



Utilisation of Artificial Intelligence-related Technology for Agricultural Extension Services among Extension Professionals in India

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10.18805/BKAP695

ABSTRACT

Background: The research examined the current understanding and utilization of AI-based digital technology in agricultural extension services. It assessed the level of adoption and identified the advantages and disadvantages of incorporating such technology.

Methods: To collect data, a structured online questionnaire was employed and responses were gathered from 131 extension professionals based in India. The data were analyzed using percentage and mean.

Result: The findings revealed that approximately 75.25% of the respondents had used AI-based digital technology at least once and 61.48% were aware of its potential applications in agriculture extension services. Among those who used AI-based technology, about 45% were able to propagate innovations, while 33.60% showcased innovations and technologies. One of the major benefits, as reported by 80.25% of the participants, was the technology's capacity to reach the target audience universally and at any time. However, 72.50% of respondents identified the high costs associated with its digital enablers as the primary drawback. The study highlighted a significant level of awareness among agricultural extension specialists regarding AI-based digital technologies. However, the actual utilization of these technologies in their services remained relatively low. To address this gap, the research recommends organizing on-the-job capacity building initiatives for current professionals. These programs aim to promote the adoption of AI-based digital technologies in agricultural extension services throughout India.

Key words: Artificial intelligence, Capacity building, Sustainability, Technology.

INTRODUCTION

The livelihoods of millions are supported by agriculture, which also makes a sizable contribution to the GDP of India. In this agrarian environment, it is crucial to effectively disseminate agricultural knowledge, best practises and cutting-edge technologies to increase production, sustainability and farmers' general well-being. A crucial link between research institutes and the farming community, agricultural extension services enable the transfer of knowledge and expertise from professionals to farmers.

The integration of cutting-edge technologies to handle numerous issues has sparked a technological revolution in the agriculture sector over time. Artificial intelligence (AI) has become a game-changer in several industries, including agriculture and is one such revolutionary force. Agricultural extension services could undergo a transformation thanks to AI-based technology, which would enable a more effective and data-driven strategy to engage farmers, answer their issues and promote agricultural growth (Aharwal *et al.*, 2023).

This study's main goal is to investigate how Indian extension specialists are using AI-based technologies for agricultural extension services. These experts, such as agricultural officers, consultants and field agents, serve as essential middlemen, connecting farmers with important knowledge and techniques that can have a big impact on their agricultural practices (Na *et al.*, 2024).

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How to cite this article: Patel, M., Khodifad, P.B. and Chaudhary, M. (2024). Utilisation of Artificial Intelligence-related Technology for Agricultural Extension Services among Extension Professionals in India. *Bhartiya Krishi Anusandhan Patrika*. 1-6. doi: 10.18805/BKAP695.

Submitted: 24-11-2023 **Accepted:** 19-10-2024 **Online:** 23-12-2024

The application of AI to agriculture has expanded the possibilities for extension services. Agricultural systems can be made smart and linked by combining AI with other cutting-edge technologies like remote sensing, the Internet of Things (IoT) and big data analytics. Large-scale data processing, intricate pattern analysis and important insight extraction are all capabilities of AI algorithms. These capabilities can help with resource optimisation, risk management and decision-making.

This study will examine the present level of AI acceptance among extension professionals with the goal

of evaluating their knowledge with, awareness of and readiness for AI-based technologies. Designing efficient strategies for broad implementation requires an understanding of the elements that affect the acceptance of AI in extension services.

AI in agriculture has a variety of advantages. Using AI-driven solutions, extension specialists can customise their advisory services for farmers by making recommendations that are specific to each farm's features and the surrounding environment. Additionally, AI-powered predictive models can offer early warnings regarding pest outbreaks, the frequency of diseases and weather patterns, assisting farmers in the proactive planning of their agricultural activities.

Despite the enormous promise of AI in agriculture, there are obstacles that extension specialists may face while using it. These can include issues with data ownership and privacy, the necessity for specialised training and restricted access to AI infrastructure (Mohan *et al.*, 2023). To ensure the seamless and effective integration of AI in agricultural extension services, these issues must be resolved.

Due to the continuous global population growth, the utilization of AI-based technology in agriculture has become increasingly significant. As projected by the World Population Data Sheet (2020), the world's population is expected to reach 9.9 billion by 2050, up from 7.8 billion in 2020, putting additional strain on the agricultural system (Liakos *et al.*, 2018). Meeting the rising food demand by 2050 would require a 60-70% increase in agricultural production from its current level (Silva, 2018). This necessity for enhanced food production calls for a more efficient and advanced approach to farming, making digital agricultural transformation crucial. Sophisticated Artificial Intelligence (AI), digital technologies and innovations, according to Trendov *et al.* (2019), will bring about significant changes in the agrifood system in the next decade.

