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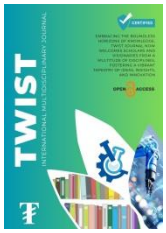

A State of Art of Adoption of ICT Innovations in Crop Farming in Developing Countries:

A Systematic Literature Review

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Abstract
Till the end of the 19th century, farming practices have been conventional where farmers greatly relied on indigenous farming tools like hoes, sickles and pitchfork to cultivate their farms. In Sub-Saharan Africa poverty is still existing and undernourishment has been increasing. This weak economic performance is connected to low technology adoption that reduces productivity growth in the agriculture sector. This study investigates the factors that have influenced adoption of ICT in crop farming in developing countries. And this was achieved by reviewing literature from three databases published between 2013-2022 to carryout analysis. This search yielded 119 papers and 35 papers were selected for analysis. The analysis showed that a number of models have been developed like TAM, DOI and UTAUT to help guide adoption of ICTs in Crop farming. In Sub Saharan Africa some ICTs like Radio, Television, Mobile phones have been adopted however, the level of adoption is not satisfying due to a number of Factors that influence this adoption like infrastructure, literacy, cost, ICT access, ICT policies and language of use.

Keywords
ICTs, Review, Crop Farming, Adoption

INTRODUCTION

Conventional farming methods were used until the end of the 19th century, and farmers heavily relied on local farming implements like hoes, sickles, and pitchforks to develop their farms. This conventional approach needed a lot of physical labor but produced relatively little productivity Liu (2021). In Sub-Saharan Africa, poverty is still a problem, and malnutrition has been becoming worse. Low technology adoption is related to this poor economic performance since it slows productivity growth in the agriculture sector (Odame, et al 2013). In low income nations like sub-Saharan Africa, low agricultural production and persistent food insecurity have prompted the adoption of new technology to increase productivity. For instance, widespread mobile phone use has lowered transaction costs and enhanced access to information. Yet, the rural farmers' adoption of these profitable technologies is not satisfactory. (Takahashi. et al 2019). Most people have not adopted cutting-edge agricultural methods, and they struggle to make ends meet, which contributes to deficiencies. (Mwangi.M.&Kariuki.S.2015). Technologies that could help raise agricultural production by applying the necessary nutrients, being cost-effective, raising production value, and bolstering farmers' economies have replaced traditional methods of crop production. (Elemike, et al 2019) The main goals of modern agricultural technology development are to enable farmers achieve the largest yields and the greatest economic returns. (Rehman. et al 2017). Farmers in Tanzania who adopted technology received essential input information that let them make informed decisions that increased agricultural productivity (Kante., et al. 2019). Several ICT innovations for agriculture have been created, including the ERIGNU, JAGUZA, AKORION, E-voucher system, SUFACE model, Kudo, and VIAZI systems, among

others. However, the majority of these technologies are still in the prototype, idealization, and validation stages, and only a small number have been adopted by farmers (9.3% of available technologies) (Mirembe & Lubega. 2019). This study looks factors influencing adoption of ICT innovation in crop farming in developing countries. Relevant studies were retrieved from various electronic databases, synthesized presented to be able to respond to research questions that were formulated. These studies were basically pointing out ICTs that have been adopted in crop farming, models that have been used for ICT adoption, factors influencing ICT adoption among crop farmers in developing countries.

RELATED WORK

There has been a large adoption and diffusion of digital technologies Fox, et al (2021). Modern technology in the agricultural sector can significantly increase agricultural production and sustainability provide proper management like pest control, hybrid selection among others (Rehman. et al 2017). If adopted ICT tools can offer easy and cheap communication between farmers and buyers as well as reducing on the cost incurred like travel costs. Mallory, et al (2022) If available technologies like Radios, Televisions, Cell phones and computers are adopted, then farmers are going to experience an enhancement in their agricultural production (Miwanda et al 2014).

Nguyen, L.L.H. et al, (2022) conducted a review on determinants of precision agriculture (PA) technology adoption in developing countries. The factors were classified in to two that is individual level factors and organization factors. At the personal level, criteria that encouraged Precision Agriculture adoption were the technology's relative advantages, observability, triallability, farmer familiarity with technology, innovativeness, risk tolerance, education, and expertise, whereas farmer age and technology complexity hampered adoption. Farm size, resource availability, perceived need for technology characteristics, technology compatibility, social impact, competitive pressure, and government backing were factors favoring PA adoption at the farm level. Giacomo Zanello, et al (2015) concluded that there are barriers to innovation that include institutional factors like intellectual property rights (IPRs) and the interaction between the private (firms) and public sectors, as well as political characteristics like a weak political system and widespread corruption in society. Economic characteristics include openness of an economy and level of economic development. Meng, et al. (2013) concluded in their study that there are barriers to usage of ICT in developing countries that can be solved by infrastructure maintenance, community partnership, properly training staff and managers, and partnership with local government and private sector and better financial planning. It has been found in numerous earlier research that SMEs continue to adopt ICT at a lesser rate than anticipated. Some obstacles have been identified as reasons for the low adoption of ICT by SMEs, including a lack of management issues, a lack of government support, a lack of ICT infrastructure, a lack of support from banks, and a lack of knowledge about ICT Albar, and Hoque (2017).

