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The Role of Artificial Intelligence Applications in Providing Extension Services and Supporting Environmental Sustainability from the Point of View of Agricultural Employees in Tikrit District / Iraq

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Abstract: *The research aims to identify the role of artificial intelligence applications in providing extension services from the point of view of agricultural employees in Tikrit District / Salah al-Din Governorate. And to find the correlation between the role of artificial intelligence applications in providing extension services from the point of view of agricultural employees and each of the personal variables. The research area included (the Directorate of Agriculture in Tikrit District, the Tikrit Agriculture Division, and the Extension Center in Tikrit District), where the number of agricultural employees in the research community was (101) employees. A random sample of 80% was selected proportionally so that the number of respondents who underwent the research procedures became (81) employees. The questionnaire form was prepared from two main parts to collect the study data. The first part includes a set of variables related to the personal aspect, and the second part scale consists of (42) paragraphs distributed over six main areas related to the field of artificial intelligence, which are answered through a three-point scale (major role, medium role, weak role). The results showed that the role of artificial intelligence applications in general is average to low, as 80% of the respondents were in the average and weak category. We conclude from this that artificial intelligence applications are not widely available or are not used intensively in agricultural areas. The results showed that artificial intelligence applications were effective in some areas, such as providing weather information. At the same time, their role was weak in other areas, such as diagnosing pests and managing field crops. The researchers recommended giving training programs for agricultural employees and improving the digital infrastructure in agricultural areas.*

Keywords: *Artificial Intelligence, Extension Services, Agricultural Employees*

INTRODUCTION

Agriculture and agricultural development are among the main pillars of achieving economic growth and social stability in developing countries, where a large portion of their population depends on agriculture as a primary source of livelihood. These countries face multiple challenges in the agricultural sector, including scarcity of resources and climate change, which makes it necessary to adopt reform policies to enhance agricultural productivity. This helps attain food security and reduce poverty rates, improving sustainability and holistic development. (Abdullah,. 2021) Agriculture is a key sector in Iraq; representing a large section of the population, this sector is a primary livelihood. However, this agricultural reality in Iraq has many challenges. (Abdulla, & Yosif, 2014) The whole world has witnessed amazing development during the last couple of decades in the sphere of technologies and digital innovativeness, where artificial intelligence emerged prominently in achieving the never-before-witnessed Information Revolution. At the moment, artificial intelligence forms a core part of driving innovations in all fields, emphasizing agriculture, one of the most important sectors of the economy in any country. Applications based on artificial intelligence improve the effectiveness of agriculture, raising

its productivity and reducing environmental risks by offering several innovative solutions regarding managing agricultural resources, pest control, and finding the optimal time to plant and harvest crops. Many studies have shown that the use of artificial intelligence technologies in agriculture leads to a significant improvement in efficiency and productivity. The technologies help farmers improve agricultural decision-making, reduce waste, and increase returns. Artificial intelligence applications, which heavily depend on limited natural resources, can improve how these resources are used and reduce their loss. (Nardev Singh, 2020)

Inside such a framework, it will, therefore, be convenient to define artificial intelligence as all those systems and software combined that are able to consult huge databases of agricultural statistics, including meteorological phenomena, soil types, moisture, and many such factors, to drive action or provide advice based on the data. For example, applications in artificial intelligence can provide accurate advice on planting and harvesting time based on analysis of climate data or decisions concerning the best irrigation methods according to soil moisture and crop needs. (Al-Mahab & Eid 2023) With the increase in population, climate change, and degradation of the environment, the need for more efficiency and innovation in agriculture becomes an urge for those concerned with this sector. Here comes the role of technology, especially artificial intelligence applications, in supporting agricultural decisions. Artificial intelligence is increasingly used to improve agricultural advisory services by analyzing statistical data related to land, climate, crops, and pests and providing accurate recommendations to farmers on best agricultural practices. Therefore, this technology has become a strategic partner in improving agricultural performance and providing solutions to farmers' daily intractable problems. (Faiza, 2021) In this context, there is increasing interest in understanding how artificial intelligence can improve agricultural extension services and how agricultural employees view these applications as front-line workers in providing these services to farmers. From this angle, it will be relevant to explore agricultural workers' perceptions of the introduction of artificial intelligence in the provision of extension services to understand the level of acceptance of the challenges they face and the opportunities that can be tapped to enhance the effectiveness of these applications in boosting agricultural productivity. The effectiveness of artificial intelligence applications in agricultural extension service delivery is highly dependent on the willingness of personnel in the agricultural sector to adopt this new-age technology. On the other hand, these applications require a certain level of technical expertise to operate and interpret their outcomes effectively. On the other hand, agricultural employees must be convinced that this technology will improve the quality of the extension work they provide and make their tasks more effective and less complex. Therefore, there is a need to examine the preparedness of these workers to embrace artificial intelligence technologies and the complications they are likely to encounter. (Al-Dulaimi. 2023)

