INFORMATION AND COMMUNICATION TECHNOLOGIES ADOPTION AND USE WITHIN THE AGRICULTURAL SECTOR IN DEVELOPING COUNTRIES: A SYSTEMATIC LITERATURE REVIEW

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Abstract

This study aimed to review the literature on the adoption and usage of Information and Communication Technologies (ICTs) in the agricultural sector, specifically in developing countries. The use of ICTs in agriculture can assist in achieving development goals and promote food security. While previous studies have shown the potential benefits of ICTs in the agricultural sector, there are still gaps in understanding their applications, innovations, and appropriate theoretical frameworks for guiding their adoption. This review aims to address these gaps and answer two research questions: (1) What is the status of literature on ICT adoption and usage in the agricultural sector in developing countries? (2) What are the main research trends in literature on ICT adoption in the agricultural sector in developing countries? This study provides valuable insights into the role of ICTs in achieving the Sustainable Development Goal (SDG) 2 of ending hunger, achieving food security, and promoting sustainable agriculture. The paper is organized into sections on introduction, methodology, results, discussion, conclusion, and future work. This study is a systematic review of the use and adoption of information and communication technologies (ICT) in the agricultural industry in developing countries. The review analyzed 16 relevant papers from 2012 to 2022, and found that mobile phones and related services were the most commonly used ICTs in the agricultural sector in developing nations. However, poor policy environments, lack of capability, and insufficient technological infrastructure hindered the adoption and usage of ICTs. The study suggested the need for empowering and educating farmers, creating supportive corporate and policy environments, and conducting more research in this area. Future studies could focus on ICT policies in the agricultural sector and the role of governments in enforcing standards and policies to improve agriculture in developing countries.

Key Words: Information and Communication Technologies, Agricultural Sector

Introduction

Information and Communication Technologies (ICT's) has the potential to revolutionize the agricultural sector. The design and use of ICT's can, assist in achieving development goals, according to academic research and govt agencies. The global economy's in the agricultural sector is one of many sectors that is utilizing ICT extensively across all aspects of its operations. Farmers play a critical role in promoting food security, especially in developing countries where a large portion of the population depends on agriculture for their livelihoods (Alant & Bakare, 2021). The farmers contribute to food security in several ways even though they face numerous challenges, including limited access to information and resources that can improve their farming practices and increase their productivity. ICTs can play a critical role in addressing these challenges and supporting the farmers in the developing countries. ICTs encompass a wide range of tools and technologies, including mobile phones, internet-enabled devices, online platforms, and agricultural information systems. According to Ayisi Nyarko & Kozári, (2021), the application of ICT across various sectors of the global economy has revolutionized the game in terms of increasing productivity and labor efficiency. The importance of ICT tools as a means to enhance adaptive capacity and resilience of the farmers in the face of climate variability has long been recognized globally (Alant & Bakare, 2021).

The study done by Ayim et al., (2020) shows that the efficiency and productivity of the agricultural value chain have significantly increased as a result of the successful integration of ICT in the agriculture sectors of American and European countries. For instance, traceability technologies like radio frequency identification (RFID) and blockchain have made it possible to track and trace food from farm to fork, allowing transparency and efficiency throughout the food chain. Unfortunately, in most developing countries, this transformation has not yet occurred (Ayim et al., 2020).

While prior studies have contributed significantly in laying the foundation for ICT tools adoption within the agricultural sector, understanding how ICT has contributed within the sector is important. Previous studies have shown that ICT tools can provide farmers with access to information on weather patterns, crop prices, soil fertility, and pest control, among other things (Ayisi Nyarko & Kozári, 2021). They can also facilitate communication between farmers, extension workers, and other stakeholders within the agricultural value chain.

Over the past decades have seen a growing trend in research toward ICT adoption within the Agricultural sector in developing counties. Finding gaps in prior studies, trends, and potential areas for future research are becoming more and more important as the body of knowledge as this field expands. Previous literature reviews on the ICT adoption in the Agricultural sector have highlighted the following:

- Studies on the combined application of ICTs Tools in agriculture are limited resulting in a lack of understanding of their applications (Liu et al., 2021).
- There are few literatures done on ICT innovations in the past studies (Ayim et al., 2020).
- Appropriate theoretical framework for guiding ICT innovations is lacking (Ayim et al., 2020), (Zewge & Dittrich, 2017).
- Developing countries remain under-researched (Zewge & Dittrich, 2017).

