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Utilisation of Artificial Intelligence-based Technology for Agricultural Extension Services among Extension Professionals in Nigeria

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Abstract

The study examined the current awareness and usage, determined the level of utilisation of AI-based digital technology for agricultural extension services, and identified the merit and demerit of using AI-based digital technology for agricultural extension services. Data were collected through an online structured questionnaire from 131 extension professionals across Nigeria. Percentage and mean were used to describe and summarise the data. The findings revealed that 79.4% of the respondents were aware that AI-based digital technology can be used for agricultural

extension services, while 55.7% reported that they had used the technology at one time or the other. About 45% of the respondents disseminated innovations and 34% demonstrated innovations and technologies through the use of AI-based digital technology. Also, 77.9% perceived reaching the target audience everywhere and every time as the major merit of AI-based digital technology while 71.8% identified high-cost implications of digital enablers as its major demerit. There was a high level of awareness but a low level of utilization of AI-based digital technology for agricultural extension services among agricultural extension professionals. On-the-job capacity building should be organized for the current professionals to promote the use of AI-based digital technology for agricultural extension services in Nigeria.

Introduction

Artificial Intelligence (AI) is an emerging technology in the agricultural sector. AI is the science of making intelligent machines and programmes. It is rooted in the principle that machines can accurately describe and replicate human intelligence, allowing them to efficiently carry out tasks ranging from basic to the most complex. The basic idea of AI is to create technologies that mimic the functioning of the human brain. (Adilakshmi et al., 2021, Parekh et al., 2020; Jani et al., 2019). The technologies are made by studying how the human brain thinks and how people learn, make decisions, and work while solving a problem (Adilakshmi et al., 2021).

The use of AI-based technologies in the agricultural sector became important because of the continuous increase in the human population. Based on the World Population Data Sheet (2020), the world's population is projected to rise from 7.8 billion in 2020 to 9.9 billion by 2050. As a result, the agricultural system will face greater strain due to this population growth (Liakos et al., 2018). This implies that there is a need to enhance global agricultural production by approximately 60-70 percent from its present state to satisfy the rising food demand by 2050 (Silva, 2018). To achieve this increase in the demand-supply food chain, there is a need for a smarter and more efficient approach to farming which makes the digital agricultural transformation to become very crucial. Trendov et al. (2019), observed that over the next 10 years, there will be dramatic changes in the agrifood system, driven by advanced Artificial Intelligence (AI) as well as digital technologies and innovations among other factors.

AI-based equipment and machines have the potential for digitalizing and taking agriculture systems to a higher level in communication, data gathering, and dissemination, as well as production and consumption. Information and Communication Technologies (ICTs) in Agriculture are important for the development of a viable and sustainable food security strategy (Miiro et al., 2020; Ridley et al., 2019). According to Rakhra et al. (2022), artificial intelligence-based technologies have aided in increasing productivity across all industries, including the agricultural sector, by addressing challenges in areas such as crop yield, irrigation, soil content sensing, crop monitoring, weeding, and crop establishment. Singh and Jain (2022), stated that artificial intelligence technologies help in achieving healthier crops, pest control, and soil monitoring and improve a wide range of agriculture-related tasks in the entire food supply chain including harvesting, processing, and marketing.

Talaviya et al. (2020) observed various hi-tech computer-based systems have been created to assess various crucial aspects of crop production, including weed detection,

yield detection, crop quality, and many other techniques (Liakos *et al*., 2018). Other technologies used to enhance productivity and reduce the workload on the farm include those used for automated irrigation, weeding and spraying, and various automated soil sensing techniques. According to the Technical Centre for Agricultural and Rural Cooperation (CTA), digitalization of agriculture is the process of transforming agricultural practices throughout the value chain and addressing bottlenecks in agricultural production, post-harvest handling, and market access, finance and supply chain management to increase smallholder farmers' incomes, enhance the agricultural value chain economy for both large and small agricultural enterprises, boost youths and women's economic participation, enhance food and nutrition security, and increase climate resilience.

Agricultural extension professionals are very significant in agricultural transformation in Africa, including Nigeria because they have the expertise to communicate innovation and technologies to the majorly resource-poor farmers. Recently, leveraging on the high rate of utilization of mobile-phone among Nigerians, including farmers (both in the urban and rural communities), the conventional face-to-face extension professionals' contacts with farmers are gradually being supported with AI-based mobile phone-enabled digital technologies (Rotondia et al., 2020).