AI-based tools and technologies have the potential to digitize farming systems, leading to improved production, consumption and data collection and dissemination. To establish a sustainable food security strategy, the integration of information and communication technologies (ICTs) in agriculture is essential (Miirio *et al.*, 2020; Ridley *et al.*, 2019). Rakhra *et al.* (2022) emphasize that artificial intelligence-based technologies have proven beneficial in addressing various agricultural aspects, such as crop yield, irrigation, soil content sensing, crop monitoring, weeding and crop establishment, resulting in increased productivity across all industries, including agriculture. Singh and Jain (2022) further add that artificial intelligence technologies enhance multiple agriculture-related tasks throughout the food supply chain, including harvesting, processing and marketing. They also contribute to healthier crops, effective pest management and soil monitoring (Kim and AlZubi, 2024).

Before the COVID-19 crisis, most agricultural extension services primarily relied on traditional "on-the-field"

techniques, such as farm tours, group training and demonstration plots, as highlighted by Olagunju *et al.* (2021). However, the pandemic and physical distance-related restrictions prompted a shift toward utilizing modern tools to provide services to farmers by agricultural employees using smartphones (Maertens *et al.*, 2020). These digital instruments, such as smartphones, enable broader access to agricultural extension activities, providing farmers with market information, pricing details and hotlines for technical agricultural advice (Danso-Abbeam *et al.*, 2018).

Recognizing the potential of AI-based digital solutions to enhance extension service delivery and the lack of sufficient data on the adoption of these technologies by those involved in agricultural extension, the study focused on assessing respondents' knowledge regarding the current utilization of AI-based digital technology in agricultural extension services within the research area. The study aimed to address the extent of AI-based technology use in agricultural extension services and its implications.

1. Calculate the level of knowledge and adoption of AI-based digital technology in services for improving agriculture.
2. Enumerate the extent to which AI-based digital technology is used in agriculture among responders, extension services.
3. Find out the benefits and drawbacks of employing digital technology based on AI in among the respondents in the study area.

MATERIALS AND METHODS

The research was conducted at Navsari Agricultural University, Navsari, Gujarat, India, A country with a land area of approximately 3.287 million square kilometers and a population of about 1.4 billion (UNFPA, 2021). The study included extension agents from both public and private sectors, lecturers, researchers and contact farmers (farmer-led extension workers) as respondents. To ensure standardization, a structured survey on a Google form was created and pretested among nine experts in rural sociology and agricultural extension. This research was conducted over a 3 year period from 2021 to 2023. The online questionnaire was distributed to 186 extension professionals through email addresses obtained from relevant professional associations, such as the Indian Society of Agricultural Extension, Indian Society of Extension Education and the National Institute of Agricultural Extension Management. Additionally, 82 unregistered extension professionals in India were approached individually. Eventually, 131 extension professionals completed and submitted the online questionnaire within a month. The data were processed using Version 21 of the IBM-SPSS statistics program and statistical measures such as percentage and mean were utilized to characterize and summarize the data.

The research defined the concept of using artificial intelligence (AI)-based technology for agricultural extension as the awareness and utilization of AI (involving human and expert-based intelligence) in communication, sourcing and disseminating information, farm and weather-related data and innovations and capacity and soft skill enhancement. It also covered extension services in farm management, such as on-farm innovation and technology adoption, diseases management, on-farm monitoring and inputs.

To determine the level of awareness, respondents were asked whether they had heard of AI-based technology and provided a “yes” or “no” response. The first stage of “utilization” was ascertained through this awareness assessment. For evaluating the utilization, respondents were asked if they had ever used AI-based digital technology for extension services and their responses were scored with one mark for a “yes” and zero for a “no” response. The extent of utilization for each stated conventional extension activity was also assessed, with a maximum score of ten (10) and a minimum score of zero (0).

The overall utilization score was calculated by summing up the separate scores for awareness, use and the areas of utilization. To categorize the level of utilization, the equal interval method proposed by Adisa *et al.* (2022) was employed and responses were divided into high and low levels of utilization, based on an average score of 5 marks. Scores below the average were considered low, while scores above were classified as having a high degree of utilization. Additionally, respondents were asked to provide their opinions on the advantages and disadvantages of employing digital AI technology for agricultural extension services. Positive responses were awarded a “1” mark, while negative responses received a “0” mark.

RESULTS AND DISCUSSION

Awareness of AI digital technology

According to Fig 1, a significant proportion of respondents (61.48%) demonstrated awareness regarding the application of digital technology based on artificial intelligence in agricultural extension services. This high level of awareness among extension experts indicates their familiarity with the technology, potentially influencing its utilization. In the process of adopting and accepting any technology, awareness plays a crucial role as it sparks interest in the innovation adoption process.

