, 2016; Wyche & Oslon, 2018; Kante et al., 2019; Krell et al., 2021). Based on the identified research gap and the research problem statement, there is need to investigate what factors influence the adoption of mobile phone-based services on agricultural market information in Bungoma County.

Research has shown that smallholder farmers in developing countries hardly use mobile phone services to access agricultural market information; instead, they use mobile phones for their personal social reasons (Wyche & Steinfield, 2016; Kabbiri et al., 2018). With the proliferation and advancement of the mobile phone-based technology services the mobile phone has transformed from a simple communication tool to a service delivery tool with the potential to provide agricultural market information among smallholder farmers (Aker & Mbiti, 2010; Baumüller, 2013; Kabbirri et al., 2018; Hoang, 2020).

However, in the current situation, smallholder farmers are not connected to other traders within the agricultural value chain, smallholder farmer positioned at the upstream of the chain, are liable to exploitation for exploitation by other traders and middlemen (Hoang, 2020). Consequently, smallholder farmers experience low bargaining power and accept any price offer due to incomplete market information (Kabbiri et al., 2018).

Mobile Phones in Africa

The prevalence of mobile phone ownership across African provide a realistic opportunity among smallholder farmers to resolve historical market failures, through provision of market information, access to markets, and availability of market prices (Katengeza et al., 2011; Crandall, 2012; Crandall, Otieno, Mutuku & Colaco, 2012; Aker & Mbiti, 2010; Ogbeide & Ele,

2015; Wyche & Steinfield, 2016; Kante et al., 2019). As more technological innovations are emerging, there is need of mobile phone-based functions from a simple communication tool to a service delivery platform (Aker & Mbiti, 2010). Additionally, numerous scholars acknowledge that the mobile phone device is the only ICT device available for use to overcome digital divide if any in rural parts of developing countries (Kante et al., 2019). Smallholder farmers in rural parts of Africa have not been able to keep pace with digital transformation, (Ogbeide & Ele, 2015; Kabbiri et al., 2018). For instance, in Kenya less than 2% of smallholder farmers in rural areas are directly connected in the global supply chain network (Mwambi et al., 2016). This emphasis is founded on the belief that the smallholder farmers in rural parts of Africa are predominantly poor and small scale (Magesa et al., 2014; Chikuni & Kilima, 2019).

Consequently, smallholder farmers are faced with lack of agricultural market information or asymmetric information which is attributed to low adoption and use of existing mobile phone-based services leading to insignificant contribution of mobile phone technology to agricultural market information in rural parts of Africa (Kante et al., 2017; Kante et al., 2019). Similarly, previous study findings support that in developing countries claimed that smallholder farmers do not seem to be connected within the rural agricultural supply chains due to insignificant adoption of existing mobile phone-based services (Kante et al., 2017; Kante et al., 2019; Baumüller, 2015; Wyche & Steinfield, 2016; Barakabitze & Sanga, 2017).

Efforts to transform the agricultural sector in Africa has led to the dissemination of several mobile phone-based services, a digital report (Baumüller & Kah, 2019) revealed that only 33million farmers currently reached by digital applications as of 2019, that is projected to reach 200 million by 2030.

Overview of Kenya

Kenya has an approximate population of 53 million (Kenya national bureau of statistics, 2019, as cited by Nyaware, 2019). Majority of African countries, including Kenya have the biggest portion of the population residing in rural areas and dependent on agriculture for livelihood (ChelangatRono, 2018). Agriculture remains the backbone of Kenya's economy owing to its contribution to major economic indicators like 33% direct contribution to the GDP, 27% indirect contribution to GDP through related industries: manufacturing and service industries, 40% of overall job creation, and 70% of job creation in rural parts of Kenya, with approximately 70% of the population living in the rural areas and depend on agriculture (Wyche et al., 2015; Muriithi, 2017; ChelangatRono, 2018; Hoang, 2020; Ayim et al., 2020).

Smallholder cereal farming dominates the agricultural sector in developing countries consisting of 80% of consumed food in Africa (Ele & Ogbeide, 2015; Kante et al., 2017). The common cereals grown in African counties include maize, sorghum, rice, which form the main agricultural products and staple foods for most African countries including Kenya (Kante et al., 2019). Despite the important role of cereals in agricultural supply chain in most African countries, cereal activities are characterized by low productivity, inefficiency along the agricultural supply chains largely linked to underuse of modern technologies to access market information that limit smallholder farmers from accessing price information, variety of markets and effective market linkages (Ele & Ogbeide, 2015; Kante et al., 2017, 2019). For instance, in Kenya approximately 3.5 million smallholder farmers operate without basic agricultural market information (KTM, 2013, as cited by Kante et al., 2018).

In Kenya like other African countries, agricultural markets are often constrained by long chains of transaction between the farmer and the buyer due to poor access to timely market information often leading to low productivity. The lack of market information is a significant

impediment to market access especially for smallholders. Thus, for a given commodity, e.g., Corn (Maize) the agricultural supply chain consists of numerous middlemen, each taking a margin at every step of the chain; and the price variations in space and time are often large and erratic. As such, lack of access to market information is a major impediment among smallholder poor farmers: it substantially increases transaction costs and reduces market efficiency (Mukhebi, 2004; Ele & Ogbeide, 2015; Kante et al., 2017; Kante et al., 2019).

Smallholder farmers in developing countries, Kenya included rely on traditional methods of communication which include face to face or interpersonal communication through agricultural extension officers, radio to access market information, lack of complete market information often leads to information asymmetry between buyers and sellers. For example, in Homabay district in Kenya dissemination of agricultural information is delivered by agricultural extension officers sponsored by faith-based organizations and non-governmental organizations. The potential of mobile phone-based services could largely contribute towards bridging information asymmetry and market linkages gap within the agricultural chains in rural Kenya (Crandall, 2012; Baumüller, 2015).

Prior studies hypothesized agricultural extension officers in Kenya play a critical role in distributing knowledge, technologies, and agricultural information to smallholder farmers (Irungu, Mbugua & Muia, 2015). Nevertheless, in many African countries there are few agricultural extension officers, as of 2014 the average ratio of agricultural extension officers in Kenya were 1: 1000 as opposed to the recommended value of 1: 400, which is considered inefficient (Tata & McNamara, 2017). However, dearth of research presumes agricultural extension officers will use ICT to boost efficiency in sharing agricultural information (Aker 2010; Tata & McNamara, 2017).

Kenya is widely perceived as a leader in the development of mobile phone services in Africa. Owing to the vibrant mobile phone uptake facilitated by several factors, plus improved infrastructure, government protocols and a supportive innovation setting that offers access to innovation hubs. The growing customer base offers a promising market for mobile phone developers and through the mobile money payment service M-Pesa, majority Kenyans are already familiar with related activities to market information systems. A wide range of agricultural market information systems are now available to smallholder farmers. However, the usability scale of these services in accessing agricultural market information is still low, despite their impacts have been assessed (Baumüller, 2015; Wyche & Steinfield, 2016; Kante et al., 2019, & Okello et al., 2020).

Bungoma County

Bungoma is one of the forty-seven counties in Kenya, with an approximate population of 1.3 million as at 2009 (GOK, 2010 cited by Muthiani & Wanjau, 2012). According to (Wyche & Steinfield, 2016) Bungoma, Migori and Mumias are agricultural productive areas that practice subsistence farming. 80% of the population livelihood depends on farming. Bungoma was purposefully selected because smallholder farmers have been previously exposed to ICT-based MIS projects. For example, the area was targeted by the DrumNet development project, and the Kenya Agricultural Commodity Exchange development project which enabled ICT market information services to smallholder farmers implemented either individually or in a group (Okello et al. 2010; Wawire, 2013). Further, a participatory study on use of mobile phone technology services (Mfarm) was conducted in Bungoma County in May 2013 (Wyche & Steinfield, 2016). Nevertheless, many African countries experience wide digital isolation between the urban and rural areas effectively isolating smallholder farmers from rural areas to

access market information and wide variety of connected markets for better returns (Drafor, 2016).

The overall agricultural supply chain in rural parts of Africa, including Bungoma is predominantly subsistence with focus on staple cereal crops e.g., maize in Kenya, low uptake of technology and use in their daily operations, homogenous production, normally characterized by low inputs (Baumüller, 2015). To address long standing socioeconomic problems related to under use of market information by smallholder farmers, leading to lack of prices of commodities, demand of their products in different markets, contacts of potential buyers, mobile based services e.g., MFARM, ishamba and ICOW were developed in support of agricultural rural development in Kenya. Despite these efforts, the current agricultural value chain continues to be inefficient (Ogbeide & Ele, 2015). Existing mobile phone-based services continue to be insignificant on impact on agricultural market information by smallholder farmers (Baumüller, 2015; Wyche & Steinfield, 2016; Kante et al., 2019).

The current agricultural supply chain in developing countries, smallholder farmers at the upstream as chain as producers are liable to exploitation by intermediaries due to lack of complete agricultural market information (Kabbiri et al., 2018). Consequently, majority of smallholder farmers in rural parts of Kenya, as in other developing countries trade their produce to local low paying markets or at the farm gate as opposed to open integrated markets with better payments (Katengeza et al., 2011). As such, this environment continues to isolate smallholder farmers in rural parts of developing countries from global supply chain network (Mutalemwa, 2015; Ogbeide & Ele, 2015). In rural parts of Kenya, agricultural market information has largely been disseminated through face to face or interpersonal communication relying on middlemen

within the agricultural chain network, resulting to asymmetrical market information among agribusiness SMEs (Aker, 2011; Duncombe, 2012a; Misaki et al., 2018).

Contract farming was deemed as a favorable strategy responding to market failures to integrating farmers in the global value chains. However, critics argue the imbalanced power between the producers and other actors managing contract farming often leaves smallholder farmers within the agricultural supply chain with distinct dissatisfaction. For example, Mwambi et al. (2016) conducted a study in Kandara, Kenya to examine effects of contract farming on agribusiness SMEs within the avocado chain. Findings revealed that farmers felt exploited within the contract farming arrangement due to information asymmetry, they felt contract farming could not be sustained with mistrust.

This conforms to (Yankson et al., 2016; Thothela, Markus, Masinde, & Mahfouz, 2021) argument, that provision of reliable market information was a major influence on smallholder farmers choice to enter a new and sustained market. According to (Tefera et al., 2021) commitment to information sharing is critical for a sustained agricultural supply chain. Yankson, et al., (2016) shared that smallholder farmers obtain sustainable benefits through greater engagement in the local markets. In rural parts of Kenya, market information has largely been disseminated through face to face, interpersonal communication relying on middlemen, radio programs, agricultural extension officers, contract farming exposing agribusiness SMEs to exploitation. Some scholars, e.g., (Magesa, Michael & Ko, 2020) claimed that smallholder farmers are often exploited by middlemen due to lack of ready markets and agricultural market information within the agricultural supply chain.

Smallholder Farmers

The Micro and Small Enterprises (MSE) (Act of Kenya, 2012 cited by Njoki, 2020) defined smallholder farmers as entities that own from 0.1 to 10 hectares of land. Farming is their main economic activity; they have an annual turnover of less than Kenya shillings 500,000 (equivalent of USD 5,000), and capital establishment of less that Kenya shillings 5 million (equivalent of USD. 50,000) and employ less than 50 workers. It is generally accepted that small scale farming is the main source of income for majority of Africa's population (Mwombe, Mugivane, Adolwa & Nderitu, 2014). In Kenya, smallholder farmers accounted for approximately 70% of rural farming (Okello et al., 2014). Similarly, in other countries in like Mali smallholder farmers accounted for approximately 68% of the agricultural production, in Ethiopia smallholder farmers accounted for approximately 96% of agricultural production (Kante et al., 2017).

Yet agricultural activities in these regions are characterized by low productivity coupled by inefficiency along the agricultural supply chain (Kante et al., 2017, 2019). Consequently, smallholder farmers comprise majority of the rural poor in Africa, mainly engaged in subsistence farming (Kante et al., 2019). For smallholder farmers in the rural context of developing counties, adoption of mobile phone technology may imply, acquiring new capabilities of doing business as well as accessing new market segments through an efficient supply chain, eventually leading to higher economic outcomes along the value chain (Tefera et al., 2021). However, according to (Collier & Dercon, 2014) most smallholder farmers in rural parts of Africa are still trapped in low equilibrium poverty.

Local Agricultural Markets

Traditionally, agricultural markets have not worked for poor farmer smallholder farmers in Africa (Mukhebi, 2004; Chikuni & Kilima, 2019). The lack of market information denotes a major impediment to increased participation of smallholder farmers within the agricultural markets (Okello, Owour, Larochelle, Gathungu & Mshenga, 2021). Access to agricultural markets and market information is necessary for smallholder farmers to participate in agricultural markets (Magesa et al., 2014). This has been constrained by low adoption of agricultural market information (Wawire et al., 2017). However, market access is a vital factor in integrating smallholder farmers to in agricultural supply chain (Okello et al., 2020).

However, local agricultural markets remain the lifeline of smallholder farmers in rural parts of developing countries (Yankson et al., 2016). However, lack of use of agricultural technologies within the agricultural supply chains in rural parts of developing countries has constrained access of price information, market linkages and access to variety of market information (Baumüller, 2015; Kirui et al., 2014). Therefore, marketing farm produce within the agricultural chain in rural areas in Africa is beset with several challenges, including market imperfections, which often devalue the position of agribusiness SMEs within the agricultural supply chain (Yankson et al., 2016).

Agricultural markets in developing countries are fragmented, and often fail for smallholder farmers due to lack of market information, to solve endemic problem of information asymmetry between producers and buyers within the agricultural supply chain and high transaction costs associated with rural poor communication networks, with dilapidated infrastructure (Katengeza, 2012; Ogbeide & Ele, 2015: Okello, et al., 2020). Other efforts to counter absence of guaranteed markets for smallholder farmers in rural parts of developing countries include, formation of cooperative farmer organizations, and contract farming mainly

meant to link smallholder farmers with ready markets to sell their produce (Yankson et al., 2016; Ogbeide & Ele, 2015).

According to (Devaux at al., 2017) contract farming has the potential to assist with market failures within the agricultural supply chain in rural parts of developing countries. Evidence support contract farming has potential to increase smallholder farmers' income from 25-75 percent (Devaux, et al., 2017). However, the imbalance of power of smallholder farmers with companies managing contracts often disadvantages them from fully benefiting from the rural agricultural supply chain network (Mwambi et al., 2016: Nakasome, Torero, & Minten, 2014; Devaux, Torero, Donovan & Horton, 2018). Currently, majority of smallholder farmers sell their produce at the farm gate or localized markets rather than better paying regional markets (Fafchamps & Hill, 2005; Katengeza & Okello, 2011). This environment isolates smallholder farmers from participating within agricultural supply chain (Mutalemwa, 2015; Ogbeide & Ele, 2015). Smallholder farmers' access to better paying markets is important in enhancing their livelihoods (Okello et al., 2020). More broadly, scholars argued smallholder farmers obtain more benefits through engagement in the local markets (Yankson et al., 2016). For instance, study findings by Yankson et al., (2016) on marketing strategies by smallholder farmers in Ghana reported 61% of smallholder farmers sold their produce at the local community market, 19% sold at the close district markets where prices are better, 13% sold at the farm gate, 5% at the roadside stand, and 2% at the regional market in Cape Coast at a relatively higher price.

Therefore, availability of variety of markets is an important determinant in increasing smallholder farmers as producers within the agricultural value chain (Barret, 2009 cited by Okello et al., 2014; Okello et al., 2020). Therefore, encouraging smallholder farmers to access variety of markets and reliable agricultural market information is an initial step in integrating

smallholder farmers within the global or regional agricultural markets, while improving their livelihoods (Mwambi et al., 2015).

