International Journal of Computer Applications Technology and Research
Volume 15–Issue 03, 127 – 136, 2026, ISSN: -2319–8656
DOI:10.7753/IJCATR1503.1019

Utilization of ICTs in Agriculture Among Small and Middle Level Farmers in Rural Areas of Uganda

Nassanga Sharifa
PhD student
Department of Computer Science
Maseno University
Maseno Kenya

Dr. Erick Oteyo Obare
Department of Computer Science
Maseno University
Maseno Kenya

Dr. Samuel Oonge
Department of Computer Science
Maseno University
Maseno Kenya

Abstract: Information and Communication Technologies (ICTs) have surfaced as transformative tools for tackling the constraints of conventional agricultural extension systems in; crop management, soil management, irrigation, market access and livestock, to improve productivity and sustainability. This paper explores the status of utilization of ICTs among small and middle level farmers in rural areas of Uganda. The study employed qualitative research design where survey questionnaires were distributed in selected districts of Luweero, Isingiro and Mbarara using snowballing sampling technique. 247 responses were collected. Out the 247, 53.4% were male and 46.6% were female. The largest number of adopters were those below the age of 44. The most utilized ICTs were mobile phones, radios, televisions, computers with a few cases of IOT devices, integrated camera systems, web and mobile agricultural applications. These ICTs are majorly used for agricultural information access and marketing with a few cases of monitoring agriculture practices and record keeping. Mobile phones were the predominant ICT devices because of efficiency and accessibility. The study revealed that advanced ICTs that could enhance productivity are less utilized because of infrastructure and cost challenges.

Keywords: ICT utilization; smallholder farmers; Uganda

1. INTRODUCTION

Information and Communication Technology(ICT) refers to a wide range of digital tools and systems utilized for generating, manipulating, storing, and dissemination of information, as well as in the automation, monitoring and control of operation targeted operations (Khatrietal.,2024). Fatumo et al.(2021) asserts that ICT is indispensable to practically every facet of contemporary life. Globally, the agricultural sector has witnessed a growing application of ICT solutions (Nyarko and Kozari, 2021).These ICTs have surfaced as transformative tools for tackling the constraints of conventional agricultural extension systems in crop management, soil management, irrigation, market access, livestock management, paste and disease control ,weather forecasting, financial services, supply chain management and farmer education (Khatri, et al 2024). According to Javeed et al.(2020), globally, adoption of ICTs in agricultural processes has been explored to increased productivity. However, the adoption of the would-be beneficial technologies is still low in developing countries (Ruzzante et al., 2021).

In Africa the agricultural sector is dominated by smallholder farmers who lack capital assets that are critical in improving productivity (Kamara et al., 2019). In Afrifa, (2021) as cited by Magambo et al., (2023),among the causes of low adoption of innovative ICTs are low resources, insufficient training, and imperfect infrastructure. Sub-Saharan Africa, like other developing regions of the world has gravitated towards domestication of technology to meet the growing need of food security(Takahashietal.,2019). Fatumo et al,.(2021), states that the adoption of ICTs in agriculture can maximize a farmer's capacity for output and enhance their farming operations. ElBilali and Allahyari (2018),echoes the sentiments by arguing that the transition to sustainable agriculture can be achieved through the adoption of ICTs. Mirembe et al., (2023) highlighted the major ICTs used for agriculture in

Uganda; Radios, television and social media platforms to access and share important information about their produce. Majority of farmers are constrained from accessing smart phones which limit their ability to access information extension services, and quality markets. Oyewole, (2022) asserts that with vast assistance and investments, smallholder farmers can play a significant role in nourishing Africa against the alarming food crisis.

2. PAGE SIZE

2.1 **Utilization of agricultural ICTs Globally**

Globally, ICTs have been used for extension services to enable the transmission of knowledge, and agricultural practices to farmers and various stakeholders in the agricultural sector (Bhat et al.,2024). Developed nations like Europe, North America, Oceania, Latin America and Caribbean have witnessed high productivity because of ICT adoption. This high productivity is due to well-developed ICT infrastructure, pervasiveness of internet, advanced technology, improved labor efficiency and access to new market because of lesser transaction costs (Rajkhowa & Baumüller, 2023). In the United States, precision agriculture technologies have been widely utilized like GPS for field mapping, drones for aerial imaging, and IoT devices for soil moisture censoring, in the Netherlands ICTs are used in the entire supply chain of agriculture; they use advanced data analytics to improve pest control in their greenhouses (Bhatetal.,2024). ICTs have improved agricultural practices by reducing the gap between farmers and researchers as well as accelerating wide spread of systems and services in the agricultural sector (Kountiosetal., 2023).