Agricultural extension services are a means of improving agricultural productivity and securing food. (Ahmed & A. 2016) These services are a primary means of transferring knowledge and modern technological innovations from agricultural research institutions to farming communities. Farmers, through these services, receive critical advice on best agricultural practices, including appropriate crop selection, modern irrigation techniques, pest management, and other important agricultural issues. (Shada & Abdullah, 2023) However, their efficacy depends on how the information and data are brought effectively and quickly to farmers. (Amin & Ali, 2021) In this scenario, AI becomes one of the technological tools that improves efficiency and effectiveness in providing such services. While the field of artificial intelligence for applications has developed rapidly, and huge numbers of tools can contribute to increasing the productivity of agriculture, there are tremendous barriers to implementing artificial intelligence in the agricultural sector. There is a huge difference between this technology's theoretical and actual uses throughout many rural and agricultural regions in Iraq. Several factors will impede the effective adoption of this technology, including the limited knowledge of technology among the farmers and agricultural workforce (Mohammed, 2024). Agricultural extension services are integral to sustaining agriculture and increasing crop production. However, human resource, infrastructural, and technological challenges prevent the effective delivery of such services (Hamed & Abdullah 2024).

On the other hand, the role of agricultural personnel could be of major importance in the efficient use of artificial intelligence technologies. As an intermediary between technological innovation and the agricultural practitioner, he will inform and train the farmer to effectively utilize the technology involved. Accordingly, agricultural personnel will introduce agricultural knowledge and technical know-how to farmers, providing a vital link between the farmers and modern technology developments. (Ibrahim et al, 2024) Few studies have investigated their perceptions of artificial intelligence applications in providing agricultural extension services. Tikrit District, one of the districts of Salah al-Din Governorate, is considered one of the main agricultural areas in Iraq. The region is characterized by natural resources supporting agriculture; hence, it is considered an important venue for applying artificial intelligence technology. With the rapid development witnessed by the world in the field of artificial intelligence technologies, there is increasing interest in studying the views of agricultural employees in this region on the use of these technologies, what obstacles they face, and what are their prevailing perceptions about the ability of these applications to provide agricultural advisory services. These employees are considered the link between farmers and technology, and the research came to answer the following question:

- What is the role of artificial intelligence applications in providing extension services from the point of view of agricultural employees in Tikrit District / Salah al-Din Governorate?

Research objectives:

- The first objective: To identify the role of artificial intelligence applications in providing extension services from the point of view of agricultural employees in Tikrit District / Salah al-Din Governorate in general.
- The second objective: To identify the role of artificial intelligence applications in providing extension services from the point of view of agricultural employees in Tikrit District / Salah al-Din Governorate in each of the following fields: (climate and weather applications, crop management applications, e-shopping applications, social communication, area measurement programs, plant disease, and pest control applications).
- The third objective: To find the correlation between the role of artificial intelligence applications in providing extension services from the point of view of agricultural employees in Tikrit District / Salah al-Din Governorate and each of the following variables: (age, educational attainment, training courses, specialization, number of years of service, sources of obtaining information).

Research methodology:

The research relied on the descriptive approach, which focuses on describing and collecting information about a specific phenomenon. Then, the characteristics of that phenomenon, its interpretation, and the factors affecting it are analyzed.

Study population and sample:

The research population included (the Directorate of Agriculture in Tikrit District, the Tikrit Agriculture Division, and the Extension Center in Tikrit District). The number of agricultural employees in the research community was (101) employees. A random sample of 80% was selected proportionally so that the number of respondents who underwent the research procedures became (81) employees, as shown in Table No. 1:

Table No. (1) Research population and sample

Administrative Formation	Number of employees	Research sample
Directorate of Agriculture	70	56
Tikrit Agriculture Department	13	10.4
Extension Center	18	14.4
total	101	81

***Preparing the questionnaire in its initial form*:**
The questionnaire was prepared in its initial form by reviewing scientific sources and previous studies and seeking the help of experts and specialists. It was formulated according to the study problem and in light of its objectives and the type of data consistent with it to achieve the study objectives. The questionnaire consisted of two main parts to collect research data:

- Part One: The first part of the questionnaire includes a set of questions related to the personal and social aspects of the respondents, namely: (age, academic achievement, training courses, specialization, number of years of service, sources of obtaining information).