Agricultural Market Information

The dissemination of agricultural market information remains a challenge among smallholder farmers African countries (Kante et al., 2019). Several scholars argued fast evolution of mobile phone-based services gives superior aptitude to dissemination of agricultural market information (Wyche & Steinfield, 2016; Baumüller & Kah, 2019; Okello et al., 2020; Kante et al., 2019). Consequently, it was predicted that ICT based services have potential to lessen high transaction costs, growth in market linkages and increased market participation by smallholder farmers in rural areas in Africa (Aker & Ksoll, 2016; Baumüller, 2013; Chikuni & Kilima, 2019).

Despite the wide spread of numerous agricultural ICT initiatives in developing countries, aimed at strengthening smallholder farmers' linkage to regional agricultural markets (Okello, et al., 2020). The adoption and use of agricultural market information among smallholder farmers across Africa, Kenya included remain below expectations (Kante et al., 2019). A central assumption of using ICTs for agricultural outcomes is the potential to address market failure of poor rural in developing countries (Aker et al., 2016). Hence, a significant amount of research exists documenting this disparity, leading to monopolist markets, undermining smallholder farmers efforts in rural parts of developing countries participation in agricultural supply chain (Magesa et al., 2020).

Trends in Adoption and Use of Existing Mobile Phone Services

The proliferation and development of the mobile phone-based technology services has transformed the mobile phone usability from a simple communication tool to a delivery services platform (Aker & Mbiti, 2010; Qiang, Kuek, Dymond & Esselaar, 2012). However, the impact of the mobile phone-based services within rural agricultural supply chain in developing countries remains insignificant (Baumuller 2018; Kante et al., 2019). In Kenya approximately 5% of the population is using mobile phone technology within integrated trade as cited by Wyche & Steinfield, 2016). In Malawi, Tanzania, and Senegal approximately only 6% of the small-scale cereal farmers are using mobile phone technology, despite having over 140 ICT mobile based services initiated in developing countries as at 2015 (Kante et al., 2019).

According to Krell et al. (2021) the urban populations have higher rate of adoption and use of ICTs compared to their rural. Additionally, some scholars suggested that smallholder farmers in rural parts of developing countries experience digital gap and are often isolated from the agricultural value chain (Baumuller 2013; Ogutu et al., 2014; Wyche & Steinfield, 2016; Kabbiri et al., 2018; Kante et al., 2019; Krell et al., 2021).

Information Needs of Farmers

A study has identified information needs among smallholder farmers (Wyche & Steinfield, 2016). Furthermore, (Mittal, Gandhi & Tripathi, 2010) identified three major categories of communication needs: farm input information, pricing information, and weather information. In a study extract some of existing mobile phone-based services in rural Kenya and common uses by farmers (Baumüller, 2015). The common information needs among smallholder farmers is illustrated in Table 1.

Table 1

Common Information Needs among Smallholder Farmers

Source of information	Type of crops to grow	How much to grow	Sell produce
M-farm	24	7	65
Radio	24	13	11
Farmer coop	23	18	7
Family	10	13	2
Other farmers	8	4	13
Middlemen	6	4	1
Extension agent	9	13	3
Extension agent	9	13	3
Government office	6	5	4
ADS	14	13	10
EAG	10	9	18
Other sources	7	16	3
No information	7	23	2

Source: Baumüller, 2015

Mittal et al. (2010) study findings in India identified three broad categories of information needs of smallholder farmers of which ICTs could be applied:

- Information which helps smallholder farmers know what to plant.
- Market information and pricing
- Information on weather

Impact of ICTs in Agriculture

To date the impact of agricultural market phone-based services are still far-off from satisfying their anticipated targeted population (Baumüller, 2018). For example, recent study findings reported that MFarm app in western Kenya, a mobile phone-based service that was one's revolutionary, proved to be defunct, it was almost impossible to come across active MFarm users in western Kenya (Wyche et al., 2019). However, the extent to which smallholder farmers

could succeed in agricultural value chain relies mainly on the accessibility of accurate, reliable and targeted agricultural market information (Ali & Kumar, 2011). To date use of mobile phone-based service technology is not well spread among smallholder compared to other non-agricultural sectors (Anoop, Ajjan & Ashok, 2015; Ogbeide & Ele, 2015; Kabbiri et al., 2018; Kante et al., 2019).

A participatory study using videos on storyboard motivated the development of "ishamba", in Kenya, unlike other similar mobile based services (i.e iCow, MFarm, kilimo salama and ishamba). "ishamba" subscribers can access information in the local language and owns a call center service, based on "ishamba" website ishamba.com. However, success of such programs will be motivated by being aligned to factors that motivate smallholder farmers' decision to adopt and use the mobile phone technology. Numerous studies have concluded that the use of mobile phone technology has potential to improve productivity among smallholder farmers; however, according to some scholars, like (Krell et al., 2021) argued that use of ICTs have both positive and no impact on agricultural market information.

Martin and Abbot (2011), study findings in Bungoa, in Bugerere area reported that the use and adoption of mobile phone technology by dairy farmers to access remote market information eliminated approximately 75 miles of travelling distance to the market. Similarly, a Jensen (2007) study reported that the adoption and use of mobile phone technology among fishermen and other retail traders resulted to reduced operating costs and elimination of wastes among fishermen in Kerala in India. Jensen (2007) also reported there was limited violation on the Law of price, with one good having the same price in several locations, Jensen (2007) further noted fish wastage in Kerala was eliminated.

Similarly, Fafchamps and Minten, (2012) investigated the effect of SMS based services among smallholder farmers in India. The study focused on benefits derived from weather and market information. The study acknowledged there was low adoption of the system which may have been attributed to lack of interest among smallholder farmers, however, the study reported that smallholder farmers experienced approximately 12% increase in sales upon using the SMS based mobile phone technology. This conforms to Drafor's (2016) claim that use of mobile phone technology is beneficial for accurate decision making among traders, by enabling timely, adequate, and appropriate information among actors within the supply chain. An earlier study conducted by on assessment of "Esoko", a market information system (MIS) in Ghana, Africa, meant to facilitate agricultural food chains through technology in Ghana. "Esoko" provides agricultural stakeholders with market information such as prices, platforms for advertising and platforms for negotiating that integrates into the World Wide Web. Similarly, a study by Baumuller (2015) found that farmers sold their yam at higher prices, approximately 11% higher prices with the adoption and use of "Esoko" a mobile-based service in Ghana, Africa.

On contrary, (Srinivasan & Burrell, 2013) argued that the use of mobile phone technology should not be relied on for access of agricultural market information among smallholder farmers in developing countries. However, with the wide spread of existing mobile phone technologies in Kenya and other parts of Africa, it is unclear how many smallholder farmers in rural parts of Kenya use these apps (Baumüller, 2015; Wyche & Steinfield, 2016; Krell et al., 2021).

Numerous scholars argued that insignificant impact of mobile phone-based services is directly related to low adoption and use of the mobile phone-based technology (Kante et al., 2019). Further, Wyche and Steinfield (2015); Lwoga and Sangeda (2019) posited that the

existing mobile-based services have not scaled up to match needs of users within the agricultural value chain. For example, empirical study findings on MFarm, found that that the mobile phone-based technology service which was supposed to link farmers with other actors within the agricultural value chain, appeared to have limited impact on connecting farmers to other traders in the network (Baumüller, 2015).

According to (Kabbiri et al., 2018) agribusiness SMEs may choose not to adopt or use the new technology if they lack required skills and knowledge to operate the new technology. Ease of use of new existing mobile phone technology is an important factor to consider in Kenya, this aligns with previous study findings of (Okello,2014 cited by Kante et al., 2017) that a population of agribusiness SMEs in Kenya found adoption and use of mobile phone technology complicated. Further, (Kabbiri et al., 2018) argued that an individual may fail to utilize a new technology despite being at ease to operate the new technology if one is unaware of the benefits associated with the innovation. Several studies support the cost of technology influences uptake (Misaki et al., 2018, Kabbiri et al., 2018).

According to (Drafor 2016), study findings 50% of the farmers were willing to pay more for quality information, even though they felt the service should be free. In Kenyan context, (Wyche et al., 2016) study findings revealed financial cost of sending a text message was significant and would influence the patterns of using mobile phone-based services. According to Aker and Mbiti (2010) and Ogbeide and Ele (2015) the adoption and use of mobile technology by agribusiness SMEs in rural parts of Africa is largely influenced by perceptions of the targeted rural population. In the same regard (Duncombe, 2012b) shared that there is need to understand the needs of agribusiness SMEs and their context before implementation of a new mobile phone technology. This conforms to the views of (Avgerou, 2008; Walsham, 2017; Lwoga & Sangeda,

2019) that use of ICTs including mobile phone technology is locally and socially embedded in a community. An example of definition of major constructs for this study in the rural context. However, there is still great enthusiasm among policy makers, ICT developers, and agricultural rural development agents on the promotion of mobile based technology services on agricultural rural development in developing countries, leading to the rise of ICT based apps in the last decade (Okello et al., 2010; Kante et al., 2017; Kante et al., 2019; Okello et al., 2020). In contrast to the availability of agricultural market information, adoption and use of the existing mobile phone-based services remains a challenge (Kante et al., 2019).

Factors affecting adoption and use of ICTs among smallholder framers

Common socio-demographic factors that influenced the adoption and use of new technology included, education, cost, gender, individual innovativeness and attributes of innovation that included: relative advantage, observability, cost, compatibility, simplicity, social influence and information quality (Ogbeide & Ele, 2015; Kabbiri et al., 2018; Kante et al., 2019; Krell et al., 2021 Hoang, 2020; Okello et al., 2014; Ogbeide & Ele, 2015; Katunyo et al., 2018). In the same regard, a study conducted in Vietnam to investigate factors influencing use of mobile phone technology among smallholder farmers, concluded that male educated smallholder farmers belonging to a community-based organization are more likely to adopt and use existing technologies than the counterparts. Similarly (Wyche & Steinfield, 2016) emphasized that lack of skills, literacy or level of education, language barrier, language barrier and life batteries impacted the level of adoption of ICT among smallholder farmers in rural communities in developing countries. Based on these study findings, the adoption and use of existing technologies was highly influenced by the social environment (Rogers, 2003.

Perception on adoption and use of ICTs

Perception can be viewed as a process of realizing and interpreting reality, based on comprehending words of individuals' interaction with their environs (Abbasian, 2018). Whereas cognitive behavior models focused on intentions of the predictors, the diffusion of innovation is regarded as a social process whereby consumers form a general attitude towards the technology (Creswell, 2007). According to Kante et al. (2019) the underuse of ICT-based farm input information services in developing countries model is influenced by farmers' perceptions. For instance, a study conducted in Mali identified factors influencing ICT-based farm information using systematic literature review based on 18 published studies from the following countries: Benin, India, Indonesia Iran, Kenya, Mali, Nigeria, Pakistan, Tanzania, Uganda, Senegal, China, Bangladesh, Burkina Faso, Jamaica, Trinidad, Tobago, and Fiji, these perceptions included relative advantage, compatibility, complexity, observability, trialability, perceived costs, observability, social influence, information quality and voluntariness (Richardson, 2009; Kante et al., 2019).

Numerous studies acknowledged that adoption and use of ICT depends on the perceptions of the potential user (Kante et al., 2017; Aker & Mbiti, 2010; Kante et al., 2019). Numerous authors concluded that an individual's perceptions are positively related to the adoption of ICT (Kante et al., 2019). For instance, a study conducted by (Okello, 2014, cited in Kante et al., 2017) concluded smallholder farmers found use of mobile phone-based technology services complex to use. Another study conducted in Benin concluded that positive attitude from the users influenced the use of mobile phone-based technology services (Kante et al., 2017). According to Roger (1983) the rate of technology adoption is affected by the perception of potential adopters. This was highlighted by many studies on ICT adoption/use in many studies (Atkinson, 2007).

To identify factors affecting adoption/use of ICTs Kante et al. (2019) reported there is a relationship between ICT use and perception. Therefore, farmers' perceptions are considered an important determined in adoption of new technology. The definition of constructs and application in the study context is illustrated in Table 2.

Table 2

Definition of Constructs and Application in the Study Context

Construct	Definition	Application
Relative Advantage	The extent to which the mobile phone technology is supposed to be superior to the traditional available means of agricultural communication in rural Kenya.	Offers agricultural market information that appears to be useful when equated to other existing ICTs or means of communication.
Observability	Extent to which the impact or results of the new technology are visible by the already users and potential users.	Results of use of new technology are visible through interaction with others.
Compatibility	Costs incurred as initial set up cost plus transaction cost.	Cost farmers pay to access the service
Complexity/Simplicity	If farmers perceive mobile phone technology is supporting and enabling efficient supply chain integration within the rural context.	Support of supply chain integration within the agricultural supply chain.
Social Influence	Effortless to adopt and use mobile phone technology for agricultural supply chain integration.	Less difficulties in using mobile phone technology for supply chain integration.
Perceived Cost	If farmers perceive mobile phone technology is supporting and enabling efficient supply chain integration within the rural context.	Support of supply chain integration within the agricultural supply chain.
Information Quality	Effortless to adopt and use mobile phone technology for agricultural supply chain integration.	Less difficulties in using mobile phone technology for supply chain integration.

Note: Kante et al., (2019) adapted from An ICT model for increased adoption of farm input information in developing countries. A case in Sikasso, Mali.
https://www.sciencedirect.com/science/article/pii/S2214317318301355

In a study conducted in Mali on use of mobile phone technology on users "senekela" found that relative advantage, compatibility, simplicity, and information quality were the major factors influencing agribusiness SMEs use of mobile phone technology within the agricultural chain in that country (Kante et al., 2019). These findings (are illustrated in table two) were from eighteen other developing countries e.g., Uganda, Burkina Faso etc. An additional focus of inquiry was to conduct empirical studies from other developing economies to validate similar or additional perceived to develop and propose an ideal model for increased mobile phone based for increased adoption and use of mobile phone technology (Kante et al., 2019). The studies summary of factors affecting the use of ICT-based farm input information is illustrated in Table 3.

Table 3

Factors affecting the use of ICT-based farm input information

Construct	**No of counties**	**Countries**
Relative Advantage	13	Benin, India, Indonesia, Iran, Kenya, Mali, Nigeria, Pakistan, Tanzania, Uganda, Senegal, China, Bangladesh.
Compatibility	6	Benin, India, Indonesia, Iran, Kenya, Mali.
Complexity/ Simplicity	7	Benin, India, Indonesia, Iran, Kenya, Mali, Nigeria, Pakistan, Tanzania, Uganda, Senegal, China, Bangladesh
Trialability	1	Iran
Observability	7	Benin, Iran, Mali, Tanzania, Uganda, Fiji, India, Burkina Faso
Information Quality	8	India, Kenya, Mali, Nigeria, Tanzania, Pakistan, Uganda, China
Cost	10	Mali, Tanzania, Uganda, Kenya, Pakistan, Jamaica, Bangladesh, India, Trinidad and Tobago
Social Influence	10	Guinea, Iran, Mali, Tanzania, Uganda, Pakistan, Fiji, Nigeria, India, Burkina Faso
ICT skills	6	Uganda, Mali, Tanzania, India, Jamaica, Burkina Faso
Literacy/illiteracy	5	Benin, Tanzania, Mali, Pakistan, Burkina Faso

Note: Kante et al., (2019) adapted from An ICT model for increased adoption of farm input information in developing countries. A case in Sikasso, Mali.
https://www.sciencedirect.com/science/article/pii/S2214317318301355

Diffusion of innovation theory has been applied in recent years to describe and predict the rate of adoption of an innovation in a social system (Richardson, 2009, & Kante et al., 2019). According to (Rogers, 2003), the perceived attributes of innovation influence potential adopter's decision to adopt and use the existing technology. Previous empirical study findings emphasized that relative advantage, compatibility, trialability are positively associated with rate of adoption.

