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Usage patterns and socio-economic factors affecting ICT usage among smallholder farmers in Northern Ghana

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Abstract

This study investigated the usage of ICTs among farmers and the socio-economic factors influencing their usage. It was to fill a gap in ICT usage among crop farmers in rural communities in Northern Ghana. A multistage sampling technique was employed to collect primary data from 210 crop farmers (105 males and 105 females) from seven (7) districts in the Northern Region of Ghana. Structured interview questionnaires were used to collect data on key ICT Knowledge and awareness issues, usage and perceptions, challenges and constraints, and benefits of usage. The data was analyzed using simple descriptive statistics (percentages, frequencies, means, and standard deviations) and inferential statistics (Probit regression). The results indicated that the popular ICT devices among the farmers were mobile phones (48.5%), radio (34.9%), and television (13.9%). Younger farmers (40 years and below) were more predisposed to using ICTs than their older counterparts. [With 75.21% (CI 0.28503 - 1.21918, *P*=0.002)]. Farming experience (71.50%; CI 0.23258 - 1.19742, *p*=0.004 and ICT training (136.76%; CI 0.78537 - 1.94986, *p*=0.004) also influenced the use of ICT tools. The main constraints of ICT usage among the farmers in the study included poor reception, language, and content limitations. Others were the high cost of recharge credit and ICTs - particularly televisions, computers, and a lack of awareness about specific ICTs like email and the internet. The government and policymakers need to provide customized and subsidized ICTs, particularly mobile phones, for farmers in the study area. Agricultural extension officers should also consider training farmers to use mobile phones, televisions, and radios to obtain current information relevant to farming and marketing of agricultural produce, both in Ghana and abroad, to help curb poverty and food insecurity.

Keywords: ICTs, smallholder farmers, crop farmers, ICT knowledge

Introduction

In Africa, agriculture provides a livelihood for 75 percent of the people who live in rural areas. Unfortunately, the rural areas in Africa have the largest concentration of poverty and food insecurity. One of the causes of poverty or low incomes in rural Africa is the low productivity of agriculture (Goyal & Nash, 2017) [23]. Lack of technological and market information has been the primary reason for the low productivity in African agriculture. Therefore, any attempt to reduce poverty should pay particular attention to transforming the agricultural sector, primarily through sustained improvement of technological information, land, and labour productivity in the sector, facilitated by remunerative markets.

The study explores the critical role of agriculture in Africa, particularly among rural communities where it supports the majority of livelihoods (Akudugu *et al*, 2021) [7]. Despite this centrality, "rural areas are burdened with high poverty and food insecurity, mainly due to low agricultural productivity". Over 80% of the extremely poor people in Africa are estimated to reside in rural areas, with more than three-quarters engaged in agriculture (Our World in Data, 2021) [66]. The low labour productivity in agriculture contributes significantly to persistent poverty and food insecurity in these regions. Several factors, including limited technological and market information access, contribute to this challenge. Consequently, transforming agriculture through improved access to knowledge and remunerative markets becomes pivotal (World Bank, 2025) [57]. Asenso-Okyere and Mekonnen (2012) [67] posit that the lack of technological and market information is one of the primary reasons for the low productivity in African agriculture. Adopting Information and Communication Technologies (ICTs) is increasingly seen as a catalyst for enhancing productivity, offering smallholder farmers timely and relevant agricultural knowledge, thereby strengthening the linkage between research and on-farm practice.

ICTs have demonstrated global potential in cheaply disseminating agricultural innovations and market information. They also support the diffusion of essential

information related to health, environmental changes, and resource management. Complemented by ICTs, agricultural extension services are vital for increasing productivity and improving livelihoods. However, the adoption and effective use of ICTs are contingent on several factors, including awareness, affordability, education, language, and the social context within which farmers operate. These factors influence the choice and effectiveness of ICT tools, and in many rural areas, challenges such as limited infrastructure and low literacy continue to hinder full utilization.

Research underscores that although ICTs have proliferated globally, their use among farmers in Sub-Saharan Africa, including Ghana, remains limited (Our World in Data, 2021) [66]. Despite significant investments in ICTs for development, there is insufficient data on their impact on agricultural productivity. This is particularly relevant in Northern Ghana, where illiteracy and poverty are widespread, reducing the likelihood of smallholder farmers embracing ICT tools. As such, the study identifies a significant knowledge gap regarding the socio-economic determinants of ICT usage in rural farming communities. Understanding these determinants is necessary to inform policy and design interventions that improve ICT adoption and agricultural output.

The research evaluates the socio-economic factors affecting ICT usage among smallholder farmers in Northern Ghana. Specifically, it seeks to identify the ICT devices farmers currently use, the information farmers access, and the constraints farmers face. The study is justified by the need to provide empirical data to guide policy, particularly as ICTs are becoming essential to socio-economic development. Limitations encountered in the study include language barriers, potential mistranslations, and sample size constraints, which may have introduced bias or affected the depth of responses. Despite these limitations, the study addresses a critical gap in knowledge and sets the foundation for more inclusive ICT policy in agricultural development in Ghana.