In Ethiopia, Information communication Technology has been utilized to build a large agricultural extension system which are considered to be the largest in the world. This extension system is used to provide advice and training to farmers in the country (Anteneh &Melak,2024).

In Africa, the digitization of agriculture, specifically using mobile phones has improved agriculture during production and after production, a case of marketing and promotion. A number of agricultural practices have been improved through the usage of ICTs and these include; Nutrient Management, Sustainable agricultural practices, crop management, improved Seeds, weather and climate information, integrated Pest Management, Market and Price Information, Post-Harvest, Crop Diversification, labor Management, Pest Management and Water Management (Mulungu et al, 2025). Through ICTs, climate risks have lessened because of the advanced warnings given and farming activities are managed efficiently (Erlanggaetal, 2023). ICT has significantly revolutionized the agriculture industry in Malaysia where it has been utilized for information sharing and creating decision support systems for agriculturalists. However, adoption of these ICTs remains moderate in Malaysia and this has been due to the cost of ICTs, illiteracy and inadequate technology infrastructure (Ismail et al 2023).

2.2 Utilization of agricultural ICTs in developing countries

Mobile phones have been identified as predominantly utilized ICTs in developing countries enabling farmers to get instantaneous weather forecasts, information on pests and market prices through SMS (Khatrietal.,2024). Furthermore, mobile phones provided direct and indirect effects on farmers' livelihood to farmer groups in Uganda and Kenya where they were used to access information that helped reduce human-elephant conflict that let to crop damage by elephants(Grahamet al., 2012 as cited by Erlangga et al.,2023). Therefore, if properly utilized, mobile phones have the capability of boosting livelihoods of farmers in developing countries and becoming chain partners (Alam et al., 2023). However, in Africa, Asia and a significant portion of Latin America rural farmers have not fully utilized ICTs to improve their productivity because of illiteracy, insufficient training and poor infrastructure (Rajkhowa & Baumuller, 2023). Awareness and access to information that is related to available

technology is still limited in developing nations (Soodan et al., 2022). In these emerging nations, challenges such as prominent inequality, under sized ICT communication infrastructures, and reluctance to invest in ICT has persisted (Okunola et al., 2017 as cited by Shouet al., 2024).

2.3 Utilization of agricultural ICTs among smallholder farmers

Small holder farmers are crucial players in realizing food security and contributing to reduction of poverty in Sub Saharan Africa because they constitute 60-80%of the produced food in the region (Mapiye et al., 2023). The agricultural sector is majorly depicted by a bigger proportion of smallholder farmers (Oyewole,2022). According to (Eastwood et al., 2010 as cited by Kamara et al., 2019), Smallholder farms are basically those who cultivate less than five hectares. A July 2013 report by International Finance Corporation World Bank Group(IFCWBG,2013) asserts that smallholder farm in the developing nations is predictably a family-owned enterprise that produces yields or livestock on two or less hectares. Kountios et al.,(2023) Mentions that there is approximately 525 million small holder farms existing worldwide. Out of this, Asia has 388 million smallholder farmers, 44 million are in Europe and Russian, 5 million are in America and 33million smallholder farmers are found in Africa.In Sub-Saharan Africa mobile and web-based applications have been utilized to distribute agricultural information and services which include Esoko, iCow, Community Knowledge Workers, WeFarm and DigiFarm (Mapiyeetal.,2023).In Tanzania, there has been utilization of different ICTs ranging from traditional ones like print media, newspapers to advanced modern ICT tools like mobile phones, radios, televisions, websites, and social media to extend public and private extension services to small holder farmers (Ndimboet al.,2023). According to Ireri et al. (2021), smallholder farmers in southeastern Kenya use radio and television to acquire agricultural information. Other means used include internet, computers and cell phones though at a very smaller percentage of less than 10%. These smaller percentages have constrained agricultural productivity in the area. In a study conducted in Indonesia, smallholder farmers in three villages of Beran, Cepoko and Gentong predominantly used smartphones which were perceived fast and simple to use. These were used for recording daily transactions, surfing and information sharing(Hendrawanet al.,2023). Research on rice smallholder farmers in South Eastern Nigeria revealed that radio, mobile phone, short message service and online Magazines were the most utilized ICTs though their usage was hindered by limited knowledge on ICT (Gbughemobi et al., 2021). Nwangwu et al., (2022) identified ICTs being used by smallholder farmers in south Eastern Nigeria to access agricultural information as mobile phone, radio, television, internet and computer. Mobile phones were pronounced more effective as they reduced transaction costs, helped in getting information on transportation costs, price fluctuation, output price, when and where to sell agricultural produce. Adeyemietal.(2023) asserts that smart phones, wireless radio and television are best options reliable for agricultural information among smallholder farmers in Gwagwalada Area Council, Abuja, Nigeria. However, there is still a low adoption of these ICTs because of lack of awareness of ICTs and costs associated with them.