(a) **Relative Advantage** is the extent to which an innovation is perceived to be better than the idea it succeeds or existing substitutes. A new technology could be of economic, social, or personal benefit measured in form of profitability, minimize discomfort when using the new technology, and time saving (Rogers, 2003; Askar, Usluel, Mumcu, 2006).

(b) **Compatibility** is the extent to which an innovation is perceived to align to known values: including needs, beliefs, and life experiences of potential adopters (Rogers, 1995; Roger, 2003. P 15). For this study, compatibility is perceived as the new technology being with smallholder farmers' values in the study context.

(c) **Complexity** is the extent to which the innovation is perceived to be difficult to use (Rogers, 2003). To understand the greater difficult to use a new technology is essential, to ascertain that the anxiety of technological complexities does not present themselves as an obstruction to potential adopters. Complexity was recognized by Roger as the grade to which an invention is measured as relatively complicated to be understood and used (Roger, 2003). As Rogers alleged, that complexity is reverse to the other factors of innovation, it is said to have a negative correlation with the average of adoption.

(d) **Observability** is the extent to which the outcomes of using an invention are visible and can be explained to others (Roger, 1995).

(e) **Trialability** is the extent at which the innovation could be tested to a limited scale prior to the actual use (Rogers, 2003).

Logic of Inquiry

Quantitative method is aligned with the research goal to identify and examine the correlations between dependent and independent variables (Venkatesh, Sue & Bala, 2013). Saunders, Lewis, and Thornhill, (2009) considered surveys as an appropriate data collection tool; surveys permit collection of data to be analyzed using quantitative techniques and draw relationships between variables. For this study, use of online surveys with a Likert scale questionnaire was utilized (Zohrabi, 2013). Use of online survey strategy helps control survey related cost, time efficient, and little social pressure on participants as they feel anonymous (Abebe & Cherinet, 2019; Saunders et al., 2009). Self-administered survey questionnaires can be administered by mail, email, web-based or online, self-administered questionnaires can cover a wider scale, are cheaper and considered to be time effective, with a low response rate. Face to face administered questionnaires can be more expensive and time consuming compared to self-administered questionnaires (Venkatesh et al., 2013).

Rationale for Quantitative

The rationale for a quantitative research inquiry is founded on the research problem or the research questions for the anticipated study. Need for a quantitative inquiry falls into four categories: descriptive, relationship, historical and comparative. The descriptive research questions seek measurable analysis on more than one variable. Frequently, the research questions start with “What” fall in the descriptive group. For example, “what are the causes of capital income?” could be considered as descriptively bound research questions that need a quantitative inquiry (Onwuegbuzie & Leech, 2006; Sekaran & Bougie, 2010, p. 105, as cited by Khalid,

Abdullah & Kumar, 2012). The comparative group of research questions or the research problem seeks to equate one or more independent variables with the dependent variable, For example, the impact of capital market on organizational performance. The third group of research question includes the "relationship nature question". For example, the relationship between capital and stock split initiation. Onwuegbuzie and Leech (2006) stated that these types of research questions include words such as: association, relationship, and trend. Lastly, historical type of research questions seeks to predict the future. The type of research questions or problem is mainly built on the deduction approach that includes hypotheses development and testing, of dependent and independent variables (Onwuegbuzie & Leech 2006).

Quantitative research methods lay emphasis on objective measurements through numerical analysis utilizing statistical procedures to manipulate data collected utilizing questionnaires through surveys (Babbie, 2010). Variables take different forms and can either be independent, dependent, or extraneous. Independent variables are factors that are presumed to affect the dependent variable. Creswell (1994, p.63) described dependent variables as follows, "outcomes or results of the influence of the independent variables". This definition implies that independent variables assert some effect on dependent variables. Extraneous variables are unwanted factors that influence the outcome of a study. Findings from collected data are then generalized across a given population to offer insights on a given phenomenon of interest (Babbie, 2010).

An added rationale for adopting quantitative measures for this empirical study is the required the application of quantitative tools in data analysis (Basri, 2015). Based on the literature review, this study was prepared to exhibit the relationship between the independent variable, the dependent variable, and the three moderating variables of this study. For similar

reasons, Hill (1998) suggested 10 to 30 participants for pilots in survey research. While Julious (2005) echoed a minimum of 12 subjects per group be considered appropriate for pilot studies. According to (Basri, Alendejani & Almadani, 2018) most quantitative studies focused on the relationships between independent and dependent variables applied correlation and regression statistics to exhibit the relationships between X and Y factors.

Research Paradigms

According to Sanders, Lewis, and Thornhill (2009) a paradigm is a way of probing a social phenomenon from a certain understanding. There are five major types of research paradigms: (a) positivism, (b) critical realism, (c) interpretivist, (d) postmodernism, and (e) pragmatism. While Candy (1989) suggested there are three main research paradigms (a) positivist, (b) interpretivist, and (c) critical paradigm. Other researchers such as (Tashakkori & Teddlie, 2003) proposed four essential research paradigms: (a) positivist, (b) interpretivist/ constructivism, (c) critical /transformative paradigm, and (d) pragmatic paradigm.

Positivism Paradigm

Creswell, 2002 argued that positivism was rooted in the works of a French philosopher and sociologist, Auguste Comte from 1798 to 1857. According to Alvesson, 2009 the word positivism originated from a Latin word which means facts positioned for a researcher. Positivists claimed the social world can be understood in an objective manner and opposed to personal views, in the same perspective positivists advocated for scientific methods to understand the social world (Crotty, 1998, p8-9, cited by Schuil, 2020). While Comte (1856) suggested that experimentation and observation ought to be the basis of understanding a phenomenon. The following are characteristics of research embedded in the positivist paradigm:

(a) beliefs that theories are universal, (b) there exists a single reality, (c) ignoring the context of the phenomena, (d) knowledge is discovered, (e) results of inquiry can be quantified, (f) studies often rest on formulation and testing of hypothesis, and (g) application of scientific methods (Tashakkori & Teddlie, 2003; Tashakkori & Creswell, 2007). The following research terminologies are associated with positivist paradigm: experimental, casual relative, reductionism, theory examination, correlation, determinism, and regulatory (Creswell & Tashakkori, 2007). Additionally, positivist studies often focus on understanding the relationships of phenomena (Saunders et al., 2009). Therefore, a positivist research philosophy has been selected for this study.

Interpretivist/Constructivist Paradigm

Interpretivist/ constructivist paradigm emerged as a critic of dominance of positivist paradigm. Interpretivists embrace a relativist ontology which is assumed there is no single reality, while subjective epistemology stated that meaningful reality is contingent to human behavior (Crotty, 1998). The central endeavor is to understand subjective nature of human experiences). This approach holds views that that reality is socially constructed and has possible multiple realities, studies are conducted in their natural setting often using grounded theory, ethnography, and case studies for in-depth knowledge in the social context. Constructive view suggested that individuals took objective knowledge, and the truth is a result of their perspectives, therefore, truth and reality are created not discovered, consequently, researchers tend to gain a deeper understanding of the phenomena in the context (Guba & Lincoln, 2005 p. 204, cited by Mertens, 2014, & Creswell & Tashakkori, 2007). Common research terminologies associated with interpretivist/constructivist paradigm: naturalistic, phenomenological,

ethnographic, theory creation, hermeneutic, case studies, interpretivist, and interviews for data collection (Creswell & Tashakkori, 2007).

Critical/transformative paradigm

Critical realists claim reality is constructed through social justice and endeavors to address issues about oppression (Common research terminologies associated with interpretivist/constructivist paradigm: naturalistic, phenomenological, ethnographic, theory creation, hermeneutic, case studies, interpretivist, and interviews for data collection (Creswell & Tashakkori, 2007). It is assumed reality is independent of the observer. Critical realists undertake to explain what is observed and experienced in terms of available structures that shape observable events. The common terminologies associated with critical paradigm are critical theory, neo-Marxist, feminism, critical race theory, emancipation, defense, sexual theory, interventionistic and historical experiences (Creswell & Tashakkori, 2007).

Pragmatism paradigm

Hall's (2013) pragmatic paradigm aim to bridge the gap between positivist and interpretivist views about nature and possible truth, in this sense pragmatic paradigm was developed end the 'paradigm wars' between positivist and social constructivist stance. Proponents of pragmatic paradigm claim it is difficult to solve social world problems using one scientific method (Tashakkori & Teddlie, 2003; Patton, 2002). Proponents of pragmatic paradigm claim the choice of research paradigm must be aligned with the research problem and research questions at hand (Greene, 2007). Further, philosophers (such as Tashkkori & Teddlie, 2003; Patton, 2002, cited by Emmel, 2013) the world needs a worldview that provide research methods that are deemed appropriate to address research questions.

According to (Teddlie & Tashakkori, 2009) pragmatic thoughts are applicable when they support action; therefore, this study is founded on a pragmatic paradigm view that assumes there can be multiple realities. Consequently, the best research method responds effectively to a research problem in question. The mixed method approach originated from the premise that use of both qualitative and quantitative research methods aids in better understanding of the social phenomena (Creswell, 2003). Some critics argue the notion of linking pragmatic paradigm with mixed method research based on the stance of "what works" threatens validity of the study (Denzin, 2012). However, Green (2007) argued pragmatic perspective about "what works" enables the researcher to employ multiple research methods incorporating both qualitative and quantitative stand points giving priority to the research problem and research questions, which is largely associated with the rise of mixed method studies (Creswell, Klassen, Clark & Smith, 2011).

Summary of Data sources and Search Strategy

This section reviewed existing peer reviewed papers between 2010 and 2020. Data sources include the following databases: Wiley Online Library, ScienceDirect, Google scholar and Digital Library. Search criteria involved combinations of key terms: ICT, mobile phone services, smallholder farmers.

Summary of reviewed articles common methods used under quantitative design were survey, questionnaire, and surveys, while qualitative methods employed were interviews, focus groups, and observation. Mixed method approaches included semi-structured interviews, descriptive representation, surveys, questionnaire and focus groups. The snapshot of the reviewed work is illustrated in Table 4.

Table 4

Snapshot of Reviewed Work

Author	Focus	Research Design	Method
Wyche & Steinfield (2016)	To find out why farmers are not using m- services to access market prices in rural parts of Kenya	Qualitative	Interviews, observations Focus groups
Wyche et al., (2018)	Participation of women m -services use in rural parts of Kenya	Qualitative	Group interviews and observations
Kabbiri et al., 2018	Adoption of Mobile phones among smallholder farmers in Uganda	Quantitative	Questionnaire
Drafor, 2016	To access to MIS for farm level decision making	Quantitative	Descriptive statistics (Secondary data)
Terefa, Bijman & Slingerland, (2019)	Role of multinational and modernization on agricultural value chains in African Countries	Qualitative	Document review, Interviews Focus group discussions
Martin & Abbott (2011)	MIS and Rural livelihoods among smallholder farmers in remote Uganda	Mixed Method	Semi structured interviews Descriptive statistics
Sikundla, Mushunje & Akinyemi, 2018	Socio economic drivers of MIS adoption among SMEs in South Africa	Quantitative	Semi structured questionnaire (face to face)
Kamunge et al., (2014)	Factors Influencing the Performance of SMEs in Limuru municipality market, Kenya	Quantitative	Descriptive statistics
Mwambi et al., (2016)	Effect of contract farming among avocado smallholder farmers income in Kandara, Kenya	Quantitative	Instrumental variable model
Yankson et al., (2016)	Challenges and strategies for improving for MIS in Developing Countries in Ghana, Kenya	Mixed Methods	Surveys, Focus groups
Ogbeide & Ele (2015)	Small scale farmers and MIS in sub–Saharan Africa	Quantitative Analysis	Quantitative questionnaires based on multistage sampling
Mutula & Brakel (2007)	ICT skills for emerging digital economy among small business in developing countries: Case study of Botswana	Qualitative case study	Focus groups
Ahmad (2016)	Usage of MIS by SMEs in attaining vision 2020 Goals	Qualitative	Interviews
Ardjouman (2014)	Factors influencing small and medium enterprises (SMEs) in adoption and use of technology in Cote d'Ivore	Quantitative	Surveys
Litondo (2013)	Determinants of Mobile Phone Usage for E –commerce among Micro and small enterprises in the informal sector of Kenya	Quantitative	Surveys
Rono (2018)	The Use of mobile technology and the performance of agro-based small and medium enterprises	Quantitative	Descriptive survey
Lwoga et al., (2018)	ICTs and development in developing countries	Qualitative	Systematic literature review
Baumuller (2015)	Evaluating the role of mobile phone in offering price information and market linkages	Mixed method	Semi structured interviews, Focus group, Questionnaire based surveys
Perekwa, Prinsloo & Deventer (2016)	The Effect of mobile phone technology on small enterprises in Zimbabwe	Quantitative	Questionnaire

Review of Methods

Table 5

Method Applied

Author	Focus	Research Design	Method
Kante et al., (2017)	Influence of Perception and Quality of Quality of ICT Based Agricultural Input Information on Use of ICTs by farmers in Developing Countries: case of Sikasso in Mali	Quantitative	Surveys
Kante et al., (2019)	An ICT Model for Increased Adoption of Farm Input Information in Developing Countries: A case in Sikasso, Mali	Qualitative	Surveys
Ifeoma & Mthitwa (2015)	Analysis of Impact of the use of mobile communication Technologies By Framers in Zimbabwe: A case of Esoko & EcoFarmer Platforms	Qualitative	Focus group discussions
Chikuni & Kilima (2019)	Smallholder farmers' market participation and mobile phone-based Market information services in Lilongwe, Malawi	Quantitative	Surveys
Albar & Mustafa (2019)	Factors Affecting the Adoption of Information and Communication Technology in Small and Medium Enterprises: A perspective from rural Saudi Arabia	Qualitative	Surveys
Okello, Kirui & Gitonga (2020)	Participation in ICT based market information projects, smallholder farmers' commercialization, and agricultural income effects: findings from Kenya	Quantitative	Surveys
Katunyo et al., (2018)	Factors influencing the intensity of use of ICT tools by youth along Agricultural value chains: Evidence from Busia County, Kenya	Quantitative	Surveys
Diaz at al., (2021)	Factors affecting farmers willingness to adopt a mobile phone app in the marketing of bamboo products	Quantitative	Surveys
Krell et al., (2020)		Quantitative	Surveys
Katengeza & Okello (2011)	Use of mobile phone technology in agricultural marketing; The case of smallholder farmers in Malawi	Quantitative	Surveys
Owuso, Yankson, & Frimpong (2017)	Smallholder farmers' knowledge of mobile telephone use: Gender Perspectives and implications for agricultural market development	Quantitative	Surveys
Okello et al., (2020)	Effect of ICT tools attributes in a accessing technical, market and financial information among youth dairy farmers in Tanzania	Quantitative	Surveys
Diaz et al., (2021)	Factors affecting farmers' willingness to adopt a mobile phone app in the marketing of bamboo products	Quantitative	Surveys
Magesa (2014)	Access to agricultural market information by rural farmers in Tanzania	Quantitative	Surveys
Ogutu et al., (2014)	Participation in ICT based market information projects, smallholder farmers' commercialization	Quantitative	Surveys

Reliability and Validity

The foundation a rigorous research design lies in the approval of both a valid and reliable research instrument (DeVon et al., 2007). Similarly, (Merriam (1998) postulated that good research is geared toward producing valid and reliable knowledge. Therefore, assessing the validity of a research instrument is crucial in adding credibility to the selected research design (Masuwai, Tajudin & Saad, 2016; Tashakkori & Teddlie, 2003). Similarly, (DeVon et al., 2007) recommended that a survey instrument should be validated to check internal consistency and factor analysis.