Literature Review

The literature review explores the concept of Information and Communication Technologies (ICTs), particularly their definitions, components, and impact. ICTs integrate information systems with communication tools, including traditional media and digital platforms (FAO AIMS, 2025; Wikipedia, 2025) [22, 69]. The World Economic Forum (2025) and Jung *et al* (2021) underscore the evolving and converging nature of ICTs, noting their ability to connect various devices for efficient information exchange. Technologies such as computers, mobile phones, digital cameras, and even e-books are considered ICTs due to their capacity for data sharing and communication across diverse media platforms (Wikipedia, 2025; Research Gate analysis, 2017) [69].

A breakdown of ICT devices/tools reveals the broad scope of technologies influencing rural agriculture and its development. The key ICT tools for this study included computers, the internet, radio, mobile phones, and television. Each tool has evolved technologically and has specific roles in information dissemination. Computers and the internet enable access to global networks and research dissemination but remain costly and infrastructure-dependent (Caspary & O'Connor, 2003) [68]. Due to its low cost and broad reach, radio remains crucial in areas with high illiteracy or restricted freedom of expression. Mobile phones have democratized communication, enabling farmers and rural communities to access critical market and weather information, while television is recognized for its powerful audio-visual communication and influence in areas such as education and agriculture (Adewuyi *et al*., 2022; Byamukama *et al*., 2023) [4, 14].

The literature further discusses the current global state of ICTs, emphasizing their role in knowledge diffusion and economic growth. ICTs are seen not only as development products but also as tools to achieve it. According to the World Bank and UNDP, ICTs are vital in integrating knowledge into national strategies, reducing poverty, and promoting inclusive growth. Though often disadvantaged, rural areas possess untapped potential that can be harnessed through ICTs for social and economic transformation (World Bank, 2012) [56]. The shift from seeing ICTs as luxury items to necessities for development marks a critical change in the international development discourse (IDRC, n.d) [26].

Finally, ICTs are shown to have a direct role in agricultural and rural development. Their application spans from policy planning to service delivery and individual empowerment. ICTs help improve decision-making, agricultural extension services, and access to real-time information, transforming traditional practices (World Bank, 2025; Frontiers, 2025; Leta *et al*., 2024) [57, 16]. They enable cost-effective, timely, and interactive communication, empowering rural populations. The growing integration of ICT in agriculture allows for better productivity and market access, which are vital for rural smallholder farmers and their livelihoods. As Smith *et al* (2025) [49] note, ICTs are reshaping how agricultural knowledge is accessed and applied, thus significantly contributing to the broader goals of rural development (Frontiersin, 2025; Review on Ethiopia ICT-extension, 2024) [49, 9]. The key challenge to ICT adoption remains illiteracy and the high cost of equipment or tools, particularly in rural communities where the deployment of ICTs is mainly needed.

According to the FAO, ICTs have emerged as transformative tools across the agricultural value chain-from input procurement to marketing. Their ability to facilitate timely, customized, and interactive information exchange makes them particularly beneficial in agriculture, where decision-making depends heavily on dynamic environmental and market conditions (FAO, 2020a; FAO e-Agriculture, 2020b) [19, 20]. ICTs are especially valuable in rural areas, providing affordable and efficient means of information dissemination and capacity building. However, the potential of ICTs remains underutilized due to conceptual ambiguities around their role in development and the dominance of top-down, techno-centric development models that often neglect the contextual realities of marginalized communities.

Rural development, intrinsically linked to agricultural activities, focuses on enhancing economic and social conditions in non-urban areas. Effective rural development demands participatory governance, investment in infrastructure, and equitable access to services. Despite recognition of information as central to development, the

needs and perspectives of rural populations are often overlooked in favor of institutional decision-making. ICTs, if properly integrated, can empower rural populations by enhancing access to relevant knowledge and allowing for greater engagement in governance and market systems. However, successful implementation requires technologies tailored to local needs, languages, and realities.

The application of ICT in agriculture-termed e-Agriculture-encompasses a wide array of technologies from mobile phones and radios to sophisticated systems like Global Positioning System (GPS) and Geographic Information Systems (GIS). Precision agriculture exemplifies the advanced use of ICTs for site-specific farming, enabling optimized input use and productivity. However, numerous barriers inhibit ICT adoption in developing countries: inadequate infrastructure, high costs, limited access, low literacy, language issues, gender disparities, and cultural attitudes. In countries like Ghana, ICT is increasingly being leveraged to meet higher market standards and improve rural livelihoods. However, for ICT to truly benefit rural agricultural communities, interventions must be locally grounded, inclusive, and supported by adequate training and infrastructure.

Impact of ICT in Agriculture

Over the past two decades, integrating Information and Communication Technologies (ICTs) into agriculture-called e-Agriculture-has transformed agricultural practices, particularly in rural communities where farming remains a primary occupation (Abubakari *et al*, 2023) [2]. As Wikipedia (accessed August 2024) [69] defines, E-Agriculture involves conceptualizing, designing, developing, evaluating, and applying ICTs to enhance agriculture and rural development. It serves as a global Community of Practice, facilitating the exchange of information, ideas, and resources (FAO, 2025) [57].