Furthermore, before the COVID-19 crisis, Olagunju et al. (2021) observed that agricultural extension services primarily relied on "on-the-field" methods, including activities like demonstration plots, group training, and farm visits. These approaches involved direct face-to-face interactions, as highlighted by Maertens et al. (2020). Olagunju et al. (2021) and Farinde et al. (2022) reported that physical distance-related COVID-19 measures prevented such the former approach, compelling the extension workers to adopt digital tools for delivery services to farmers. Utilizing mobile technologies as digital tools could expand the scope of agricultural extension services, by providing farmers with access to market data such as market locations and prices, as well as technical agricultural advice hotlines (Danso-Abbeam et al*.,* 2018). Realizing the potential of AI-based digital technologies in enhancing the performance of extension service delivery and the fact that there is inadequate statistical evidence on the usage of these technologies among agricultural extension stakeholders in the study area prompted this study. The study examined the awareness of respondents about AI-based digital technology and its level of utilization in agricultural extension services in the study area. The objectives of the study were to

i. ascertain the awareness and usage of AI-based digital technology in agricultural extension services;
ii. determine the level of utilization of AI-based digital technology in agricultural extension services among respondents; and
iii. identify the merits and demerits of using AI-based digital technology in agricultural extension services among the respondents in the study area.

Methodology

The research was conducted in Nigeria~~;~~ which spans 923,769 square kilometers with a population of about 211 million people (UNFPA, 2021). Nigeria is located at 9°4.92' N and longitude 8°40.517' E of the equator. The respondents for the study were extension agents public and private), lecturers, researchers, and contact farmers (farmer-led extension workers). A structured questionnaire on an online Google form was designed and pretested among nine professionals from agricultural extension and rural sociology to produce a standardized questionnaire. The online questionnaire was sent to the one

hundred and eighty-six extension professionals via e-mail addresses collated from relevant professional associations (the Rural Sociological Association of Nigeria (RUSAN), Agricultural Extension Society of Nigeria (AESON), and the International Research and Development Network of Children and Youth in Agriculture Programme (CYIAP). Eighty-two non-registered extension professionals in Nigeria were individually contacted. After a month, only one hundred and thirty-one extension professionals completed and submitted the online questionnaire. IBM-SPSS statistics software version 21 was used for data processing. Percentage and mean were used to describe and summarise the data.

The utilization of AI-based technology for agricultural extension was conceptualized as the awareness and use of Artificial Intelligence (with human and expert-based intelligence) in communication (sourcing and dissemination of information, farm and weather-related data and innovations, capacity and soft skill enhancement) and extension services in farm management such as on-farm innovation and technology adoption, diseases management, on-farm monitoring, inputs and marketing, and general home management by the extension professionals among the agriculture value chain actors conventionally referred to as “farmers”. Awareness, as the first stage in the concept of “utilization,” was determined by requesting the respondents to indicate if they had heard about AI-based technology; with a “yes” or a “no” response. Use was determined by asking the respondents to indicate whether they had used the AI-based digital technology for extension service before and their responses were scored; 1 mark for a “yes” and zero mark for a “no” response. The area of utilization was determined by a “yes” (1 mark) or a “no” response to each listed conventional extension activity; with a maximum point of ten (10) and the minimum point of zero (0) attainable by each respondent.

A sum of the individual scores on awareness, the use, and areas of utilisation gives the utilisation score. The utilisation score was used to determine the level of utilisation using an equal interval approach as used by Adisa et al. (2022). The range of the utilization score was calculated and divided by two to categorize the respondents into high and low levels of utilization, with 5 marks as the average score. Scores below the average score were categorized as low while scores above fall in the category of a high level of utilization. Furthermore, the respondents were asked to indicate their perception of the list of merits and demerits of using AI digital technology for agricultural extension services. Affirmative response on each merit and demerit was scored a “1” mark; otherwise “0” mark was scored.

Results and Discussion

Awareness of AI digital technology

Figure 1 shows that the majority (79.4%) of the respondents were aware that AI-based digital technology can be used for agricultural extension services. The awareness by the majority of extension professionals is an indication that they had good knowledge of this technology which might likely influence its utilization. Awareness is a precursor for the adoption and utilization of any technology and also stimulates interest in the innovations adoption process. This agrees with the findings of Fatty (2019) that as a result of the Covid 19 restriction measure of physical distancing, extension personnel is using digital tools for service delivery among farmers.