Reliability

Reliability is an essential but not a complete component of assessing validity; it defined as the ability of a questionnaire to consistently measure a variable (DeVon et al., 2007). According to (Cronbach & Shavelson, 2004) researchers should be able to observe the following subjects when assessing reliability:

- Standard error of the survey instrument
- Representative sampling
- Diverse content
- Uses of the research instrument.

Lastly, internal reliability of the questionnaire can be evaluated by means of Cronbach Alpha to ensure the items or questions tied to each construct were measuring the intended attribute (Cronbach, 1951; Nunnally, 1978 cited by Drost, 2011). However, some researchers differ when it comes on a standard acceptable alpha to justify reliability of the research instrument. (Nunnally & Bernstein, 1994, cited by Šerbetar & Sedlar, 2016) recommended an alpha of at least 0.90 for clinical research, while for field studies an alpha of 0.70 is acceptable.

The approach of developing the validity of the research instrument is like previous studies like (Moore & Benbasat, 1991). The author applied Cronbach alpha technique to determine internal reliability of the survey instrument.

Validity

It is defined as the ability of a research instrument to measure what it is intended to measure (DeVonet al., 2007; Masuwai et al., 2016). Support for the validity of survey questionnaire has been determined by examining constructs. The four main types of validity namely, face validity, content validity, and construct validity, criterion validity (Taherdoost, 2016). The author applied content and construct validity.

Face Validity

According to (DeVon et al., 2007) face validity enabled respondents to evaluate each research question in terms of; clarity of the wordings to the possible targeted audience based on the Likert scale 1- 4; strongly disagree = 1, disagree = 2, agree =3, and strongly agree = 4 or a dichotomous scale with categorical choices of "Yes" and "No". Common score scale for face validity is connected to following:

- Appropriateness of language
- Clarity of variables
- Grammar
- Spelling mistakes
- Correct structuring of questions
- Overall structure and format of the instrument. (Masuwai et al., 2016).

Construct Validity

The extent to which the instrument measures the constructs intended to be measured and is aligned to the theoretical constructs (Kane, 2001; DeVon et al., 2007). When the construct consists of several items, factor analysis is preferred to estimate construct validity (Bryman & Cramer, 1999). Factor analysis is a statistical tool often used in grouping items in a common cluster, based on the factor/component loading (Munro, 2005). In previous studies the application of internal reliability, factor analysis; principal component analysis, discriminant and convergent reliability have been applied to establish construct validity (Kante et al., 2019). The author used component factor (Munro, 2005).

Content Validity

Assessment through expert judgement, it relies on feedback from experts on relevance and completeness of experts' opinion. Content validations are generally during the design of a new instrument or for validation purposes (Masuwai, et al., 2016). For this study the author used content validity index (CVI), feedback on content validity is based or content validity ratio (CVR) (Masuwai, et al., 2016). The evidence is based on the experts' ratings (Terwee, et al., 2018). The selection of experts for content validity is illustrated in table 6.

Table 6

General Schedule for the Content Scaling Structure Procedure

Step	Description
Development of the expert questionnaire	Define clear instructions and working definitions in an item booklet.
Selection of experts	Select a minimum of five experts from diverse fields (within or outside the domain field).
Individual information gathering with each expert	Face to face interview, Emails there is no time limit listed.
Summary of the results based on predefined rules	Summarize the results: mean percentages of the assignments, relevant dimensions for each item. Content-analyze responses to open-ended questions or think-aloud responses.
Meeting of the experts, discussion of the results	A least of two experts from diverse fields discuss the outcomes.
Validation study	Inspect the validity of the instrument in an illustrative sample using an appropriate psychometric model (item-response models, factor-analytic approaches).
Final definition of the latent construct. If necessarily go back to point 1 or to point 5	Based on all outcomes, enhance the operational definition of the target construct measured by the instrument if necessary, and identify other latent constructs that impact the response process. Based on the research interest, respond to further topics like discriminant and congruent validity. Integrate the results.

Acceptance of content validation approach permits the study to demonstrate that the intended instrument for data collection is all-inclusive with respect to consciousness and completeness needed to determine the instrument's credibility at the initial stages (Lynn, 1986). The expert panel member nominated need to possess a wide range knowledge and demonstrate a good grip of the subject. The instrument is evaluated by content validity index (CVI) or content validity ratio (CVR) (Masuwai, et al., 2016). The adequacy of the final content of the test instrument would be constructed on the collective opinion of these experts based on their expertise (Sangoseni, Hellman & Hill, 2013).

Theoretical Background Review

Over the past decades, the diffusion of innovations has been a subject of investigation. This section describes some common theories applied on adoption of ICTs in the field of information system. Lwoga and Sangeda, (2019) reviewed 57 articles on ICT from 1990 to 2017, the results revealed qualitative studies were predominant with limited in-depth of indicators, In the same study, (Lwoga & Sangeda, 2019) observed the inclusion of participatory approaches to qualitative studies to enrich the outcomes. For instance, Wyche and Steinfield (2016) applied affordance theory using the participatory approach to qualitatively understand perceptions that impeded adoption of M-services among farmers in rural Kenya. Based on the literature review based on 386 articles published from 1998 to 2006 (Kante et al., 2019) reported Technology Acceptance Model (TAM), Diffusion of Innovation (DOI), Theory of Planned Behaviors (TPB) and Social Cognitive Theory (SCT) were the most applied models in the field of information system.

Technology acceptance model (TAM)

The TAM model has been used in prediction and explanation on end users' reaction to new technology, the applicability of TAM involves understanding key concepts for adoption of adoption, the attitude or intent to use the new technology determines its adoption and actual use of the new technology by individual users (Kabbiri et al., 2018). Based on previous literature, TAM is considered the most popular model on technology adoption because of its flexibility to accommodate other variables (Luarn & Lin, 2005; Chuttur, 2009); Kabbiri et al., 2018). TAM is popular and flexible to accommodate other variables on adoption on new technology (Kabbiri, et al., 2018).

However, (Luarn & Lin, 2005; Chuttur, 2009) stated that the three major drawbacks of TAM model are the assumption on non-existence of factors that impede an individual behavioral intention to adopt to new technology. What can motivate an individual to adopt or not adopt to new technology, and failure of TAM to recognize relative advantage as an influence on behavioral intention to adopt and use the new technology. For example, according to Kabbiri et al., 2018 one may find use of the mobile based service is useful and easy to operate but may still fail to adopt the service until he/she recognizes the perceived relative advantages associated with the use of mobile phone technology, compared to other existing alternatives like radio in accessibility of market information. TAM has been used in studies to investigate adoption and use of mobile phones in agricultural food chains in Africa (e.g., Faris-Martinez & Virsesa, 2012; Islam & Grönlund, 2011; Kabbiri et al., 2018).

Affordance Theory

Affordance theory has been adopted in an effort to understand people's interaction with technology to inform design in achieving ICT4D in regions that experienced digital isolation (Wyche & Steinfield, 2016). Clear understanding of affordance functional of technology would enable to assess if these technologies would be effective for use (Conole, 2002). Furthermore, with focus on human computer interaction (HCI), (Wyche & Steinfield, 2016) study findings concluded there was a mismatch of the design of the current existing mobile phone-based services with the needs of farmers in the rural context of Kenya.

Diffusion of Innovation Theory (DOI)

According to Rogers (2003) diffusion of innovation (DOI) is defined as "a process by which an innovation is communicated through certain channels over time a social system" (p. 3).

DOI conceptual framework fits better than TAM based on the goal of this study as it expounds on how a new technology gains momentum. First, the application of the DOI was originally applied in the field of agriculture Ryan and Gross (1943) who examined farmers adoption on ICT- based farm information, and later applied in other fields of technology adoption (Kante et al., 2019). Second, DOI fits better with identified constructs relevant to this study toward gaining accurate information on rate of adoption (Richardson, 2009; Kante et al., 2019). Although (Rogers, 2003) relied on the five attributes of innovation, which included: relative advantage, compatibility, observability, complexity and trialabity the adoption gap. Some critics like (Khan & Woosley, 2011) argued that DOI does not put in account individuals' access to resources and social support. Therefore, this study added three more constructs: quality, cost and innovativeness to describe perceived the innovation attributes of this study.

Rogers's diffusion on innovation theory, further classified potential adopters as: early adopters of the new innovation, early majority adopters of the new innovation, late majority adopters of the new innovation, and lastly the laggards (Rogers, 2003). Furthermore, (Van Braak, 2001) defined innovativeness as socially constructed decision dependent on the individual's characteristics to adopt and use the new technology. According to (Rogers, 2003) an individual's innovativeness aids in understanding one's behavior in the decision-making process.

Conceptual Framework

Based on the reviewed literature, the conceptual frame adopted for this study was based on extended diffusion of innovation (DOI) model. The DOI model fits well with the identified constructs which been previously applied in similar studies (Kante et al., 2019). The model visually described the framework of variables to be examined. In investigating factor influencing the adoption and use of adoption, at the same time examine the relationship between adoption

and explanatory variables in the study context. The figure shows a combination of the extended theoretical framework and demographic such as age, education, gender, income, and period of adoption constituted preliminary part of the study. The research model of the study is illustrated in Figure 3.

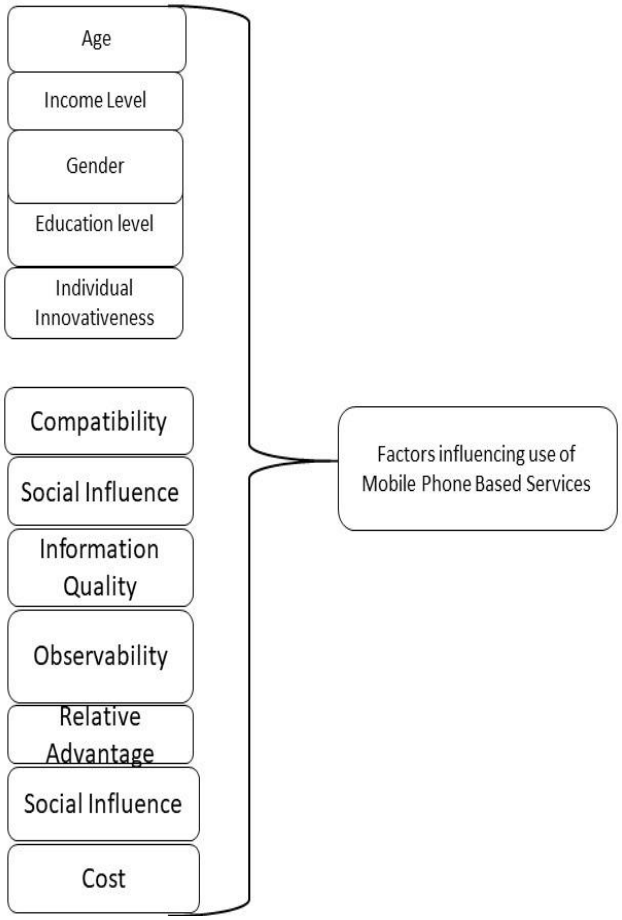

Figure 3. *Conceptual Framework*

CHAPTER 3: METHODOLOGY

Introduction

This chapter covered research methods and procedures that were applied to investigate factors associated with the use of mobile phone-based services regarding the use of agricultural market information in Bungoma County, Kenya. The themes included purpose of the research, research design study site and target population, sample size and sampling technique, data collection procedures, validity and reliability, data analysis, and ethical considerations.

Purpose of Study

The purpose of this study was to identify and examine factors that are likely to influence use of mobile phone-based services among smallholder farmers in Kenya. The author used multinomial regression method to examine factors that are associated with the use of mobile phone services. This study was grounded on the original premises of DOI theory (Rogers, 2003). In addition, (Rogers, 2003) claimed the original DOI model consists of five perceived attributes that influence the adoption and use of an innovation which include: Compatibility, Complexity, Relative Advantage, Observability and Trialability (Roger's, 2003). Similarly, empirical study findings supported the five attributes of innovation accounted for 49-87% variance on innovation gap in a social system (Moore & Benbasat, 1991; Rogers, 1995; Pankratz & Cho, 2002; Rogers, 2003; Richardson, 2009; Kante et al., 2019). Therefore, this study applied the following independent variables to gain knowledge and understand factors associated with the use of mobile phone-based services in the study context which included: relative advantage, observability, perceived costs, compatibility, social influence, information quality, gender, level

of education, income and the period of adoption and use of mobile phone-based services among smallholder farmers in Bungoma Country, Kenya.

Research Questions

The following research questions guided this study:

1. What factors influence the adoption and use mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County, Kenya?
2. What is the relationship between use of mobile phone-based services and the perceived characteristics of innovation among smallholder farmers in Bungoma County, Kenya?
3. What demographic characteristics influence the adoption and use of mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County?

Study Site Context

The study was conducted in Bungoma County. It is one of the forty – seven counties in Kenya. This County was purposefully selected as it is one of the high potential agricultural areas located in rural part of Kenya, mainly dominated by subsistence small-scale farming. Secondly, abundance of mobile phone-based services awareness among smallholder farmers, for instance, the region was previously targeted for developmental projects involving use of ICTs and among smallholder farmers, for instance the DrumNet development project and the Kenya Agricultural Commodity Exchange development project which enabled ICT market information services to smallholder farmers implemented either individually or in a group (Okello et al., 2010; Wawire, 2013). A participatory study on use of mobile phone technology services (Mfarm) focused on mobile phone technology design was conducted in Bungoma County in May 2013 (Wyche &

Steinfield, 2016; Krell et al., 2021). Therefore, it is assumed smallholder farmers in Bungoma County area aware of the existing mobile phone –based services in the region. The study area – Bungoma County is illustrated in Figure 4.

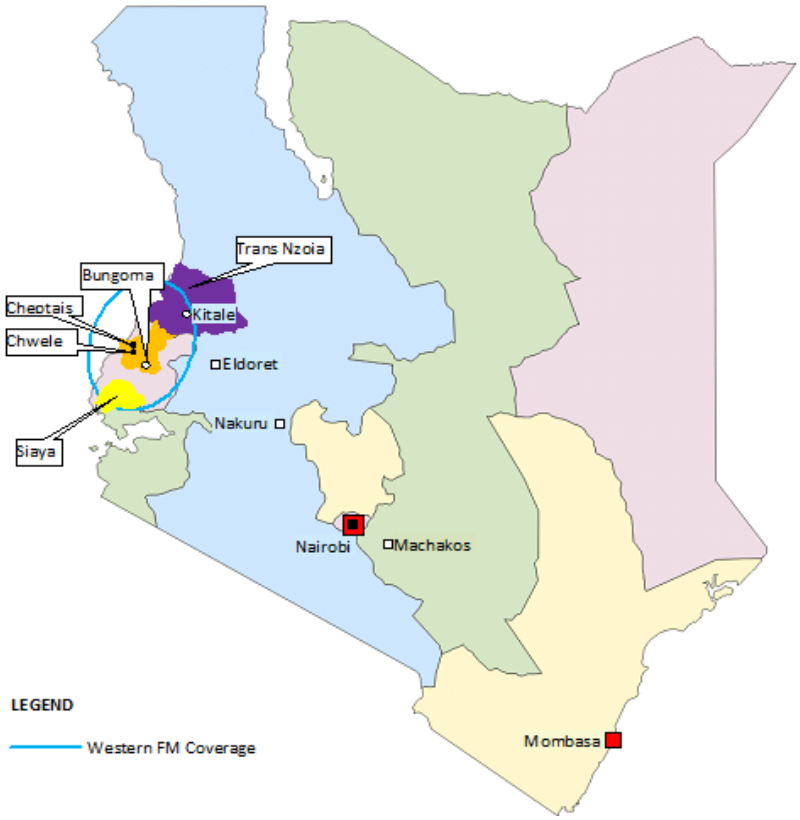

Figure 4. *Study Area – Bungoma County*
Source: Bungoma DNP, 2005 -2010, Oloo, Ngigi, Mshenga (2013)

Research Design

This study utilized a cross-sectional correlational design to examine factors associated with the adoption and use of mobile phone-based technologies in the study context (Lodico, Spaulding & Voegtle, 2010). Data was collected from a convenience sample of 150 smallholder farmers from Bungoma County, using self-administered online surveys. The questionnaire contained: (a) closed ended questions on the demographic characteristics, and (b) a five point-

Likert scale questions on perceived characteristics of the attributes of the new technology, with illustration of the scale as "5" for strongly *agree* to 1: strongly disagree on questions related to characteristics of mobile phone-based services in the study context. The independent variables under study included: relative advantage, observability, costs, compatibility, complexity, social Influence, information quality, income, age, gender, education, innovativeness.