[25]. The Food and Agriculture Organization (FAO, 2023) [21] under WSIS Action Line C7 highlights e-Agriculture as a platform that supports the marketing of agricultural produce. Recognized under the World Summit on the Information Society (WSIS) as a key action area, e-Agriculture is championed by UN agencies, particularly the FAO, to support sustainable practices by disseminating agricultural knowledge and promoting public-private partnerships.

According to the FAO (2023) [21], e-Agriculture operates at the intersection of agricultural informatics, development, and entrepreneurship, using the Internet and related technologies to deliver services and disseminate innovations. It goes beyond technical deployment to integrate multimedia, culture, and knowledge-sharing among stakeholders at local, regional, and global levels. Applications include access to real-time market prices, extension services, and advanced tools such as GPS, satellites, and computer systems to boost productivity and efficiency. Precision agriculture and e-commerce are advancing agricultural profitability and environmental sustainability in developed countries. Conversely, in developing regions, grassroots ICT initiatives and distance learning are critical in enhancing farmers' access to information and improving the knowledge base of service providers.

Barriers to ICT Adoption

The adoption of Information and Communication Technologies (ICTs) by farmers in developing countries is hindered by several critical barriers, particularly in rural areas. Poor technical infrastructure is a foundational challenge, as the high cost of establishing and maintaining ICT facilities remains unaffordable for many rural communities (Mng'ong'ose *et al*, 2018) [55]. This directly limits access to ICT services, leaving many farmers reliant on traditional media such as radio and television (Gwani, 2024) [35]. Furthermore, the high cost of ICT devices, including computers and related equipment, places them beyond the financial reach of most rural dwellers (World Bank, June 2025) [57]. Even where NGOs or donor-supported government projects introduce such technologies, their sustainability remains uncertain once funding ends (Makombe, 2022) [33].

In addition to infrastructural and economic constraints, social and cultural barriers significantly restrict ICT uptake. Many rural areas suffer from low ICT awareness and limited digital literacy, aggravated by high illiteracy rates and a general lack of e-readiness, especially in Sub-Saharan Africa (Chisango & Lesame, 2017; Mwansa *et al*, 2025) [15, 43]. The absence of locally relevant content, including language accessibility, limits ICT effectiveness (Makombe, 2022) [33]. Gender disparities are another major constraint, with women facing discrimination in access to education and ICT resources, often due to policy oversight and cultural norms (UNESCO, 2025) [53]. Attitudinal barriers also emerge, where ICTs are sometimes perceived as complex or elitist, despite evidence of positive community receptiveness to ICT initiatives (Smith & Moyo, 2024) [48]. Overcoming these barriers requires inclusive, locally tailored strategies that address infrastructural, educational, economic, gender, and cultural challenges holistically.

Evidence of Impact of ICT for Agriculture Innovations in Africa

In Kenya, the proliferation of mobile phones has transformed agriculture through platforms like iCow, M-Farm, Arifu, and Digital Green. These innovations enable farmers to access real-time weather forecasts, market prices, veterinary services, and financial products via SMS or apps. Support for these platforms is strengthened by partnerships with NGOs, government agencies, and mobile operators like Safaricom through M-Pesa (Mwita, 2019; Engineering for Change, 2025) [71]. Similarly, Ghana's Esoko and Farmerline platforms provide localized voice and SMS alerts on market prices, weather updates, and agricultural extension services. These services are backed by government initiatives and international donors such as USAID and GIZ (Yawson *et al*., 2024) [60].

In Nigeria, ICT solutions like Hello Tractor, AgroMall, and Crop2Cash have improved access to tractor-sharing services, financial inclusion, and agricultural inputs, supported by the Federal Ministry of Agriculture and private investors (additional country-specific citation needed). Across East Africa, Rwanda's Smart Nkunganire System and e-Soko have enabled digital voucher systems for seed and fertilizer distribution and access to market information, facilitated by robust government ICT policies (Sartas *et al*, 2024) [73]. Uganda benefits from platforms such as Agrinet,

AgUnity, and Wefarm, which provide farmers with pricing data, training content, and networking opportunities, primarily through NGO-led efforts like CTA and GSMA (Ajambo *et al*, 2022) [5]. In Ethiopia, the ATA's 8028 Hotline offers nationwide agronomic advice in local languages via voice calls, reaching over five million farmers with the backing of the Ethiopian Agricultural Transformation Agency and the Bill & Melinda Gates Foundation (Anteneh& Melak, 2024) [9]. Tanzania's initiatives, including Tigo Kilimo and M-Kilimo, connect farmers to agricultural tips, weather forecasts, and input information through public-private partnerships involving telecom companies (Ndimbo *et al*, 2024) [44]. These examples illustrate how ICT innovations enhance productivity, knowledge sharing, and market access for farmers across Africa.

