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# Digital technologies competencies and training needs of agricultural extension agents

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## ABSTRACT

Application of digital technologies are imperative to enhance agricultural productivity and food systems sustainability. At the heart of improved agricultural production is agricultural extension. Agricultural extension support farmers with accurate and timely information about technologies such as digital technologies that have the potential to increase production and the livelihoods of farmers. There is inadequate empirical data on digital technologies competencies and training of needs of extension agents who expected lead the digital transformation in the agricultural sector. A questionnaire was used to survey of 125 agricultural extension agents from four regions in Ghana. Data were processed with International Business Machine Statistical Package for Social Sciences (IBM SPSS) version 27 and Microsoft Excel version 16. Frequencies, percentages, means, standard deviation and Borich's Needs Assessment Model were utilised for data analysis. The results largely show that, extension agents possessed moderate competencies (overall mean = 2.59±1.00) in digital technologies for agricultural extension delivery. While extension agents exhibited moderate knowledge (overall mean =2.57±0.93) and attitudes (overall mean 2.81±1.09) towards digital technologies, their skills were low (overall mean = 2.39±0.98). The study further revealed that application of drone technology (0.0146), robotics (0.0142), big data analytics (0.0133), and machine learning (0.0119) are key training needs of extension agents. The results points to the fact that there must be a consented effort by the Ministry of Food and Agriculture to initiate training and development programmes aimed at building the capacity of agricultural extension agents to adopt digital technologies for extension delivery in the study area.

**Keywords**: Agricultural extension agents, Borich Need Assessment Model, Competencies, Digital technologies, Extension delivery, Training needs.

## RÉSUMÉ

L'application de technologies numériques est essentielle pour améliorer la productivité agricole et la durabilité des systèmes alimentaires. En effet, l'extension agricole joue un rôle clé en fournissant aux agriculteurs des informations précises et rapides au sujet de ces technologies numériques, susceptibles d'accroître la production et de renforcer les moyens de subsistance. Cependant, les données empiriques restent limitées quant aux compétences des agents de vulgarisation en matière de technologies numériques, et quant à leurs besoins de formation à ce sujet, alors même qu'ils sont censés piloter cette transformation digitale dans le secteur agricole. Dans cette étude, un questionnaire a été administré à 125 agents

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de vulgarisation agricole issus de quatre régions du Ghana. Les données recueillies ont été analysées grâce à IBM SPSS version 27 et Microsoft Excel version 16, et des indicateurs tels que fréquences, pourcentages, moyennes, écarts types ainsi que le modèle d'évaluation des besoins de Borich ont été utilisés. Les résultats indiquent que, globalement, les agents de vulgarisation possèdent des compétences modérées (moyenne globale = 2,59 ± 1,00) en technologies numériques pour l'extension agricole. Malgré une connaissance moyenne (moyenne = 2,57 ± 0,93) et une attitude modérée (moyenne = 2,81 ± 1,09), leurs compétences techniques demeurent faibles (moyenne = 2,39 ± 0,98). L'analyse met en avant des besoins de formation critiques en matière de technologies liées à l'usage des drones (0,0146), de la robotique (0,0142), de l'analyse de mégadonnées (0,0133) et de l'apprentissage automatique (0,0119). Face à ces constats, il apparaît impératif que le Ministère de l'Alimentation et de l'Agriculture initie des programmes ciblés de formation et de développement pour renforcer la capacité des agents de vulgarisation à intégrer efficacement les technologies numériques dans leurs prestations.