The research design aligned with research questions guiding this study and required a correlational statistical method to determine the relationship between the dependent variable and the independent variables (Johnson, Onwuegbuzie & Turner, 2007; Johnson & Christensen, 2019; Lodico et al., 2010; Rahman, Masuwai, Tajudin, Tek, & Adnan, 2016). For this study the dependent variable had multiple categorical outcomes, that are unranked (Nathans, Oswald, & Nimon, 2012; Hosmer – Lemeshow test, 2000 cited by Yu, Xu, & Zhu, 2017). Thus, Multinomial regression statistical was well suited for this study because the results of MLR would suggest whether a predictive relationship exists between use of mobile phone-based services (the dependent variable) with the independent variables, which include gender, education level, age, long run usage, relative advantage, observability, costs, compatibility, social influence, and information quality. Thus, the application of multinomial logistic regression provided a formidable tool to examine independent variables associated with categorical dependent variables. In this study the author employed multinomial regression to determine the relationships independent variables and the adoption and use of mobile phone (Lodico et al., 2010). See figure 5 below for an illustration of the research design of this study

Figure 5. *Research Design (Lodico, et al., 2001)*

Target Population

The population sample for the study was a convenience list of 200 smallholder farmers that was provided by the agriculture office of the County Government of Bungoma, Kenya. A convenient sample of 150 smallholder farmers was selected to gather data in the final study. For convenience, the sampling method was non-probabilistic. Invitation emails were sent out to all eligible participants in the month of July 2021. The inclusion criteria were smallholders who were at least over 18 years of age with email addresses. Participation in the study was voluntary.

Sample Size and Sampling Technique

The study used simple random sampling for the pilot study phase and used nonprobability convenience sampling for the final study phase. Members who participated at the pilot study phase were excluded from the final study. Data was analyzed using multinomial logistic regression technique. According to (Statistics Solutions, 2017) there is no known standard threshold for a required sample when using multinomial logistic regression. However, (Kline, 2013) argued a good study should have a sample size of at least 200 cases. On the other hand, (Creswell, 2007) shared that a sample size designed for MLR should have 10 times participants in relation to the number of independent variables under study. The final study yielded 119 responses from 150 questionnaires distributed to smallholder farmers in Bungoma County yielding a response rate of 79.3%. This conforms to (Goodhue, Lewis & Thompson, 2012) recommended that sample size on quantitative studies for MLR should be between 30 to

500 participants. Likewise (Bailey, Sabbagh, Loiselle, Boileau & McVey, 2010) shared that when using multinomial logistic regression, a sample size of at least 30 observations is considered appropriate for a study. Figure 6 below illustrates the participant selection data collection procedures.

Participant Selection and Data Collection Process

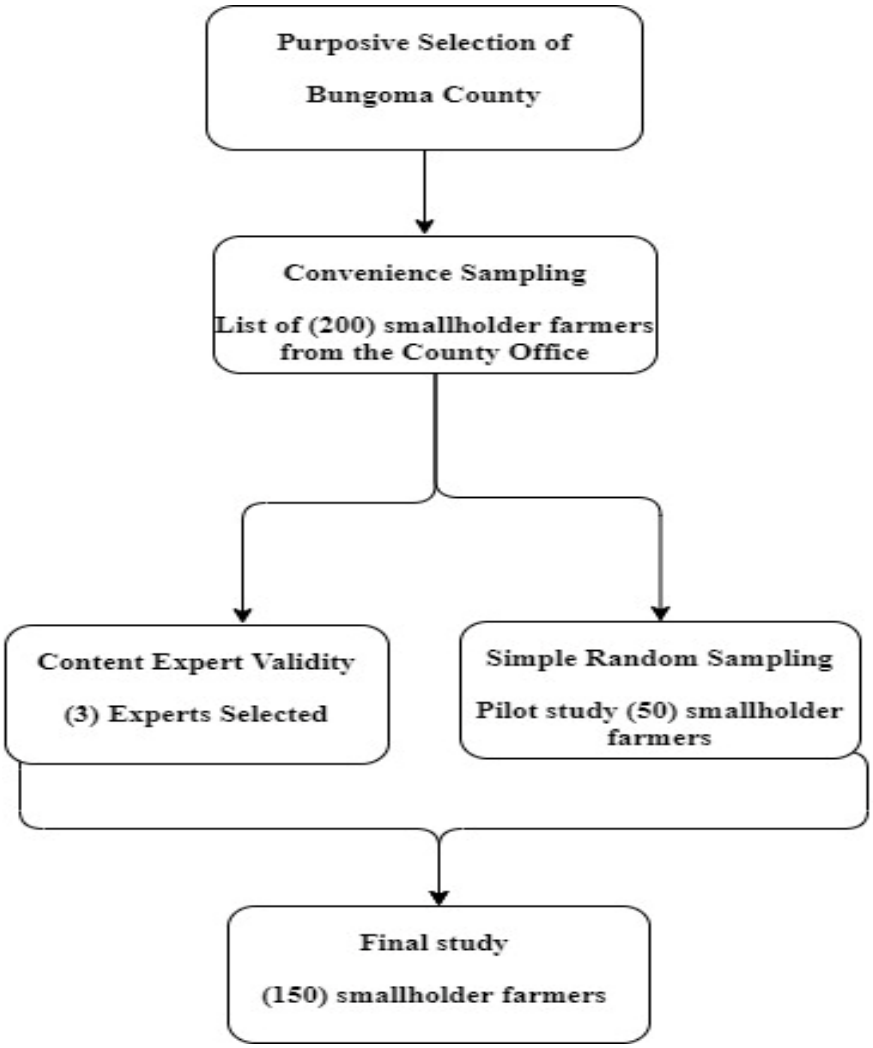

Figure 6. *Participant selection and Data Collection Process*

Instrumentation

The questionnaire for this study was adapted and slightly modified to fit this inquiry. The original version of the instrument was developed by Moore and Benbasat (1991) and used in various other studies (Venkatesh, 2003; Atkinson, 2007; Richardson, 2009; Kante et al., 2019). The questionnaire for this study was developed using Qualtrics software. The instrument was modified and based on Rogers' diffusion of innovation theory and literature related to technology adoption (Rogers, 2003; Kante et al., 2019). According to (Sudman & Bradburn, 1982) a questionnaire is an important tool used to obtain information from a large population in a short period of time. The questionnaire of this study (see appendix D) consisted of three sections. First section covered demographic characteristics of smallholder farmers including age, gender, level of education, income level, and innovativeness. The second section captured the innovation characteristics founded on the extended DOI model (Rogers, 2003; Richardson, 2009; Kante et al., 2019), the questions were based on a five-point Likert scale ranging from strongly agree to strongly disagree, that examined the following constructs: relative advantage, social influence, simplicity, compatibility, observability, information quality, and costs. The third section was designed to capture two (2) open ended questions that provided the respondents an opportunity to express their opinions on future use of mobile phone technology among smallholder farmers (Foddy & Foddy 1994).

Face Validity

Face validity is used to detect differences associated with superfluous statements (Tod hunter, 2015). The process for this study was undertaken for a period of two weeks to help in the wordings and non-ambiguity of the research instrument. The study questionnaire was designed

using simple words to ensure smallholder farmers can easily obtain clarity and provide responses on their perceptions of using mobile phone services.

Content Validity

A panel consisting of three experts with extensive knowledge in the field of information system and agricultural food systems in rural Kenya was utilized to establish content validity of the instrument of this study. The criteria for selection for this panel required that these experts have more than five years of research experience or familiarity with the concept through teaching and practice at a higher level. The research instrument was self-administered with an introductory letter to each expert. As suggested by (Masuwai et al., 2016) the experts were provided with detailed instructions on the process of rating and provision of feedback to the researcher. The validity was established using content validity index (CVI) method (Lynn, 1986, Masuwai et al., 2016). The administration of the content validity phase was conducted for a period of three (3) weeks. The calculation of content validity (1 –CVI) N = 3 Experts is illustrated in Table 7.

Table 7

Calculation of Content Validity (1 –CVI) N = 3 Experts

Item	Relevant	Not relevant	1-CVI	Interpretation
Complexity	3	0	0	Appropriate
Social Influence	3	0	0	Appropriate
Information Quality	3	0	0	Appropriate
Perceived Costs	3	0	0	Appropriate
Relative Advantage	3	0	0	Appropriate
Trialability	1	2	0.33	Eliminated
Voluntariness	2	1	0.67	Eliminated

Pilot Study

After the content validity phase, a pilot test was conducted. The pilot study was administered to 50 smallholder farmers randomly obtained from the list of 200 smallholder farmers provided by Bungoma County Office. The pilot study objectives were to validate the survey instrument through Cronbach alpha (DeVon et al., 2007; Rovai, Baker, & Ponton, 2014). The pilot study yielded 35 responses out of 50, which yielded a response rate of 70%. Constructs were measured with a 5- point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Participants reported they were comfortable handling the length of the questionnaire and had a clear understanding of the questions, therefore the author did not reduce the number of the survey questions nor modify the wordings the questions. However, based on the feedback a total of 5 questions were eliminated tied to trialability and voluntariness construct. The internal reliability of constructs is illustrated in Table 8.

Table 8

Internal Consistency Reliability of the Construct

Construct	Cronbach's Alpha	Items in Construct
Relative advantage	.777	2
Complexity	.837	2
Compatibility	.888	2
Observability	.819	2
Trialability	-.962	2
Information Quality	.815	2
Perceived Cost	.734	2
Social Influence	.707	2
Voluntariness	.524	2

The analysis yielded alpha coefficient values ranging from. -96272 to .88 to check for internal reliability. A minimum accepted standard internal reliability is .70 (Cronbach, 1980). Thus, the overall Cronbach alpha score was for the survey instrument was an acceptable score at 0.82. The results showed most constructs of the survey instrument were reliable except the scales on Trialability and Voluntariness. Therefore, Trialability and Voluntariness were eliminated after analysis of pilot data.

Data Collection

The data collection process employed online self-administered surveys. Due to research restrictions during Covid -19 pandemic, this study relied on a convenient sample of 150 smallholder farmers obtained from a list of 200 farmers provided by Bungoma County office in Kenya. The final study was conducted for a period of eight weeks from June 30th to August 29th, in 2021. The first step of data collection process was sending invitation emails to potential participants. Because at the time of data collection the author was in the USA, and unable to travel to the field. The author contracted a research consultant to be in contact with the farmers during the eight-week period. The completed online questionnaires were reviewed and checked for completeness. Cleaning of data was completed and a code sheet prepared. Data was populated into SPSS v26 package. A total of 119 smallholder farmers completed the survey from the population total of 150 smallholder farmers (a response rate of 79.3%).

Construct Validity

Construct validity is essential as it ensures each item in the instrument measures the construct, and there is a correlation of the items being investigated (Mitchell & Jolly, 2011).

According to (Comrey, 1973) principal component analysis was applied with Varimax rotation to measure construct validity.

Principal Component Analysis

Principal component analysis (PCA) was used to test correlations of variables aligned to each construct; this statistical technique was applied to test for construct validity using component matrix like factor loading (Todhunter, 2015). According to Comrey (1973) factor loadings of 0.45 could be deemed as fair, 0.55 could be considered well, 0.63 quite good and 0.71 could be deemed as excellent. The principal component matrix/factor loading is illustrated in Table 9.

Table 9

Principal Component Analysis

Constructs	Component Matrix
Relative Advantage Items	
The use of mobile phone app enables me to access a variety of markets	0.766
The use of a mobile phone app enables me to make more profits	0.820
The use of a mobile phone app enables me to connect with more buyers	0.799
The use of a mobile phone enables me to accomplish my tasks more quickly than relying on middlemen	0.830
The use of mobile phone app enables me to access a variety of markets	0.766
Observability Items	
I have no difficulty talking about the benefits of using a mobile phone	0.717
I have difficulty explaining the benefits of using mobile phone apps to my fellow to my fellow farmers	0.713
The benefits of using mobile phone app are visible to me	0.706
Costs Items	
The setup cost/ enrolment cost of a mobile phone app is not expensive	0.727
The transaction cost (bundles) for using a mobile phone app worries me	0.830
Getting market information through other means such as TV, extension agricultural officers, community meetings is expensive than using a mobile app	0.814
Compatibility Items	
Using a mobile phone app is compatible with most aspects of my work	0.834

Table 9

Continued

Using a mobile app is compatible with the way I would like to sell my products	0.925
Using a mobile phone app fit well with my lifestyle	0.933
Using a mobile phone app fit well with my work style	0.899
Complexity Items	
Using a mobile phone app requires little mental effort	0.886
When using the mobile phone app. I had difficulty finding the information I need	0.964
It is easy to become skillful when using a mobile phone app	0.960
It is easy to understand how to operate mobile phone apps	0.955
I feel using a mobile phone app gives me social status (kuheshimiwa) than those who do not use it	0.944
Neighbors (majirani) think I should continue using a mobile phone app	0.969
My friends use a mobile phone app to access agricultural market information	0.959
Information Quality Items	
Using a mobile phone app provides me with complete market information	0.913
Using a mobile phone, a mobile phone app provides me with relevant market information	0.970
Information I got from using a mobile phone app was in a suitable format	0.961

The results show high correlation among variables or components measuring each construct.

Assumptions of MLR Applied in the Study

The model assumes the membership of the dependent variable cannot be accurately predicated from the independent variables in the study. The application of MRL model is a good choice for this dataset as it does not assume normality, linearity, or homoscedasticity (Starkweather, 2011).

Data Analysis Process

Data was analyzed using statistical Package Social Sciences (SPSS version 26). Principal component analysis (PCA) was applied in this study to establish correlation among variables and estimated factor or component (Todhunter, 2015). Descriptive and multinomial logistic regression was considered suitable in identifying factors associated with the use of mobile phone-based services among smallholder farmers, and to examine relationships between the

dependent variable the significant independent variables. The multinomial logistic regression model is useful where the dependent variable has more than one categorical variable that are not ordered (Agresti, 2018; Hosmer – Lemeshow test, 2000 cited by Yu et al., 2017).

Research Permission and Ethical Considerations

Purdue University Institutional Review Board (IRB) approved the protocols of this study on April 23, 2021(IRB 2020 -1232), coupled with a permission letter dated August 27, 2020, obtained from Bungoma County agricultural office. Participation was voluntary, and no financial incentive was offered to smallholder farmers in Bungoma County for participation.