ICT usage in Agriculture in Ghana

The increasing application of Information and Communication Technologies (ICTs) in Ghana's agricultural sector significantly enhances production efficiency, sustainability, and farmer livelihoods. According to the World Bank (2023), the growing demand for high-quality agricultural products necessitates compliance with stringent standards, which ICT tools can help address by providing timely, relevant, and accurate information. These tools support farmers in making informed decisions on pest and disease control, new crop varieties, production optimization, and quality regulation. The Millennium Development Goals (MDGs) Task Force Report (2015) further emphasizes the importance of public-private cooperation in extending the benefits of new technologies to rural populations.

Several ICT initiatives in Ghana have shown measurable impact. According to GSMA (2018), a project was facilitated by Farmerline and Trade in Space (UK), which linked soybean farmers to processing mills via satellite and mobile technologies, ensuring fair income and stable supply chains. The Sat4Business (G4AW) consortium used satellite data to provide agronomic advice, market information, and access to finance for over 140,000 Ghanaian smallholders working in cocoa and palm oil. This platform offered real-time crop monitoring and insights into soil and moisture, and it was integrated with mobile payments for transparent transactions. The VOTO initiative of 2014 leveraged mobile phones to deliver voice-based agricultural information in local languages, promoting behavioral change regardless of literacy levels (Munthali *et al*, 2018; Making All Voices Count, 2016) [10, 32]. Meanwhile, platforms like Esoko (Van Schalkwyk *et al*, 2017) [54] provide market data and facilitate buy/sell transactions across 30 markets in 19 African countries, empowering roughly one million farmers-half of them in Ghana-to make more informed decisions and negotiate better prices for their produce. Similarly, Cocoalink, launched by the Ghana Cocoa Board in 2012, offered free voice and SMS messages to cocoa farmers, disseminating critical information on best practices and marketing strategies. These initiatives collectively illustrate how ICT transforms Ghana's agriculture by bridging information gaps and empowering farmers.

Determinants of ICT use

Several key determinants influence the usage of ICTs in agriculture, particularly among smallholder farmers. One major factor is membership in farmer organizations or cooperatives, which facilitates peer learning and technology diffusion. Manda *et al*. (2020) [34] affirm that collective action within such groups enhances ICT adoption, as shared access to devices leads to broader usage among members. In Kenya, a study among smallholder cassava farmers found that only 37% reported receiving ICT tool training, and that training explained about 60% of ICT adoption among extension agents, with a statistically significant correlation ($r = +0.776$, $p<0.01$) between training access and ICT use in extension services (Dimo *et al*., 2022) [17]. According to Mustapha *et al*. (2022) [41] and Katungi *et al*. (2019) [28], the frequent and competent use of ICTs by extension workers significantly influences farmer adoption, with farmers often relying on their expertise and recommendations. For example, in Zimbabwe, a study finds that when public extension officers (AGRITEX) are well-supported, resource-equipped, and trained, their effective ICT use significantly raises the rate at which small-scale farmers adopt recommended agricultural practices (Masere & Worth, 2021) [36].

Location also plays a crucial role in determining ICT access and usage. The study by (Mwansa *et al*, 2025) [43] emphasize significant obstacles concerning infrastructure, cost, and digital literacy, which together impede access to and use of ICTs" in rural South Africa, underscoring how poor access to ICT infrastructure, service providers, and training disadvantages rural enterprises, vendors, and training institutions. Additionally, exposure to dynamic market environments increases the likelihood of adoption due to cultural exchanges and greater access to information (Meijer *et al*., 2015) [38]. However, low educational levels, inadequate training, and weak perceptions of technology can inhibit ICT uptake. Amoussouhoui *et al* (2024) [38] and Tesfaye and Tessema (2023) [23] underscore the positive correlation between education and technology adoption, while note that education enhances adaptability and decision-making in fluctuating market conditions.

Economic and infrastructural constraints further limit ICT adoption in agriculture. Nkhoma & Chirwa (2022) [46] identify high technology costs as a key deterrent, and Akpabio *et al* (2016) [6] link economic inequality to reduced ICT access. In developing regions, additional barriers include limited extension service capacity, poor infrastructure, and low levels of ICT proficiency (Adetunji *et al*, 2021) [3]. Factors such as trust in ICT systems, household characteristics (e.g., size, income, assets), and proximity to financial services also influence usage. As a result, this study investigated socio-economic variables such as age, sex, education, marital status, household size, farming experience, ICT training, and crop types cultivated-particularly those prevalent in northern Ghana-to understand their role in shaping ICT adoption patterns and compare findings with previous research.