In recognition of the fact that there is a growing body of research on ICT adoption and use in the agricultural sectors, studies in developing countries are still few making it a motivating factor in performing this research. In this context, the review tries to address to the following questions:

RQ1. What is the status of development of literature on ICT adoption and usage in the agricultural sector in developing countries?

RQ2. What are the main research trends in literature on ICT adoption in the Agricultural sector thin developing countries?

Our study offers important contributions to the body literature. It sheds light on the role of ICT adoption and usage in agricultural sector within the developing countries. This review of literature on ICT adoption in agriculture within developing countries will also be valuable to help in achieving the Sustainable Development Goal (SDG) 2, which is one of the 17 goals set by the United Nations in 2015 as part of the 2030 Agenda for Sustainable Development. SDG 2 aims to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture" worldwide.

The paper is organized as follows: the introduction is discussed in section 1, section 2 presents the research methodology, section 3 presents the results of the SLR, section 4 presents the discussion of the findings, and the conclusion is presented in section 5 and finally, section 6 discusses the conclusions and future work.

Information and Communication Technologies (ICT's) Adoption

The term ICTs (Information and Communication Technologies) is defined by (Kamala et al., 2019) as a varied set of technological tools and assets to generate, stockpile, produce value and manage information. According to Alant and Bakare, (2021), ICT literacy is the ability to access, manage, integrate, assess, and produce information using digital technology, communication tools, and/or networks in order to perform tasks in a knowledge-based society. The on-going technology revolution in the developing countries has caused considerable excitement in recent years over the role that ICTs can play in economic development (Alemu & Negash, 2015). ICTs have impacted society and every sector of the economy, transforming it into an information society.

Innovative ICT's ranging from computers, radio, television and mobile phones to advanced technologies such as blockchain, artificial intelligence, cloud computing, Internet of Things (IoT) and big data analytics are among the current trends (Ayim et al., 2020). (Ayim et al., 2020) argue that disruptive ICT trends hold the potential to contribute to sustainability transitions in agriculture by increasing efficiency, enhancing transparency and traceability. In the era of globalization, ICT is the most powerful resource for the widespread transfer and sharing of information (Islam et al., 2017).

According to Mushtaq et al., (2022), ICT adoption within the SMEs sectors reduces information asymmetry between borrowers and lenders, which in turn eases credit conditions. Firms that adopt ICT extensively are less likely to experience financial constraints because banks consider ICT adoption as an indication of firms' "willingness to innovate".

Another study done by Cuevas-Vargas et al., (2022), shows that ICT adoption has a significant impact on absorptive capacity (ACAP) and open innovation (OI) for a greater business performance. There are various kinds of benefits that can be gained because of ICT adoption, i.e., ecological, economic, sociocultural, and political (Ziemba, 2020). ICT adoption in local governments should aim at increasing the efficiency and effectiveness of management and decision-making, and reducing costs in Government units (Ziemba, 2020). ICT increases project efficiency in terms of time and expense(Dixit et al., 2021).

Due to these numerous benefits ICT innovation and adoption in different sectors, agricultural sector should adopt and use ICT in most of its operations.

Information and Communication Technologies Adoption and Usage in Agricultural sector within developing countries

Food security is a key component of the Sustainable Development Goals (SDGs) of the United Nations (UN), which were adopted in response to the significant rise in global population (United Nations). According to the latest World Economic Forum report, about 70% of the African population depends on agriculture for their livelihood (Ayim et al., 2020). This makes agriculture a critical sector within the developing countries in the quest to sustain food security (Ayim et al., 2020). Growth and development of the agriculture sector can be achieved through the effective deployment of Information Communication Technology (ICT). According to the Food and Agriculture Organization (FAO, 2017), ICT has been a significant contributor to the growth and socio-economic development in countries and sectors where they are well deployed (Ayim et al., 2020). The role of ICT to enhance food security and support rural livelihoods is, therefore, a key driving force in this information age.

Agricultural growth is therefore crucial for raising economic development and feeding the ever-growing population in the developing countries. According to (Islam et al., 2017), it is vital that farmers should receive agricultural information as fast as possible so that they understand, interpret, accept and use the information to get desired benefit. Farmers may be equipped with mobile technologies, internet access and laptops to promote ICT within the agricultural sector.