2.4 Growth and utilization of agricultural ICTs in Uganda

Agriculture is one of the imperative sectors in Uganda(Mirembeetal.,2023).The annual agriculture survey of 2019 by the Uganda bureau of statistics indicated that 80% of Uganda households are farmers. The Ugandan government has acknowledged ICT as a crucial enabler of social and economic development (Dagne & Oguamanam, 2018). The agricultural sector in Uganda is gradually incorporating ICT usage in agriculture because of the opportunity ICTs have demonstrated for example increasing access to agricultural information at al ow cost(Aker, 2008 as cited by Lwasa et al.,2018),with major ICTs being radio, television and social media platforms (Mirembe et al., 2023). ICT has aroused

sustainable agriculture practices in Uganda (Ali, et al., 2023). Masuki, et al., (n.d) Posits that in western Uganda, it was discovered that low-income earners in rural areas are progressively accessing mobile phones which are utilized to get agricultural information and for marketing something that has improved on their revenue and food security. In another study conducted by Aregu et al., (2008), agriculturalists in Uganda claimed to have obtained agricultural information from university library websites, NGO websites and united nations agencies websites. According to Munyua et al., (2008), farmers in Uganda were trained by the International Small Group and Tree Planting Alliance (TIST) on how to use PDAs and GPS to gather reforestation data, the Agricultural Research and Extension Network (ARENET) and the Collecting and Exchange of Local Agricultural Content (CELAC) used to provide information to small scale farmers in Uganda using websites,. In a study conducted by Subramanian et al., (2022), mobile phones were used for accessing good agricultural practices, after-harvest practices, monitoring financial transactions, seeking advice from extension officers and market links. However, farmers have hindrences to ICT utilization that include finance. Dickson, (2022) asserts that SMEs in developing countries for example Uganda are hesitant to ICT adoption because of infrastructure, high cost of adoption and use, poor government policy and other factors. Low adoption also stems from lack of knowledge on return on investment and lack of technical knowledge on the usage of the ICTs (Campenhout, 2021).

3. METHODOLOGY

3.1 Study area

The study was conducted from three districts of Mbarara, Isingiro and Luweero districts respectively. These were selected because agriculture is their major economic activity and most households have access to at least an ICT that can be deployed for best agriculture practices because the infrastructure present in these areas like mobile network, radio and TV signals could allow for proper utilization of available ICTs. The target group was famers who have utilized any ICT for agriculture purposes. In Luweero district 30 out of 40 young farmers can access internet to visit agro-based websites using their phones and internet cafes (Lwanga 2015). Luweero which in central region and Isingiro which is western region are the regions that had the highest usage of ICT solutions as per the 2017 report by (NIRA) National Identification and Registration Authority (Tinzaara et al., 2025).

Byamukama, et al.,(2023) mentioned that most of the farmers have access to mobile phones, radios, television and laptops. It was also observed that most smallholder farmers in these selected areas had experience in ICT usage for at least two years therefore they were suitable for the study because they had experience of ICT adoption so they could give a clear representation.

