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Adoption of ICT-in-Agriculture Innovations by Smallholder Farmers in Kenya

Fredrick Mzee Awuor[1], Dorothy Apondi Rambim[2]

[1]School of Information Science and Technology, Kisii University, Kisii, Kenya
[2]School of Computing and Informatics, Masinde Muliro University of Science and Technology, Kakamega, Kenya
Email: fawuor@kisiiuniversity.ac.ke, darambim@mmust.ac.ke

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Abstract

Agricultural development is a powerful tool for raising incomes for deprived population in developing countries, such as Kenya and to support livelihoods by ensuing food security. This has seen the agricultural sector position itself as an engine for sustainable development and economic growth in Kenya. However, the profile of the farming community in Kenya is mainly female smallholders who are illiterate and that practice traditional farming methods. Therefore, there is urgent need to examine emerging digital tools that can support these farmers, and to adopt these tools accordingly to meet their farming needs. In this regard, this paper seeks to explore the willingness and ability of these smallholder farmers to accept and adopt ICT-in-agriculture innovations towards supporting their farm operations, improving their farm productivity, and providing readily and accessible market for their produce. Specifically, this study identifies the factors that influence smallholder farmers' decision on ICT innovations adoption in agriculture, and examines how these factors are perceived by smallholder farmers on adoption of ICT innovations. The study was carried out in Siaya County, Kenya with sample population of 100 smallholder farmers. A simple random sampling was used, with questionnaires used to collect data. The findings from this study indicate cost, illiteracy, ICT skills, quality of the information and gender as some of the key factors that influence smallholder farmers' choice and decision on ICT-in agriculture innovations to adopt.

Keywords

ICT-in-Agriculture, Innovation, Technology Adoption, Smallholder Farmers, Agriculture Technology

1. Background of the Study

Agriculture is the backbone of most Sub-Saharan countries' economies and con-

tributes highly to their Gross Domestic Product (GDP) (AGRA, 2017; Filho & Gomez, 2018). According to Africa agriculture status report (2017), smallscale agriculture is the main source of livelihood for over 70% of the population in Africa. In Kenya, agricultural sector accounts for 65% of Kenya's total exports and provides more than 70% of informal employment in the rural areas (Davis, 2004). A report by Kenya Government (AGRA, 2017; KenyaRep, 2016) states that agricultural sector is not only the driver of Kenya's economy but also the means of livelihood for the majority of Kenyan.

As the agriculture sector is anticipated to continue playing an important part in the rural economy, the dynamics of poverty in developing nations are changing and directly influencing the country's agricultural sector. Most smallholder farmers that use rain-fed farming systems, are being pushed into dryer, more marginal areas where they become increasingly vulnerable to drought and the unpredictability of weather patterns resulting from climate change (Angello et al., 2016). Given the importance of agriculture in rural areas of Kenya where poverty is prevalent, the sector's importance in poverty alleviation cannot be overstated. Strengthening and improving the performance of the agricultural sector and enabling the engagement of the poorest and most vulnerable in this process is, therefore, a prerequisite and a necessary condition for achieving economic growth in Kenya even after recent years of drought has slowed agricultural development (FAO, 2020a).

Studies indicate that information is very important and more so, when the information is accurate and reliable, and this makes it a key element in sustainable development (Angello et al., 2016). Information has become one of the most important components in the transformation of the society today, playing a pivotal role in decision making and policy formulation. In the agricultural sector, relevant and timely information empowers farming communities to make the right choices towards sustainable and long-term growth. Use of such information enhances farming as an enterprise that largely depends on productivity and marketing for survival. Thus, availability of information on weather trends, best farming practices, disease control and market distribution provides farmers with the necessary help to pursue value added agriculture as a strategy for growth and development that is sustainable in the long term.

Information is a key to any business as it allows people to make informed decisions. Furthermore, particular information to farmers can influence productivity; information on soil, seed, fertilizer, planting time among others. The information the farmer gets from the soil test, determine the crops the farmer can grow and the inputs required. Access to market information will assist the farmer decide which crop(s) will bring him the greatest returns (Odera, 2020). Therefore, information is the bedrock of Agriculture and is necessary throughout the value chain.