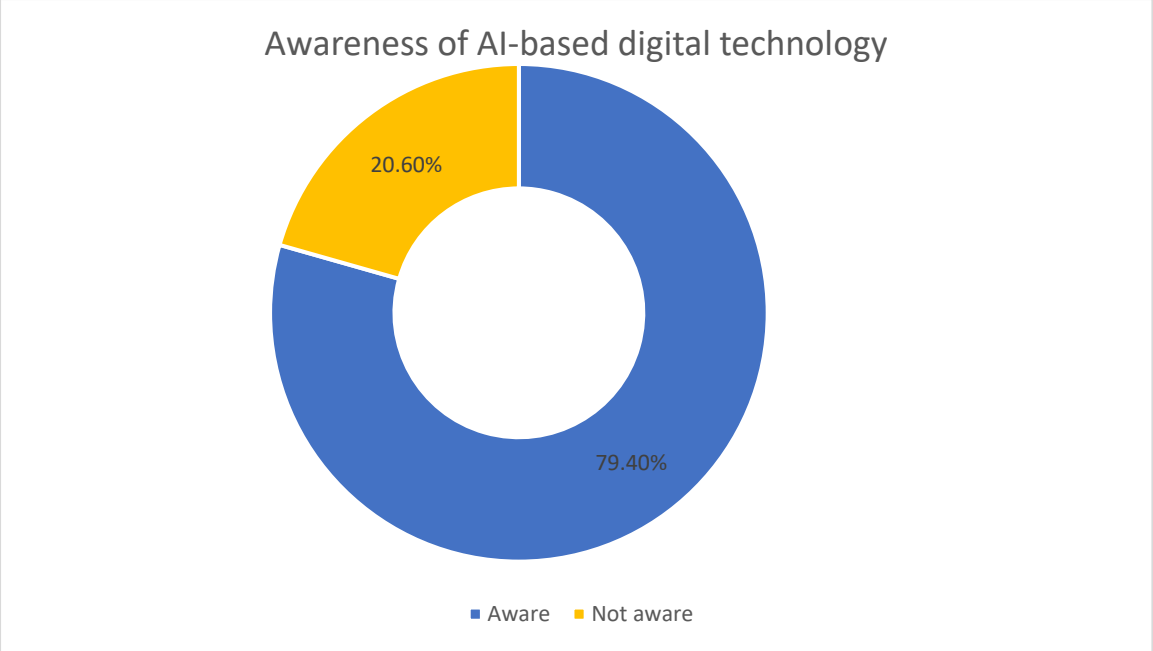

Figure 1: Awareness of AI digital technology in agricultural extension services
Source: Survey, 2021

Use of AI Digital Technology for Agricultural Extension Services

Figure 2 reveals that about 56% of the respondents indicated that they had used AI digital technology while 44% indicated that they have never used it for agricultural extension services. This finding implies that more than half of the extension professionals were already using AI-based digital technology for agricultural extension services in Nigeria. This could be an indication that extension professionals are aware of AI-based digital technology's relative advantage over the conventional face-to-face extension approach. The use of digital platforms has become an alternative response during the Covid-19 pandemic and post-Covid-19 era (Olagunju et al., 2021); thereby providing a new way of solving the low-extension-farmers ratio. AI-enabled agricultural extension and decision support systems have the potential for effective extension farmers' interaction beyond the conventional face-to-face approach.