**Mots-clés :** agents de vulgarisation agricole, modèle d'évaluation des besoins de Borich, compétences, technologies numériques, prestation de services en vulgarisation, besoins de formation

## INTRODUCTION

The agricultural sector plays a significant social and economic role in developing countries by supporting the realization of national goals like social cohesion, employment creation and food security (Dhehibi *et al*., 2020). For instance, in Ghana, the sector provides food for an ever-increasing population, supplies of sufficient raw materials (inputs) to industries, provides market opportunities for goods and services, and a net foreign exchange earner (Ministry of Food and Agriculture [MoFA], 2015). It is estimated that 32% of the population works mostly in the informal agricultural sector, contributing for more than ten years an average of one-fifth (20%) of the nation's gross domestic product (GDP (Ghana Statistical Service [GSS], 2023). In spite of the enormous benefits the agricultural sector provides to the nation, the sector is faced with many production challenges like prolonged droughts, rapid urbanisation, the effect of climate change (Trendov *et al.* 2019), pest and disease outbreaks, geographical farming dispersion, seasonality, inadequate knowledge, and high transaction cost (Martey *et al*., 2020). Other factors such as transportation costs, local production costs, supply chain interruptions, and seasonal swings that influence access to food and create variance in prices over time also persist (GSS, 2020). These inconsistencies have a significant influence on farmers' capacity to obtain reasonable prices farm produce (GSS, 2024).

Previous research has shown that farmers can easily and economically deal with the production challenges when information communication technologies (ICTs) are used (Annor-Frempong *et al*., 2006; Ahsan *et al*. 2023). Application of ICTs in agriculture such as digital technologies is at the centre of agricultural transformation in developing countries and driving productivity and efficiency (Trendov *et al*., 2019). Using digital technologies in agriculture assist farmers to make informed decisions, encourage the efficient and cost-effective use of production resources, reduce risk, lessen the impact of climate change, and strengthen the resilience of agri-food and farming systems (Norton and Alwang, 2020). Additionally, digital literacy and competencies of agricultural extension agents (AEAs) directly and indirectly impacts farmer's productivity and income activities (Bhat *et al*., 2024). Enhanced digital skills received from AEAs enable farmers to access vital agricultural information, improve decision-making, and foster entrepreneurial activities, ultimately leading to increased productivity and income (Abdulai, 2024).

Agricultural sector initiatives aimed at bringing socio-economic development to many emerging economies, including Ghana, has been led by agricultural extension (Annor-Frempong *et al*., 2006; Bhat *et al*., 2024). Cognisant to the fact that majority of smallholder farmers work outside farmer based organisations, they miss out on opportunities provided by groups, such as knowledge and training, financing and input access, and effective extension-farmer engagements (Akomaning *et al*., 2017). Agricultural advisory and extension services provide farmers with timely and accurate information about modern technologies including digital technologies that have the potential to improve the quality of life in rural areas (Kremer and Houngbo, 2020). According to the Food and Agricultural Organization (2019), "agricultural extension is an informal educational approach directed towards the rural population, which provides advice and information to assist them in resolving their problems (p.1)." Extension education serves two other educational purposes in addition to its primary function of providing farmers with relevant and practical information about agriculture, which are to help farmers accept and embrace change (Asiedu-Darko, 2013; Bhat *et al*., 2024). The role of extension in embracing and accepting change is anchored on understanding and implementing strategies that strike a balance between proactive management and accepting change (FAO, 2019). This two-pronged strategy is essential. While change focuses on making calculated changes to enhance results, acceptance entails accepting and recognizing the current situation (Bhat *et al*., 2024). Their implementation in various situations in extension programmes, highlights the distinctions between these functions (Abdulai, 2024).