ICT has been considered as an important tool for dissemination of information. The rapid development of internet, mobile phone and other forms of ICTs in the Kenyan agricultural sector have provided an opportunity for the transfer

and access of agricultural information (Aker, 2011). Farmers in most parts of Kenya, particularly those with resources and good education, have been known to use ICT innovations for agriculture (Mwombe et al., 2014). Smallholder farmers are now able to identify new market opportunities for their crops and access new input technologies, which was otherwise difficult and expensive to obtain. In Kenya, the National Agricultural Sector Policy (NASEP) presumes that extension service providers and clients will increasingly apply ICT for sharing agricultural information (Mwombe et al., 2014). In Uganda, small traders have used mobile phones to carry out transactions with producers in rural areas and buyers in urban markets increasing profits and sales (Komunte et al., 2012).

However, studies still indicate that in developing economies, the availability of timely and needed information is skewed in favour of more informed individuals or organizations which often force underprivileged smallholder farmers to sell their harvests to them at low price. Smallholder farmers in developing nations are still faced with various challenges; lack of access to market, lack of credit facilities, leading to significant differences in the ability to leverage individual and regional strengths (FAO, 2017). Insufficient extension services and poor access to information widen the gap in the adoption of new technologies and normally lead to lower productivity (Takahashi, 2019). Therefore, this paper looks at the challenges in adoption of ICT innovations for agriculture.

To this end, this paper seeks to explore the willingness and ability of these smallholder farmers to accept and adopt ICT-in-agriculture innovations towards supporting their farm operations, improving their farm productivity, and providing readily and accessible market for their produce. Specifically, this study identifies the factors that influence smallholder farmers' decision on ICT innovations adoption in agriculture, and examine how these factors are perceived by smallholder farmers on adoption of ICT innovations, skills, quality of the information and gender as some of the key factors that influence smallholder farmers' choice and decision on ICT-in agriculture innovations to adopt.

To achieve this, the following research questions were derived:

1) What is the willingness and ability of smallholder farmers to accept and adopt ICT-in-agriculture innovations towards supporting their farm operations, improving their farm productivity, and providing access to market?

2) What are the factors that influence smallholder farmers' decision on ICT innovations adoption in agriculture?

2. Literature Review

The use of ICT to improve agricultural economies is an area of concern, and full potential has yet to be grasped. A survey on Kenya's Competitiveness (Economics, 2018) indicated that the rate of adoption of agricultural technologies and subsequently food production in the country is low. With most innovation limp in the pilot phase, research is necessary on how ICT innovations can enhance and improve farm productivity. In developing countries, this has been supported by the extension service officers who are currently hardly employed by the gov-

ernment. Studies indicate that potential issue for extension services is the question of viability, and such services may need to be supported on a regular basis by local governments or downstream players, such as lead buyer firms, which clearly benefit from long-term productivity improvements in farmers' yields. ICT suppliers can facilitate and fast-track operation among farmers, banks, input retailers and buyers and to put in place processes and mechanism that help the parties to complete transactions (FAO, 2020b).

In understanding the farmers' knowledge on agricultural ICT innovation adoption, it is stated that users acceptance, integration and use of new technology occurs and develops overtime due to the influence of many interrelated issues (Mng'ong'ose & Victor, 2018). Similarly, FAO (2013) indicates that ICT-in-agriculture innovations are available to assist improve the effectiveness and efficiency of agricultural activities, and to demonstrate how ICT stimulate activities in the agriculture value chains. Additionally, parties implementing the ICT innovations vary too, such as governments, non-governmental organizations (NGOs) and private companies. The use and value of the different ICT innovations are portrayed from the farmer's or producer group's perspective, with examples from typically larger upstream or downstream players' perspectives, such as banks, cooperatives or processors (FAO, 2013).