CHAPTER 4. RESULTS AND ANALYSIS

Introduction

This study identified and examined factors that are likely to influence the use of mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County, Kenya. This chapter presents the results from the analyzed complete questionnaires, i.e., 112 valid responses using the SPSS statistical tool v26 package. Data was collected using an online self-administered survey that was validated using Cronbach alpha, component factor analysis statistical technique. The author applied multinomial logistic regression technique to identify factors associated with adoption and use of mobile phone-based services regarding agricultural market information and examine relationships between the dependent variable and the independent variables. Descriptive statistics was applied at the basic level to present frequency, mean and percentages of the demographic characteristics of smallholder farmers in Bungoma County.

The logistics regression tool has been used to predict the likelihood of membership of the outcome variable (Peng & Nichols, 2003). Multinomial logistic regression is applied where the dependent variable has more than one categorical variable that are not ordered (Hosmer - Lemeshow, 2000 cited by Yu et al., 2017). Thus, the application of MRL model was a good choice for this dataset as it does not assume normality, linearity, or homoscedasticity (Starkweather, 2011).

The multinomial logistic regression (MRL) was used to predict relationships between the use of mobile phone-based services with the independent variables which included age, gender, education, long run, relative advantage, observability, costs, complexity, and compatibility (Peng, Manz, & Keck, 2001; Hosmer, Lemeshow & Sturdivant, 2013). Application of

multinomial logistic regression is a well-known statistical tool that has been used to predict probability of membership categorical dependent variables (Peng & Nichols, 2003).The application of a multinomial logistic regression model with a baseline could be formulated as follows: Log ($\pi i / \pi I$) = $\alpha i + \beta i$ x, i = 1,…..,I-1.The dependent variable labelled as "USE" in the data collection and analysis corresponds to the adoption and use of mobile phone-based services literature. The dependent variable is illustrated in Table 10.

Table 10

Categorical/Dependent Variable Assigned Values

Category Variable	Assigned Variables
Use of Mobile phone-based services	0 = Seasonal 1 = Monthly 2 = Weekly 3 = Daily

Source: survey instrument

The multinomial logistic regression statistical techniques were selected to identify and examine the relationships between the dependent variable (use) of mobile phone-based technology and the explanatory variables that included: gender, age, income, innovation, education level, relative advantage, observability, perceived costs, complexity, complexity, social influence, and information quality. Table 11 illustrates the independent variables of this study.

Table 11

Explanatory Variables

Description	Measurement
Age	Coded 0 = less than 30 years, 1= 31- 40 years. 2 = 41-50 years, 3= Over 51 years
Gender	Coded 0 = Male, 1 = Female
Education	Coded 1= Primary, 2 = High school, 3= College
Long Run/Innovatiness	Coded 1 = less than 6 months, 2 = 6 months – 2 years, 3 = Over 2 years
Income level	Continuous
Relative Advantage	Continuous Likert Scale
Observability	Continuous Likert Scale
Perceived cost	Continuous Likert Scale
Complexity	Continuous Likert Scale
Compatibility	Continuous Likert Scale
Social Influence	Continuous Likert Scale
Information Quality	Continuous Likert Scale

The study was guided by the following research questions:

The following research questions were formulated to achieve these objectives:

1. What significant factors influence the use mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County, Kenya?
2. What is the relationship between the use of mobile phone-based services and the perceived factors of innovation among smallholder farmers in Bungoma County, Kenya?
3. What demographic factors influence the use of mobile phone-based services in Bungoma, Country?

Descriptive Statistics

This section presents descriptive analysis on data collected from smallholder farmers in Bungoma County, Kenya.

Demographic Description: Out of 150 questionnaires distributed to smallholder farmers in Bungoma County in Kenya from July 30th to September 29th, 119 were returned at a response rate of 79.33%. The features of respondents in this study were presented regarding the following demographic traits: age, gender, level of education, income, and innovativeness level.

The findings showed that 55.4% of the respondents were male, 44.6% were female, and there were more males than females. 41.1% of the respondents were between the ages of 40 – 49, followed by 30.4% of respondents were between 50 -59. The third group of respondents at 25% were aged between 18 -39. Lastly, 3.6% of the respondents were aged 60 years and above. The results showed 50% of the respondents' highest level of education was at high school, followed by 30.4% at primary level and 19.6% at college level.

The findings showed income level of the respondents at 88.4 % included 0 -30,000 KES (i.e., approximately 0- $300), followed by 6.3% 30,001 – 50,000 KES (i.e., approximately $300- $500), 2.7% of the respondents between 50,001 to 70, 000 KES (i.e., approximately $500- $300), and at 2.7% over 70,001 KES (i.e., approximately $700). The distribution of participants on period of mobile phone use showed (51.8%) had been using the mobile phone apps for over 6 months and less than 2 years, followed by (26.8%) for over 2 years, and (21.4%) for less than 6 months. The population demographic distribution of sampled respondents is illustrated in Table 12.

Table 12

Demographic Distribution of sampled Respondents

Variable	Frequency	Percentage
Gender		
Male	62	55.4%
Female	50	44.6%
Age		
18 -39	28	25%
40 -49	46	41.1%
50 -59	34	30.4%
60+	4	3.6%
Education		
Primary	34	30.4%
High school	56	50.0%
College	22	19.6%
Income		
0 – 30,000	99	88.4%
30,001 -50,000	7	6.3%
50,001 -70,000	3	2.7%
70,000+	3	2.7%
Innovation level		
Less than 6 months	24	21.4%
6 -24 months	58	51.8%
24 months +	30	26.8%

The results regarding gender distribution show 55.4% were male, while 44.6% were female. The result concerning gender distribution is illustrated in Table 12 below.

Table 13

Gender Distribution

GENDER

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	62	55.4	55.4	55.4
	1	50	44.6	44.6	100.0
	Total	112	100.0	100.0	

The results indicated that 25% of the participants were between 18-39 years, 41.1% were aged 40 -49 years, 30.4% were aged between 50 -59 and 3.6% over 60 years. The result concerning age distribution is illustrated in Table 13 below.

Table 14

Age

AGE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	28	25.0	25.0	25.0
	1	46	41.1	41.1	66.1
	2	34	30.4	30.4	96.4
	3	4	3.6	3.6	100.0
	Total	112	100.0	100.0	

Education level

The result showed that majority of participants, approximately 50% had completed high school level education, 30.4% were at primary level, and 19.6% were at college level. The education distribution level is illustrated in Table 15.

Table 15

Education Distribution

EDU

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	22	19.6	19.6	19.6
	1	56	50.0	50.0	69.6
	2	34	30.4	30.4	100.0
	Total	112	100.0	100.0	

Innovativeness (coded =Long Run)

The extent of smallholder farmers' use of mobile phone-based service required that the respondents report how long they have adopted to use of the mobile phone - based app. Length of adoption of mobile phone-based services are illustrated in Table 17.

Table 16

Innovative level (Long Run)

LONG

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	24	21.4	21.4	21.4
	1	58	51.8	51.8	73.2
	2	30	26.8	26.8	100.0
	Total	112	100.0	100.0	

The Results showed 51.8% participants had used the app between (6 months to 2 years), followed by 26.8% for over (2 years) and 21.4 % for (less than 6 months). This conforms to (Rogers, 1995) argument that individuals in a social system do not adapt to new technology at the same time, but in a time sequence. The innovativeness of smallholder farmers is illustrated in Table 17.

Table 17

Innovativeness of smallholder farmers

Innovation level/Long Run	Category	Percentage
Less than 6 months	Late Majority adopters	21.4%
6 months to 2 years	Early majority adopters	51.8%
More than 2 years	Early adopters	26.8%

Income Distribution

Table 18 summarizes the distribution of monthly income among participants. These findings revealed that majority of the participants at 88.4% earned less than 30,000 KES, followed by 30,000 - 50,000 KES per month at 6.3%, at 2.7% participants earned 50,000 – 70,000 KES, and at 2.7% participants earned over 70,000 KES per month. The income distribution is illustrated in Table 18.

Table 18

Income Distribution

INCOME

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	99	88.4	88.4	88.4
	1	7	6.3	6.3	94.6
	2	3	2.7	2.7	97.3
	3	3	2.7	2.7	100.0
	Total	112	100.0	100.0	

Case Processing Summary

The results showed that a total of N = 112 of valid observations with no missing data. The marginal column showed the proportion of valid responses in each response variable group. The case processing summary is illustrated in Table 19.

Table 19

Case Processing Summary

Case Processing Summary

		N	Marginal Percentage
USE	0	10	8.9%
	1	36	32.1%
	2	45	40.2%
	3	21	18.8%
AGE	0	28	25.0%
	1	46	41.1%
	2	34	30.4%
	3	4	3.6%
GENDER	0	62	55.4%
	1	50	44.6%
Valid		112	100.0%
Missing		0	
Total		112	
Subpopulation		112[a]	

a. The dependent variable has only one value observed in 112 (100.0%) subpopulations.

Measurement Model Evaluation

MLR assessment typically follows a two - step separate model evaluations. This section discusses model fitting information and pseudo-R-square. The model fitting information is illustrated in table 20.

Table 20

Model Fitting Information

Model Fitting Information

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	276.463			
Final	194.561	81.902	48	.002

In demonstrating that the independent factors were significant to the final model, a chi-square test of independent variables was performed to examine the relationship between M-services adoption and the independent variables. The final model is statistically significant χ^2 = 81.902, p < .002, confidence level of 95%. The final model proves there is a significant relationship between the dependent variable and independent variables, therefore the final model is a good fit (illustrated in Table 20).

Pseudo R-Square

The Cox and Snell pseudo R2 =0.525. Nagelkerke R squared (Max rescaled R squared) =0.571. McFadden = 0.296. A portion of 57.1% variance is explained all the independent variables applied in this model. A lower pseudo R2 results allow room to consider other variables that may influence the outcome/dependent variable. The Pseudo R-Square is illustrated in Table 21.

Table 21

Pseudo R-Square

Pseudo R-Square

Cox and Snell	.513
Nagelkerke	.558
McFadden	.286

Likelihood Ratio Tests

At the initial level of multinomial logistic regression analysis. The results showed out of the 12 independent variables being investigated, only the innovative variable was at (p=0.014). The innovative level was categorized as (less than 6 months = 0, 6 months – 2 years = 1, over 2

years = 2). The other independent variables were not significant. The likelihood ration tests are illustrated in Table 22.

Table 22

Likelihood Ratio Tests

Likelihood Ratio Tests

Effect	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests Chi-Square	df	Sig.
Intercept	194.561[a]	.000	0	.
age	196.161	1.600	3	.659
logincome	202.273	7.712	3	.052
RA	197.369	2.808	3	.422
OB	196.065	1.503	3	.682
PCOST	196.365	1.803	3	.614
C	201.542	6.980	3	.073
SI	197.960	3.398	3	.334
SO	198.231	3.670	3	.299
IQ	199.368	4.806	3	.187
gender	204.932	10.371	6	.110
education	201.510	6.949	9	.642
long	210.449	15.888	6	.014

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom. The threshold is $p \leq 0.05$.

The Stepwise Backward Elimination

The rerun of the same regression model applied the stepwise backward selection, a statistical step that combines all independent variables. The analysis removed all insignificant variables that included: observability, relative advantage, complexity, education, information quality, gender, and perceived cost.

Table 23

Backward Stepwise Summary

Step Summary

Model	Action	Effect(s)	Model Fitting Criteria -2 Log Likelihood	Effect Selection Tests Chi-Square[b]	df	Sig.
0	Entered	<all>[a]	194.561	.		
1	Removed	OB	196.065	1.503	3	.682
2	Removed	education	203.027	6.962	9	.641
3	Removed	RA	205.057	2.030	3	.566
4	Removed	PCOST	208.428	3.371	3	.338
5	Removed	gender	216.038	7.611	6	.268
6	Removed	SI	220.024	3.986	3	.263
7	Removed	IQ	225.412	5.388	3	.146

Stepwise Method: Backward Elimination

a. This model contains all effects specified or implied in the MODEL subcommand.

b. The chi-square for removal is based on the likelihood ratio test.

In demonstrating significant variables using backward elimination, only the interactions which were significant will appear in table 24 below.

Table 24

Likelihood Ratio Test

Likelihood Ratio Tests

Effect	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests Chi-Square	df	Sig.
Intercept	225.412[a]	.000	0	.
long	240.296	14.884	6	.021
age	232.219	6.807	3	.078
logincome	232.689	7.277	3	.064
C	233.848	8.436	3	.038
SO	235.550	10.138	3	.017

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Question 1 Results

What perceived factors influence the adoption and use mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County, Kenya?

In response to question 1: Table 24 showed the following significant variables on use of mobile phone-based services. The most significant variable was social influence at (p = 0.017), followed by innovativeness at (p = 0.021), and compatibility at (p = 0.038). Other two important variables listed in the final model, though not significant included: age at (p = 0.078), and

income at (p = 0.064). The threshold was p≤ 0.05. Therefore, age and income variables were not significant for this study.

Table 25

Parameter Estimates

Parameter Estimates

USE[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
0	Intercept	4.101	4.038	1.031	1	.310			
	[long=1]	-1.454	1.302	1.248	1	.264	.234	.018	2.996
	[long=2]	-1.406	1.059	1.762	1	.184	.245	.031	1.954
	[long=3]	0[b]	.	.	0	.	.	.	.
	age	.056	.052	1.140	1	.286	1.058	.954	1.172
	logincome	-.337	.618	.296	1	.586	.714	.213	2.399
	C	-.332	.154	4.650	1	.031	.717	.531	.970
	SO	-.098	.247	.158	1	.691	.907	.559	1.471
1	Intercept	3.926	3.115	1.589	1	.207			
	[long=1]	.362	1.098	.109	1	.741	1.437	.167	12.360
	[long=2]	1.399	.819	2.919	1	.088	4.050	.814	20.150
	[long=3]	0[b]	.	.	0	.	.	.	.
	age	.092	.039	5.682	1	.017	1.097	1.017	1.183
	logincome	-1.206	.539	5.006	1	.025	.299	.104	.861
	C	-.205	.112	3.334	1	.068	.815	.654	1.015
	SO	-.135	.187	.518	1	.472	.874	.606	1.261
2	Intercept	7.694	2.938	6.856	1	.009			
	[long=1]	1.063	.952	1.246	1	.264	2.894	.448	18.711
	[long=2]	.815	.729	1.249	1	.264	2.258	.541	9.421
	[long=3]	0[b]	.	.	0	.	.	.	.
	age	.033	.035	.867	1	.352	1.034	.964	1.108
	logincome	-1.050	.493	4.541	1	.033	.350	.133	.919
	C	-.041	.101	.161	1	.688	.960	.787	1.171
	SO	-.453	.170	7.113	1	.008	.636	.456	.887

a. The reference category is: 3.

b. This parameter is set to zero because it is redundant.

Table 26

Categorical Variable Assigned Values

Category Variable	Assigned Variables
Use of M-services	3 = Seasonal
	2 = Monthly
	1 = Weekly
	0 = Daily

In the analysis 3 = seasonal has been used as a reference/ baseline category.
There are four categories 0 = Daily, 1 = Weekly, 2 = Monthly and 3 = Seasonal.

Question 2 Results

What is the relationship between use of mobile phone-based services and the perceived factors of innovation among smallholder farmers in Bungoma County, Kenya?

Table 25 provides information on the interpretation of the parameter estimates of the final model. While each score was not significant, the odds ratio Exp(B), is the exponentiation of the final model. An odds ratio greater than 1 indicate the outcome event was more likely to occur than the reference outcome, and vice versa (Hosmer, Lemeshow & Sturdivant, 1989).

Daily verses Seasonal Use

The response variable here is log $(\frac{use=0}{use=3})$.

- At 95% confidence level, in this category, one increase of smallholder farmers who used mobile phone services for less than **6 months** and between **6 months to 2 years** are **less likely** to use M- services on **daily** basis than at the **seasonal level**, both categories were insignificant.