The adoption of digital technologies in agriculture by smallholder farmers is greatly aided by agricultural extension agents (Ocran *et al*., 2024). Previous studies underscore the significance of furnishing farmers with decisive agricultural data via digitalized extension services (Ragetlie *et al*. 2022). Certain services, such as short message services (SMS) campaigns, have demonstrated potential in raising farmers' knowledge and uptake of agricultural technologies (Karanja *et al*. 2020). On the contrary, effectiveness and efficiency delivery has lagged behind due to low digital literacy and competencies of AEAs (Singh *et al*., 2023). The efforts to build competencies of Extension Agents in digital technologies have shown mixed results, indicating both progress (Prangya *et al*. 2024; Sugihono *et al*. 2024) and significant challenges (Ocran *et al*., 2024). Extension agents must, however, possess the competencies to use digital technologies in order to develop digital interventions to close the gap between agricultural information delivery and technology access, to assist farmers integrate digital agriculture in their activities (Ragetlie *et al*. 2022). Furthermore, extension agents can be guided by the principles of responsible innovation (RI) to ensure that digital technology development is inclusive, reflexive, and responsive to famers' demands while negotiating the socio-ethical difficulties associated with the adoption of digital technologies in agriculture (Jakku *et al*., 2022). Nyarko and Kozári (2021) examined the use of ICTs among extension agents in Ghana and revealed that extension agents general adopt ICTs for personal communication but not frequently for extension delivery. By strengthening their competencies in digital technologies, agricultural extension agents can effectively assist smallholder farmers earn the rewards of digital transformation in agriculture (Ragetlie *et al*. 2022). Competencies are described as the set of skills, attitudes and knowledge that are manifested in observable quantifiable, and assessable job behaviour (Bahua, 2018).

The essentials for digital transformation in agriculture require extension agents possessing good communication skills, agricultural knowledge, digital literacy and flexibility to acquire new skills (Ortiz-Crespo *et al*., 2021). Training extension agents in digital technologies and data management is necessary for digital agriculture because extension agents must possess knowledge and skills in digital farming (Sekabira *et al*., 2023). Nonetheless, limited empirical data exist on the competencies of agricultural extension agents on the application of digital technologies in agricultural extension in Ghana. Also unknown are the training needs of extension agents on specific digital technologies where capacities are required for effective extension delivery. Ahsan *et al*. (2023) argues that there are knowledge gaps in the developing countries due to low competencies of extension agents, hence, digital technologies are rarely used in agriculture at the grassroots level. In recent years, nations in Sub-Saharan African, such as Ghana, are developing digital infrastructure to eventually allow extension workers assume responsibilities of human resource trainers, problem solvers, and farmer educators in digital agriculture (Atengdem *et al*., 2022). Therefore, extension agents must receive training in digital tools and technologies (Ortiz-Crespo *et al*., 2021). This current paper sought to examine the competencies and the training needs of extension agents in digital technologies in Ghana, to provide empirical data that could be used by policy makers in agricultural extension to develop curriculum framework to facilitate training of extension agents. The study sought to specifically examine the competencies (knowledge, attitudes and skills) of extension agents in digital technologies in agriculture and to determine the digital technologies training needs of extension agents for agricultural extension delivery.