Methodology

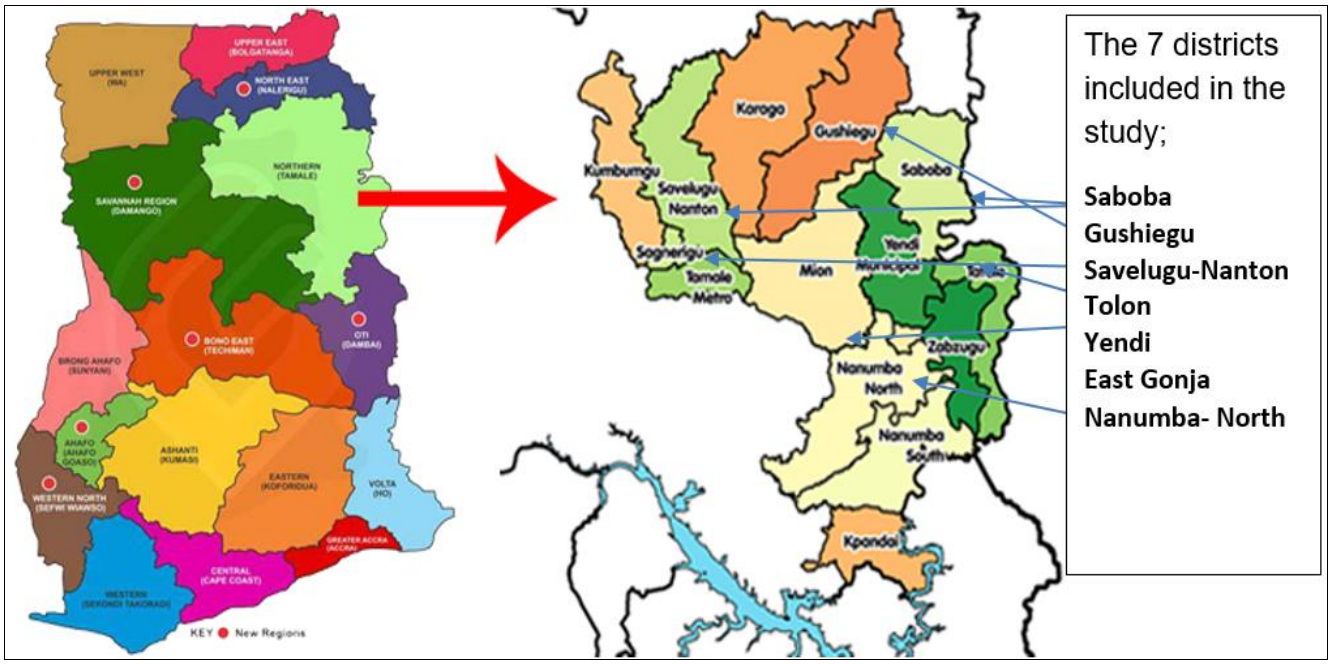

Fig 1: Map of the study area - Northern Region of Ghana

The study focused on the Northern Region of Ghana, one of the country's most significant regions by land area, comprising 16 districts. Seven districts-Savelugu, Tolon, Gushiegu, Yendi, Saboba, Nanumba North, and East Gonja-were selected for this research. The region is located between latitude 9.35338° N and longitude -0.9670655° E and is bordered by multiple Ghanaian regions and neighboring countries. It features a relatively young population, with most residents aged between 15 and 40, and a population growth rate of 3% annually. The region experiences a single rainy season and prolonged dry periods with harsh winds, contributing to environmental challenges such as desertification and soil degradation. Its vegetation is largely savannah with drought-resistant species, while soils are generally unproductive and face issues like erosion and limited organic matter.

Agriculture is the primary occupation for over 90% of the population aged 15 and above, indicating a shift away from industrial and manufacturing sectors. Typical crops include yam, maize, millet, and rice, with irrigation schemes supporting off-season farming. ICT connectivity is growing due to telecom expansion and increased mobile subscriptions, although disparities remain compared to global standards. The study employed a cross-sectional research design using binary regression analysis to assess how socio-economic factors influence ICT adoption among farmers.

The study sample consisted of 210 smallholder crop farmers from the seven selected districts, with an equal representation of men and women to ensure gender balance. Slovin's formula

$n = N / (1 + Ne^2)$, where: **n** is the required sample size, N is the total population size, and e is the desired level of precision or margin of error (expressed as a decimal).

Was applied to determine the appropriate sample size from a total farming population of 630 smallholder farmers. A multistage sampling approach was employed, combining purposive, quota, and stratified random sampling techniques to select districts, communities, and individuals.

Firstly, the seven districts were selected randomly because the smallholder rural crop farmers were in all the districts of the Northern region. Secondly, seven communities were selected across the seven districts using a purposive sampling technique because they were from rural communities. The list of members of a household survey was used to reach the members selected to participate in the study based on their availability. Again, a quota-sampling technique was used to select 30 respondents from each community in each district. Moreover, farmers in selected communities were further stratified into male and female farmers to ensure a fair representation of both sexes. The individual farmers were also selected through random sampling.

Data was gathered from primary (quantitative and qualitative fieldwork) and secondary (literature review) sources to ensure comprehensive and reliable findings. This methodological framework enabled the researchers to effectively investigate ICT usage patterns and their socio-economic determinants in a rural agrarian context.

The primary data were collected using structured questionnaires designed and administered to the farmers in the sampled areas. Close-ended questions were used to capture numerical and quantitative data, linking theory to research (quantitative method) and enabling the researcher to describe the magnitude of the findings statistically. Open-ended questions and other qualitative attributes (qualitative method), also called interpretive research methods (Bogdan & Biklen, 2009) [74], were utilized. Respondents' perceptions/opinions on the benefits of ICT were measured using a 5-point Likert scale of 1 to 5 scores to facilitate the analysis. The scale was from; 1 = Strongly agree, 2 = Agree, 3 = Neutral, 4 = Disagree, 5 = Strongly disagree. This was used to determine crop farmers' awareness and access to ICTs. It was also used to determine the ICT devices owned and used by the farmers, the types of information obtained and disseminated, and the constraints to ICT use.