METHODOLOGY

A systematic literature review was to evaluate and summarize the available research on our current study to identify the existing gasps. A review protocol was developed that aided in making specific review to avoid the possibility of bias. The review protocol followed was based on that proposed by Kitchenham,. and charter, (2007). It involves planning, search process definition, definition of search criteria, quality assessment, extraction and synthesis.

Research questions

In this paper I was engrossed in finding studies on current adoption of technologies in agricultural sector in Sub-Saharan Africa, existing models that have been used for technology adoption and factors influencing adoption of ICTs in developing countries thereby addressing the gap. This was achieved through the following steps:

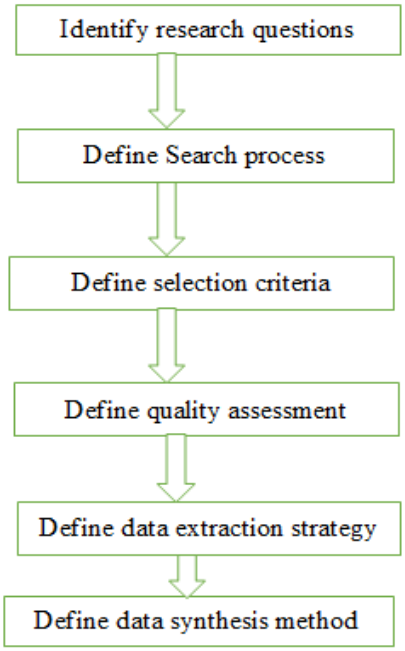

Fig. 1 SLR protocol based on kitchenham and charter

RQ1. What ICTs have been adopted in crop farming?
RQ2. What models have been used for technology adoption in crop farming?
RQ3.What factors have influenced adoption of ICTs in crop farming?

Search process

The search strategy was inclusive of scope and search method where the scope covered time of publication and place of publication. Time considered publications between 2013-2022 which was applied at selection phase and the place of publication considered majorly Sub-Saharan Africa and slightly East Asia publications were selected from three research databases and these were Google scholar, Sage publication and Wiley-online library. The search string was conducted using the keywords in the research questions that were formulated as follows: (ICT OR Technologies AND Agriculture AND Sub-Saharan Africa), ("Technology Adoption Models"), ("challenges of ICT adoption AND Agriculture"). The table below shows the results of overall search.

Table 1 overview of literature search results

Database	Retrieved papers	Selected Papers
Google Scholar	53	23
Wiley-online Library	41	8
Sage Publications	25	5
Total	**119**	**35**

Study selection criteria

The retrieved studies were numerous so we had to choose those that served the researcher's interest by using an exclusion criterion. They were 119 publications that were retrieved so the researcher had to read their titles and abstracts to find out if they were meeting the search interest and then the researcher went ahead to read the entire paper to select those that meet the criteria. After application of our selection criteria, only 35 papers were retained. The table below shows the exclusion criteria

Table 2 Exclusion criteria

CR1	Papers published before 2013
CR2	Papers that were not complete
CR3	Papers not Talking about ICT innovation
CR4	Paper Talking about ICT but not on agriculture

Quality assessment criteria

Quality assessment criteria was performed on the remaining 40 studies to affirm whether they had an abstract, the rigor, quality reporting, answered the research questions, whether the studies were relevant to the study, had clear methodology, whether theories were clear, whether the conclusion was in line with the title of the paper and finally whether the limitations were clearly mentioned.