## METHODOLOGY

The study employed descriptive cross-sectional survey design to collect quantitative data from agricultural extension agents on their competencies and training needs in digital technologies applied in agricultural extension delivery. The operationalisation of the study followed that of Blatch-Jones *et al*. (2018). The study was carried out in the Central, Ahafo, Bono East and Upper East Regions of Ghana at one point in time (March to April 2023) in the natural work setting of extension agents (Spector, 2019). Population of agricultural extension agents in the four regions number up to 496 (N = 496) (MoFA-DAES, 2021). Simple random probability sampling techniques was utilized to sample 217 extension agents from the population of 496 agents (Wang and Cheng, 2020). Krejcie and Morgan's (1970) table was used to estimate the sample size for the study. The corresponding sample size from the population of 496 was 217. Structured questionnaire of eleven digital technologies applied in agriculture was developed and administered to the extension agents (Tumiran, 2024). The digital technologies included, artificial intelligence (AI), big data analytics, block chain technology, drone technology, gene editing, global positioning system (GPS) technology, internet of things (IoTs), machine learning, mobile applications, sensors, and robotics were adopted from Tsan *et al*. (2019). These technologies are significant in enhancing agricultural systems and supporting extension agents because they facilitate improved communication, data-driven decision-making, and real-time access to agricultural information, eventually leading to increased productivity and sustainability in farming practices (Atengdem *et al*., 2022). Knowledge, attitude and skills of extension agents in the application of digital technologies in agricultural extension were measured on a 5-point Likert-type scales. Knowledge and skills were measured on a scale of 1 = very low, 2 = low, 3 = moderately high, 4 = high, and 5 = very high. Attitude was however measured on a scale of 1 = not important, 2 = less important, 3 = moderately important, 4 = important, 5 = very important. A section on background characteristics of agricultural extension agents was also included. The structured questionnaire was validated by two agricultural extension experts from the University of Education, Winneba and a field extension professional from the Directorate of Agricultural Extension Services of the Ministry of Food and Agriculture, Ghana (Memon *et al*., 2023). McDonald's Omega coefficients were computed to examine the reliability of the questionnaire after pre-testing with ten extension agents from the Greater Accra Region of Ghana (Goodboy and Martin, 2020). International Business Machine Statistical Package for Social Sciences (IBM SPSS) version 27 used for the reliability analysis. IBM SPSS was chosen as the preferred tool for the reliability analysis because of its strong statistical capabilities, user-friendliness, and widespread industry acceptability for reliability test like McDonald's Omega (Pallant, 2016). The results of the McDonald's Omega reliability were knowledge = 0.92, attitude = 0.96, and skills = 0.94 (Ravinder and Saraswathi, 2020). Copies of the structured questionnaire were then administered to the 217 selected extension agents in the respective regions. After one month of data collection, only 125 extension responded to the survey (n = 125), representing 58% response rate. This is regarded by Baruch and Holtom (2008) as appropriate sample size for studies in the social sciences. Descriptive statistics including frequencies, percentages, means, and standard deviation were used to analyse background characteristics, while means and standard deviations were computed to examine knowledge, attitude, skills and overall competencies of extension agents in application of digital technologies is agricultural extension (Pallant, 2016). Borich's (1980) mean weighted discrepancy score (MWDS) were computed to determine the overall ranking of extension agents' competencies in application of digital technologies in agricultural extension. To compute the MWDS, the following procedure was adopted:

1. discrepancy score (DS) was computed for each extension agent for their competency by subtracting ability (skills) from importance (attitude) ratings,
2. weighted discrepancy score (WDS) was afterwards computed for each extension agent by multiplying the discrepancy score by the mean importance (attitude) rating,
3. mean weighted discrepancy score (MWDS) for each digital technology was computed by summing the weighed discrepancy score divided by the sample size of 125 extension agents,

$$MWDS = \sum [(I_{ith} - C_{ith}) \text{ x } \bar{X}_i / \text{N}]$$

Where I = importance rating (attitude) for each digital technology, C = ability ratings (skills) for each digital technology, $\bar{X}_I$ = mean importance rating, N = number of extension agents who participated in the study. Adopting the MWDS, the eleven digital technologies were ranked to determine the competencies of the extension agents in application of these technologies in agricultural extension (Man *et al*. 2016; Diaz *et al*., 2019; Shimali *et al*., 2021; Kamanda *et al*., 2022).