Use of AI digital technology for agricultural extension services

Fig -2 illustrates that approximately 38.52% of respondents reported never having used digital AI technology for agricultural extension services, while roughly 61.48% of respondents indicated that they had employed such technology. This finding suggests that in India, more than half of the extension specialists were already utilizing AI-based digital technologies to support agricultural extension activities. This could imply that these specialists recognize

the advantages of AI-based digital technologies compared to traditional face-to-face extension approaches. Especially during the Covid-19 pandemic and in the post-Covid-19 era, the adoption of digital platforms has emerged as an alternative solution (Olagunju *et al.*, 2021), offering a novel approach to address the challenge of a low extension-farmers ratio. Beyond the limitations of traditional face-to-face methods, AI-enabled agricultural extension and decision support tools have the potential to significantly enhance interactions with farmers effectively.

Areas of utilisation of AI digital technology in agricultural extension services

Table 1 displays the applications of AI in agricultural extension services. Slightly over 45% of the respondents reported using AI-based digital tools to disseminate technologies, while 34% utilized AI-based technology for demonstrating innovations and technologies. Additionally, respondents mentioned employing AI digital technology for livestock disease control (16%), crop disease management (19.8%) and consultation with subject matter experts (25.2%). These findings align with the research by Sarker *et al.* (2019) and Olagunju *et al.* (2020), which also

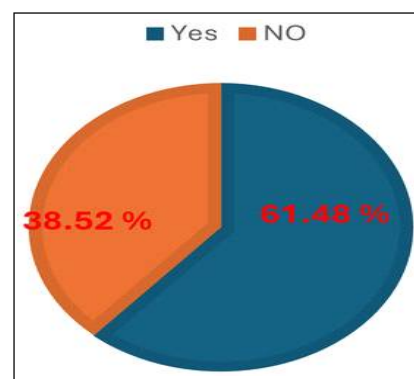


Fig 1: Awareness of AI digital technology in agricultural extension services in India.

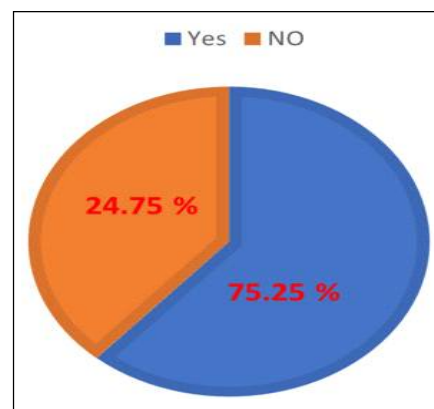


Fig 2: Respondents using AI digital technology in agricultural extension services.

indicated that AI-based digital technology can be effectively used for marketing, consultation and transmitting information related to crop and livestock disease control. However, it is notable that the respondents used AI-based digital technology primarily as communication tools rather than fully integrating them into extension service tools for farm management and monitoring. This suggests that there is room for greater utilization of AI-based technology in agricultural extension services.

As shown in Fig 3, a significant majority of respondents (79.25%) reported using digital AI technology at a low level, while only a small percentage (20.75%) utilized it at a high level. This finding indicates that, despite the potential benefits of AI-based digital technology for agricultural extension services, the majority of extension practitioners are not fully harnessing its capabilities. One possible reason for this underutilization could be the lack of capacity building among extension specialists and their limited experience in using AI-based digital technology for agricultural extension services.

Benefits considered of using digital technology based on AI for extension services

Table 2 illustrates that a majority of extension professionals acknowledged several benefits of using AI-based digital

technology in agricultural extension services. These benefits include the ability to reach the target audience universally and at any time (80.25%), providing extension services without physical contact (66.15%), promoting agricultural digitalization (45.62%) and simplifying, optimizing and making agriculture more precise (18.25%). These findings suggest that AI-based digital technology has the potential to address various challenges, such as a shortage of extension agents, a gap between research and development, limited funding, inappropriate adoption of innovations and technologies, outdated and inaccurate farm data, as well as issues related to monitoring and management and bridging the gap between extension and farmers. These outcomes clearly demonstrate that extension specialists were aware of the vast possibilities that AI-based digital technologies offer for enhancing efficiency in agricultural extension services in India.