3.2 Study population

Based on the report by (UBOS) Uganda National Bureau of Statistics (2024),Mbarara City has a total population of 264,425,Isingiro has a population of 635077 and Luweero has a population of 616242 which makes a total population of 1515744

3.3 Data collection and sample size

Survey questionnaires were designed and distributed to smallholder farmers in selected districts, and farmers were selected using snowball sampling technique where first respondents provided information to the researcher about other prospective respondents from their own network. This process was repeated with subsequent respondents until the targeted number of respondents was achieved in each selected district. The study employed a formula proposed by Yamane (1967). This formula was ideal due to the fact that the study population of the different selected districts was well known by the researcher. The1967 Taro Yamane formular is stated as below;

$$n = \frac{N}{1+Ne^2}$$

International Journal of Computer Applications Technology and Research
Volume 15–Issue 03, 127 – 136, 2026, ISSN: -2319–8656
DOI:10.7753/IJCATR1503.1019

n= required overall sample size N= study population

e=margin error which is 0.05

In this case our N was equal to 1515744. Which gives us a sample size of 400.03 respondents. A total of , 247 questionnaires were filled and returned.

4. STUDY FINDINGS

The total number of respondents who returned their filled questionnaires was 247 smallholder farmers

4.1 Utilization of ICT by Gender

Out the 247, 53.4% were male and 46.6% were female. The predominance of male in ICT utilization is because in Uganda men control the house hold income.

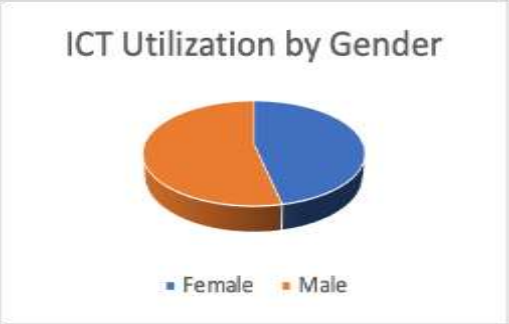

Figure 4-1 Figure1 ICT utilization by gender

4.2 Utilization of ICTs by Age

Age bracket	No. Of Responses
18-27 years	47
28-29 years	95
36-43 years	73
44-55 years	18
>52 years	14

Figure 4-2 age bracket of farmers and utilization of ICTs

The study revealed that there is a significant relationship between ICT utilization and age of respondents. This is so because respondents below the age of 44 were the most adopters of the available ICTs. The table below shows the number of respondents against their age brackets.

4.3 4.3 Experience of ICT Utilization among farmers.

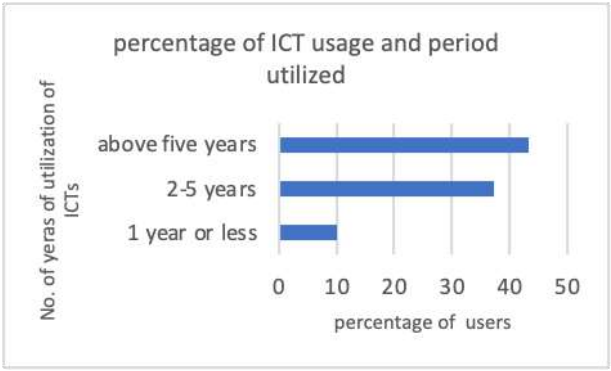

Figure 4-3 percentage and period of respondent's usage of ICTs

The study indicated that 43.3% had utilized the ICTs for more than five years, 37.2% had utilized them for 2-5 years and only 10.1% had utilized ICTs for 1 or less years. This is an indication that majority of the respondents is selected districts had experience in ICT utilization.

4.4. Agricultural ICTs Utilized

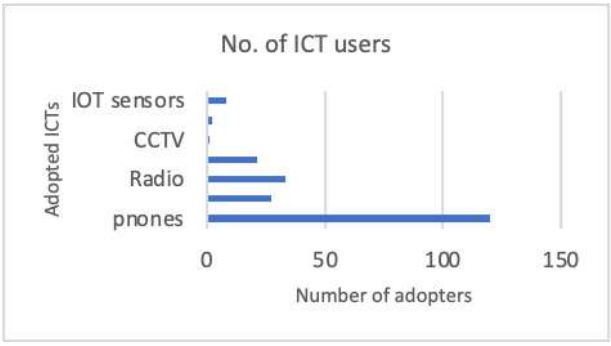

Figure 4-4 Agricultural ICTs utilized

Our study revealed that the mobile phone was the most dominant ICT. Most smallholder farmers (120) had access to mobile phones and could utilize them for their agriculture practices this is because mobile phones are easy to use and efficient. According to Wade, (2004),as cited by Masuki et al.,(2010),there has been a wide spread of mobile phones in Africa where almost one person in five Africans owns a mobile phone.