Awuor et al., (2013) points out that ICTs in agriculture have the potential to increase the efficiency, productivity and sustainability agriculture by providing information and knowledge sharing, even though in the developing countries, the use of ICTs by farmers and the rural population to overcome hunger and food security remains in its early stages (Awuor et al., 2013). According Baddegamage, (2014), ICT can be used in the agriculture sector with government influence in developing countries that are creating competitive and substitute products. By adopting education, enabling direct access to the market, upholding quality standards, expanding the market, and branding products through government influences, they can employ ICT in the areas of awareness, marketing, and standardization (Baddegamage, 2014).

Ayisi Nyarko and Kozári, (2021) points out that ICT applications have the potential to identify and find solutions to some of the numerous problems faced in the field of agriculture, which includes prolonged droughts, pest and disease outbreaks, seasonality and spatial dispersion of farming; high transaction costs and information asymmetry. In order to achieve their objective, farmers can leverage B2B portals, information and knowledge management systems, information systems, and mobile technologies. Longo et al., (2023) suggests that the use of ICTs in agriculture can greatly increase production and reduce waste. ICT innovations can enhance farmer cooperation, transform everyday routines, and make poor nations more adaptable to current climate change. (Longo et al., 2023). ICT tools can assist farmers in resolving a number of challenges, including access to financial services and loans, information sharing on agricultural inputs, knowledge access, the creation of business connections, and the sustainability of farming systems. (Longo et al., 2023).

Study done by Prasad and Pradhan, (2019) highlights the numerous advantages of ICT-based services for the improvement and strengthening of the agricultural sector in developing countries, including the ability to conduct online marketplace and e-commerce, better and location-specific agricultural practices and advices in local language, better exposure to daily market pricing, and time-critical information on weather forecasts and calamities.

(Ayim et al., 2020) stressed that remote sensing using satellite technologies, and geographical information systems can be used to increase agricultural output within the developing countries. Big data analytics can also be utilized to restructure corporate processes, drive real-time operational choices, and provide real - time insights for farming operations (Ayim et al., 2020).

ICT implementation along the agricultural value chain may provide chances for chain participants to get accurate, timely, and relevant information, which will improve food security, sustainable agriculture, and profitable agriculture in addition to profitability (Ayisi Nyarko & Kozári, 2021). As the agricultural sector advances constantly with implication of new technologies and ICT, it has become very important to adopt those improvements to achieve a sustainable growth in the sector (Subashini & Fernando, 2018).

Even though the literature has shown that ICT has numerous advantages that the farmers and consumers may reap from, some of the of the most important barriers to introduce ICT to farmers is the lack of knowledge on ICT and the trustworthiness on information available through ICT, which should be addressed with effective educational programs (Subashini & Fernando, 2018). In the agriculture industry, an extremely well-planned ICT system will have a wide range of positive effects, including advancing farmers' careers. Apart from getting the greatest rates and access to new, high-quality products, consumers will also benefit from the ability of firms to improve product quality, efficiency, and profitability.

Research methodology

The review protocol proposed by Ayim et al., (2020) was followed in this study (see Figure 1). Following this protocol, we started by identifying the research questions the SLR must address. This was followed by detailing the search strategy, including defining study selection criteria. Then we defined quality assessment criteria in the form of a well-defined checklist to assess the selected studies. We then applied the selection and quality criteria to select primary studies. We then extracted the relevant review data from the primary studies and analyzed the data.

Figure 1: Research Protocol
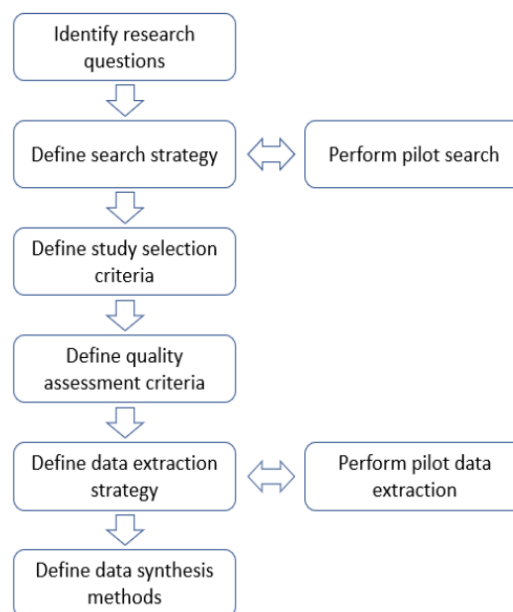
Adapted from (Ayim et al., 2020)