- Part Two: The scale consists of (42) paragraphs that are answered in the form of a three-point scale (major role, average role, weak role) distributed over six main areas related to the field of artificial intelligence, as shown in Table No. (2):

Table No. (2). Distribution of research paragraphs according to areas

The field	Number of paragraphs
1- Climate and weather applications	7
2- Crop management applications	7
3- E-shopping applications	7
4- Social communication	7
5- Area measurement programs	7
6- Plant disease and pest control applications	42 paragraphs
Total paragraphs in the fields	Number of paragraphs

Initial test (Pre-test):
The questionnaire was presented to a random sample of the research community of (10) respondents to extract the stability and validity coefficient. The Cronbach alpha method was used to find the stability. The stability coefficient value was (0.86) and the validity coefficient value was (0.92).

Measuring the dependent variable
The role of artificial intelligence applications was measured through (42) paragraphs, each representing information about artificial intelligence applications in the agricultural field. Answer alternatives were placed in front of each section (major role, medium role, weak role), and the following numbers were given (1-2-3) respectively. Thus, the total scale response scores ranged between (42-126) degrees.

Statistical methods:
The data must be tabulated and analyzed to achieve the research objectives, and the results must be reached and presented in their final form. The following statistical methods were used: (percentage, frequency, standard deviation, range, average, Spearman correlation coefficient, Pearson correlation coefficient, and t-test.

Results and discussion
First objective: To identify the role of artificial intelligence applications in providing extension services

from the point of view of agricultural employees in Tikrit District / Salah al-Din Governorate in general.

The results showed that the lowest degree expressing the role of artificial intelligence applications was (42) degrees, and the highest degree was (126). The respondents were divided into three categories according to the theoretical range, as shown in Table (3).

Table No. (3) Categories of the role of artificial intelligence applications in general

Categories	Number	%	Overall average	s.d
(42-69) Weak	23	28.40	95.43	8.21
(70-97) Medium	41	50.61		
(98-and above) High	17	20.99		
Total	81	100%		

From Table (3), it is clear from the results that 50.61% of the respondents are in the middle category, followed by the weak category with a percentage of 28.40%, so the role of artificial intelligence applications is described as medium tending to weak, and this may be due to several factors. Artificial intelligence applications may not be widely available or not used extensively in agricultural areas, which limits their ability to have an actual impact on agricultural extension. In addition to the weak infrastructure in agricultural regions, such as high-quality internet networks, the availability of modern devices, and high costs, the available agricultural data may be insufficient or inaccurate, which limits the efficiency of these applications in providing agricultural extension. Figure 1 shows the percentage of each role category in general.

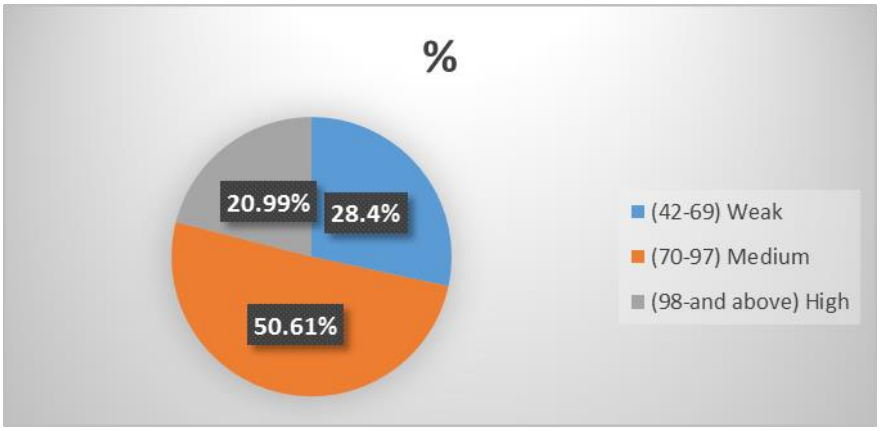

Figure 1: Percentage of role categories

Second objective: Identify the role of artificial intelligence applications in providing extension services from the point of view of agricultural employees in Tikrit District / Salah al-Din Governorate in each of the following fields: (climate and weather applications, crop management applications, e-shopping applications, social communication, area measurement programs, plant disease, and pest control applications).