Statistical Package for Social Science (SPSS) version 20 and Stata 13 were used for statistical analysis due to their accessibility and efficiency in exploring variable relationships.
Stata (version 13) was used to run the Probit regression, which was used to identify determinants of farmers' use of ICT. Farmers who used ICT were coded as 1, whereas those who did not use ICT were coded as 0. The equation or model for the probit regression is indicated below.

$$Yi=\beta_0+\beta_1X_1+\beta_2\ X_2+\beta_3\ X_3+\beta_4\ X_4+\beta_5\ X_5+\beta_6\ X_6+\beta_7\ X_7+\beta_8\ X_8+\ldots\ldots\ldots+\beta_{15}\ X_{15}+Ui$$

(Where Y1 was the dependent variable, use of ICT (1 if farmers used ICT and zero otherwise; β0 = Intercept, β1-β15 = parameters to be estimated, X_1-X_{15} = Vector of explanatory independent variables.

Ui = error term.

Stata was also used to test the strength of association between independent and dependent variables and differences between sub-groups.
There were two main variables - the dependent and the independent variables. The dependent variable was the usage of ICTs. For this study, the technology (innovation) was about the following ICTs: Mobile phone, Radio, Television, Computer, the Internet, and Email. Use of any of the ICTs was coded as 1 or 0 otherwise. All the farmers had used at least one of the ICT tools. The independent variables included age, gender, educational status, head of household, marital status, household size, and farming experience. Others included ownership of land, annual income, training in ICT received, maize cultivation, rice cultivation, millet cultivation, groundnut cultivation, and yam production.

Table 1: Measurement of Independent Variables and Their a priori Expectations

Study variable	Explanation	Expected sign
Age (X_1)	Measured in years.0 = <40, 1= >40	+
Gender (X_2)	Sex of respondent - Male = 0, Female = 1	+
Education level (X_3)	Measured in years of access to formal education. 0 = No formal Education, 1 = formal education.	+
Head of household (X_4)	Whether the respondent is/or is not head of household: No 0, Yes, one head of household	-
Size of household (X_5)	Dependents were dichotomized into 0= <5, 1= > 5	+
Farming experience (X_6)	No. of Years farmed. 0 =<5 years, 1= > 5 years	+
Ownership of Land (X_7)	Ownership of land 1= Yes, 0= No	+
Average income (X_8)	Measured in Ghana cedis. 0=<500Ghs, 1= >500	-
Received ICT training (X_9)	Whether the respondent has received ICT training, No = 0, Yes = 1	+
Marital status (X_{10})	Marital status, Single = 0, Married = 1	+/-
Maize cultivation (X_{11})	Crop grown by farmers - No maize =0, Maize =1	+/-
Rice Cultivation (X_{12})	Crop grown by farmers - No rice =0, Rice =1	+/-
Groundnut cultivation (X_{13})	Crop grown by farmers - No groundnut =0, Groundnut =1	+/-
Millet cultivation (X_{14})	Crop grown by farmers - No millet =0, Millet =1	+/-
Yam cultivation (X_{15})	Crop grown by farmers - No yam =0, Yam =1	+/-

Results and discussions

Table 2: Age, Sex, and marital status of farmers

Variable	Frequency	Percentage
Age (years)		
Below 31	74	35.2
31-40	78	37.1
41-50	23	11
Above 50	35	16.7
Total	210	100
Sex		
Male	105	50
Female	105	50
Total	210	100
Marital status		
Married	165	78.6
Single	36	17.1
Widowed	9	4.3
Total	210	100

Source: Survey Data, 2015

To appreciate the associations within some variables, some cross-tabulations were run in SPSS. Below are a few of them using ICTs and some demographics. From Table 3, the study revealed that the respondents in the age bracket 40 years and below used more ICTs (71%) than those above 41 years (29%). The respondents below 40 years were in the majority in the use of mobile phones (36.7%), Radio (18.6%), and Television (5.2%). This is supported, who wrote that younger farmers may be more flexible and more likely to use and adopt new technologies. Azumah *et al*. (2022) [13] also found that the average age of farmers who adopted agricultural innovations in the Northern Region of Ghana was 40 years. The implication is that the younger the farmer, the greater the probability of using ICTs, since older people are less inclined to use ICTs, due to their technical nature. Older people are found to have higher level of technophobia (Nimrod, 2018) [45] and experience higher degree of technology anxiety than the younger people (Dos Santos & Santana, 2018) [18]. Older people were stereotyped

as less receptive or reluctant to accept new technologies (e.g., Knowles and Hanson, 2018; Lin *et al*., 2020) [29, 30]. A deliberate attempt is needed to get them interested in using ICTs, particularly for farming purposes.