A number of studies on technology adoption in developing countries disclose that various factors influence technology adoption, and they can be categorised based on factors such as characteristics of human, relative performance of the technology and program and institutional factors (Melesse, 2018). According to Boer (2001a) human characteristics are education level, experience with the activity, age, gender, level of wealth, farm size, plot characteristics, labour availability, resource endowment, risk aversion, among others. According to Boer (2001a), factors related to the performance of the technology and practices include food and cash generation functions of the product, the perception by individuals of the characteristics, complexity and performance of the innovation, its availability and that of complementary inputs, the relative profitability of its adoption compared to substitute technologies, the period of recovery of investment, local adoption patterns of the technology and the susceptibility of the technology to environmental hazards Boer (2001b). Similarly, the institutional factors include availability of credit, the availability and quality of information on the technologies, accessibility of markets for products and inputs factors, the land tenure system, and the availability of adequate infrastructure, extension support among others (Melesse, 2018). Enabling policies and programs, market linkages, access to institutional support and credit were found to play a positive role in stimulating farmer investment in and adoption of sustainable technologies (Shiferaw & Okello, 2009).

According to Chowhan & Ghosh (2020), penetration of mobile phones in the rural community has significantly increased the adoption of ICT in agriculture in Bangladesh. This has supported agricultural activities such as collection and sharing of timely and accurate news on weather, inputs, markets, and prices.

Notably, the role of ICT in e-agriculture revolves around collection, storage, processing and dissemination of information to the farming community including relevant stakeholders. Such information may include real time information on farm and crop management, input availability, irrigation, soil quality, fish culturing, market access etc. Action network theory is used in Birke & Knierim (2020) to analyse the roles of the human and non-human actors in adoption and use of ICT-in agriculture innovations. The findings demonstrate the potential of telecenters as a strategy to provide agricultural extension services to the rural community.

While there is a significant increase in deployment of technology-based systems to support farmers in farming activities such as selection of crops to plant, management and control of pests among others, Harris & Achora (2018) reports that these systems hardly consider the actual context of use in the rural farming communities particularly in the developing countries. These farmers face challenges ranging of illiteracy to ill-developed technological infrastructure that can support these systems. As such, promoting adoption of these systems may need to leverage human centered participatory design and development approach.

A number of theories have used to understand innovation adoptions. The most popular are Diffusion of Innovation Theory (DOI), Technology Acceptance Theory (TAM) and Theory of Reasoned Action (TRA) (Lai, 2017). In area of agricultural information system, DOI and TAM have been applied in developing countries to develop model of ICT adoption by smallholder farmers (Kante, 2018). The innovation diffusion model has some limitations, main challenge of the model is that it generally assumes that the most important variable is information and the willingness of the individual to change (Hagelaar, 2018). Similar to Kante (2018), DOI and TAM were used to inform this study.

In the agricultural sector, researchers have emphasised that the perception is positively related to ICT adoption and use. In addition (see Mng'ong'ose & Victor, 2018 and citations therein), studies related to agriculture dissemination of innovation report the same relationship between ICT's use and user's perception (Mng'ong'ose & Victor, 2018). The question that has remained unanswered is what these perceptions are and to what extend they influence the adoption and use of ICT innovation by the smallholder farmers. This study attempts to explore these unanswered questions.

3. Research Methods

In order to understand the smallholder perception on innovations, this paper, embraced a positivism, deductive approach and quantitative strategy which were considered to fit the focus. According to Saunders et al. (2012), researchers are content to estimate a population's characteristics at 95% certainty to within plus or minus 3% to 5% of the true values for most research. For this research the sample size was required to be representative of the views of approximately 1000 smallholder farmers. Therefore, a sample size of 100 was used in this study.

A self-administered questionnaire was used to collect data on the level of adoption of innovation; the present extent of the success/failure of ICT Innovations; and the strategies to improve ICT agricultural innovations adoption. The questionnaires were further supplemented with interviews with the group leaders and stakeholder to assure their reliability. The respondents completed the questionnaire on their own but the researcher was available in case problems were experienced. The questionnaires were pre-tested to ensure that all items were clear and understandable.

