

The Importance of Electronic Communication in the Use of Artificial Intelligence Programs and Applications in the Field of Smart Agriculture from the Point of View of Agricultural Extension Workers in Nineveh Governorate, Iraq

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Abstract— The study aimed to identify the level of importance of electronic communication among agricultural extension workers in using artificial intelligence (AI) programs and applications in the field of smart agriculture. It also aimed to identify the most frequently used electronic communication means by extension workers in employing AI programs and applications and rank them according to their relative importance; measure the contribution of electronic communication to improving extension workers' efficiency in using AI programs and applications in smart agriculture; identify individual differences in the importance of electronic communication and the use of AI applications according to selected independent variables, namely gender, educational qualification, years of service, training courses, level of Internet use, and willingness to use social networking sites concerning smart-agriculture technologies; and identify the obstacles facing extension workers in using AI applications in smart agriculture. To obtain the study data, a questionnaire consisting of five parts was used. The first part concerned the respondents' personal and occupational information. The second part included a scale measuring the importance of electronic communication among extension workers in using AI programs and applications in smart agriculture. The third part measured the electronic communication means most frequently used by extension workers in employing AI programs and applications. The fourth part measured the contribution of electronic communication to improving extension workers' efficiency in using AI programs and applications in smart agriculture. The fifth part contained 15 items measuring the major obstacles facing extension workers in using AI applications in smart agriculture. After establishing the face validity of the questionnaire, reliability was assessed using Cronbach's alpha, which reached 0.95. The study population consisted of extension workers in the Nineveh Directorate of Agriculture and its 32 agricultural divisions, totaling 256 extension workers. A simple random sample of 128 extension workers, representing approximately 50% of the population, was selected. The data were coded, tabulated, and analyzed using SPSS. The results showed that the level of importance of electronic communication among extension workers in using AI programs and applications in smart agriculture was moderate and tended toward high, with a percentage of 48%. The item "Using electronic platforms belonging to agricultural institutions to obtain information related to AI programs and applications" ranked first, with a mean of 4.34. The contribution of electronic communication to improving extension workers' efficiency in using AI programs and applications in smart agriculture was high, with a percentage of 46%. No significant differences were found in the importance of electronic communication according to gender or training courses, whereas significant differences were reported according to educational qualification, years of occupational service, level of Internet use, and willingness to use social networking sites concerning smart-agriculture technologies. The item "Poor compatibility of some AI applications with the nature and needs of agricultural extension work in Nineveh Governorate" was identified as the most important obstacle. The major recommendation was for the Ministry of Agriculture to establish or develop official agricultural electronic platforms affiliated with agricultural and extension institutions and containing updated information on AI applications and their use in different agricultural fields. The main proposed future study was to investigate the obstacles to using AI applications in agricultural extension work in Nineveh Governorate from the perspective of extension workers.

Keywords— Electronic Communication; Artificial Intelligence Applications; Smart Agriculture; Agricultural Extension Workers.