In this study, a structured literature method was used to code and analyze studies published between 2012 and 2021. The following well-known databases were used to search for the targeted research papers: Science Direct, IEEE, Taylor & Francis and Emerald because of their credibility. In addition, we searched Google Scholar because of its accessibility and potential to uncover research from developing countries researchers that might be published in avenues not listed in the more established databases. The automatic search was achieved by searching electronic databases using defined search strings. The keywords are grouped in a search string as follows:

Str1: "ICT Adoption" AND "USAGE" AND "AGRICULTURE" AND "DEVELOPING COUNTRIES"

Str2: "ICT ADOPTION" AND "USAGE" AND "DEVELOPING COUNTRIES"

Str3: "ICT ADOPTION" AND "USAGE" AND "AGRICULTURE"

Str4: "ICT ADOPTION" AND "AGRICULTURE" AND "DEVELOPING COUNTRIES"

Str5: "ICT USAGE" AND "AGRICULTURE" AND (DEVELOPING COUNTRIES OR NATIONS)

Selection Criteria

The search string provides many potential research papers, including journal articles, conference papers, and book chapters. From the searched results, we performed the selection criteria presented in Table 1 to identify the most relevant studies. Firstly, the selection criteria were applied by choosing only journal articles and reading the studies' title and abstract. After that, the next stage was reading the studies thoroughly and performing the exclusion criteria. After applying these criteria, 16 of the 428 papers were selected. The selection process is presented in Table 2.

The result of the overall search process after applying the search queries is given in Table 1.

Source	Retrieved	Included	Selected
ScienceDirect	383	20	4
IEEE	10	5	5
Emerald	23	5	2
Taylor & Francis	7	5	2
Google scholar	5	2	2

Table 1: Selection Criteria

Based on these search strings, a total of 428 articles were identified (Science Direct= 383, IEEE=10, Emerald= 23, Taylor & Francis = 7, and Google Scholar=5).

Screening

The following inclusion and exclusion criteria were used (Rumo & Backhouse, 2021):

Exclusion

- Papers that do not have full text available papers which not written in English
- The duplicate publication that were found in multiple sources
- Relevance for the research questions: papers that do not discuss the agricultural domain
- Papers do not validate the proposed study
- publication period – published within the past 10 years (2012-2022).

- geographic location – developing countries
- publication types – peer-reviewed journal articles

Inclusion

The following terms form the basis of the inclusion criteria.

- Those papers will be included if they contain a detailed explanation of ICT usage and adoption in agriculture
- Those studies that explore the adoption of ICT in Agriculture.
- Those study publications that examined adoption of ICT in Agriculture in developing countries.
- Those papers that have discussed the process of adopting adoption of ICT in Agriculture in developing countries.
- The papers that were written entirely in English.
- The papers that has keywords that are comparable to our search query.

Quality assessment criteria

In this study, data extraction included the quality assessment. Quality assessment will help in minimizing the risk of bias and increases confidence in review findings. We utilized a three-point scale (yes, partial, no) for each criterion identified during the process in order to rate the studies according to the quality of their result.

No.	Question	Yes (1)	Partial (0.5)	No (0)
Q1	Objectives of the study clearly stated			
Q2	Scope and Context clearly defined			
Q3	Variables are valid and reliable			
Q4	The research process documented adequately			
Q5	All study questions answered			
Q6	The main findings clearly stated			
Q7	Conclusions relate to the aim of the purpose of the study			

Table 2: Quality Assessments

The results of the quality assessments show that there is no biasness in the literature. The minimum score Of the quality assessment was 6 with a maximum score of 7. This shows that all the selected journals met the quality criteria.

Data extraction

A data extraction form was developed to collect and retrieve all needed information from the different studies. The development of the data extraction form was an iterative process. We first selected several articles randomly and read them rigorously to create the data extraction form. After that, the initial data extraction form was used on other selected articles to extract the data. It was a repeated process. Eventually, the final data extraction form includes general information such as

- the authors;
- study focus area;

- year of publication;
- research method used;
- framework used or developed; and
- Study location

Once this was done, this developed framework was subjected to piloting. Five articles were randomly selected and used in the piloting stage. There were no ambiguities or inconsistencies reported from the piloting. This process helped in increasing the reliability of this study. Additionally, by independently doing the extraction, data errors and potential biases were reduced (Rumo & Backhouse, 2021).

Results / Findings

The findings related to RQ 1 for this study are reported in the following subsections:

RQ1: What is the status of development of literature on ICT adoption and usage in the agricultural sector in developing countries?