4. Findings and Discussion

Table 4 shows that of the total respondents, the age group range of above 50 are the majority with a percentage of 38.8%, which constituted that most of the smallholder farmers are above 50 years, followed by the age range of 40 - 50 at 30%; followed by the age range of 30 - 39 at 20%; while the age below 30 at 11.3%.

Table 1 illustrated that in rural Kenya, farming is mostly practiced by the aged. This implies that youths are to consider farming as an alternative form of employment. The youths are mostly migrating to town leaving the rural farming to the aged. There is need to provide sensitization to the community on potentials of agricultures, and farmer centered training on emerging farming techniques that can improve farm productivity irrespective of its size.

Considering the education level of the respondents, the majority had high school education (43%), followed by pre-high school education (36.3%) and post-high school training (e.g., Diploma level) at 20% as shown in Table 2 below.

While a great proportion of the sampled population had the ability to read and write, there is a huge percentage (29%) who may not access or utilize the emerging ICT-in-agriculture farm innovations due to their level of literacy. However, their farmers' groups with group leaders who are literate can be leverages to support such farms adopting and utilizing these innovations.

Table 3 presents the employment status of the respondents. 77.5% of the respondents reported to be self-employed while 22.5% reported to have a formal employment.

Table 1. Age of respondents.

Age					
		Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Valid	Below 30	9	11.3	11.3	11.3
	30 - 39	16	20.0	20.0	31.3
	40 - 50	24	30.0	30.0	61.3
	Above 50	31	38.8	38.8	100.0
	Total	80	100.0	100.0	

Table 2. Education level.

Education					
		Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Valid	Primary	29	36.3	36.3	36.3
	Secondary	35	43.8	43.8	80.0
	Diploma	16	20.0	20.0	100.0
	Total	80	100.0	100.0	

Table 3. Employment status.

Employment Status					
		Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Valid	Employed	18	22.5	22.5	22.5
	Self Employed	62	77.5	77.5	100.0
	Total	80	100.0	100.0	

The findings in Table 3 above demonstrate that farming is majorly practices as the main source of income, as the self-employed rely exclusively on their smallscale agriculture to support their food supply. This implies that there exists a potential for smallscale agriculture to be made robust and productivity to support these farmers as their main avenue for self-employment. Thus, such farmers would ordinarily desire access to emerging farming techniques that can improve their productivity, and ICT-in-agriculture innovations provide a platform to provide this.

The results of Table 4 summarize the ICT devices available in the farming community and the ownership of these devices. The results show that over 96% of the respondents had access to some form of ICT devices (smartphones, basic-feature phones, televisions, and radios).

The indication that most farmers own some form of ICT device arguable provides a motivation to develop and deploy digital farming solutions for these devices to provide timely, accurate and relevant information to these farmers. However, almost twice the time these devices were owned by male farmers, which makes it difficult to ensure that such digital solutions would get to the female farmers given the parochial nature of local community setting in the study area. Thus, there is a need to provide a supportive system to enable the female farmers to have access and ownership to ICT devices.

The results of Table 5 show the awareness of ICT-in-agriculture innovations by the farming community. At least 80% of the sampled population are aware or rather heard about ICT-in-agriculture innovations.

Table 4. Ownership of ICT devices.

Age, Gender and Ownership of Technology device							
		Ownership of ICT device					
Age		Yes		No		Total	
		Male	Female	Male	Female	Frequency	Percentage (%)
Below 30	Count	7	2	0	0	9	11.8%
30 - 39	Count	7	9	0	0	16	21.1%
40 - 50	Count	13	11	0	0	24	31.6%
Above 50	Count	20	7	1	2	30	35.5%
Total	Count	47	29	1	2	79	100.0%

Table 5. Awareness of ICT-in-agriculture innovations.