## RESULTS and DISCUSSION

**Background characteristics of extension agents.** Table 1 presents background characteristics of extension agents, majority (91.2%) of the extension agents were males who dominate their female counterparts. The dominance of male extension agents over their female colleagues in this study is consistent with by studies by Olayemi *et al*. (2022), Ozioko *et al.* (2022) and Aregaw *et al*. (2023). The high number of male extension workers in this study may have impact on accessibility and communication methods, which could have an impact on how inclusive agricultural extension services are. This would restrict interaction with female farmers, which would affect the general effectiveness and efficiency of services provision (Suleiman *et al*., 2022). One-fifth of extension agents (20%) were between 21 and 30 years. Thrice as much extension agents (60.0%) were between 31 and 40 age bracket while the rest (19.2%) were above 41 years. The mean age of these extension agents was 35.67±7.00 years. The results is similar to that of (Olorunfemi *et al*., 2020) which found that majority of extension agents were between age 31 and 40 years. Young extension agents' engagement in agriculture greatly accelerates the adoption of digital technologies improving agricultural practices (Singh *et al*. 2023). Young agents, who are frequently endowed with technology know-how, can communicate and share knowledge more effectively with farmers by bridging the gap between traditional farming and contemporary digital solutions (Ayamga *et al*., 2023). Generally, more than three-fourth of agents (76.8%) had less than ten years of working experience in extension services with mean experience of 8.06±6.53 years. Loki *et al*. (2019) found that most extension agents had between 11 and 20 years of work experience. Singh *et al*. (2023) posited that experience of extension agents is essential for helping farmers successfully integrate digital technology, guaranteeing well-informed choices, and optimizing the advantages of these advancements in farming methods. Since extension agents' knowledge and experience directly affects famers' access to information and sustainability of dissemination methods, which in turn affect the successful implementation of sustainable agricultural practices, their experience is essential for the successful adoption of digital technologies in agriculture (Hameed and Sawicka, 2023). More than half (52.8%) were holders of Bachelor's degree certificates in various field of agriculture including, Agricultural extension, Horticulture, General Agriculture and Animal Husbandry. Sugihono *et al*. (2024) noted that, increased digital literacy among extension agents is correlated with higher education, which improves their capacity to positively accept and use digital technology. For Ghana' agricultural sector to innovate and provide improved services, increase in digital skills is essential (Atengdem *et al*., 2022).

**Competence of extension agents in digital technology.** Knowledge, attitudes, skills and competencies of extension agents in digital technologies is presented in Table 2. When knowledge of extension agents in digital technologies were assessed, it was observed that agents possessed moderate knowledge (overall mean =2.57±0.93) in digital technologies. While extension agents demonstrated moderate knowledge in IoTs, machine learning, and the use of sensors, they exhibited high knowledge in mobile applications and GPS technology for extension delivery. The results are similar to the findings of Ifeanyi-obi and Ibiso (2020) which concluded that Abia State extension agents had overall moderate knowledge in application of digital technologies but are more adept at using GPS technology and mobile applications than they were with IoTs, machine learning and sensor utilization. Also consistent with the results of this present study is the findings of Ezeh *et al*. (2021) which reported that when it comes to mobile applications and GPS technology for extension delivery, Ebonyi State, Nigeria, extension agents are very knowledgeable. The findings of this study suggest a range of expertise among extension agents with respect to various digital technologies used in agriculture. That notwithstanding, the results highlight the significance of continuous training and capacity building initiatives to improve agents' knowledge with cutting-edge digital technologies. The knowledge will enable extension agents to better utilise these instruments for agricultural extension services and assist communities in implementing novel practices that will increase productivity and sustainability (Ragetlie *et al*., 2022).

Table 1. Background Characteristics of Extension Agents

| Variables | Frequency | Percent |
|---|---|---|
| **Sex** | | |
| Male | 114 | 91.2 |
| Female | 11 | 8.8 |
| **Age** | **($\bar{X}$ = 35.67, σ = 7.00)** | |
| 21 – 30 | 25 | 20.0 |
| 31 – 40 | 76 | 60.8 |
| 41 – 50 | 16 | 12.8 |
| 50 – 60 | 8 | 6.4 |
| **Experience** | **($\bar{X}$ = 8.06, σ = 6.53)** | |
| 1 – 10 | 96 | 76.8 |
| 11 – 20 | 22 | 17.6 |
| 21 and above | 7 | 5.6 |
| **Level of Education** | | |
| Certificate | 22 | 17.6 |
| Diploma | 21 | 16.8 |
| Bachelor's degree | 66 | 52.8 |
| Master's degree | 16 | 12.8 |