I. INTRODUCTION

In recent years, the agricultural sector has undergone a rapid transformation toward employing digital technologies and modern communication technologies to produce and exchange agricultural information and support production- and resource-management decisions in order to increase production and achieve food security. Information and communication technologies are no longer limited to the traditional transfer of agricultural information and knowledge; rather, they have become part of an integrated system that includes smartphones, applications, digital platforms, the Internet, and artificial intelligence, which contribute to improving access to agricultural knowledge and developing services provided to farmers in a safe and effective manner. Recent literature indicates that digital agricultural services provided to farmers have become one of the major pathways for developing extension and advisory services, particularly in delivering agricultural information and knowledge to farmers more rapidly and effectively (Shaikh, Rasool, & Lone, 2022). Social communication, driven by digital technology, has become a major means of communication in general and agricultural information production in particular, changing the course of communication and making it easier to obtain information, knowledge, and experience in an organized and rapid manner through AI applications, placing them among the leading achievements of the information revolution (Al-Janabi et al., 2023). Electronic communication represents one of the fundamental components of transformation in agricultural extension work, as it enables extension workers to communicate with farmers through multiple channels, such as smartphone applications, social networking platforms, electronic messages, extension websites and platforms, educational videos, and interactive digital media. It also provides agricultural information at the appropriate time, creates greater opportunities for interaction and experience exchange, and facilitates responses to agricultural problems, while emphasizing the importance of developing the digital skills of workers and beneficiaries (FAO, 2023). Artificial intelligence has become one of the technologies incorporated into modern agricultural systems through the use of machine-learning algorithms, data and image analysis, environmental-condition monitoring, decision support, and other functions. Recent studies indicate that AI applications in agriculture are moving toward more data-driven systems that combine AI with sensors, the Internet of Things, and communication technologies to provide information that supports more precise management of agricultural operations (Klie et al., 2018). The effectiveness of AI in agriculture is not limited to the availability of programs, applications, and technical devices; it is also associated with the availability of electronic communication channels capable of transmitting data, information, and results among smart systems, extension workers, and farmers. Communication represents the link between technology and its users and helps agricultural extension workers access information generated by AI applications, interpret it, and transform it into understandable and applicable extension messages and recommendations (Hamada, 2014). Therefore, modern extension systems are moving toward integrating AI with digital extension platforms and decision-support systems while maintaining the human role of the extension worker in verifying information, interpreting it, and presenting it to farmers (Lin & Shyu, 2020). Smart agriculture relies on a set of interconnected digital technologies aimed at improving resource-use efficiency, increasing productivity, and enhancing the capacity to respond to agricultural and environmental problems. AI is an important component of this system, alongside the Internet of Things, sensors, data analytics, communication networks, and cloud computing. Scientific reviews indicate that AI applications in agriculture include crop monitoring, water management, nutrient management, pest and disease detection, yield prediction, agricultural robots, and protected agriculture (Tan et al., 2024). Agricultural extension workers represent an important link in transferring agricultural knowledge and technology from scientific and technical sources to farmers, and their role becomes increasingly important with the emergence of AI technologies, which may be complex for some users (Jad, 2021). In the digital environment, extension workers need the ability to deal with electronic information sources, understand AI applications, communicate through digital platforms, interpret technical outputs for farmers, and verify the suitability of information to local agricultural conditions. Recent literature indicates that developing the human capacities of extension workers is an essential pathway for digital transformation in agricultural extension and advisory systems (Kpodo, 2026). The study of electronic communication in agriculture is particularly important in Nineveh Governorate because of the importance of agricultural activity, the diversity of production systems, crops, and rural areas, as well as the need to develop communication methods and transfer agricultural information in ways compatible with digital transformations. A recent study examined the use of digital technology to obtain agricultural extension information in Tel Kaif District, Nineveh Governorate, indicating growing research interest in the role of digital technology in obtaining agricultural information in the local environment of the governorate (Wank et al., 2022). Despite the increasing development of AI applications and smart agriculture, the actual benefit from these technologies in agricultural extension work requires an effective electronic communication system linking digital knowledge sources with extension workers and farmers. The spread of smart applications does not necessarily mean that they are used efficiently (Azimi et al., 2019), as factors such as weak digital skills, limited or problematic connectivity, difficulty accessing data, insufficient training courses, and low confidence in technology may