International Journal of Computer Applications Technology and Research
Volume 15–Issue 03, 127 – 136, 2026, ISSN: -2319–8656
DOI:10.7753/IJCATR1503.1019

Phones are more adopted by rural farmers because they perceive them as easy, fast and convenient way for communication and getting quick responses. Mobile phones were followed by radio users (33) and most of these respondents who utilized radio were the aged. Byamukama et al.(2023) observed that in Uganda's selected districts like Rubanda, Mayuge and Mbarara radio was used by farmers above 40 years and with limited formal education farmers, furthermore,the number of radio users is slightly high because they broadcast in local languages as evidenced in Hailu et al. (2017). Respondents who utilized computers were (27),Television (21). Sensors (8) CCTV(1),and agriculture apps(2). The study revealed that highly advanced ICTs have a very low adoption rate because of infrastructure and cost as observed in Kagona,(2025) Who asserted that in East African community where Uganda is a member, low adoption of AI and IOT is due to the cost of technology, lack of training and poor infrastructure. Other reasons for low utilization of these ICTs as posited by Campenhout, (2021) are traced to lack of knowledge on return on investment and lack of technical knowledge on the usage of the ICTs.

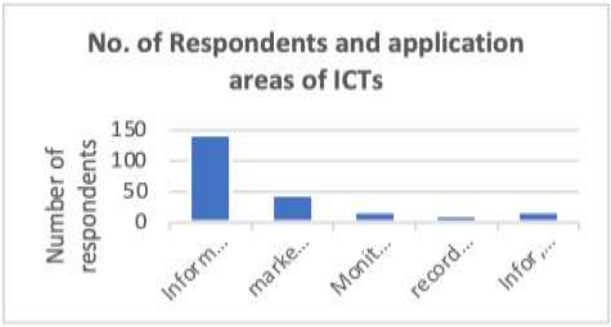

Figure 4-5 application areas of utilized ICTs

The study revealed that 141 respondents utilized ICTs for provision of information like research, getting information from Television and Radio programs about best agricultural practices, accessing information from social media platforms like Facebook, You Tube and TikTok. ICTs were also utilized for marketing and advertising (45 respondents), (18) respondents utilized ICTs for monitoring. Other farmers used agricultural ICTs for a combination of information access, marketing and monitoring(18 respondents), whereas (10) respondents utilized ICTs like computers for record keeping.

4.5. ICT applications areas

The study revealed that there is a significant relationship between ICT utilization and age of respondents. This is so because respondents below the age of 44 were the most adopters of the available ICTs. The table belo

5. DISCUSSION

ICT has become an indispensable part in all aspects of life agriculture inclusive. This is evidenced by the way it has been applied globally to build extension systems, man she climate change, water management and information provision among other applications.

In developing countries small scale farmers dominate the agriculture sector and greatly contribute to food security. Their major ICTs are phones yet other farmers have not been able to adopt ICTs due to infrastructure and cost challenges. In Uganda 80% of the households are farmers and they are swiftly incorporating ICTs in the agriculture sector because of benefits that come with ICTs like access to information at a low cost.

In this study, the number of men involved in Utilization of ICTs are more compared to women since men had ICT access opportunities than women. In a study conducted by Sekabira, (2015) in Uganda, male were more active in ICT usage than female because they controlled the house hold income and some women were denied access to mobile phones by their husbands. In Ghana, men unlike women were in position to get financial resources and controlled household income which put them in a better position to buy mobile phones to respond to climate change using climate information services (CIS) (Partey, et al., 2018).

Most adopted ICTs are phones, radios and television because they have been perceived easy to use and flexible and they are utilized majorly for information access. Similarly in west afrifrican countries like Nigeraia and Ghana, farmers used devices like mobile phones, radio and television to access information related to climate change(Zougmore, & Partey, (2022).