Similarly, the attitudes of extension agents towards digital technologies were examined. The extension agents showed that the use of digital technologies for agricultural extension was moderately important (overall mean 2.81±1.09). Extension agents exhibited varying attitude towards different digital tools. The agents observed that the use of IoTs, machine learning, big data analytics, drone technology, AI, and sensors to be moderately important, while the use of GPS technology and mobile applications were seen as highly important. Tian *et al.* (2023) argued that agricultural extension agents' attitudes towards innovative technologies are greatly influenced by the way that digital technologies are treated due to differences in the acceptability of different tools. Olayemi *et al.* (2022) added that the degree to which extension agents use digital technologies influence these attitudes. Furthermore, Landini and Conti (2022) argued that a range of individual and sociodemographic factors impact on extension agents' approach towards innovations, underscoring the significance of understanding extension agents' perspectives and inclinations in embracing novel technologies and methodologies in agricultural extension services.

Data from prior published studies show that extension agents in different countries have difficulty with digital technology skills (Ozioko *et al.*, 2022; Aregaw *et al.*, 2023). This study confirms this assertion from previous research. The results revealed that largely, skills of extension agents in digital technologies for extension delivery is low (overall mean = 2.39±0.98). While extension agents exhibited low skills in machine learning, block chain technology, and AI, they demonstrated moderate skills in mobile applications and GPS technology. The results suggest that specialized training programmes are required to improve agents' skills in these cutting-edge digital tools. The findings of the study also highlights the importance of investing in education in order to maintain and enhance extension agents' skills, particularly when it comes to digital technologies in agricultural extension (Aregaw *et al.*, 2023). Extension agents can effectively use digital technologies for agricultural development and extension services delivery by filling these skills gaps with tailored-made training programmes.

The highest level of competency required by an extension agent in order to provide the relevant means was 5.00 (Borich, 1980). The results generally show that, extension agents possessed moderate competencies (overall mean = 2.59±1.00) in digital technologies for agricultural extension delivery. Specifically, extension agents possessed moderate competencies in mobile applications, GPS technology, and IoTs, while their competencies in drone technology, robotics, gene editing, block chain technology and AI was low. It was observed that the results are consistent with the findings of Farida *et al.* (2023) who studied competencies of extension agents in Indonesia and found that their competencies in advanced technologies like drones, robotics and AI were low. Aregaw *et al.* (2023) examined the factors affecting the competence level of agricultural extension agents in North Western Ethiopia and reported that extension agents demonstrated moderate competencies in digital technologies for agricultural extension, with higher proficiency in mobile applications, GPS technology and IoTs compared to drone technology, robotics, gene editing, block chain technology and AI. Moreover, the study conducted by Tian *et al.* (2023) underscored the noteworthy impact of digital information handling on the perspectives and efficacy of agricultural extension workers, specifically in augmenting their services capacity and acknowledging innovation via the digital economy. These findings collectively suggest that while extension agents exhibited moderate competencies in some digital technologies, there is a need for further training and development, especially in advanced technologies like drone technology, robotics, gene editing, block chain technology, and AI to enhance their effectiveness in agricultural extension services.