constrain their use. The Food and Agriculture Organization has pointed to a digital divide related to digital skills and access to digital services, while recent studies have indicated that cost, infrastructure, and human skills represent challenges to expanding smart agricultural environments (Al-Jailawi & Al-Mashhadani, 2026). The research problem arises from the fact that the rapid development of AI programs and applications in agriculture has created new opportunities for developing smart agriculture in Iraq in general and Nineveh Governorate in particular, and for improving resource management and agricultural decision-making (Rodríguez et al., 2021). However, benefiting from these applications in extension work depends not only on the availability of technology, but also on an effective electronic communication system that enables extension workers to access and exchange information and data, interact with digital applications and platforms, and transfer their outputs to farmers clearly and appropriately. In Iraq, recent studies indicate a need to develop the use of information and communication technologies in extension work, strengthen workers' capacities and infrastructure, and improve access to digital extension knowledge (Alvarez & Nuthall, 2006). In Nineveh Governorate, the use of digital technology to obtain agricultural extension information highlights the need to study electronic communication as an essential component in employing modern agricultural technologies. Consequently, there is a need to determine the importance of electronic communication in using AI programs and applications in smart agriculture from the perspective of extension workers in Nineveh Governorate. This can help diagnose the communication situation and identify the development, training, and technical-support areas required to strengthen the use of AI in agricultural extension work. The importance of addressing this problem is further increased by the need to develop the use of information and communication technologies in agricultural extension work. Recent studies of technology use among extension workers in Iraq have emphasized the need to improve infrastructure, skills, and capacities and to enhance beneficiaries' access to extension information and knowledge. This raises the question of the extent to which extension workers recognize the importance of electronic communication when dealing with modern applications and programs, particularly AI applications related to smart agriculture (Ferris, 2017). The need for this type of study is particularly evident in Nineveh Governorate in light of recent indications of the use of digital technology to obtain agricultural information in some areas of the governorate. This calls for moving from studying the use of digital technology in general to a more specialized examination of the importance of electronic communication in using AI programs and applications in smart agriculture from the perspective of the extension workers themselves. Accordingly, the research problem is represented by the need to identify the level of importance of electronic communication in supporting the use of AI programs and applications in smart agriculture from the perspective of extension workers in Nineveh Governorate; identify the most important communication means used for this purpose; and examine their relationship to extension workers' ability to access smart applications, exchange agricultural data and information, communicate with farmers, and provide extension recommendations based on modern technologies.

II. RESEARCH OBJECTIVES

- 1) To identify the level of importance of electronic communication among extension workers in using AI programs and applications in the field of smart agriculture in general.
- 2) To identify the electronic communication means most frequently used by extension workers in employing AI programs and applications and rank them according to their relative importance.
- 3) To measure the contribution of electronic communication to improving extension workers' efficiency in using AI programs and applications in the field of smart agriculture.
- 4) To identify individual differences in the importance of electronic communication and the use of AI applications according to selected independent variables among extension workers, namely gender, educational qualification, years of service, training courses, level of Internet use, and willingness to use social networking sites concerning smart-agriculture technologies.
- 5) To identify the obstacles facing extension workers in using AI applications in the field of smart agriculture.

III. MATERIAL AND METHODS

The study was conducted in Nineveh Governorate, Iraq. The study population included all agricultural employees working at the Nineveh Directorate of Agriculture and its affiliated 32 agricultural divisions. The total population consisted of 256 extension workers distributed between the Directorate headquarters and its agricultural divisions. A simple random sample of 128 extension workers, representing 50% of the population, was selected. Data were collected using a questionnaire consisting of five parts. The first part concerned the personal and occupational information of agricultural extension workers. The second part consisted of 26 items measuring the level of importance of electronic communication among extension workers in using

AI programs and applications in smart agriculture, with five response alternatives: strongly agree, agree, neutral, disagree, and strongly disagree, coded 5, 4, 3, 2, and 1, respectively. The third part included 15 communication means to identify the electronic communication means most frequently used by extension workers in employing AI programs and applications, using the same five-point response scale. The fourth part included 15 items measuring the contribution of electronic communication to improving extension workers' efficiency in using AI programs and applications in smart agriculture, also using the five-point scale. The fifth part included 15 items measuring the major obstacles facing extension workers in using AI applications in smart agriculture, with response alternatives: very high, high, moderate, low, and very low, coded 5, 4, 3, 2, and 1, respectively. The items were developed after reviewing previous studies and literature relevant to the topic. Face validity and content validity were established by presenting the questionnaire to a group of experts and specialists in educational and psychological sciences at the College of Education for Humanities, University of Mosul; faculty members in the Department of Agricultural Extension and Technology Transfer, College of Agriculture and Forestry, University of Mosul; a specialist in educational and psychological sciences at the College of Education, University of Zakho; and a specialist in agricultural engineering sciences at the University of Baghdad. Their comments and suggestions concerning the question types, wording, clarity, and suitability to the respondents' level were considered. Some items were revised, some were reworded, and others were deleted. A criterion of 70% agreement among experts was adopted. For reliability testing, a sample of 30 employees was selected and excluded from the main population. Cronbach's alpha was used to assess scale reliability, and the coefficient was 0.95, indicating excellent reliability. The statistical analyses were conducted using SPSS.