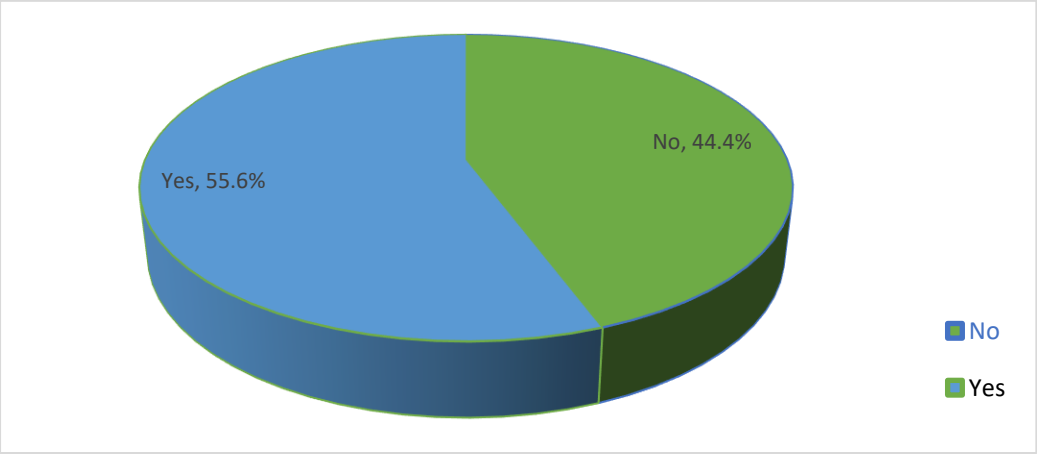

Figure 1: Respondents using AI digital technology in agricultural extension services
Source: Survey, 2021

Table 1 shows the areas of utilization of AI for agricultural extension services. About 45% of the respondents indicated that they disseminate technologies through the use of AI digital tools and 34% of the respondents indicated they demonstrate innovations and technologies through AI-based technology. While respondents also claimed they use AI digital technology for consultation with the subject matter specialist (25.2%), crop disease management (19.8%), and livestock disease management (16%). This result is similar to the findings of Sarker et al. (2019) and Olagunju et al. (2021) that AI-based digital technology can be used for dissemination of crop disease management, livestock disease management, marketing, and consultation. This result indicates the under-utilization of AI-based technology, as the extension professionals used AI-based digital technology more as communication tools than as extension service tools at farm management and monitoring levels. The prevailing low technical know-how among the extension personnel, low usage of smartphones, poor connectivity, and high cost of the internet as reported by Nikola et al. (2019) might be responsible for the under-utilization of AI technology in Agriculture in Nigeria.

Table 1: Areas of utilisation of AI digital technology in agricultural extension Services

*Areas of utilisation	Percentage (%) (n=131)
Dissemination of innovations and technologies	45
Demonstration of innovations and technologies	33.6
Consultation with the subject matter specialist	25.2
Crop diseases management	19.8
Livestock Disease management	16
Farm management	2.3
Fertilizer application management	1.5
Irrigation and water conservation	1.5
Weed management	1.5
Harvesting	0.8

*Multiple responses, **Source:** Survey, 2021

Level of Utilisation of AI Digital Technology for Agricultural Extension Service

Figure 2 shows that the majority (80.9%) of the respondents were at a low level of utilization of AI digital technology; Very few respondents (19.1%) were at a high level of utilization. This result implies that the majority of extension professionals are underutilizing AI-based digital technology for agricultural extension services despite the inherent potential associated with the use of these technologies. This could be a result of low sensitization and low capacity building of extension professionals on the use of AI-based digital technology for agricultural extension services.