First: Climate and weather applications

The results showed that the lowest degree expressing the role of artificial intelligence applications in climate and weather was (7) degrees. The highest degree was (21), and the respondents were divided into three categories according to the theoretical range, as shown in Table (4):

Table No. (4) Categories of the role of climate and weather applications

Categories	Number	%	Overall average	s.d
(7-11) Weak	14	17.29	14.2	2.43
(12-16)	38	46.91		

Medium				
(17-21) High	29	35.80		
Total	81	100%		

It is clear from Table (4) above that 46.91% of the respondents are in the medium category, followed by the large role category with a percentage of 35.80%. Therefore, the size of artificial intelligence applications' role in climate and weather is described as medium to large. This may be because the applications provide climate information and weather data that support agricultural decisions, such as determining the appropriate times for planting, irrigation, fertilization, and harvesting. However, some challenges still hinder reaching full effectiveness, such as the need for greater accuracy in forecasts and more frequent local data updates. This evaluation may also reflect the desire of employees to improve the characteristics of these applications to better meet their needs in agricultural extension.

Second: Crop management applications

The results showed that the lowest degree expressing the role of artificial intelligence applications in crop management was (7) degrees, and the highest degree was (21). The respondents were divided into three categories according to the theoretical range, as shown in Table (5):

Table No. (5) Categories of the role of crop management applications

Categories	**Number**	%	**Overall average**	**s.d**
(7-11) Weak	38	46.91	12.12	2.11
(12-16) Medium	30	37.04		
(17-21) High	13	16.05		
Total	81	%100		

It is clear from Table (5) above that 46.91% of the respondents fall within the weak role category, followed by the medium role category with a percentage of 37.04%. Therefore, the size of artificial intelligence applications' role in crop management applications is described as weak. This is due to the difficulty of understanding technical recommendations, the lack of accurate and updated data on crops, soil, and local climatic conditions, technical challenges, and lack of training, which limits the effectiveness of these applications in guiding farmers on field crop management.

Third: E-shopping applications

The results showed that the lowest degree expressing the role of artificial intelligence applications in e-shopping applications is (7) degrees, and the highest degree is (21). The respondents were divided into three categories according to the theoretical range, as shown in Table (6):

Table No. (6) Categories of the role of e-shopping applications

Categories	**Number**	%	**Overall average**	**s.d**
(7-11) Weak	27	33.33	13.45	1.98
(12-16) Medium	40	49.38		
(17-21) High	14	17.29		
Total	81	%100		

It is clear from Table (6) above that 49.38% of the Respondents fall within the average role category, followed by the weak role category with a percentage of 33.33%. Therefore, the size of artificial intelligence applications' role in e-shopping applications is described as average, as these applications provide good assistance to farmers in choosing and purchasing agricultural products, such as fertilizers and seeds, based on customized recommendations and crop needs. However, this average role may reflect certain challenges, such as the lack of diversity in the products offered or difficulty accessing

sufficient information about suppliers and quality. Additional development may also need to improve the e-shopping experience and facilitate decision-making based on more accurate data and comprehensive farmer recommendations.

Fourth: Social media programs

The results showed that the lowest degree expressing the role of artificial intelligence applications in the field of social media applications is (7) degrees, and the highest degree is (21), and the respondents were divided into three categories according to the theoretical range, as shown in Table (7):

Table No. (7) Categories of the role of social media applications

Categories	Number	%	Overall average	s.d
(7-11) Weak	17	20.99	14.6	3.11
(12-16) Medium	35	43.20		
(17-21) High	29	35.81		
Total	81	%100		

It is clear from Table (7) above that 43.20% of the respondents are in the medium role category, followed by the large role category with a percentage of 35.81%. Therefore, the size of the role of artificial intelligence applications in social communication is described as medium tending to large. This is attributed to the ability of these applications to facilitate the exchange of information and knowledge about the latest agricultural practices, share useful recommendations, and solve agricultural problems quickly. These applications also provide an interactive platform to connect farmers and agricultural experts, contributing to building a knowledge community and continuous support. In addition, artificial intelligence algorithms help provide customized content based on the needs and circumstances of farmers, making these applications an effective and valuable tool in agricultural extension.