Data extraction

The major studies that were selected for review are indicated in Table 3. These studies were selected based on the fact that they were answering the research questions of our study that is ICTs adopted, available technology adoption models and factors influencing adoption of ICTs. Other criteria followed to select these studies include the publication year, paper being complete and paper having innovation element. The selected studies that I was able to review were listed in a table pointing out the author, title, publication year and type of document. See Table 3;

Table 3

Author	Tittle	Year
Salajan., et al	The Role of Peer Influence and Perceived Teaching Quality in Faculty Acceptance of Web-Based Learning Management Systems	2015
Zaremohzzabieh,. et al	A Test of the Technology Acceptance Model for Understanding the ICT Adoption Behavior of Rural Young Entrepreneurs	2015
Verma, et al	Integrating perceived economic wellbeing to technology acceptance model: The case of mobile based agricultural extension service	2017
Nazir, et al	Identification of roles and factors influencing the adoption of ICTs in the SMEs of Pakistan by using an extended Technology Acceptance Model (TAM)	2022
Ahmad ,	Unified Theory of Acceptance and Use of Technology (UTAUT): A Decade of Validation and Development	2014
Nistah et al,	Internet of Things Adoption Among Micropreneurs in Regional Coast of Sabah	2021
Molina-Maturano et al	Understanding Smallholder Farmers' Intention to Adopt Agricultural Apps: The Role of Mastery Approach and Innovation Hubs in Mexico	2021
Kahenya, et al	Assessing Use of Information Communication Technologies among Agricultural Extension Workers in Kenya Using Modified UTAUT Model International Journal of Sciences:	2014
Sahin,	Detailed review of rogers' diffusion of innovations theory And educational technology-related studies based on rogers' Theory	2006
Kanteet al	Influence of perception and quality of ict-based agricultural input information on use of ICTs by farmers in developing countries: case of sikasso in Mali	2017

Jere et al.	Evaluating the influence of information and communications technology on food security',	2017
Mwombe,. et al.	Evaluation of Information and Communication Technology Utilization by Small Holder Banana Farmers in Gatanga District, Kenya	2014
Basnet., et al.	The State-of-the-Art of Knowledge-Intensive Agriculture: A Review on Applied Sensing Systems and Data Analytics	2018
Akera., , et al	The promise (and pitfalls) of ICT for agriculture initiatives	2016
Chabla., et al	IoT Applications in Agriculture: A Systematic Literature Review	2019
Sreekantha,. et al	Agricultural Crop Monitoring using IOT- A Study	2017
Zhao, et al,	The Study and Application of the lOT Technology in Agriculture	2010
Ghosh,.	Climate-smart Agriculture, Productivity and Food Security in India	2019
Krone, et al	The use of modern information and communication technologies in smallholder agriculture: Examples from Kenya and Tanzania	2015
Uduji, , et al.	The impact of e-wallet on informal farm entrepreneurship development in rural Nigeria	2018
Freeman,. et al.	ict use by smallholder farmers in rural mozambique: a case study of two villages in central mozambique.	2017
Clarkson, et al	Can the TV makeover format of edutainment lead to widespread changes in farmer behaviour and influence innovation systems? Shamba Shape Up in Kenya	2018
Onyancha et al	Information and communication technologies for agriculture (ict4ag) in sub-saharan Africa: a bibliometrics perspective based on web of science data	2020
Isaya, et al	Sources of agricultural information for women farmers in Tanzania	2016
Harris, et al	Designing ICT for Agriculture (ICT4A) Innovations for Small-holder Farmers: The Case of Uganda	2018
Ayim, et al	Adoption of ICT innovations in the agriculture sector in Africa: a review of the literature	2022
Ninsima,	Factors affecting adoption of an information communications technology system for agriculture in Uganda.	2015
Purnomo, et al	Barriers to acceptance of information and communication technology in agricultural extension in Indonesia	2018
Misaki, et al,	Challenges facing sub-Saharan small-scale farmers in accessing farming information through mobile phones: A systematic literature review	2018
Nonvide,.	Adoption of agricultural technologies among rice farmers in Benin	2018
Amankwah-Amoah,.	Technological revolution, sustainability, and development in Africa: Overview, emerging issues, and challenges	2019
Baffoe-Bonnie, et al	Agricultural extension and advisory services strategies during COVID-19 lockdown	2021
Nguimkeu, et al	Leveraging digital technologies to boost productivity in the informal sector in Sub-Saharan Africa	2021
Cunningham, et al	Factors impacting on the current level of open innovation and ict entrepreneurship in AFRICA	2016

RESULTS

The review that was carried out had a time scope of studies that were published between 2013 to 2022. These studies were from a number of journals and the databases were limited to majorly three that is google scholar, Sage publications and Wiley-online library. Fig. 2 shows the distribution of the studies that were used according to their years of publication

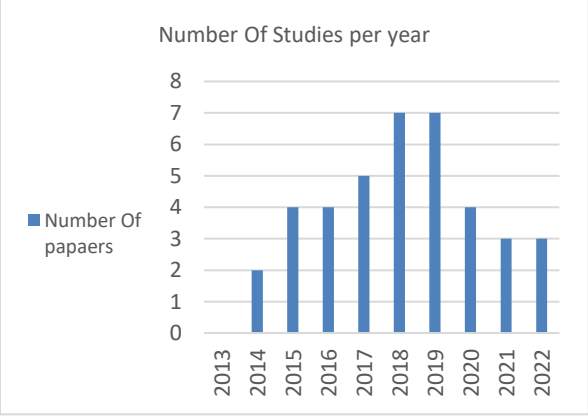

Fig. 1 Studies distribution by year

RQ1 what ICTs have been adopted?