There has been a slow adoption of advanced ICTs like IOT and Cameras. This study indicates that there is a low adoption of advanced ICTs which estimated at 0.4% for cameras, 0.8% for agriculture apps and 3.2% for IOT devices. This is due to infrastructure challenges and cost associated with them these ICTs. In South Africa, though IoT has been seen as significant in improving agriculture, farmers cannot properly utilize them due to complexity, data insecurity challenges and absence of supporting infrastructure and technical skills. According to Bayih, et al., (2022), in many developing countries in Africa, it is quite challenging to install and operationalize IOT and wireless sensor networks for smallholder farmers because of poor infrastructure and high cost

Most adopters of ICTs were the young adults especially those below the age of 40 those above the age above have no formal education they majorly use radio and Television because they broadcast in local languages. In Ethiopia similarly, older farmers could not utilize ICTs because they were not in position to read or write, they were risk averse and less exposed to information about available ICTs in comparison with young farmers in Ethiopia(Ayalew & Girma, 2025). In another study by Yokamo, (2020) young farmers were enthusiastic to use modern technologies on their farms compared to older farmers due to their innovativeness and capability to access information. In Enugu state Nigeria, older farmers did not accept new technologies as fast as young farmers did (Agwu et al., 2008).

6. CONCLUSION

Smallholder farmers play a vital role in ensuring food security globally and they greatly contribute to the GDP of many countries. The evolution of ICTs in many facets of life agriculture inclusive has greatly helped smallholder farmers where they have utilized a number of ICTs in agriculture to improve productivity and agricultural practices. Among the predominantly utilized ICTs are mobile phones because of their efficiency and flexibility. Mobile phones are majorly used for information access though they are capable of operating advanced application but they are hindered by infrastructure knowledge and financial challenges. Other utilized ICTs are radio, Televisions, and computers and these are basically utilized for information access and advertising or marketing. Advanced web and mobile Application, CCTV cameras and IOT devices have been seen significant in improving agricultural practices but they are less utilized because of financial constraints, limited skills and infrastructure challenges yet these ICTs can greatly improve farmers' livelihood and productivity something that could curb the persistent problem of food security especially in developing countries like Uganda. To improve the utilization of agricultural ICTs for productivity, there is need by government and stakeholders to address the highlighted challenges through ICT awareness programs, reducing the cost of ICTs devices and improving the infrastructure.

7. REFERENCES

i. Khatri, A., Lallawmkimi, M. C., Rana, P., Panigrahi, C. K., Minj, A., Koushal, S. & Ali, M. U. (2024). Integration of ICT in agricultural extension services: a review. *Journal of Experimental Agriculture International, 46(12) 394-410.*

ii. Nyarko, D. A. & Kozari, J. (2021). Information and communication technologies (ICTs) usage among agricultural extension officers and its impact on extension delivery in Ghana.

iii. Kamara, A., Conteh, A., Rhodes, E. R, & Cooke, R. A. (2019). The relevance of smallholder farming to African agricultural growth and development. *African Journal of Food Agric. Nutr. Dev. 2019, 19(1)14043-14065.*

iv. Mirembe, D. P., Lubega, J. T., Ssekkito, B., Nambogo, F. & Namagembe, B. (2023). Smallholder farmer access to ICTs and digital

content: experiences from Uganda. *African Journal of Rural Development, 8(1) 27-39*

v. Oyewole, B. (2022). Boosting smallholder farmers' productivity to feed Africa against the looming food crisis. AfDB Virtual Evaluation Week, 28-29.

vi. Mapiye, O., Makombe, G., Molotsi, A., Dzama, K. & Mapiye, C. (2023). Information and Communication Technologies (ICTs): The potential for enhancing the dissemination of agricultural information and services to smallholder farmers in Sub-Saharan Africa.

vii. Bhat, P.P., Rahul, P. R., Anil, K., Abhishek, J., Manohar, K. N., Rajesh, C. M., & Shashank, L. R. (2024). The role of information and communication technology in enhancing the effectiveness of Agricultural extension programs worldwide: A review. *Journal of Scientific Research and Reports, 30 (7) 963-76.*

viii. Rajkhowa, P. & Baumüller, H. (2023). Assessing the potential of ICT to increase land and labour productivity in agriculture: global and regional perspectives. *Journal of Agricultural Economics. DOI: 10.1111/1477-9552.12566.*

ix. Kountios, G., Konstantinidis, C. & Ioannis Antoniadis, L. (2023). Can the adoption of ICT and advisory services be considered as a tool of competitive advantage in agricultural holdings? a literature review.