Fifth: Area measurement applications

The results showed that the lowest degree expressing the role of artificial intelligence applications in the field of land area measurement applications is (7) degrees, and the highest degree is (21), and the respondents were divided into three categories according to the theoretical range, as shown in Table (8):

Table No. (8) Categories of the role of area measurement applications

Categories	Number	%	Overall average	s.d
(7-11) Weak	33	40.74	11.43	2.61
(12-16) Medium	28	34.56		
(17-21) High	20	24.70		
Total	81	%100		

It is clear from Table (8) above that 40.74% of the respondents fall into the weak role category, followed by the medium role category with a percentage of 34.56%. Therefore, the size of the role of artificial intelligence applications in measuring land area is described as weak. This may be because these applications may not be able to consider the various characteristics of the land, such as terrain and different divisions. In addition, farmers may face difficulty in using these applications due to a lack of training or the complexity of their interfaces, which makes them less dependent on them. The lack of accurate geographic data updates may also negatively affect the applications' efficiency, limiting their usefulness in providing precise extensions to farmers.

Sixth: Applications for combating plant diseases and pests

The results showed that the lowest degree expressing the role of artificial intelligence applications in the field of applications for combating plant diseases and pests is (7) degrees, and the highest degree is

(21), and the respondents were divided into three categories according to the theoretical range, as shown in Table (9):

Table No. (9) Categories of the role of applications for combating plant diseases and pests

Categories	Number	%	Overall average	s.d
(7-11) Weak	43	53.08	11.11	1.78
(12-16) Medium	22	27.16		
(17-21) High	16	19.76		
Total	81	%100		

It is clear from Table (9) above that 53.08% of the respondents fall within the category of weak role, so the size of the role of artificial intelligence applications in combating plant diseases and pests is described as weak. This may be due to the limited accuracy of the applications in diagnosing diseases and identifying pests correctly or providing effective and appropriate solutions for local conditions. The lack of accurate data on the types of diseases and pests that affect plants in certain areas may reduce the effectiveness of these applications. In addition, agricultural employees may face difficulty using these applications due to their complexity or lack of training, which hinders their full benefit from providing the necessary extension for combating pests.

Objective Three: Finding a correlation between the role of artificial intelligence applications in providing advisory services from the point of view of agricultural employees in Tikrit District / Salah al-Din Governorate and each of the following variables: (age, educational attainment, training courses, specialization, number of years of service, sources of obtaining information). The correlation between the role of artificial intelligence applications and the personal independent variables of employees was identified by extracting the value of the correlation coefficient, as shown in Table 10 below:

Table No. (10): Shows the distribution of respondents according to the categories of personal independent variables

Variable name	Categories	Number	%	Average role	R-value	Significance
Age	25-34 years	32	39.5	99.9	-0.39	Negatively Significant
	35-44 years	30	37.04	89.2		
	45-54 years	19	23.46	77.9		
	Total	81	%100			
Academic achievement	Agricultural Preparatory School	11	13.59	76.9	0.37	Positively Significant
	Diploma in Agriculture	15	18.51	85.8		
	Bachelor's Degree in Agriculture	45	55.56	92.4		
	Postgraduate Degree	10	12.34	104.2		
	Total	81	%100			
Training Courses	Participant	23	28.39	103.5	0.32	Positively Significant
	Not participating	58	71.61	93.6		
	Total	81	%100			
Specialization	Extension Specialization	16	19.76	103	0.42	Positively Significant
	Non-Extension Specialization	65	80.24	90.8		
	Total	81	%100			
Number of	3 – 13 years	41	50.62	99.4	-0.41	Negatively

years of service	14- 24 years	20	24.69	89.5		Significant
	25 – 35 years	20	24.69	78.6		
	Total	81	%100			
Information sources	Low (5 - 8)	38	46.92	80.5	0.36	Positively Significant
	Medium (9 - 12)	23	28.39	90.8		
	High (13 - and above)	20	24.69	101		
	Total	81	%100			

Table (10) shows the correlation between the role of artificial intelligence applications and the independent variables listed below:

- Age: The results showed that the young age group (25-34) had the highest percentage, and to find a correlation between the role of artificial intelligence applications and age, Pearson's correlation coefficient was used, which reached a value of (0.39-), an inverse significant relationship. This may be attributed to the fact that older employees tend to rely on traditional methods in agricultural work or may find it difficult to adapt to modern technologies. In comparison, younger employees may be more receptive and use technology. This difference may affect the evaluation of the role played by artificial intelligence applications in agricultural extension.