- At 95% confidence level, in this category, one increase of smallholder farmers with **increased age** are **1.058 more likely** to use M-services on **daily** basis than at the **seasonal level**, the category was insignificant.
- At 95% confidence level, in this category, one increase of smallholder farmers with **increased income**, **compatibility and social influence** are **less likely** to use the M-services on **daily basis** than at the **seasonal level**, both income and social influence were insignificant. Only the compatibility variable was significant at (**p = 0.031**).

Weekly verses Seasonal Use

The response variable here is log $(\frac{use=1}{use=0})$.

- At 95% confidence level, in this category, one increase of smallholder farmers who used the mobile phone- based services for **less than 6 months** were **1.437 more likely** to use the M-services on weekly basis than at the seasonal level. Though the category was insignificant.
- At 95% confidence level, in this category, one increase of smallholder farmers who used the mobile phone – based services for **6 months – 2 years** were **4.050 times are more likely** to use M-services on **weekly basis** than at the **seasonal level**. Though the category was insignificant.
- At 95% confidence level, in this category, one increase of smallholder farmers with increased age are **1.097 more likely** to use M-services on **weekly basis** than at the **seasonal level**. This category was significant at (**p = 0.017**).
- At 95% confidence level, in this category, one increase of smallholder farmers on income, compatibility, and social influence **are less likely** to use M-services on weekly

basis than at the seasonal level. At this category, both compatibility and social influence are insignificant. The income category was significant at (**p = 0.025**).

Monthly verses Seasonal Use

The response variable here is log $(\frac{use=2}{use=0})$.

- At 95% confidence level, in this category, one increase of smallholder farmers who had used mobile phone-based services for **less than 6 months** are **2. 894 times more likely** to use the M-services on **monthly** than at the **seasonal level**, though the category was insignificant.
- At 95% confidence level, in this category, one increase of smallholder who had used the mobile phone-based services for **6 months – 2 years** are **2.258 times more likely** to use the M-services on **monthly** than at the **seasonal level**, though both the categories were insignificant.
- At 95% confidence level, in this category, one increase of smallholder farmers **age** are **1.034 times more likely** to use the M-services on **monthly** than at the **seasonal** level, though this category was insignificant.
- At 95% confidence level, in this category, one increase of smallholder farmers value on income, compatibility and social influence are less likely to use M-services on monthly than at seasonal level, though the category was insignificant.

Question 3 Results

What demographic characteristics influence and the adoption and use of mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County?

In response to question 3: Innovativeness was the only demographic variable identified as significant at (p=0.021). Other demographic variables including age, income, education, and gender had no significant relationship on adoption and use of mobile phone-based services in the study context.

Discussion on Extra Survey Questions

Results showed, 63.4% of smallholder farmers supported that they found it difficult to access agricultural market information before using the mobile phones app. 43.8% of smallholder farmers agreed they found it difficult to use agricultural market information before using the mobile phone app. Additionally, 58.9% of smallholder farmers reported they intend to keep using the mobile phone -based services. While 41.1% of smallholder farmers reported they would recommend to other farmers to use the existing mobile phone-based services.

Summary

In this chapter, I analyzed 112 valid observations to identify and examine factors associated with the adoption and use of mobile phone -based services among smallholder farmers in Bungoma County, in Kenya. Data was collected using online surveys. The survey resulted in a higher response rate at 79.3%. I used descriptive statistics to show demographic distribution of gender, age, education, income, and innovative level. To respond to three (3) research questions, I employed multinomial logistic regression and chi-square. The primary multinomial logistic regression model showed that innovations was the most significant variable at (p = 0.014). The second rerun of the multinomial logistic regression method using the same dataset applied stepwise backward selection eliminated seven (7) variables that had a p value greater than one (1). Three (3) significant variables social influence, innovativeness, and

compatibility on use of mobile phone-based services in the study context. Additionally, age and income were identified as important variables though not significant (Hosmer, Lemeshow & Sturdivant, 1989). The parameter estimates provided information on use of mobile phone technology based on the significant and important variables in the model. I was unable to conclude of a discrete relationship between each variable and use of mobile phone - based services. However, a combination of all variables proved the final model is significant on use of mobile phone – based services among smallholder farmers in Bungoma County in Kenya.

CHAPTER 5. SUMMARY AND RESULTS

Introduction

This chapter provides a summary of the study findings. The study applied an extended Rogers' DOI model to predict factors associated with the use of mobile phone-based services among smallholder farmers in Bungoma County (Roger's, 2003; Richardson, 2009; Kante et al., 2019). The original DOI attributes employed in this study included: relative advantage, compatibility, social influence, observability, and simplicity. These variables were added to the original DOI model: included age, income level, education level, gender, innovativeness, cost, and information quality (Roger's, 2003; Richardson, 2009; Kante et al., 2019). The results showed innovativeness, social influence and compatibility were positively significant in predicting use of mobile phone-based services among smallholder farmers in Bungoma County. The results are in consistent with the works of (Kante et al., 2019; Khan Tithi, et al., 2021). The study was guided by the following three (3) research questions.

Research Questions

(1) What factors influence the use mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County, Kenya?

(2) What is the relationship between use of mobile phone-based services and the perceived characteristics of innovation among smallholder farmers in Bungoma County, Kenya?

(3) What demographic characteristics influence the use of mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County?

Rate of Adoption

Literature highlighted awareness on the widespread of existing mobile phone-based services in rural parts of developing countries continues (Aker et al., 2016; Okello et al., 2020). In contrast to the wide spread of mobile phone-based services, the adoption and utilization of these services remains insignificant among smallholder farmers in rural parts of developing countries (Chikuni & Kilima, 2019; Kante et al., 2019; Krell et al., 2021). Some scholars (e.g., Wyche & 2016; Kante et al., 2019; Krell et al., 2021) have acknowledged that there are limited studies on factors that influenced the adoption and use of ICTs in the rural contexts of developing countries. Although, a few scholars have identified several factors that influenced the use of mobile phone -based services, this was conducted in Bungoma County, Kenya to gain knowledge on factors associated with the adoption and use of mobile phone-based services in the rural context of Kenya. The design and findings of this study are in congruence with other similar studies (Chong, Chan, Ooi, 2012; Ducombe, 2016; Kante et al., 2019; Khan Tithi et al., 2021) that claim a well-designed ICT for development systems must be tailored toward the needs of potential users. This requires a deeper understanding of the physical environments and social constrains of the targeted population.

According to Kante et al. (2019) study findings, DOI was contextualized, and the result showed a highly predictive model on agricultural in put information in Sikasso, Mali. Based on the findings of this study, the proposed conceptual framework guiding this inquiry has been validated. To the investigator's knowledge, this is the second time (after Kante's study in Mali) that a relationship has been adopted, in addition to the use of ICT as well as an extended DOI model regarding agricultural information in Africa. Furthermore, this is the first time an extended DOI model has been contextualized among smallholder farmers in Bungoma County, Kenya regarding agricultural market information in support of agricultural supply chain with a

desire to increase access to agricultural market information and markets among smallholder farmers.

Demographic Differences

In an empirical study conducted in Kenya, gender had been previously found to influence the decision to adopt and use of mobile phone-based services (Meso, Musa & Mbarika, 2005. The findings of this study revealed there was no significant association on use of mobile phone-based services with gender. However, there were more male respondents at 55.4%, and female at 44.6%. In contrast, previous study findings on farmers in Central Kenya found that more female at 56% were using mobile phone-based services compared to 44% of male (Krell et al., 2021). This corresponded to a study conducted among smallholder farmers in Mali that revealed 75% of the respondents were female against 25% male (Kante et al., 2019).

Rogers's DOI theory argued that adopters of the new technology are younger than non – adopters due to the belief, younger people are more innovative (Rogers, 2003). Rogers' DOI findings corresponded to Katunyo et al. (2018) study findings on factors that influenced the use of ICTs among farmers in Busia County in Kenya. However, the results of this study did not find age to be statistically significant on adoption and use of mobile phone-based services.

The results also revealed there was no significant association between adoption and use of mobile phone-based services with education level among smallholder farmers in Bungoma County, in Kenya. Innovativeness was the only demographic characteristic that was identified as statistically significant on adoption and use of mobile phone-based services among smallholder farmers in Bungoma, County in Kenya. Interesting the results of the adoption curve, matched the original Rogers's DOI curve, majority of the adopters consisted of the early majority group (DOI, Rogers, 2003).

This study addressed common deficits on the demographic factors. For instance, (Katunyo et al., 2018) study focused on age, marital factors, transport costs, distance to the markets and land size as possible factors influencing use of mobile phone-based services. Contradictory evidence, (Krell, et al., 2021) results show that age and income were not significant in the adoption and use of m-services in the study context. Likewise, (Kante et al, 2019) final model included DOI constructs except trialability which was eliminated at the pilot study due lack of reliability.

Characteristics of an Innovation

Rogers (2003) affirmed that the five main perceived attributes of an innovation influenced or accounted for the variance of adoption. To examine factors associated with the rate of adoption and use of mobile phone-based services among smallholder farmers in Bungoma County, Kenya, the following variables were included in the model, age, level of education, income level, innovativeness, cost, informational quality, relative advantage, simplicity, compatibility, observability, and social influence.

Question (1). ***What factors influence the adoption and use mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County, Kenya?***

In Chapter 4 and summarized in Table 24, answered question (1) most directly and succinctly. With $\chi^2 = 81.902$, $p = .002$, confidence level of 95%. The multinomial logistic backward selection regression was applied. The analysis output identified three (3) constructs innovativeness, compatibility, and social influence were statistically significant at $p < .05$, with the final model caseload being statistically significant at $p = .002$.

Other independent variables included: complexity, observability, relative advantage, education, quality of information, gender, age, income, and costs were not significant on the adoption and use of mobile phone-based services among smallholder in Bungoma County, Kenya. I summarized results using the odd ratios obtained from the multinomial logistic regression. The parameters appear in Table 24.

Social Influence

According to Talukder, Quazi and Djatikusumo (2013) social influence refers to the extent to which individuals are influenced by social networks and peers in the social system. The result showed social influence had a positive and most significant variable in the prediction on use of agricultural market information among smallholder farmers in Bungoma County with p = 0. 017 based on multinomial logistic regression. Therefore, the social influence of those close to smallholder farmers influenced the use of mobile phone-based services The results are consistent with the study findings of Aker (2011), Okoroji, Lees, and Lucock (2021) and Kante et al. (2019) who concluded social influence had a positive influence on smallholder farmers' actual usage of mobile phone – based services on agricultural information. In contrast, Kante et al. (2019) as cited by Li (2010) only 25% reviewed studies on technology acceptance found social influence to be significant on the use and adoption of agricultural information among smallholder farmers in developing countries. In the study context, it has been established smallholder farmers predominantly shared information from peers who included neighbors, friends, and family members (Wyche & Steinfield, 2016; Baumüller, 2013). In this study 41.1% of the respondents stated they intend to recommend other farmers outside their households to use mobile phone apps in accessing agricultural market information. In this study, social influence had a positive

significant influence on predicting the likelihood of smallholder farmers use of agricultural market information in Bungoma County.

Individual Innovativeness

According to Rogers (2003) individuals in a social group do not adopt to an innovation simultaneously but they adopt in time sequence. Rogers (2003) classified adopters among three major categories: early adopters, early majority, and late majority adopters. In this study, 26.8 of respondents were early adopters, they had used the mobile phone-based services for more than two years, 51.8% of respondents were early majority, while 21.4% were late majority, these are farmers who had used the mobile phone-based services for less than six months. According to Rogers (2003) early adopters are often seen as opinion leaders in a group to other potential adopters before one deciding to adopt and use the new technology. The result showed innovativeness of the smallholder had a positive and the second most significant variable in the prediction on use of agricultural market information among smallholder farmers in Bungoma County with p = 0. 021 based on multinomial logistic regression. The results are consistent with the study of (Aubert, Schroeder & Grimaudo, 2012). In this study, individual innovativeness had a positive significant influence on predicting the likelihood of smallholder farmers use of agricultural market information in Bungoma County.

Compatibility

According to Rogers (2003) compatibility is the degree to which a new technology is perceived as consistent with the existing values. The result showed compatibility had a positive and third most significant variable in the prediction on use of agricultural market information among smallholder farmers in Bungoma County with p = 0. 038 based on multinomial logistic

regression. The results are consistent with the study of Kante et al. (2009), that found compatibility to be the most effective driver of ICT use by smallholder farmers on agricultural information. In this study, compatibility had a positive significant influence on predicting the likelihood of smallholder farmers use of agricultural market information in Bungoma County.

Question (2). ***What is the relationship between use of mobile phone-based services and the perceived characteristics of innovation among smallholder farmers in Bungoma County, Kenya?***

The parameter Estimates Results in Table 25 at 95% confidence level.

The respondents who value compatibility factor on using the mobile phone -based services regarding agricultural market information are less likely at .717 to use the app on daily basis than on seasonal basis at ($p = 0.031$).

Respondents with increased aged are more likely at 1.017 times to use the mobile phone-based services regarding agricultural market information on weekly basis than seasonal basis at ($p = 0.017$).

Respondents with increased income are less likely at .104 to use the mobile phone-based services regarding agricultural market information on weekly basis than seasonal basis at ($p =0.025$).

Respondents with increased income are less likely at .350 to use the mobile phone-based services regarding agricultural market information on monthly than on seasonal basis at ($p =0.033$).

Respondents who value the social influence factor were less likely at .636 to use the mobile phone- based services regarding agricultural market information on monthly basis than on seasonal basis at ($p = 0.08$).

Additionally, the results showed respondents who used the mobile phone services between 6 months – 2 years were more likely at 4.050 to use agricultural market information on weekly than seasonal basis. This category showed the most positive association, though it was not significant with a $p = 0.88$ that failed to meet the $p \leq 0.05$ threshold.

Question (3). What demographic characteristics influence and the adoption and use of mobile phone-based services regarding agricultural market information among smallholder farmers in Bungoma County?

Innovativeness was the only demographic characteristic that was identified as statistically significant on adoption and use of mobile phone-based services among smallholder farmers in Bungoma, County in Kenya. Interesting the results of the adoption curve, matched the original Rogers's DOI curve, majority of the adopters consisted of the early majority group (DOI, Rogers, 2003).

Theoretical Contribution

The Diffusion of Innovation model provided a basis for understanding factors that influence adoption and use of mobile phone-based services among smallholder farmers in Bungoma County, Kenya. According to Zewge & Dittrich (2017) TAM and DOI are the most used models in explaining and predicting associated with technology adoption in developing countries. These theoretical models have been applied in different contexts. However, this study is focused on factors that influence adoption and use of mobile phone-based services among smallholder farmers in the study context. Numerous scholars (Kabbiri et al., 2018; Diaz et al.,

2021) have highlighted that TAM model does not fully explain social factors that may influence users' intention to use a new technology. On the other hand, Rogers (2003) claimed the original DOI attributes accounted for 49-87% for the variance in the rate of adoption, these attributes included: relative advantage, complexity, observability, trialability, and compatibility. The application of the extended DOI model has proved to be beneficial in better understanding factors influencing the adoption and use of a new technology in the study context (Richardson, 2009; Kante et al., 2019).

The final model was successful to identify significant factors associated with the adoption and use of mobile phone-based services. However, a contextualized extended DOI model has been successfully applied in other in other developing and mid- economies, like a study conducted by Khan Tithi et al. (2021) in Bangladesh suggested that the agricultural market information among women. According to (Okello et al., 2020; Khan Tithi et al., 2021) study findings suggested the application of extended DOI context participatory studies are more likely to improve adoption of ICTs among previously marginalized populations.