Perceived drawbacks of using digital technology based on AI for extension services

Based on the data presented in Table 3, the primary drawbacks cited by the majority of respondents regarding the use of AI-based digital technology for extension services include the high costs associated with acquiring and maintaining smartphones and other infrastructure facilities

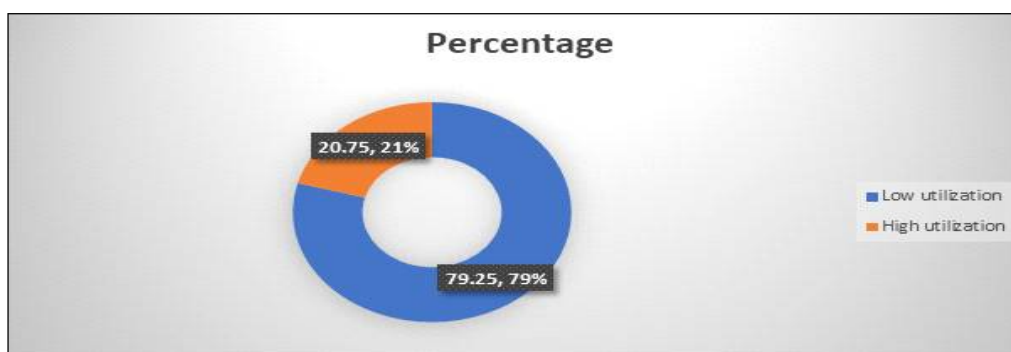


Fig 3: Level of utilisation for AI digital technology for agricultural extension services.

Table 1: Level of utilisation of AI digital technology for agricultural extension service. (n=131)

*Areas of utilisation percentage (%)	%age
Transfer of innovations and technologies	45
Make demonstration of innovation and the technologies	33.6
Discussion with the subject matter specialist	25.2
Field crop diseases management	19.8
Management of Livestock diseases	16
Farm management and improvement	2.3
Fertilizer application	1.5
Irrigation scheduling and water conservation	1.5
Weed management in field	1.5
Harvesting/post-harvest operations	0.8

*Multiple responses.

Table 2: Perceived merits of using AI-based digital technology for agricultural extension service. n=131

Merits	%age
Ability to reach target audience everywhere and every time	80.25
Provision extension services without the physical presence	66.15
It encourages agricultural digitalization	45.62
It makes Agriculture easy, smart and precise	18.25
It can easily be used to reach many clienteles at the same time	17
It is SMART; supports the effective utilization of resources and is very appropriate for precision and climate-smart farming	8
Easy access to farmers, extended reach to farmers and serve as a community voice and help solve agricultural challenges holistically	6.35

*Multiple responses.

Table 3: Perceived drawbacks of using digital technology based on AI for extension services. (n=131)

*Demerits	%age
High costs associated with acquiring and maintaining smartphones and other infrastructure facilities	72.50
Low literacy rates among farmers	56.27
Need for technical and financial expertise to operate AI technologies	42.50
Insufficient digital skills and education among extension agents	40.80
Highly technical and requires high of cost training to use	32.15
Lead to unemployment of extension experts	26.95
Prevents farmer-extension agent relationship	20.65

*Multiple responses.

(72.50%), low literacy rates among farmers (56.27%), the need for technical and financial expertise to operate AI technologies (42.50%) and insufficient digital skills and education among extension agents (40.80%). This suggests that extension professionals in India, who typically earn average incomes, may encounter challenges in adopting technology due to its high costs, particularly advanced Artificial Intelligence technology. The findings align with the observations made by Farinde *et al.* (2022), indicating that the adoption of AI-based digital tools for extension practices in India is hindered by factors such as high costs, low levels of literacy and a lack of technical expertise among extension personnel and farmers.

CONCLUSION AND RECOMMENDATION

The utilization of AI-based digital technologies for extension services among extension specialists in India is currently at a low level. To enhance the adoption and effective use of AI-based digital technology for extension services, especially in rural areas, several measures can be taken by the government and other stakeholders.

Firstly, the government and relevant stakeholders should provide digital enablers, such as affordable smartphones, digital infrastructure and reliable internet connections, to facilitate access to digital technology in remote regions. Lowering the price of internet data by internet service providers would make internet access more accessible to all consumers, including extension professionals and farmers.

Secondly, the Ministry of Agriculture and Rural Development, in collaboration with the Ministry of Communication and Digital Economy, should regularly organize and facilitate accessible programs aimed at building the capacity of agricultural extension professionals in digital technology usage. These capacity-building programs will empower extension specialists with the necessary skills and knowledge to leverage AI-based digital technologies effectively in their extension services. Furthermore, to ensure long-term sustainability and promote scientific validity, subjects related to AI-based digital technology should be integrated into the university agricultural curriculum, specifically in agricultural extension programs. By incorporating these subjects into the curriculum, future extension professionals will be well-equipped with the expertise required to utilize digital technology optimally in their agricultural extension practices.

Through these initiatives, there is a greater likelihood of enhancing the use of AI-based digital technology for agricultural extension services and ultimately improving the overall extension services provided to farmers across India.

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