- Educational attainment: The results showed that 55.56% of the respondents had bachelor's degrees, the highest percentage of all the participants. Spearman's rank correlation coefficient was used to determine the strength and nature of the correlation between the use of artificial intelligence applications and academic levels, and it was found to be 0.37, which indicates a significant association. This is probably because people with higher education have more awareness and knowledge about technology and how it would help increase productivity. Thus, those with higher qualifications are even more open to using such applications and understanding how the software works. Employees with lower academic qualifications face some difficulties using these apps or may prefer traditional methods, which decreases their eagerness to accept technology transfer for agricultural activities.

- Participation in training courses: The results showed that 71.61% of respondents never participated. To find the relationship between the impact of artificial intelligence applications and training course participation, Spearman's correlation coefficient was applied, and the value of (0.32) was found, thus indicating a positive and significant relationship. This suggests that those employees who have received training programs on the understanding of technology and artificial intelligence attach a higher regard toward the role of these apps. Participation in the above training programs enables them to develop professional knowledge and skills of useful implementation for better work appreciation. On the other hand, those employees who have not attended such courses might find it difficult to use the technology. Thus, their perception of its importance in agricultural extension is reduced.

- Specialization: The results showed that 80.24 % of the respondents are not specialized in agricultural extension, and to find a correlation between the role of artificial intelligence applications and specialization, Spearman's correlation coefficient was used, which reached a value of (0.42), which is a positive significant relationship. This is because agricultural extension specialists have a deeper understanding of the requirements of extension work and how modern technologies, such as artificial intelligence, can improve it. Their experience also makes them more able to see the practical benefits of these applications in facilitating agricultural extension and extension processes and supporting farmers effectively.

- Number of years of service: The results showed that 50.62% of the respondents are in the low category, and the correlation between the role of artificial intelligence applications and years of

service was not found. Pearson's correlation coefficient was used, reaching (0.41-), an inverse significant relationship. This may be because employees with long experience often rely on traditional methods in agricultural work and feel more comfortable with the usual methods, which makes them less receptive to new technologies. In contrast, new employees with less experience but are more flexible towards technological developments tend to see a greater role and higher importance of artificial intelligence applications in agricultural extension.

- Information sources: The results showed that 46.92% of the respondents are in the low communication category, and the correlation between the role of artificial intelligence applications and communication was not found. Spearman's correlation coefficient was used, which reached (0.36), which is a positive significant relationship. This is because the availability of information sources facilitates the effective use of artificial intelligence applications, as they can access accurate and updated data to support their extension decisions. Employees connected to information sources also see the value of these applications in improving extension efficiency and providing informed, data-driven recommendations, increasing their appreciation for their role.

Conclusions: Based on the research results, the following conclusions were reached:

- The results showed that the role of artificial intelligence applications is average and tends to decrease. We conclude from this that artificial intelligence applications are not widely available or are not used intensively in agricultural areas.

- The results showed that artificial intelligence applications showed greater effectiveness in some areas, such as providing weather information. At the same time, their role was weak in other areas, such as diagnosing pests and managing field crops. This disparity is attributed to the different needs of each area and the availability of data and technical support for each type of application, which highlights the need to develop applications dedicated to meeting the diverse agricultural needs in Tikrit District.

- The results showed a significant correlation between the role of artificial intelligence applications from the point of view of agricultural employees and each of the following variables: (age, educational attainment, training courses, specialization, number of years of service, sources of obtaining information). We conclude from this the importance of these variables and that they affect determining the role of artificial intelligence applications.

Recommendations: Based on the findings of this study, the researchers recommend the following:

- Providing training programs for agricultural employees: It is recommended that specialized training courses be organized to familiarize agricultural employees with using artificial intelligence applications in agricultural extension, focusing on pest diagnosis and crop management applications, to ensure increased efficiency in modern technology.

- Improving the digital infrastructure in agricultural areas: It is recommended that the digital infrastructure in Tikrit District be enhanced by providing a strong internet connection and suitable devices to facilitate the effective use of artificial intelligence applications and improve access to modern agricultural information.

- Developing an accurate local database: It is recommended that an updated local database that includes information on crops, diseases, and climatic conditions in the Tikrit region be created so that artificial intelligence applications can benefit from this data and provide accurate and customized extension recommendations that suit the needs of farmers in the area.

Author Contributions
All Authors contributed equally.

Conflict of Interest
The authors declared that no conflict of interest.

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