x. Ndimbo, G. K., Yu, L. & Buma, A. A. N. (2023). ICTs, smallholder agriculture and farmers' livelihood improvement in developing countries: evidence from Tanzania. *Sage Publication Journal. DOI: 10.1177/02666669231165272.*

xi. Ireria, D. M., Awuora, M. Ogaloa, J. & , Nzuki, D. (2021). Role of ICT in the dissemination and access of agricultural information by smallholder farmers in South Eastern Kenya. *Acta Informatica Malaysia (AIM) DOI:* http://doi.org/10.26480/aim.01.2021.31.41.

xii. Hendrawan, S. A., Trihandoyo, A. & Saroso, D. S. (2023). Implementing Technology Acceptance Model to measure ICT usage by smallholder farmers. *Sinergi, 27(1) 123-132.*

xiii. Gbughemobi B. O, Nkamigbo, D. C., & Meludu, N. T. (2021). Analysis of accessibility and level of knowledge of farmers on the use of ICT among small holder rice farmers in Southeast, Nigeria. *International Journal of Research and Review*, 8(10).

xiv. Nwangwu K. N., Opata P. I., Chiemela C. J., Onah T. L. (2022). ICT tools and their utilization in accessing agricultural information among smallholder farmers in rural areas of Southeast Nigeria. *J. Asian Rur. Stud, 6(1) 1-10.*

xv. Adeyemi, S. O., Sennuga, S.O., Alabuja, F, O. & Osho-Lagunju, B. (2023). Technology usage and awareness among smallholder farmers in Gwagwalada area council, Abuja, Nigeria. *Direct Res. J. Agric. Food Sci, 11(3) 54-59.*

xvi. Anteneh, A. & Melak, A. (2024). ICT-based agricultural extension and advisory service in Ethiopia: a review, *Cogent Food & Agriculture, 10(1).*

xvii. Erlangga, E., Machuku, O. & Dahino, C. J. (2023). A review article on the impact and challenges of mobile phone usage on agricultural production in Africa, *Cogent Food & Agriculture, 9(2).*

xviii. Mulungu, K., Kassie, M. & Tschopp, M. (2025). The role of information and communication technologies-based extension in agriculture: application, opportunities and challenges, *Information Technology for Development, 31(4) 1117-1146*

xix. Ismail, N. A., Bakar, M. A. & Hilmi, M. I. (2023). Encouraging factor for ICT usage in agriculture from supplier view: A case study in Southern region, Malaysia. Esteem Journal of Social Sciences and Humanities, 7(2).

Soodan, V., Jamwal, M., Rana, N. P., Deeksha Sharma, D., & Chakraborty, S. (2022). Modelling the adoption of agro-advisory mobile applications: a theoretical extension and analysis using result demonstrability, trust, self-efficacy and mobile usage proficiency. https://www.emerald.com/insight/2044-0839.html

xx. Shou, M., Jia, F., Yu, J. & Wu, Y. (2024). Challenges in developing information and communication technology (ICT) use for rural e-governance: An ecology perspective. *Willey journal DOI: 10.1111/isj.12540.*

xxi. Alam, G. M. M., Khatun, M. N., Sarker, N. I., Joshi, N. P. & Bhandari, H. (2023). Promoting agri-food systems resilience through ICT in developing countries amid COVID-19. *Frontiers in Sustainable Food Systems.*

xxii. Dagne, T. W. & Oguamanam, C. (2018). ICTs in agricultural production and potential deployment in operationalizing geographical indications in Uganda. *Open Air African innovation research.*

xxiii. Lwasa, S., Asingwire, N., Julius J. Okello, J. J. & Kiwanuka, J. (2013). Awareness of ICT-based projects and the intensity of use of mobile phones among smallholder farmers in Uganda: The case of Mayuge and Apac Districts. *DOI: 10.4018/978-1-4666-3607-1.ch007*