Development of Literature

To answer the RQ1, the number of articles published annually throughout the study period between 2012 and 2022, the journals in which the author(s) published, as well as the Citation Score for each work were examined.

#	Study focus Area	Journal or Conference	Author & Year of Publication	Citation Score
1.	Adoption of ICT innovations in the agriculture sector in Africa	*Electronic Journal of Information Systems in Developing Countries*	Zewge and Dittrich, (2017)	13
2.	ICT Solution Architecture for Agriculture	*IST-Africa Conference and Exhibition,*	Awuor et al., (2013)	55
3.	Empowerment of Farmers Through ICT Literacy	*National Information Technology Conference, NITC*	Subashini and Fernando, (2018)	14
4.	A case study of the relationship between smallholder farmers' ICT literacy levels and demographic data	*Heliyon (Elsevier BV)*	Alant and Bakare, (2021)	13
5.	Information and communication technologies' (ICTs) use among farmers in Qena Governorate of Upper Egypt	*Library Hi Tech Emerald*	Mansour, (2021)	0
6.	An overview of approaches and methodologies for supporting smallholders:	*Procedia Computer Science*	Longo et al., (2023)	0
7.	Mobile Information System for Small-Scale Rural Farmers	*IEEE International Conference on Technological Innovations in ICT for Agriculture and Rural Development, TIAR*	Alemu and Negash, (2015)	20
8.	ICT Availability and Usage by Farm women in Agriculture	*International Journal of Current Microbiology and Applied Sciences*	Kamala et al., (2019)	4
9.	Utilization of ICTs in Agricultural Extension Services of Bangladesh M.	*Asian Journal of Agricultural Extension, Economics & Sociology*	Islam et al., (2017)	23

10	Assessing the Extent of ICT Usage by Farmers for Sustainable Agriculture in Sub-Himalayan Region C.	*International Journal of Current Microbiology and Applied Sciences*	Prasad and Pradhan, (2019)	2
11	ICT in Sri Lankan Cinnamon Industry: Bridging the Digital Divide	*International Journal of Information and Computation Technology*	Baddegamage, (2014)	1
12	ICT and environmental sustainability: Any differences in developing countries? Lasme	*Journal of Cleaner Production*	N'dri et al., (2021)	51
13	Information and communication technologies (ICTs) usage among agricultural extension officers and its impact on extension delivery in Ghana	*Journal of the Saudi Society of Agricultural Sciences*	Nyarko and Kozári, (2021)	33
14	ENHANCING AGRICULTURAL PRACTICES THROUGH MOBILE TECHNOLOGY INTERVENTIONS	*IEEE Global Humanitarian Technology Conference, GHTC*	Matiyabu and Ndayizigamiye, (2019)	3
15	ICT adoption, innovation, and SMEs' access to finance	*Telecommunications Policy*	Mushtaq et al., (2022)	19

Table 3: Development of Literature
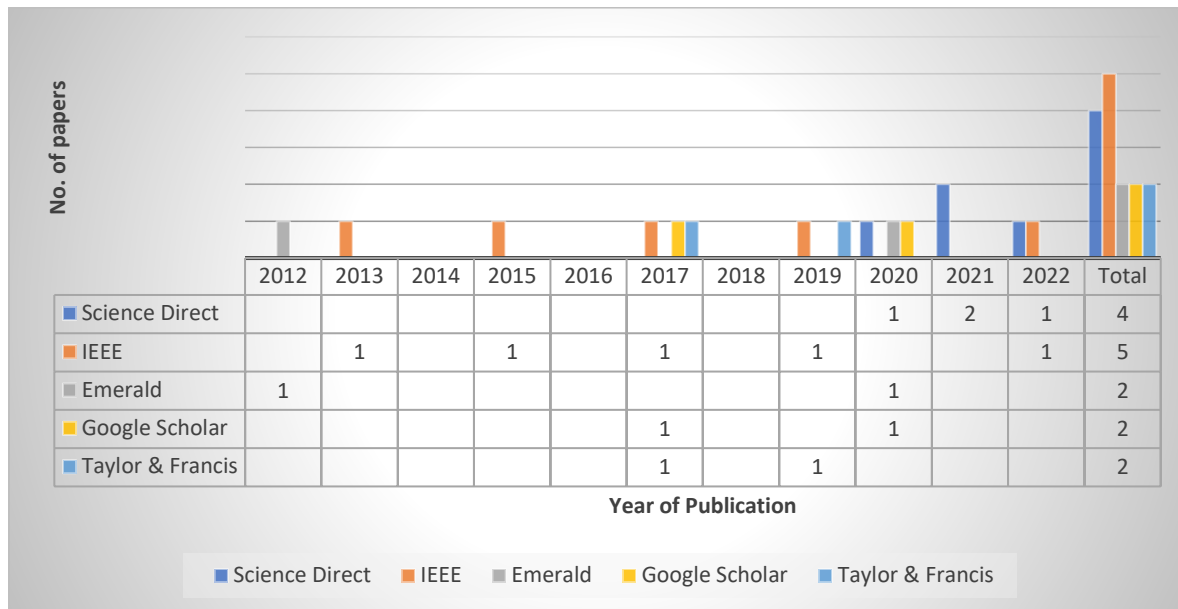
Overview of selected studies