Table 2. Competences of Extension Agents in Digital Technologies

| Digital technologies | Knowledge | | Attitude | | Skills | | Competence | |
|---|---|---|---|---|---|---|---|---|
| | X̄ | σ | X̄ | σ | X̄ | σ | X̄ | σ |
| Internet of Things (IoTs) | 3.38 | 1.25 | 3.14 | 1.26 | 2.96 | 1.33 | 3.16 | 1.28 |
| Drones | 2.17 | 1.23 | 2.54 | 1.30 | 1.89 | 1.12 | 2.20 | 1.22 |
| Robotics | 1.95 | 1.20 | 2.40 | 1.30 | 1.77 | 1.06 | 2.04 | 1.19 |
| Machine learning | 2.55 | 1.31 | 2.78 | 1.29 | 2.25 | 1.24 | 2.53 | 1.28 |
| Big data analytics | 2.43 | 1.30 | 2.77 | 1.30 | 2.18 | 1.26 | 2.46 | 1.29 |
| Gene editing | 1.90 | 1.16 | 2.43 | 1.37 | 1.96 | 1.25 | 2.10 | 1.26 |
| Block chain technology | 2.13 | 1.26 | 2.53 | 1.30 | 2.06 | 1.24 | 2.24 | 1.27 |
| Artificial intelligence | 2.22 | 1.27 | 2.59 | 1.33 | 2.19 | 1.26 | 2.33 | 1.29 |
| Mobile applications | 3.53 | 1.17 | 3.45 | 1.29 | 3.35 | 1.28 | 3.44 | 1.25 |
| GPS technology | 3.50 | 1.18 | 3.52 | 1.22 | 3.29 | 1.25 | 3.44 | 1.22 |
| Sensors | 2.46 | 1.28 | 2.72 | 1.37 | 2.38 | 1.29 | 2.52 | 1.31 |
| **Overall mean** | **2.57** | **0.93** | **2.81** | **1.09** | **2.39** | **0.98** | **2.59** | **1.00** |

Means were calculated using a scale of very low = 0.45-1.44, low = 1.45-2.44, moderate = 2.45-3.44, high = 3.45-4.44, very high = 4.45-5.44.

**Digital technologies training needs of extension agents for agricultural extension delivery.** Digital technologies training needs of agricultural extension agents shown in Table 3 were computed using the Borich's needs assessment model for calculating mean weighted discrepancy score (MWDS). According to Borich (1980), the higher MWDS of extension agents in the application of digital technologies, the more training is needed to upgrade the competencies in application digital technologies for agricultural extension delivery. On the other hand, lower MWDS values indicate better competencies in the specific digital technologies for extension delivery hence, less training needed to upgrade the competencies of the extension agents (Man *et al*. 2016). The results showed that the four most important digital technologies extension agents need training for extension delivery were application of drone technology (0.0146), robotics (0.0142), big data analytics (0.0133), and machine learning (0.0119). The results imply that extension agents prioritize application of drone technology in agriculture, robotics, big data analytics and machine learning as key digital technologies where they would require training to improve their competencies for effective extension delivery. The results mirror the findings of Thomas and Laseinde (2015) which highlighted a high demand for digital technology training among extension agents to enhance agricultural information dissemination. Prior research has shown that the use of drones (UAVs) has great potential to address some of the most pressing problems faced in agriculture production including soil analysis, yield estimation, crop health analysis, crop spraying etc. (FAO and ITU, 2018). It can be deduced that extension agents envision to leverage on the enormous benefits of deploying drone technology in the field of agricultural extension including real-time images and sensor data from farms that are difficult to access by car or on foot (Ayamga *et al*. 2021). Cheng *et al.* (2023) argued that agricultural robots have rapidly evolved, relying on diverse cutting-edge technologies for varied applications scenarios, due to recent advances in computer science, machine learning, AI, sensing and control methodologies. It is worth noting that integrating machine learning (ML) technologies into agricultural extension, especially when it comes to strengthening extension services and farmer capabilities (Patel and Patel, 2023). Agricultural practices can be adjusted through the use of machine learning, which will boost sustainability and productivity (Esau *et al.*, 2023). These applications are stimulating precision agriculture (Lowenberg *et al*. 2019). The same hold true for online services and methods used in conjunction with the internet, like cloud computing and IoTs, which enable big data and digital twin technologies (Emmi *et al.* 2023). Application of digital technologies like GPS technology (0.0052), IoTs (0.0040), and mobile applications (0.0022) were ranked the least among extension agents. Indicating that extension agents are familiar with these technologies and so do not require much training in order to adopt them for extension delivery. The findings are in line the previous studies which revealed that extension agents have some experience working with GPS technology and mobile applications (Bosompem, 2021; Atengdem *et al*. 2022). For instance, Bosompem (2021) revealed that cocoa extension agents deploy GPS technology for mapping cocoa farms in Ghana. Atengdem *et al*. (2022) indicated that extension agents in Ghana utilise a range of ICTs enabled devices such as mobile applications, radio, social media, television, and emerging technologies for extension delivery. This result is consistent with that fact that extension agents possess high knowledge on application of GPS technology and mobile applications in agricultural extension delivery that needs to be preserved.