IV. RESULTS AND DISCUSSION

4.1 First: To identify the level of importance that extension workers place on digital communication when using artificial intelligence programs and applications in the field of smart agriculture in general.

To achieve this objective, the minimum observed value for the importance of electronic communication among extension workers was 62, while the maximum observed value was 130. Using the range and class width, respondents were divided into three categories. The arithmetic mean was 103.53 and the standard deviation was 15.27, as shown in Table 1.

TABLE 1
LEVEL OF IMPORTANCE THAT EXTENSION WORKERS PLACE ON ELECTRONIC COMMUNICATION

Range	Frequency	Percentage
62–84 (Low)	17	11.33
85–107 (Medium)	73	48.67
108–130 (High)	60	40
Total	150	100
Arithmetic mean	103.53	
Standard deviation	15.27	

The results showed that the level of importance of electronic communication among extension workers in using AI programs and applications in smart agriculture was moderate and tended toward high, with a percentage of 48%. This may be attributed to the fact that extension workers recognize the importance of electronic communication in using AI programs and applications in agricultural extension work, but the level of importance has not yet reached a high level and the utilization of these programs and applications is not fully integrated among all workers. Electronic communication has also become an important means of obtaining up-to-date agricultural information, following technological developments, communicating with specialists and farmers, and exchanging experiences related to AI applications.

4.2 Second: To identify the electronic communication tools most commonly used by extension workers in the implementation of artificial intelligence programs and applications, and rank them in order of relative importance.

To achieve this objective, the arithmetic mean and percentage weight were calculated for each electronic communication means and ranked according to priority, as shown in Table 2.

TABLE 2
RANKING OF THE MOST COMMONLY USED ELECTRONIC COMMUNICATION METHODS AMONG EXTENSION WORKERS

T	Paragraphs	Mean	Rank
1	I prefer using electronic communication means rather than traditional communication means when dealing with AI programs and applications in smart agriculture.	4.12	3
2	Electronic communication means facilitate the exchange of experiences among extension workers regarding the use of AI applications in smart agriculture.	3.77	15
3	I use electronic communication means and applications to coordinate with researchers and experts regarding AI applications in smart agriculture.	3.95	9
4	Cloud applications are important for sharing information related to AI-based extension work.	3.8	14
5	I use specialized electronic platforms to exchange experiences between extension workers and scientific research centers concerning AI applications in extension work.	4.02	7
6	I benefit from generative AI platforms via the Internet to obtain information or prepare agricultural extension content related to smart agriculture.	4.16	2
7	I use electronic search engines to access information related to AI programs and applications for smart agriculture.	4.06	6
8	It is important to follow digital educational channels, such as webinars and online training courses, to learn about the latest AI applications.	3.91	10
9	I use agricultural extension smartphone applications to access AI services and learn how to use them.	3.97	8
10	I use specialized smart-agriculture websites to obtain information about AI applications.	4.08	4
11	I use electronic platforms belonging to agricultural institutions to obtain information related to AI programs and applications.	4.34	1
12	I benefit from virtual meetings through video-communication applications, such as Zoom, Google Meet, or Microsoft Teams, to discuss AI applications in extension work.	4.07	5
13	I use social networking platforms to publish and follow information related to AI applications in agriculture.	3.9	11
14	I use email to exchange information and files related to AI programs and applications.	3.86	12
15	I use instant-messaging applications, such as WhatsApp or Telegram, to communicate about AI programs and applications in smart agriculture.	3.83	13

The results in Table 2 showed that the item "I use electronic platforms belonging to agricultural institutions to obtain information related to AI programs and applications" ranked first, with a mean of 4.34. This may be attributed to the fact that agricultural extension workers regard these affiliated electronic platforms as important and reliable sources for obtaining up-to-date agricultural information related to AI programs and applications. AI applications are characterized by rapid development and continuous updating, which makes extension workers need electronic information sources that enable them to follow developments and applications that can be employed in agricultural extension work. Electronic platforms also provide workers with rapid access to information without being restricted by location or official working hours, which is consistent with the nature of extension work, where information must be obtained at the appropriate time and transferred to farmers in a way that contributes to sustainable food security.