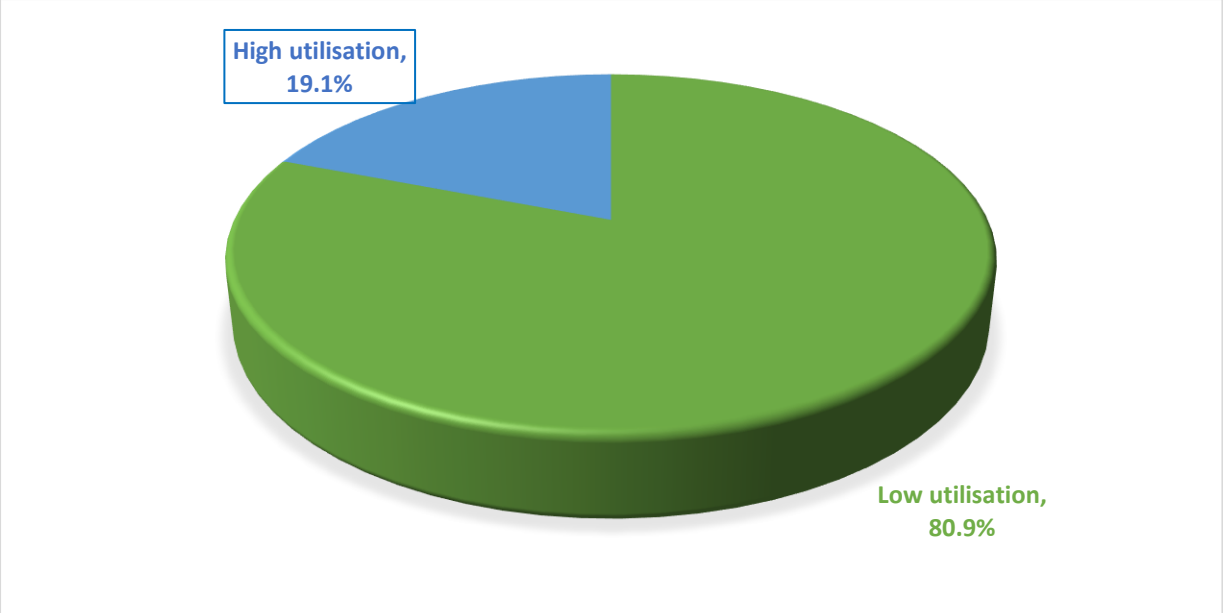

Figure 2: Level of utilisation for AI digital technology for agricultural extension services
Source: Survey, 2021

Perceived Merits of Using AI-Based Digital Technology for Extension Services

Table 2 shows that extension professionals mostly acknowledged that the use of AI-based digital technology in agricultural extension services has the following advantages: reaching the targets audience everywhere and every time (77.9%), provision of extension services without physical contact (70.2%), encourages agricultural digitalization (58%) and making agriculture easy, smart and precise (55.7%). This implies that AI-based digital technology is capable of solving the problems of shortage of extension agents, research-development gaps, paucity of funds, the inappropriateness of innovations and technologies, untimely and inaccurate farm data, monitoring, and management, and extension-farmers gaps. It is evident from these results that the extension professionals understood and recognized the potential inherent in the use of AI-based digital technology for effective agricultural extension services in Nigeria.

Table 2: Perceived merits of using AI-based digital technology for agricultural extension service

Merits	Percentage
Ability to reach target audience everywhere and every time	77.9
Provision extension services without the physical presence	70.2
It encourages agricultural digitalization	58
It makes Agriculture easy, smart and precise	55.7
It can easily be used to reach many clienteles at the same time	49.6
It is SMART; supports the effective utilization of resources and is very appropriate for precision and climate-smart farming	46.6
Easy access to farmers, extended reach to farmers and serve as a community voice and help solve agricultural challenges holistically	40.5

*Multiple response, **Source:** Survey, 2021

Perceived Demerits of Using AI-Based Digital Technology for Extension Services

Data in Table 3 show that the respondents mostly identified high-cost implications in terms of the cost of purchasing and maintaining smartphones and other infrastructural facilities (71.8%), the low literacy level of farmers (54.2%), financial intensive and technical-know required for the operation of AI technologies (51.1%), and inadequate digital skills and education of extension agents (48.1%) as the major demerits of using AI-based digital technology for extension services. The high-cost implication of technology, especially the high-tech Artificial Intelligence technology may pose a great obstacle to its utilization among the extension professionals who are among the average income earners in Nigeria, despite their significant role in bridging the gap between agricultural research and development This results gives credence to the submission of Farinde et al. (2022) that high-cost implication, low level of literacy and lack of technical know-how among extension professionals and farmers are the constraints to the use of AI-based digital tools for extension practices in Nigeria. Furthermore, there is low-level digital education and skills, as well as inadequate digital infrastructure, such as data, software, and hardware infrastructure, which are basic requirements for the functioning of AI digital tools (Nikola et al*.,* 2019; Tsan et al., 2019).

Table 3: Perceived demerits of using AI-based digital technology for agricultural extension services

*De**m**erits	Percentage
High-cost implication	71.8
Low level of farmers' Literacy	54.2
Financial intensive and required technical know-how for operation	51.1
Inadequate digital education of extension agents	48.1
Highly technical and requires high of cost training to use	45.8
Lead to unemployment of extension experts	38.9
Prevents farmer-extension agent relationship	27.5

*Multiple responses, **Source:** Survey 2021

Conclusions and Recommendations

There is a low level of utilization of AI-based digital technology for extension services among extension professionals in Nigeria. Government and other stakeholders should provide digital enablers such as affordable smartphones, digital infrastructure, and good internet facilities to facilitate better utilization of AI-based digital technology for extension services, especially in rural areas. Internet service providers should reduce the cost of Internet data to make it affordable to all Internet users. Regular digital technology sensitization and capacity-building programmes should be made available and easily accessible to agricultural extension professionals by relevant stakeholders such as the Ministry of Agriculture and rural development and the Ministry of Communication and digital economy. Furthermore, topics on AI-based digital technology should be mainstreamed into the tertiary education agricultural curriculum in agricultural extension to ensure scientific validity and sustainability.

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