As was previously mentioned, the review specified the search time frame, which was set at the research selection stage and covered publications published between 2012 and 2022. Figure 3 displays the year-wise distribution. As indicated in Table 1 there were only 16 publications in total during the period considered in this study (Science Direct=4, IEEE=5, Emerald=2, Google scholar=2 and 2 journals from Research Gate).

Figure 2 demonstrates that the number of publications during the research period did not increase consistently. In contrast to the years 2014,2016, and 2018, which had no publications, 2019, 2021 & 2022 had (2) publications each. The years 2017 & 2021 had the most publications (3) each while the years 2012, 2013 and 2015, had each one publication over the reviewed period. This result demonstrates slow progress in research on ICT adoption in the agricultural sector in developing nations. The papers were classified according to their year of publication as shown in Figure 2.

The Publish or Perish software from Harzing was used to obtain the citation index (CI) scores. The CI ratings have been used to evaluate the relevance of studies in a field of study since they represent the frequency with which the work has been cited by other studies. According to the CI score, earlier works are more likely to be cited than later ones. The study done by Awuor et al., (2013) had the highest score followed by Ayisi Nyarko & Kozári , (2021) and N'dri et al., (2021) respectively. Both (Longo et al., 2023) and (Mansour, 2021) had zero CI score despite the fact that they were more current literature.

The articles chosen for this study were from distinct developing nations namely Kenya, Ghana, Egypt, Ethiopia, Congo, Benin, Sri Lanka, Tunisia, and South Africa. The study shows there was little academic partnerships of collaboration between the Global South and Global North.

Figure 2: Publication Count between the Years 2012-2022

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
■ Science Direct									1	2	1	4
■ IEEE		1		1		1		1			1	5
■ Emerald	1								1			2
■ Google Scholar						1			1			2
■ Taylor & Francis						1		1				2

Year of Publication

■ Science Direct   ■ IEEE   ■ Emerald   ■ Google Scholar   ■ Taylor & Francis

Year of publication of the primary studies

The results of the study show that there is a growth in literature focusing on both ICT Adoption and the agricultural industry. ICT adoption research domain is a potential area of interest as shown from the results. The growth of ICT in developing countries offers a new opportunity for farmers in the rural communities in developing countries (Zewge & Dittrich, 2017).

Regarding the publication outlets, some of the journals where the papers were published are presented as below:

- IEEE Global Humanitarian Technology Conference, GHTC
- Electronic Journal of Information Systems in Developing Countries
- IST-Africa Conference and Exhibition
- International Journal of Information and Computation Technology

Conceptualization of the Information and Communication Technologies

Information and Communication Technologies are described as a varied set of technological tools and assets to generate, stockpile, produce value and manage information (Kamala et al., 2019). ICT adoption and usage in the agricultural sector refers to the process of acquiring and integrating information and communication technologies into the agricultural sector. It involves the selection, implementation, and use of ICT tools, technologies, and services to improve performance, efficiency, and effectiveness. Some of the ICT applications developed in agriculture domain include mobile based agro-advisory system, expert systems, knowledge management systems and monitoring system.

The adoption of ICT can bring many benefits, including improved productivity, improved resource management, better market access, and enhanced decision-making capabilities, cost savings, better decision-making, and enhanced communication and collaboration. The use of Information and communication technologies in agriculture have been termed as innovative (Aleke & Wainwright,

2010). From the literature, farmers have tried to utilize ICT in the sector, for example, ICT's have been utilized for collecting information and providing services respectively (N'dri et al., 2021; Antwi-Agyei & Stringer, (2021). The reviewed articles show that most farmers used ICT to receive agricultural information in order to understand, interpret, accept and use the information to get the desired benefit. In Benin, ICT has been utilized in the agriculture sector to allows knowledge sharing within and among a number of agriculture networks including researchers, exporters, extension services, traders and farmers (Adegbidi et al., 2012).