Table 3: A cross-tabulation of farmers' age and ICT usage

ICT use	Age of respondents				Total%
	Below 30	31-40	41-50	51+	
Mobile Phones	18.6	18.1	4.8	5.2	46.7
Computers	3.8	1.9	1.0	0	6.7
Radio	8.6	10	5.7	8.1%	32.4
Television	1.4	3.8	1.4	1.9	8.5
Internet	1.9%	1.4%	0.5%	0%	3.8
Email	0.0%	1.4	0.5	0%	1.9
	34.3	36.7	13.8	15.2	100

Source: Survey Data 2015

From table 4 below, males (24.3%) used mobile phones more than women (22.4%). Males mostly used Television (4.7%) and the Internet (2.9%). The women were found to use the radio (18.5%) more than the men did. This result, however, indicates that more males are using more ICT tools than females.

Table 4: A cross-tabulation of gender and ICT use

ICT use	Gender		Total
	Male	Female	
Mobile Phones	24.3%	22.4%	46.7%
Computers	2.9%	3.8%	6.7%
Radio	13.8%	18.5%	32.3%
Television	4.7%	3.9%	8.6%
Internet	2.9%	0.9	3.8%
Email	1.4%	0.5%	1.9%
	50%	50%	100%

Source: Field data, 2015

Educational status of farmers

The results in Table 5 are a cross-tabulation between educational status and ICT usage. It shows that those with less than 8 years of formal education mostly used ICT tools, mobile phones, radio, and television. (68.2%). Ideally, it is the expectation that only those with higher levels of education will be more inclined to use ICT tools, but this is not the case in this study. Of course, the% of respondents with no formal education was very high, 62%. Only 38% had gone through some form of formal education. This implies that the socio-cultural context is receptive to innovation, so ease of use of technology, apart from formal education, may have accounted for the results of this study.

Table 5: A cross-tabulation of farmers' educational status and ICT usage

ICT use	No formal%	Primary%	Mid/JHS%	Secondary%	Tertiary%	Total%
Mobile Phones	30.1	3.2	8.6	3.7	1	47
Computers	0	0	1.4	2.4	0.5	4.3
Radio	24.9	0.9	3.8	3.7	1.4	33.7
Television	7	2.4	1.4	0.5	0%	12.7
Internet	0	0	0.9	1.4	1.7	2.3
Email	0	0	0	0.0	0.0%	0
Total	62%	6.5%	15.1%	11.7%	4.7%	100

Source: Field data 2015

ICT tools that are currently in use among farmers

From the results in Table 4.8 below, the mobile phone remains the most popular and most used ICT tool in the northern region, with 48.5%. This is followed by radio (34.9%) and television (13.9%). This finding contradicts research by Adegbidi *et al*. (2012) [61] and Gebremichael & Alemu (2024) [62], where the radio was the most popular. The interest in radio persists since about 35.0% of the respondents possessed it in the communities covered. About 14.0% had televisions, with a paltry 2.0% having computers. Similarly, Abdulai *et al* (2023) [63] indicated that the Mobile Phone (GSM) was the most used ICT tool apart from Radio. Computer, email, and internet use were very low. In another study by Hassan *et al*. (2008) [64] and Abdulai *et al* (2023) [63], television, mobile phone, telephone, and radio were popular tools. This study agrees with Henri-Okoha, Chikezie, and Osuji (2012) [65], who reported that farmers in Ukwa West in Abia state used mobile phones, radio, and television. The study also supported Ayim *et al*.'s (2018) [75] findings that the mobile phone is another ICT tool that farmers embrace for receiving and sending information. This finding implies that, since the three ICT tools, mobile phone, radio, and television, are popular among smallholder farmers in terms of usage, they could be factored into policy formulation to enhance services to crop farmers in the northern region.

These results again tally with the findings of Owen (2008) in his USAID ICT4D program report, where he asserted that over 50.0% of the world population has access to or uses a mobile phone, and only 5.0% of the world's population has access to or uses broadband Internet. In recent times, this has changed. GSMA (2023) [24] reported that "about 95% could access mobile broadband, while 5% cannot."

Table 6: Popular ICT tools

ICT tool use	Frequency	Percentage (%)
Mobile phone		48.5
Computer		1.9
Radio		34.9
Television		13.9
Email		0.8
Total		100

Source: Survey Data, 2015

Socio-economic factors affecting the usage of ICT devices among the farmers

The Probit regression model was used to determine the factors influencing the use of ICT devices, as shown in Table 7. The dependent variable was the farmers' use of ICT tools.

The results showed that the probit model had an LR of 65.54. This value was statistically significant at the 5 percent alpha level, as shown by the p-value of 0.000. It meant that all the variables in the probit model were jointly statistically significant. The Pseudo R2 also indicated that the independent variables explained just 23.52% of the variation in default probability.

The study found that age significantly increased farmers' usage of ICT tools by 75.21% (CI 0.28503 - 1.21918 with *P*=0.002). The implication was that the younger the farmer, the greater the probability of using ICT. This is supported by Nimrod (2018) [45]. Since older people were not using ICTs, a deliberate attempt was needed to get them interested and involved in using ICTs, particularly for farming purposes.