In contrast, the item "Electronic communication means facilitate the exchange of experiences among extension workers regarding the use of AI applications in smart agriculture" ranked last, with a mean of 3.77. This may be because agricultural extension workers do not rely heavily on electronic communication means to exchange experiences and agricultural knowledge among themselves. This may be related to limited practical experience in this field, as the use of AI applications in agricultural and extension work still requires more training and practical experience. Experience exchange also requires the existence of diverse practical experiences that can be shared and discussed, whereas workers' experiences with AI applications may still be similar or limited, reducing the perceived need to use electronic communication means for exchanging them.

4.3 Third: To assess the contribution of electronic communication to improving the proficiency of extension workers in using artificial intelligence programs and applications in the field of smart agriculture.

To achieve this objective, the minimum observed value for the contribution of electronic communication was 36, while the maximum observed value was 75. Using the range and class width, respondents were divided into three categories. The arithmetic mean was 59.98 and the standard deviation was 9.33, as shown in Table 3.

TABLE 3
CONTRIBUTION OF ELECTRONIC COMMUNICATION TO IMPROVING EMPLOYEE EFFICIENCY

Range	Frequency	Percentage
36–48 (Low)	18	12
49–61 (Medium)	62	41.33
62–75 (High)	70	46.67
Total	150	100
Arithmetic mean	59.98	
Standard deviation	9.33	

The results showed that the contribution of electronic communication to improving extension workers' efficiency in using AI programs and applications in smart agriculture was high, with a percentage of 46%. This may be attributed to the fact that extension workers recognize electronic communication as an important means of developing their knowledge, experience, and attitudes toward using AI programs and applications in agricultural extension work by providing rapid access to up-to-date agricultural information, learning about agricultural applications, following agricultural experiences and practices through these programs, communicating with specialists, and exchanging knowledge and experience.

4.4 Fourth: To identify individual differences in the importance of electronic communication and the use of artificial intelligence applications according to certain independent variables among extension workers, namely (gender, educational qualification, years of service, training courses, level of Internet use, and willingness to use social media platforms related to smart farming technologies).

To achieve this objective and identify individual differences, the T-test was used for independent variables with two categories, whereas one-way analysis of variance (ANOVA) was used for variables with more than two categories, as follows.

4.4.1 Gender

To identify individual differences in the importance of electronic communication and the use of AI applications according to gender, the T-test was used, as shown in Table 4.

TABLE 4
INDIVIDUAL DIFFERENCES IN THE IMPORTANCE OF ELECTRONIC COMMUNICATION, THE USE OF ARTIFICIAL INTELLIGENCE APPLICATIONS, AND GENDER

Gender	N	Mean	SD	T-test	Sig.
Male	122	103.07	14.92	0.156	0.214
Female	28	105.5	16.84	0.156	0.214
Total	150			0.156	0.214

The results showed no significant differences between the importance of electronic communication and the use of AI applications according to gender, as the calculated t-test value was 0.156 and the reported significance value was 0.214. This indicates that males and females had relatively similar assessments of the importance of electronic communication and the use of AI applications in agricultural extension work. Gender therefore did not appear to be a direct factor shaping their attitudes

toward these technologies. The use of electronic communication means and AI applications has become associated more with the nature and requirements of professional extension work than with workers' personal characteristics. Males and females also work in a relatively similar extension environment and are similarly exposed to digital sources and modern communication means, such as smartphones and electronic platforms, making these technologies accessible to both genders without a substantial difference.

4.4.2 Educational Qualification

To identify individual differences according to educational qualification, one-way ANOVA was used, as shown in Table 5.

TABLE 5

INDIVIDUAL DIFFERENCES BETWEEN THE IMPORTANCE OF ELECTRONIC COMMUNICATION AND ACADEMIC QUALIFICATIONS

Source of variation	Sum of squares	df	Mean square	F	Sig.
Between groups	1112.062	2	370.68	1.609	0.19
Within groups	33409.052	148	230.4		
Total	34521.114	150			

The results indicated no significant differences between the importance of electronic communication and educational qualification, with a calculated F value of 1.609 and a reported significance value of 0.190, which is not significant at the 0.05 level. This may be attributed to the fact that differences in educational level did not produce substantial differences in the extent to which workers use modern information and technologies. Workers with different educational qualifications may have similar exposure to scientific and electronic sources and similar interest in electronic communication related to AI and digital technologies. Educational attainment may not necessarily be associated with greater opportunities to consult scientific and electronic sources and follow recent developments in information technology and AI.