However, from the reviewed articles, ICT adoption in the agricultural sector can also present challenges, such as the need for training, changes in work processes, resistance to change and the risk of data security breaches, language barriers since many ICT tools and applications may not be available in local languages, making it difficult for farmers who do not speak the language in which the technology is available.

Research Methodologies used

According to Figure 3, the quantitative methods was most frequently employed (at 55%) Kamala et al., (2019), followed by mixed methods (at 27%) (Ebrahim M. Mansour, 2016; Antwi-Agyei & Stringer, 2021) and lastly by qualitative methods (at 18%).

Figure 3: Research Methodologies
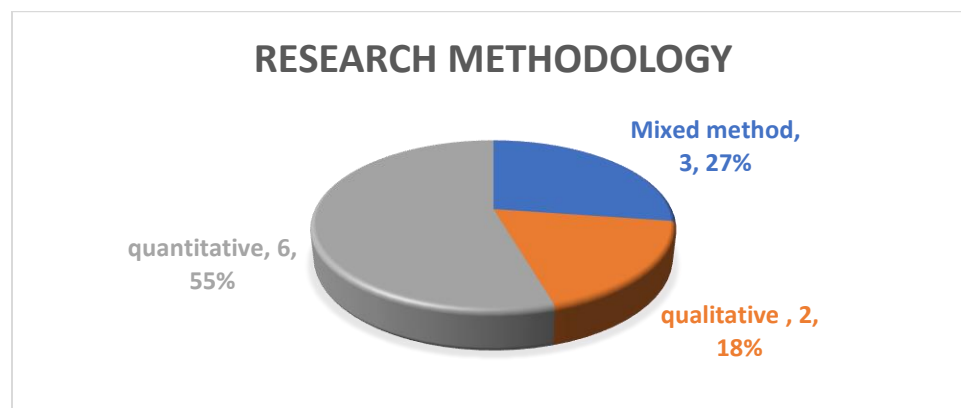
Theoretical and contextual issues

The mostly used theories were TAM, DoI and UTAUT theories. About 75% (12) did not clearly define their theoretical lens to guide their research work. We also noted that two of the studies reviewed proposed new models or theories (Awuor et al., 2013; Baddegamage, 2014). The study done by Awuor et al., (2013) proposes an e-agriculture framework to address the challenges in ICT adoption in agriculture. Baddegamage, (2014), proposes a model to overcome the digital divide.

Most studies focused on the application and adoption of ICT in the Agricultural sector. For example Ayim et al., (2020) focused on Adoption of ICT innovations in the agriculture sector in Africa. Aleke and Wainwright, (2010) also focused on ICT adoption in developing countries. Matiyabu and Ndayizigamiye, (2019) focused on enhancing agricultural practices through ICT interventions. Mansour, (2021) investigated the current situation of ICT developments in Africa's agriculture industry. (N'dri et al., 2021) focused on ICT and environmental sustainability to achieve the Sustainable Development Goals (SDGs). While the studies reviewed show evidence

of growing appreciation of ICT adoption and use within the agricultural sector in developing countries, Mansour, (2021) in their studies also reveal several barriers to effective use and adoption of ICT in the agricultural sector like:

Socioeconomic Issues:

- Socioeconomic profile of the farmers influences on the usage of ICTs as a source of agricultural information by farmers. The socioeconomic characteristics may also be capable of influencing various policies that encourage farmers to embrace ICT-based agronomic practices to increase farm productivity and agricultural sustainability (Mansour, 2021).
- Lack of awareness of the contribution's ICT can make in agriculture (Awuor et al., 2013).

Contextual and organizational issues:

- Poor infrastructure (Ayim et al., 2020; Zafar et al., 2022)
- Poor ICT policies(Ayim et al., 2020; Awuor et al., 2013; Dixit et al., 2021; Aleke & Wainwright, 2010)
- Inefficiencies in agricultural institutions (Ayim et al., 2020)
- Poorly designed and implemented ICT projects (Awuor et al., 2013)
- Lack of transparency and trust between farmers and service providers (Matiyabu and Ndayizigamiye, 2019)

Technological challenges:

- Farmers are not acquainted with how to use mobile phones to access farming information for decision making (Matiyabu & Ndayizigamiye, 2019)
- Lack of open- source software in agriculture (Matiyabu & Ndayizigamiye, 2019).
- Lack of user friendliness of ICT platforms (Dixit et al., 2021)
- Lack of availability of software to meet the need of farmers, perceived high cost of ICT adoption (Awuor et al., 2013).
- Lack of technological infrastructure (Awuor et al., 2013).