Interestingly, farmers who were household heads significantly (*P*=0.006) reduced their usage of ICT tools by 86.62% (CI -1.4796 -0.2527). This implies that a household head with limited resources may want to spend money on essential items like food, school fees, hospital bills, etc., instead of using it for ICT tools. This contradicts the work of Mutungi *et al*. (2023) [42], who suggested that male household heads were more predisposed to using technologies than their female counterparts. The findings were similar to those of Mukoko (2013) [76], where the level of income of the household head affected ICT use. In their study, lower incomes affected the ability of household heads to acquire ICTs. It also came out that farmers with more years in farming (experience) were more likely to use the ICTs. This is supported by Maina *et al*. (2023) [77], who posit that farming experience affects ICT usage, with more experienced farmers being more likely to adopt and use ICT tools in agriculture. In this study, farming experience among the farmers was identified to significantly increase usage of ICT tools by 71.50% (CI 0.23258 - 1.19742) with the p-value of 0.004. Mukoko (2013) [76] made a similar observation. Again, crop farmers who had received ICT training were found to significantly increase their usage of ICT tools (*P*=0.000) by 136.76% (CI 0.78537 - 1.94986). Abate *et al* (2024) and Tefera et al. (2024) support this finding. They wrote that the adoption of ICTs was likely to be favoured by training received in ICT usage.

Furthermore, the marital status of farmers influenced their usage of ICT tools insignificantly (*P*=0.434) by 21.19% (CI -0.3193 - 0.74305). This meant that other factors accounted for their use of ICTs. This was because married people needed to stay in touch and communicate more with their partners. Awoyemi (2015) [78] indicated that being married increases the probability of a farmer using ICT by 3.9%. However, Strang *et al* (2022) [79] believed that marital status was insignificant in their study on e-adoption in Central Nigeria. According to Tambo *et al*. 2019 [51], marital status influences the adoption and use of ICTs. Mdoda and Mdiya (2022) [37] also indicated that marital status significantly influenced the use of ICTs and new technologies.

Table 7: Probit Regression of factors influencing farmers' use of ICT tools

Variable	Regression coefficient	Standard error	Z	P>IzI	95% CI	
					Lower	Upper
Age (X_1)	0.7521*	0.23831	3.16	0.002	0.28503	1.21918
Gender (X_2)	0.3513	0.28745	1.22	0.222	-0.2121	0.91469
Education level (X_3)	-0.3890	0.26619	-1.46	0.144	-0.9107	0.13276
Head of household (X_4)	-0.8662*	0.31299	-2.77	0.006	-1.4796	-0.2527
Size of family (X_5)	-0.0145	0.22066	-0.07	0.947	-0.447	0.41796
Farming experience (X_6)	0.7150*	0.24614	2.90	0.004	0.23258	1.19742
Ownership of Land (X_7)	0.0680	0.27382	0.25	0.804	-0.4687	0.60463
Average income (X_8)	-0.7758	0.40431	-1.92	0.055	-1.5683	0.0166
Received ICT training (X_9)	1.3676*	0.29707	4.60	0.000	0.78537	1.94986
Marital status (X_{10})	0.2119	0.27101	0.78	0.434	-0.3193	0.74305
Maize production (X_{11})	-0.2140	0.26392	-0.81	0.417	-0.7313	0.30328
Rice production (X_{12})	0.1221	0.22903	0.53	0.594	-0.3268	0.57104
Groundnut production (X_{13})	0.3225	0.25007	1.29	0.197	-0.1676	0.81264
Millet production (X_{14})	0.3582	0.32623	1.10	0.272	-0.2812	0.99765
Yam production (X_{15})	0.6395*	0.28336	2.26	0.024	0.08415	1.19491
Constant	-2.0251	0.50709	-3.99	0.00	-3.019	-1.0313
LR = 65.54 (*P=0.000)*		Pseudo R^2=0.2352				

*, ** and *** means significant at 10%, 5% and 1% respectively

Conclusion

The study's findings yielded the following conclusions: The most popular ICT tools used among crop farmers were mobile phones, radio, and television. Again, farmers were aware of and used ICT tools for various services, including access to information on prices, information from their relatives, markets, seeds, and mobile money transfers.

Mobile phones have become increasingly the ICT tool of choice among farmers. The study revealed that age, head of household, farming experience, ICT training received, and the cultivation of yams were the main socio-economic predictors of ICT use among crop farmers in the Northern Region of Ghana.

This study's results indicated an immense opportunity to enhance the sharing of agricultural information that farmers received from extension workers, government officers, fellow farmers, and relatives. Based on the conclusions of this study, the following recommendations are noteworthy. It is recommended that the Ministry of Food and Agriculture (MoFA) should take advantage of the immense opportunity of the popularity of mobile phones to enhance the sharing of important agricultural services and information in rural areas. Also, the government should collaborate with private sector ICT service providers like VOTO and ESOKO to provide mobile phone services to the farmers. Farmers should be trained in their local languages to use Voice SMS to quickly access market information and emergency services. Finally, it is recommended that policymakers target the youth who are crop farmers with programs and ICT applications that will help them to improve their livelihoods and the lives in their communities.

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