From the review that was carried out, several ICTs have been adopted in some areas to a given extent and these included Radios, Televisions, Mobile phones and IOT sensor devices as indicated in Table 4. There has been a large adoption of mobile phones in developing countries because they are widely spread Takahashi,. et al (2019). Mobile phones have also been adopted because they offer a better way of communication, they are portable and allow for multiple application Michels et al. (2019). Mobile phones have speared in developing countries at a higher rate compared to other technologies, it has been estimated that three out of four people have in developing world have mobile phones and this is likely to increase with reduction in the price of mobile phones, Fabregas, et al, (2019). Fig. 3 shows the adoption of ICTs from the reviewed literature.

Table 4 Adopted ICTs

Author	Technology
Basnet, et al (2019), Chabla, et al (2019), Maina,(2017). Sreekantha,t al, (2017) Zhao, et al (2010)	IOT sensor devices
Akera. et al (2016), Isaya, et al, (2016), Krone. et al(2015), Uduji, J.I. et al (2018), Takahashi, et al (2019), Michels, et al, (2019).	Mobile phones
Freeman, et al (2017), Clarkson, et al (2018), Onyancha etc. (2020)	Television and Radio

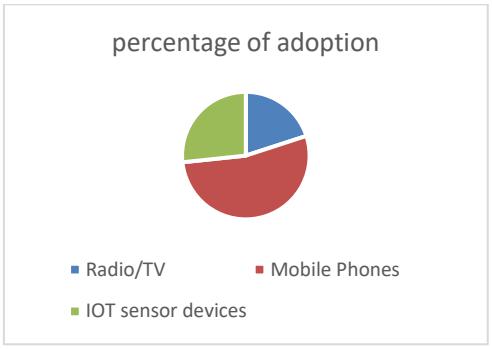

Fig. 2 Models used in adoption

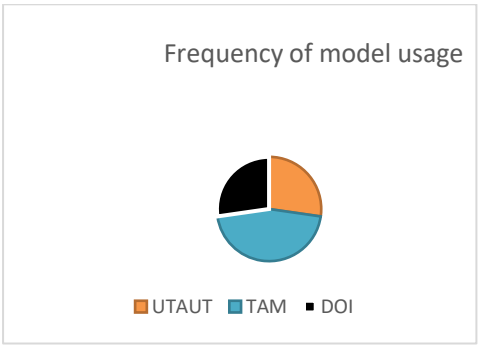

Fig. 3 Percentage of ICTs adopted

RQ 2 what models have been used to study ICT adoption?

The review showed a number of models that have been developed to study the adoption of ICTs. The major models discussed in this study were three and these were Technology Acceptance Model (TAM), Unified theory of Use and Acceptance of Technology (UTAUT) and Diffusion Of Innovation Theory(DOI) as shown in Table 5. The review show that TAM is extensively used in technology adoption studies. A popular notion in the research on innovation adaption is the TAM theory. TAM places a strong emphasis on a person's motivation for adopting a technology Tama, et al (2023). The adoption of new technology by individuals is typically explained by TAM models, and pertinent research has shown that TAM can be influenced by outside social factors Dai, and Cheng, (2022). TAM has gained popularity because of its success in explaining and forecasting the uptake of information technology. Additionally, it offers adaptability to various organizational environments (Okoroji, Lees, and Lucock, 2020). Because of its simplicity TAM was the most used adoption theory as seen in Fig. 4.

Table 5 Technology adoption models

Model	Author
TAM	Salajan., et al (2015) ,Zaremohzzabieh,. et al, (2015), Nazir. & Kha, (2022) Verma, and Sinha, (2017) Hrynevych, et al, (2022).
UTAUT	Ahmad ,(2014), Nistah et al, (2021), Molina-Maturano, et al, (2021), Kahenya, D.W., Sakwa,
DOI	Kante,., Oboko, and Chepken, (2017) , Jere, & Maharaj, (2017) Mwombe, et al (2014)

RQ 3 What factors have influenced the adoption of ICTs?