Awareness of ICT-in-agriculture innovations in agriculture					
		Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Valid	Yes	65	81.3	81.3	81.3
	No	15	18.8	18.8	100.0
	Total	80	100.0	100.0	

This shows that the farming community appreciates the availability of alternative source of information in regards to farming besides the traditional methods such as extension officers etc. That farmers are aware of ICT-in-agriculture innovation is an indicator that there exists a huge opportunity to exploit these tools for improving farming practices. The innovators only need to participatorily co-design these solutions with the farmers to increase their ownership and adopt.

Table 6 shows the utilization of ICT-in agriculture innovations including use of ICT devices to access agriculture innovation and emerging farming methods and practices. The majority of the respondents (81%) reported to being aware of the availability of ICT-in agriculture innovation. The respondents indicated to have used such innovations and digital solutions to access financial services, credit facilities and information on farming input, market price, transport and weather.

The results indicate that though most farmers have not benefited from ICT-in agriculture innovations, there is evidence that some famers, albeit a small percentage, have used solutions for their land preparation, planting, farm management, harvesting and post harvesting management including access to farming inputs and credit support. These farmers can be used as champions in rolling out ICT-in agriculture innovations and to promote their adoption.

Table 6. Awareness and usage of ICT-in agriculture innovations in agriculture.

Awareness and Usage ICT-in-agriculture innovations						
Innovation/Technology	Cases					
	Frequency			Percent (%)		
	Not Aware	Aware and have not used	Have used	Not Aware	Aware and have not used	Have used
Input information on seed, fertilizers and pests	15	55	10	18.7	68.8	12.5
Access to credit e.g. Mkopa, Mkesho, Mshwari	15	3	62	18.7	3.8	77.5
Market prices and places	15	60	5	18.7	75	6.3
Weather information	15	62	3	18.7	77.5	3.8
Transport	15	65	0	18.7	81.3	0

Similar to Chowhan & Ghosh (2020), this study noted that ICT-in agriculture increases farmers' access to financial, credit facilities and affordable insurance services even in the rural community. It also provides actionable and reliable information to the farming communities on emerging farming techniques, connects the farmers to the extensions service providers and researchers, and facilitates market access and access to farm inputs. Concurring with the findings in (Liu et al., 2021), this paper notes that adoption of ICT-in agriculture innovation is significantly influenced by the application design (e.g., whether it is radio application, TV application etc). Additionally, the socio-demographic factors inform on how the innovations are adopted.

5. Conclusion

The aim of this study was to examine the factors related to adoption of agricultural ICT-in agriculture innovation by smallholder farmers. The study results from quantitative confirm that the key factors to be considered for successful adoption are related to human, technology, economic and environmental provided for operation. The results support that characteristic of a technology is a precondition of adopting it, this has also been stated (Islam & Grönlund, 2017). The farmers' perceptions of technology characteristics significantly affect their adoption decisions. The finding of this study supports the demographic context in use and adoption of new technology. According to the findings, variables that are important in this category are: age, gender and level of education (which is directly related to skills). Most adoption studies have attempted to measure human capital through the farmer's education, age, gender, and household size (Fernandez-Cornejo et al., 2016).

The results of this study indicate that majority of the younger farmers below

30 years own the ICT devices (even if basic feature phones or radios). These younger farmers also indicated that they have used the devices to access agricultural innovation and are aware of the availability of ICT-in agriculture innovations. The findings also indicated that majority of farmers with phones have access to these innovations for accessing financial services, credit facilities, information on farm inputs, market places and pricing, transportation and weather focus.

Based on these findings, it is revealed that the combination of variables related to technology innovation adoption can be grouped based on the amount of change in the explained variation in the dependent variable

This study found that the adoption of ICT-in agriculture innovations has a number of issues that require both internal and external collaboration towards making its adoption a success. Adoption of such innovations by smallholder farmers is influenced by number of issues such as human (the farmers), social influence, economic, technological attributes, participatory and collaboration. We hope that these findings trigger practical and policy discussions in how to move ICT-in agriculture innovations from the research labs to the farming communities who need them, and how to support their deployment and adoption towards increasing farm productivity in the Global South. Future studies may consider examining the role played by these issues in adoption of ICT-in agriculture innovation by smallholder farmers in the rural community.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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