xxiv. Aregu, R., Bagaya, M. & , Prof. Nerbonne, J. (2008). An ICT-based digital content information access framework in developing countries: The case of agricultural informatics access and management in Uganda. *IST-Africa 2008 Conference Proceedings.*

xxv. Ali, N., Manjula, V. S. & Marega, F. (2023). Impact of digitization of sustainable agriculture in Uganda: A case study. *Journal of Applied Sciences, Information and Computing 4(1).*

xxvi. Munyua, H. Adera, E. & Jensen, M. (2008). Emerging ICTs and their potential in revitalizing small scale agriculture in Africa. *World conference on agricultural information and IT.*

xxvii. Masuki, K. F. Tukahirwa, J., Kamugisha, R. Mowo, J., Tanui, J., Mogoi, J. & Adera, E. O.(n.d). Mobile phones in agricultural information delivery for rural development in Eastern Africa: lessons from Western Uganda.

xxviii. Subramanian, K., Bozzola, M. & Nugent, A. (2022). The role of ICT adoption in promoting livelihoods in Eastern Africa: evidence from Uganda.

xxix. Campenhout, B. V. (2021).The Role of information in agricultural technology adoption: experimental evidence from rice farmers in Uganda. *International Food Policy Research Institute and KU Leuven Centre for Institutions and Economic Performance (LICOS)*

xxx. Byamukama, W., Businge, P. M. & Kalibwani, R. (2023). Re-examining the factors influencing the adoption of ICT for agricultural information dissemination in Uganda (Rubanda, Mayuge Districts, and Mbarara City).

xxxi. Lwanga, H. (2015). Adopting and practising ICT-led agriculture by young farmers: A success Story in Luwero district, Uganda.

xxxii. Tinzaara, W., Mulyamboli, M. , Tamubula, I. B. & Tumuhaise, V. (2015). Farmers' awareness and use of mobile phones in the management of Banana Xanthomonas Wilt Disease in Uganda) *East African Journal of Agriculture and Biotechnology*.

xxxiii. Sekabira, H. (2015). Determinants for adoption of ICT-based market information services by smallholder farmers and traders in Mayuge district, Uganda.

xxxiv. Masuki, K. F. G.,Kamugisha, R. ,Mowo, J. G., Tanui, J. ,Tukahirwa, J. Mogoi, J .& Adera E. O. (2010). Role of mobile phones in improving communication and information delivery for agricultural development: Lessons from South Western Uganda.

xxxv. Hailu, G., Pittchar, J. O., Khan, Z. R. & Ochatum, N. (2017). Perceived preference of Radio as agricultural information source among smallholder farmers in Uganda. *International Journal of Agricultural Extension.*

xxxvi. Partey, S. T., Dakorah, A. D. Zougmoré, R. B., Ouédraogo, M., Nyasimi, M., Nikoi, G. K. & Huyer, S. (2018). Gender and climate risk management: evidence of climate information use in Ghana. Climatic Change **158**, 61–75 (2020).

xxxvii. Zougmoré, R. B., & Partey, S. T. (2022). Gender Perspectives of ICT utilization in agriculture and Climate Response in West Africa: A Review. *Sustainability, 14(19), 12240.* https://doi.org/10.3390/su141912240

xxxviii. Bayih, A. Z., Morales, J., Assabie, Y., & de By, R. A. (2022). Utilization of internet of things and wireless sensor networks for sustainable smallholder agriculture. *Sensors, 22(9), 3273.* https://doi.org/10.3390/s22093273

xxxix. Myeko, Z. & Rambe, P., (2024). IoT appropriation for crop management and productivity enhancement in South Africa', *South African Journal of Information Management 26(1*).

xl. Ayalew, A. & Girma, Y. (2025).The effect of age on agricultural technology adoption by smallholder farmers in Ethiopia: A systematic review and meta-analysis. *Wiley Advances in Agriculture Volume 2025.*

xli. Yokamo (2020).Adoption of improved agricultural technologies in developing countries: literature review. *International Journal of Food Science and Agriculture, 4(2)183-190.*

xlii. Agwu, A. E., Ekwueme, J. N. & Anyanwu, A. C. (2008).Adoption of improved agricultural technologies disseminated via radio farmer programme by farmers in Enugu State, Nigeria. *African Journal of Biotechnology Vol. 7 (9) 1277-1286*