The review identified a number of a number of factors influencing the adoption of technology in agriculture and some of these challenges were illiteracy, finance, ICT policies, infrastructure, and language of use as seen in table 6. A number of studies have discussed IT knowledge as one of the major factors influencing the adoption of innovation Taylor, P. (2019). In another study farmers adoption of mobile phones for writing SMS to gain agricultural information was hindered by the level of literacy Mushunje, T.S.A. and Akinyemi B.E. (2018). A number of realistic studies have pointed out that knowledge and information are crucial factors for improving agricultural development through planning, marketing and acquisition of proper input (Ali, 2012). Most of the reviewed studies pointed out among others literacy/ knowledge/education levels as a major factor that influenced adoption of ICTs among rural farmers in developing countries. Therefore, literacy is a major influential factor for adoption of ICT followed by cost and access to technology, then ICT policies and infrastructure and lastly is language of use as depicted in Fig. 5.

Table 3 Factors influencing adoption of ICTs

Author	Factor
Harris, et al, (2018), Ayim, et al, (2022), Purnomo, et al (2018), Misaki, et al (2018).	Infrastructure
Harris, et al, (2018), Ayim, et al, (2022), Ninsiima, (2015), Misaki, et al (2018). Nonvide,.(2018). Baffoe-Bonnie, et al (2021), Cunningham,et al (2016)	Knowledge/literacy/education level
Harris, et al, (2018), Misaki, et al (2018). Nonvide,(2018). Amankwah-Amoah,.(2019), Cunningham,.et al (2016)	Cost (lack of finance)
Harris, et al, (2018), Ayim, et al, (2022), Ninsiima, (2015), Purnomo, H.S. et	Access to technology (internet and

al (2018) Nonvide,.(2018). Baffoe-Bonnie, et al (2021), Nguimkeu,. et al (2021)	devices).
Ayim, et al, (2022), Purnomo, et al (2018), Amankwah-Amoah,.(2019). Cunningham, et al (2016)	ICT policies
Ninsiima, (2015), Misaki, et al (2018).	Language of Use

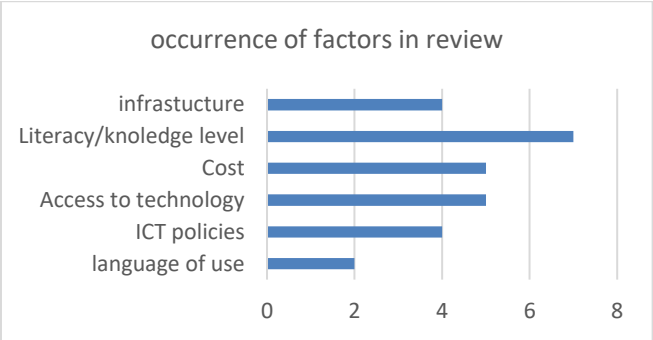

Fig. 4 Occurrence of factors influencing adoption in the review

DISCUSSION

The study shows findings from 35 studies on adoption of ICT in the agricultural sector in sub-Saharan Africa. The researcher identified papers published on this particular topic and made an Analysis which showed that the majorly used ICT in agricultural sector are mobile phones. Other Used ICTS are radios, Televisions and computers and internet to a limited extent. However, the usage is still low due to use of foreign languages, poor infrastructures, illiteracy rate, limited income to purchase the devices, poor ICT policy and weak enabling environment. The study also identified some theories for technology adoption like Technology acceptance model (TAM) and Diffusion Of Innovation theory (DOI) however these theories majorly focused on the technical bit of the story without considering other factors that are not technical in nature for example the social and economic aspects, long term adoption, culture and individual difference

CONCLUSION

The study revealed the state of art of adoption of agricultural ICTs in sub-Saharan Africa through a systematic literature review that was carried on studies published between 2013-2022 where the researcher was able to retrieve 119 studies that were analyzed and extracted only 35 studies that were primarily used in the study. The study revealed that most used ICTs are mobile phones, radios, Television and internet was used to a limited extent, however, the dominant ICT that has been adopted is mobile phones for its portability, ability to handle multiple application and reduced cost. The review looked at a number of models for adoption of ICTs and these included Technology Acceptance Model (TAM), unified theory of acceptance and use of technology(UTAUT) and diffusion of innovation (DOI), TAM was the widely used theory to study adoption of technology because of its ease and capability to cater for various working environment. The study also showed a lesser adoption due to poor infrastructures, illiteracy, poor policies and limited funds to access the devices and literacy was found as a major factor influencing other factors. The study can be used to add to existing body knowledge and to allow policy makers find out what can be done to improve on adoption of ICT so as to gain its benefits like improved productivity, efficiency and food security.

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