This research article which is the first of its kind offers insightful information about the competencies and training needs for extension agents using digital technologies to deliver extension. The general consensus the results highlights important areas for attention. Policy makers can be guided by the findings of this research when seeking to promulgate policies for improving extension agents' ability to provide extension services utilising technologies such as robots, big data analytics, drone technology and machine learning. The study also has some limitations that should be considered when interpreting the results. The generalization of the results may be limited by our dependence on extension agents' self-reported opinions gathered at one point in time. This is because opinions may change overtime as a result of additional contact with digital technologies. The study was restricted to extension agents in just four of Ghana's sixteen regions, limiting the findings' wider application to extension agents in the nation. Future research can look at expanding to scope to the other regions in the country.

## CONCLUSION

This study revealed that agricultural extension agents possessed moderate general competencies in digital technologies. While their knowledge and attitude towards these technologies were deemed to be moderate, their practical skills were identified as key area for improvement. Digital technologies that extension require training are drone technology, robotics, big data analytics, and machine learning. Training programmes that are specifically designed to close this gap and maximize the benefits of digital technologies in agricultural extension are recommended. The Ministry of Food and Agriculture in collaboration with the Regional Directorates of Agriculture in the respective regions can liaise with Departments of Computer Science in public universities in Ghana to develop training programmes aimed at improving the capacity of extension agents in digital technologies. Training modules and curriculum should be developed to cover but not drone technology, robotics, big data analytics, and machine learning. The main goal of these training programmes should be to give extension agents with the necessary know-how to use cutting-edge technologies like big data analytics, robots, drone technology and machine learning in agricultural extension delivery. Training on GPS technology and mobile applications should be considered to beef up their competencies. In so doing, extension agents would become more effective intermediaries, empowering farmers to take advantage of digital tools to enhance their farming practices while improving productivity and agri-food system sustainability.

Table 3. Digital technologies training needs of extension agents

| Digital technologies | Attitude $\bar{X}$ | Skills $\bar{X}$ | DS | WDS | MWDS | Rank |
|---|---|---|---|---|---|---|
| Drones | 2.54 | 1.89 | 0.65 | 1.83 | 0.0146 | 1 |
| Robotics | 2.40 | 1.77 | 0.63 | 1.77 | 0.0142 | 2 |
| Big data analytics | 2.77 | 2.18 | 0.59 | 1.66 | 0.0133 | 3 |
| Machine learning | 2.78 | 2.25 | 0.53 | 1.49 | 0.0119 | 4 |
| Gene editing | 2.43 | 1.96 | 0.47 | 1.32 | 0.0106 | 5 |
| Block chain technology | 2.53 | 2.06 | 0.47 | 1.32 | 0.0106 | 6 |
| Artificial intelligence | 2.59 | 2.19 | 0.40 | 1.12 | 0.0099 | 7 |
| Sensors | 2.72 | 2.38 | 0.34 | 0.96 | 0.0076 | 8 |
| GPS technology | 3.52 | 3.29 | 0.23 | 0.65 | 0.0052 | 9 |
| Internet of Things (IoTs) | 3.14 | 2.96 | 0.18 | 0.51 | 0.0040 | 10 |
| Mobile applications | 3.45 | 3.35 | 0.10 | 0.28 | 0.0022 | 11 |
| **Overall mean** | **2.81** | **2.39** | | | | |

Means were calculated using a scale of very low = 0.45-1.44, low = 1.45-2.44, moderate = 2.45-3.44, high = 3.45-4.44, very high = 4.45-5.44.

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## CONFLICT OF INTEREST

The author declares no competing interests.

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