Methodological Contribution

The analysis utilized multi nominal logistic regression, using stepwise backward elimination, the combination of all variables indicated the final model could predict 55.8% of the innovation use. These findings are consistent with original DOI gap that accounted for 48 -87% of variance gaps. However, a low pseudo R2 results gives room for other variables to influence adoption of mobile phone–based services. The Pseudo R-Square as illustrated in Table 21. Moreover, some studies found other variables like trust, cost, and farm size to be significant to the adoption and use of ICTs in previously isolated regions (Chong et al., 2012; Kante et al., 2019; Krell et al., 2021). Therefore, future work is recommended to investigate these areas.

Practical Implications and Applications

The findings of the study supported a combination of perceived factors influenced the adoption and use of M-services, which is consistent with works of (Richardson, 2009; Kante et al., 2019). According to (Tithi, et al., 2020) argued a well-designed ICT4D must be tailored to the needs of the potential users. This study has made theoretical, methodological, and practical contributions to the field of ICD4 in rural areas of developing countries. Thus, the results of this study would be considered useful for various ICTD stakeholders, to increase adoption of agricultural market information among smallholder farmers in the rural context of developing countries.

Policy Implications

For policy makers the results of this study underscore the areas to focus on ICT initiatives. Because smallholder farmers have been described as less innovative compared to their peers (Ogbeide & Ele, 2015), operating within limited resources and low capacity on innovation infrastructure (Magesa et al., 2020), the project initiatives may focus on the innovative level, social influence, and compatibility of the smallholder farmers within the context, with the aim of increased adoption. Policy makers and other interested stakeholders need to implement policies and programs that support training that target both adopters and non-adopters of M-services in support of an effective diffusion of individual innovativeness in an ecosystem. In support of social influence attribute in the rural communities, Lema, Kraemer - Mbula and Rakas (2021) recommended increased initiatives on social networking in remote communities, for example, creation of peer and social networks. The current study findings found that cost was negatively insignificant on use of mobile phone- based services in Bungoma County, while level of income showed minimum association at an insignificant level at $p = 0.064$. However, existing literature

supported that smallholder farmers operate with limited resources and capacity (Wyche & Steinfield, 2016), it would be recommendable for policies on innovation to focus on cost – benefit analysis.

Limitations of this Study

The current study was limited in time and resources, other similar studies in rural environments are longitudinal studies often funded by universities and NGOs. For example, a study conducted by Khan Thiti et al. (2021) was conducted for 5-years and co funded by Monash University and Oxfam. A similar study conducted in central Kenya by Krell et al. (2021) was a longitudinal study funded by National Science Foundation (NSF) and institutional grants. Second, the results related to the study only targeted farmers with email addresses from Bungoma County, Kenya, these results may not be generalizable to other smallholder farmers in other regions. Additionally, Covid -19 had an impact on the design of the study, initially the author had planned for an in person quantitative survey, due to public health requirement on Covid -19 at that time, the author had changed the data collection process to an online self-administered survey.

Recommendations for Future Research

The final model of this study was found to be statistically significant at 55.8%. The results allowed other variables not included in the study, to have influence on the adoption and use of M-services in the context. It is recommended that future studies incorporate, utilize, and hopefully extend the current final model in this inquiry, to gain more accurate information on factors associated with the adoption and use of mobile phone-based services in the study context.

Another recommendation would be conducting a participatory longitudinal approach coupled with theories that are focused on human – computer interaction (HCI) domain. HCI originated from human centered design (HCD) in the field of computer science to understand people's social life in their environments in developing technological solutions to their problems (Al mamum, 2017; Aker et al., 2016; Wyche & Steinfield, 2016; Karwitha, Wyche, Oslon & Kimurtho, 2022). Such a study would give insights on the role of HCD when integrated into mobile phone including ICT and how these might influence supply chain markets.

The application of the extended DOI model has proved to be beneficial in better understanding factors influencing the adoption and use of a new technology in the study context (Richardson, 2009; Kante et al., 2019). For this study, the independent variables have accounted for 55.8% variance on predicting factors that are likely to influence the use mobile phone-based services among smallholder farmers in Bungoma country in Kenya. The finding is consistent to Kante et al. (2019) final model that accounted for 68.4% variance on factors influencing use of ICTs among small cereal farmers in Mali.

Conclusion

This study was conducted to examine a critical, but under-researched issue for ICT development in the rural parts of developing countries in relation to supply chain markets. The study utilized extended diffusion and innovation (DOI) premises to understand and provide knowledge about factors associated with the adoption and use of mobile phone-based services among smallholder farmers in Bungoma County, in Kenya. The findings showed only three constructs were positively significant to predict factors that are likely to influence the use of mobile phone-based services among smallholder farmers in Bungoma county. Social influence was the most significant variable at $p = 0.017$, followed by individual innovativeness at $p =$

0.021 and compatibility at p = 0.038 related to the use of mobile phone-based services. In conclusion, at a 95% confidence level, a combination of the independent variables accounted for 55.8% of predictive factors associated with the adoption of mobile phone-based services in rural parts of Kenyan context. This study adds to the empirical evidence regarding the use of ICTs among smallholder farmers in rural parts of developing countries.

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APPENDIX A: AUTHORIZATION LETTER

REPUBLIC OF KENYA

COUNTY GOVERNMENT OF BUNGOMA
MINISTRY OF AGRICULTURE, LIVESTOCK, FISHERIES, IRRIGATION AND COOPERATIVE
OFFICE OF THE CHIEF OFFICER – AGRICULTURE AND IRRIGATION

Telephone: 055 30343
Email: wekesa2007@yahoo.com
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Kilimo House
Next to Kenya Seed
P.O. Box 33-50200
BUNGOMA
Date: August 27, 2020

Kathryne A. Newton
Associate Dean for graduate program
Polytechnic Institute
Purdue University

TO WHOM IT MAY CONCERN

I hope this email find you well. As regard to the survey of MS Christine Shikutwa, I have read the questionnaire of the study and belief she can go ahead and administer it.

I wish her well and hope that she will share the final report /Thesis with us so as to help us improve on use mobile apps in information dissemination to build capacity of farming community in agri-entrepreneur engagements.

Thank You

Chrisantus Mang'oli

County Research Extension Liaison Officer

Ministry of Agriculture, Livestock, Fisheries, Irrigation and cooperative

Bungoma County

A Hub of Diversity and Socio Economic Development

APPENDIX B: INVITATION LETTER TO FARMERS TO PARTICIPATE IN THE ONLINE SURVEY

Dear Prospective Participant

My name is Christine Shikutwa. I am a graduate student at Purdue University, USA. I will be conducting an anonymous online survey about the perceptions of farmers **on "Factors affecting the adoption of mobile phone technology by smallholder farmers on agricultural supply chain: A perspective from Bungoma county, Kenya**.
This study will help us improve use of mobile phone apps information to build capacity of farming community in Bungoma.

To participate, you must be 18 years or older. The survey is voluntary.
Since your identity will remain anonymous, PLEASE DO NOT PUT YOUR NAME ON THE SURVEY.
The survey will take approximately 6 -10 minutes. Please answer the questions yourself, and at your comfort level.

The survey link will be sent to you by Christine Shikutwa, and all questions about the survey will be addressed directly by Christine Shikutwa only- the researcher.

DO YOU WANT TO PARTICIPATE IN THE RESEARCH PROJECT?

Kindly contact Christine Shikutwa on email address: cshikutw@purdue.edu if you wish to participate in the survey.

Thank you for your consideration.

Sincerely,
Christine Shikutwa - Student researcher (Purdue University, USA).
cshikutw@purdue.edu

Prof. Kathryne Newton – Principal Investigator (Purdue University, USA).

APPENDIX C: CULTURAL APPROPRIATENESS SUPPORT LETTER

University of Eldoret
flame of knowledge and innovation

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Prof Violet Kadenyeka Mugalavai
Director, Food Processing Training & Incubation Centre
University of Eldoret
Cell: 254780384145
3/18/2021

RE: TO WHOM IT MAY CONCERN:

This letter is to kindly let you know I am an Associate professor, with a Ph.D. in Human Ecology of Moi University, specializing in Food Security and Nutrition, Kenya. My research focus areas include: Food security & livelihoods, food science and nutrition, reduction of post-harvest losses, agro food processing, and consumer behavior and sociology. I am also a cultural expert in regard to the Kenyan research field context, having lived in diverse contexts and studied human behavior. I have published 44 articles in refereed journals based on empirical data and managed 15 funded projects. I have helped coordinate field studies on food security, sensory evaluation and consumer behavior and perceptions and adoption of new products, indigenous knowledge, as well as postharvest and agro processing and nutrition related studies on behalf of Purdue University.

I confirm the anticipated study on **" Factors affecting perceptions of smallholder farmers use of mobile phone technology in support of agricultural supply chain; A perspective of Bungoma County, Kenya"** and the proposed research procedures proposed by Christine Shikutwa, a graduate student researcher under the guidance of Dr. Kathryne Newton are appropriate for the Kenyan culture. In regard to this study:

1. I have reviewed the questions to be used and I have not detected any inappropriate clause that could affect negatively nor create embracement for research.
2. The online surveys are culturally appropriate for farmers with email addresses.
3. More importantly, there is no risk to foresee as similar projects have been conducted for the study to be built on.

Thank you very much for your understanding.

Yours sincerely,

Prof Violet Kadenyeka Mugalavai
violet.mugalavai@uoeld.ac.ke

PROF. VIOLET K. MUGALAVAI
DIRECTOR
FOOD PROCESSING TRAINING & INCUBATION CENTER
UNIVERSITY OF ELDORET
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APPENDIX D: QUALTRICS SURVEY

My name is Christine Shikutwa, a Ph.D. candidate in the Department of Technology and Innovation at Purdue University. This survey helps to identify **" Factors influencing the adoption use of mobile phone service apps among farmers in Bungoma County, Kenya."**

This questionnaire is designed to collect data on a study titled: "Factors influencing adoption and use of mobile phone technology by smallholder farmers in support of agricultural supply chain in Bungoma County, Kenya.

The survey is confidential and complies with Purdue IRB (Institutional review board). All measures shall be taken to keep participants anonymous and protect the data and information. The survey will take approximately 6 - 10 minutes. I am looking for interested farmers in Bungoma County who are at least 18 years of age. Your participation is completely voluntary. However, by agreeing to participate in this survey, you will be helping support this research which could elevate the use of mobile phone apps among farmers in parts of Kenya.

Please complete the final Survey by August 06, 2021.
If you have any questions, feel free to contact me on cshikutw@purdue.edu
Alternatively, you can email:
Chris Mangoli – Principal Agricultural Officer – Bungoma County at chrismangoli63@gmail.com
Alex Wafula ---Agricultural Field Enumerator -- Bungoma County at awafula2005@yahoo.com

Principal investigator: Kathryne Newton Ph.D.
Thank you for accepting to participate in this survey.

Name the mobile phone app you are using? (e.g M-Farm)

What is your gender?

- Male
- Female
- Not willing to disclose

What is your age?

- 18 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- Above 60

What is your highest level of education?

- None
- Primary
- High School
- College

How often/ regularly do you use a mobile phone app?

- Daily
- Weekly
- Monthly
- Seasonal (Harvesting season)

How long have you used a mobile phone app?

- Less than 6 months
- 6 months - 2 years
- Over 2 years

What is your approximate **monthly income** in (Kshs e.g 20, 000/=)

Relative Advantage (RA)

(The degree to which mobile phone app appears to be beneficial when compared to other sources of agricultural market information like the use of agricultural extension offers, radio, middlemen)

Scale: 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 5 = Strongly Disagree

	Strongly Agree	Agree	Neutral	Disagree	Strongly Agree
(1) RA1. The use of mobile phone app enables me to access a variety of market prices	○	○	○	○	○
(2) RA2. The use of a mobile phone app enables me to make more profits	○	○	○	○	○
(3) RA3. The use of a mobile phone app enables me to connect with more buyers	○	○	○	○	○
(4) RA4. The use of a mobile phone enables me to accomplish my tasks more quickly, than relying on middlemen (**mabroka**)	○	○	○	○	○

Observability (OB)

(The extent to which the results of using the mobile phone app are visible due to interaction with other farmers, and likely to be adopted)

Scale: 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 5 = Strongly Disagree

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
(5) OB1. I have no difficulty talking about the benefits of using a mobile phone app	○	○	○	○	○
(6) OB2. I have difficulty explaining the benefits of using mobile phone apps to my fellow farmers	○	○	○	○	○
(7) OB3. The benefits of using the mobile phone app are visible to me	○	○	○	○	○

Perceived costs (PC)

(The setup cost and transaction cost farmers pay to access market information on the mobile phone app)

Scale: 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 5 = Strongly Disagree

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
(8) PC1. The setup cost/ enrolment cost of a mobile phone app is not expensive	○	○	○	○	○
(9) PC2. The transaction cost (bundles) for using a mobile phone app worries me	○	○	○	○	○
(10) PC3. Getting market information through other means such as radio, TV, extension agricultural officers, community meetings is expensive than using a mobile phone app	○	○	○	○	○

Compatibility (CP)

(The extent to which use of mobile phone app appears to be consistent with existing values, past experiences, and potential needs of farmers)

Scale: 5 = Strongly agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 5 = Strongly Disagree

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
(11) CP1. Using a mobile phone app is compatible with most aspects of my work	○	○	○	○	○
(12) CP2. Using a mobile app is compatible with the way I would like to sell my products	○	○	○	○	○
(13) CP3. Using a mobile phone app fits well with my lifestyle	○	○	○	○	○
(14)CP4. Using a mobile phone app fits well with my work style	○	○	○	○	○

(The extent to which the use of mobile phone app appears to be difficult/complex to understand and use)

Scale: 5 = Strongly agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 5 = Strongly Disagree

	Strongly Agree	Agree	Neutral	Disagree	Disagree
(15) SI1. Using a mobile phone app requires little mental effort	○	○	○	○	○
(16) SI2. When using the mobile phone app, I had no difficulty finding the information I need	○	○	○	○	○
(17) SI3. It is easy to become skillful when I am using a mobile phone app	○	○	○	○	○
(18) SI4. It is easy to understand how to operate mobile phone apps	○	○	○	○	○

Social Influence (s)
The degree to which a farmer perceives that other farmers believe he or she should start/keep using a mobile phone app

Scale: 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 5 = Strongly Disagree

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
(19) S1 I feel using a mobile phone app gives me social status (k**uheshimiwa**) than those who do not use it.	○	○	○	○	○
(20) S2 Neighbors(**majirani<>)** think I should continue using a mobile phone app	○	○	○	○	○
(21) S3 My friends use a mobile phone app to access agricultural market information.	○	○	○	○	○

Information Quality (IQ)

(The perceived value of market information delivered by the mobile phone app to farmers)

Scale: 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 5 = Strongly Disagree

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
(22) IQ1. Using a mobile phone app provides me with complete market information	○	○	○	○	○
(23) IQ2. Using mobile phone app provides me with relevant market information	○	○	○	○	○
(24) IQ3.Information I got from using a mobile phone app was in a suitable format	○	○	○	○	○

Increased adoption.

(Increased adoption of mobile phone-based agricultural market information)

Scale: 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 5 = Strongly Disagree

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
(25) Before I started using a mobile phone app, I found it difficult to access market information	○	○	○	○	○
(26) Before I started using a mobile phone app, I found it difficult to use market information	○	○	○	○	○
(27) After I started using a mobile phone, I have more access to agricultural market information	○	○	○	○	○

Use of mobile phone app

- **(28)** I intend to continue using a mobile phone app
- **(29)** I recommend other farmers to use a mobile phone app

We thank you for your time spent taking this survey.

Your response has been recorded.