4.4.3 Years of Service

To identify individual differences according to years of occupational service, one-way ANOVA was used, as shown in Table 6.

TABLE 6

INDIVIDUAL DIFFERENCES BETWEEN THE IMPORTANCE OF ELECTRONIC COMMUNICATION AND YEARS OF SERVICE

Source of variation	Sum of squares	df	Mean square	F	Sig.
Between groups	130.205	2	65.102	0.276	0.039
Within groups	34390.909	148	235.554		
Total	34521.114	150			

The results indicated significant differences between the importance of electronic communication and years of occupational service, with a calculated F value of 0.276 and a reported significance value of 0.039, which is significant at the 0.05 level. This may be attributed to differences in extension workers' assessment of the importance of electronic communication according to their length of service. Differences in years of service may lead to differences in professional experience and in the extent to which electronic communication means and AI applications are used in extension work, which may affect workers' perception of the importance of electronic communication for obtaining agricultural information, communicating with farmers and colleagues, and following agricultural developments.

4.4.4 Training Courses

To identify individual differences according to participation in training courses, the T-test was used, as shown in Table 7.

TABLE 7

INDIVIDUAL DIFFERENCES BETWEEN THE IMPORTANCE OF ELECTRONIC COMMUNICATION AND TRAINING COURSES

Training	N	Mean	SD	T-test	Sig.
Trained	38	106.71	16.35	0.226	0.276
Untrained	112	102.79	14.98		
Total	150				

The results showed no significant differences between the importance of electronic communication and the use of AI applications according to training-course participation, as the calculated t-test value was 0.226 and the reported significance value was 0.276. This may be attributed to the fact that participation in training courses did not produce a substantial difference in workers' assessment of the importance of electronic communication. Both participants and non-participants may be directly or indirectly exposed to modern digital means, particularly AI applications, enabling them to develop relatively similar perceptions of the importance of electronic communication and AI applications in agricultural extension work.

4.4.5 Level of Internet Use

To identify individual differences according to level of Internet use, one-way ANOVA was used, as shown in Table 8.

TABLE 8

INDIVIDUAL DIFFERENCES BETWEEN THE IMPORTANCE OF ELECTRONIC COMMUNICATION AND THE LEVEL OF INTERNET USE

Source of variation	Sum of squares	df	Mean square	F	Sig.
Between groups	84.563	2	57.231	0.201	0.019
Within groups	24456.651	148	435.799		
Total	24541.214				

The results indicated significant differences between the importance of electronic communication and the use of AI applications according to Internet-use level, with a reported calculated value of 0.201 and a reported significance value of 0.019. This may be attributed to differences in the extent to which extension workers use the Internet during their extension work and corresponding differences in their awareness of the importance of electronic communication means and AI applications. Greater Internet use provides workers with more opportunities to encounter recent agricultural ideas and information, learn about digital applications and platforms, communicate with farmers, and follow developments related to AI and smart agriculture.

4.4.6 Willingness to Use Social Networking Sites for Smart-Agriculture Technologies

To identify individual differences according to willingness to use social networking sites concerning smart-agriculture technologies, the T-test was used, as shown in Table 9.

TABLE 9

INDIVIDUAL DIFFERENCES BETWEEN THE IMPORTANCE OF USING ELECTRONIC COMMUNICATION AND THE DESIRE TO USE SOCIAL MEDIA PLATFORMS REGARDING SMART FARMING TECHNOLOGIES

Willingness	N	Mean	SD	T-test	Sig.
Willing	111	134.63	15.79	0.614	0.321
Unwilling	39	99.86	15.91		
Total	150				

The results indicated no significant differences between the importance of electronic communication and the use of AI applications according to the use of social networking sites concerning smart-agriculture technologies. The reported calculated t-test value was 0.614 and the reported significance value was 0.321, which is not significant at the 0.01 level. This may be attributed to the fact that workers' perceptions of the importance of electronic communication for using AI applications did not differ substantially according to their level of use of these communication media. Workers who use such communication sites more frequently may be more exposed to digital agricultural information, knowledge, and experience related to AI applications, but this did not translate into a statistically significant difference in their perceptions.