Literacy issues:

- Lack of education to use ICT related equipment and the language barrier as a major obstacle to ICT adoption in the agriculture sector (Subashini & Fernando, 2018; Aleke & Wainwright, 2010).
- Lack of ICT knowhow and illiteracy (Ayim et al., 2020; Matiyabu and Ndayizigamiye, 2019)

Discussion

This systematic review presented the findings of the 16 selected primary studies on the adoption of ICT's within the agriculture domain in the developing countries. We could identify that over the past years, high-quality papers have been published on the adoption of ICT's.

The section will discuss the finding of the study that will address the second research question for the study: RQ2. What are the main research trends in literature on ICT's adoption in the Agricultural sector thin developing countries? In addressing this question, we focus on several outcomes as presented in the preceding sub-sections.

Outcome No.1: Limited Studies

The number of publications during the research period is displayed in Figure 2. This is an evident indication that there is still much to be done about ICT adoption in developing countries' agricultural sector's. For their work to be recognized, authors must also publish in widely recognized journals.

Outcome No. 2: There is lack of an appropriate theoretical framework for guiding ICT innovations in the agricultural sector. Ayim et al., (2020) noted that there is lack of literature on an appropriate theoretical framework for guiding ICT innovations. Awuor et al., (2013) in their study develops a solutions architecture (e-agriculture framework) to expose farmers to the much-needed agricultural information that can boost agricultural productivity.

Outcome No. 3: Methodologies and Theoretical Models

From figure 4, quantitative methodology (Alant and Bakare, 2021; Islam et al., 2017)was the mostly used methodology followed by qualitative methodologies (Antwi-Agyei & Stringer, 2021), (Dixit et al., 2021). There were also use of Mixed methodologies (Islam et al., 2017). Most of the works were based on focus groups studies and adopted statistical approaches for data analysis. One study adopted Partial least squares structural equation modeling (PLS-SEM), (Alemu & Negash, 2015).

The study identified 3 main theoretical frameworks from the primary studies namely TAM (Perceived usefulness and Perceived ease of use as constructs), (Baddegamage, 2014), UTAUT (Performance expectancy, Effort expectancy, facilitating conditions and Social influence constructs) (Alemu & Negash, 2015), (Ayim et al., 2020) and DoI (Relative advantage, Compatibility, Simplicity, Observability and Trialability constructs) frameworks.

Outcome No. 4: The most predominant Information and Communication Technology

The primary studies' analysis demonstrated how ICTs including television, radio, computers, and mobile phones have penetrated the agricultural industry. According to the findings of the study, the mobile phone was identified as the most common information and communication technology used within the sector which is in line with the findings of (Zewge & Dittrich, 2017). The divisiveness and lack of coherence in the agricultural research system, as well as the low ICT skills and competencies of farmers in developing countries, continue to be barriers to adoption, usage, and accessibility.

Conclusion

We have provided an SLR of the acceptance and usage of information and communication technologies in the agricultural industry in developing countries in this study. The study's findings will add to the body of knowledge on ICT's adoption and use in the developing countries. The review covered primary papers from 2012 to 2022 and adhered to a precise approach. After using our search criteria, we found 16 papers that were relevant to our study topics. The primary studies' analysis showed that the most common ICT's employed in the agricultural sector of developing nations were mobile phones and related services. Poor policy environments, insufficient capability, and inadequate technological infrastructure in developing nations are only a few issues that have been discovered to hinder the adoption and usage of ICT's. The findings of the study suggest empowering and educating farmers to improve their capacity to work with emerging agricultural

technologies. Additionally, there is a need to create corporate and policy environments that support the use of ICT's and other digital technologies. To ensure greater development and awareness among the farmers in developing countries, more research is required in the area of ICT's adoption and application in the agricultural sector.

Future studies could look at ICT policies in the agricultural sector as well as the many roles and functions played by governments as the policy makers in enforcing standards and policies at various stages to improve agriculture in the developing countries.

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