4.5 Fifth: Identifying the barriers that extension workers face in using artificial intelligence applications in the field of smart agriculture.

To achieve this objective, the arithmetic mean was calculated for each item and the items were ranked according to their importance, as shown in Table 10.

TABLE 10
BARRIERS THAT EXTENSION WORKERS FACE IN USING ARTIFICIAL INTELLIGENCE APPLICATIONS

T	Paragraphs	Mean	Rank
1	Limited availability of modern devices required for using AI applications in agricultural extension work.	4.12	9
2	Weak technical support when facing problems related to the use of AI applications in agricultural extension work.	3.77	11
3	Lack of clear planning by agricultural institutions for employing AI in extension programs and activities.	3.95	4
4	High costs of AI applications and tools and their updating and maintenance.	3.8	3
5	Limited experience and digital skills among some extension workers in using AI.	4.02	7
6	The technical complexity of some AI applications makes them difficult to use.	4.16	6
7	Limited training courses addressing extension workers' skills in using AI applications.	4.06	14
8	Inadequate digital infrastructure in agricultural institutions required for applying AI technologies in agricultural extension work.	3.91	10
9	Slow Internet service limits the use of AI applications in extension work.	3.97	2
10	Insufficient financial support allocated to employing AI technologies in agricultural extension work.	4.08	13
11	Fear of assuming responsibility when using AI applications in extension work and dealing with them.	4.34	5
12	Insufficient confidence in the accuracy of some information and recommendations provided by agricultural AI applications in smart agriculture.	4.07	12
13	Poor compatibility of some AI applications with the nature and needs of agricultural extension work in Nineveh Governorate.	3.9	1
14	Difficulty convincing some farmers to use AI-based agricultural technologies and applications.	3.86	8
15	Limited availability of agricultural smart-application content that meets the needs of extension workers and farmers.	3.83	15

The results showed that the item "Poor compatibility of some AI applications with the nature and needs of agricultural extension work in Nineveh Governorate" ranked first, with a mean of 4.50. This may be attributed to the fact that some available AI applications are still designed for agricultural environments whose conditions differ from those of Nineveh Governorate, which may limit their suitability to the actual needs of extension workers. Agricultural production practices also differ from one region to another, making some applications require adaptation to local agricultural characteristics. In addition, some applications may not provide specialized content or extension recommendations appropriate to the agricultural problems encountered by extension workers in the governorate.

In contrast, the item "Limited availability of agricultural smart-application content that meets the needs of extension workers and farmers" ranked last, with a mean of 2.97. This may be because agricultural extension workers perceive that the available

smart agricultural applications provide a reasonable amount of information, knowledge, and agricultural services that support their work. They can also access diverse digital sources related to smart agriculture and use them according to their extension knowledge needs.

V. CONCLUSION

- 1) The importance of electronic communication in using AI programs and applications in smart agriculture, from the perspective of extension workers, was at an acceptable level because workers still perceive the presence of factors affecting the application of these means in extension work.
- 2) Using electronic platforms belonging to agricultural institutions to obtain information related to AI programs and applications was the most frequently used electronic communication means by extension workers.
- 3) The contribution of electronic communication to improving extension workers' efficiency in using AI programs and applications in smart agriculture was high, reflecting the importance of these applications in smart agriculture and food security.
- 4) Respondents' gender and the training courses received by agricultural extension workers were not significant factors in the importance of electronic communication for using AI applications in smart agriculture.
- 5) Educational qualification, years of occupational service, level of Internet use in extension work, and willingness to use social networking sites concerning smart-agriculture technologies were all reported as factors associated with differences in the use of AI applications in agricultural extension work.
- 6) Poor compatibility of some AI applications with the nature and needs of agricultural extension work in Nineveh Governorate was the most important obstacle facing agricultural extension workers in using electronic communication.

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CONFLICT OF INTEREST

The researcher declares that there is no conflict of interest that could influence the results or interpretation of this research.

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