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LEVEL APPLICATION OF GROWERS TO SMART FARMING TECHNIQUES TO CONFRONT CLIMATE CHANGE

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ABSTRACT

The research aims to measure the level of application of growers to smart farming techniques to confront climate change. The study population included all farmers in Sheikhhan district, totaling 300 farmers. A simple random sample of 40% was selected, resulting in 120 respondents. A questionnaire form consisting of three parts was developed. The first part included the independent variables: age, educational attainment, land area, type of land tenure, and participation in training courses. The second part comprised 50 items to measure the application level, using a three-point scale with three options: (applied extensively, applied moderately, not applied), with weights assigned as (3, 2, 1) accordingly. The third part aimed to identify the problems hindering the application of smart agriculture techniques. Data were collected through personal interviews. Subsequently, the data were coded and prepared for statistical analysis using SPSS software. The results indicated that 69.2% of respondents had a weak application level. Additionally, the results revealed a significant correlation between the independent variables (attitude toward applying smart agriculture, access to information sources, participation in extension activities) and the application level. However, no significant correlation was found between age or educational attainment and the application level. The issue of high costs ranked first with the highest percentage (2.63%). The researcher recommends attracting capital investments into smart agriculture and establishing dedicated communication channels related to food security.

INTRODUCTION

Due to the increase in the global population compared to previous years, concerns have grown regarding farmers' ability to provide food and ensure food security for populations while preserving agricultural land and preventing its depletion, particularly with the rise in climate change issues. (Mohammed and Jbara, 2024) Traditional agriculture cannot meet the increasing demand for food production and manage natural resources sustainably while protecting the environment. Smart agriculture has emerged as one of the solutions to these challenges (Noor *et al*., 2023), offering an approach that can be relied upon to confront climate change affecting farmers while ensuring environmental protection, rationalizing natural resource use, and reducing harmful emissions (Abdul Rahman and Yüksel, 2018). This is especially relevant since climate change has already become a reality that affects Iraqi agriculture, with reduced and fluctuating rainfall and high temperatures. (Barba, *et al.*, 2025).

The agricultural sector in Iraq faces climate-related challenges due to climate change, which exacerbates issues such as drought, water scarcity, and increased extreme weather events (Ruqayya and Sattam, 2023). Addressing these challenges requires strategies aimed at improving water resource management and increasing awareness of the importance of adapting to climate changes (Hajar *et al*., 2024), The term "Climate-Smart Agriculture" was first introduced in 2010 during the Agriculture, Food Security, and Climate Change conference in The Hague, where the Food and Agriculture Organization (FAO) of the United Nations presented the concept (FAO, 2018). It was formally adopted as an integrated approach covering all agricultural production aspects (animal and plant) (Zaza *et al*., 2022). Climate-Smart Agriculture is considered a tool for identifying agricultural production systems best suited to environmental conditions in the context of climate change, guiding necessary actions to restructure farming systems and support agricultural development (Brouziyne *et al*., 2023). The concept of climate-smart agriculture represents a reliable approach to addressing the climate challenges impacting agriculture and farmers (Arslan *et al.,* 2021). The upcoming agricultural revolution relies on science and technology to achieve high, environmentally safe productivity, helping to regulate the use of fertilizers and pesticides while conserving water (Hamdaoui *et al*., 2024). Traditional agriculture in Iraq faces numerous problems related to climate change, fertilizer and pesticide consumption, and water scarcity, which presents a serious challenge to achieving self-sufficiency (Mowla *et al*., 2023), Climate-smart agriculture is one of the means to determine the most appropriate production systems to combat climate change challenges in Iraq (Sulaiman *et al*., 2024) (Khalaf, 2024). It aims to direct agricultural systems to support agricultural development and food security in light of a changing climate by sustaining agricultural production, increasing income(Al-Tamimi and Al-Badri, 2023), reducing the depletion of natural resources, and conserving water (Bouabdelli *et al*., 2023). The role of agricultural extension emerges through activities, programs, and efforts aimed at developing the agricultural sector and rural development by addressing climate change challenges and adapting production systems. To achieve this, applying Smart Agriculture Technologies (Salih, 2018) is essential.

Research Objectives

Objective 1: To identify the application level of growers to smart farming techniques to confront climate change.

Objective 2: To identify the relationship between the level application of growers to smart farming techniques to confront climate change and the independent variables, which include (age, educational attainment, type of land tenure, attitude toward applying smart agriculture techniques to adapt to climate change, access to information sources, participation in extension activities).

Objective 3**:** To identify the problems growers face while implementing smart agriculture techniques.

MATERIALS AND METHODS

Research Area

The research was conducted in the Nineveh Governorate, specifically in the Sheikhan district, which is known for cultivating crops such as potatoes, tomatoes, cucumbers, wheat, and barley.

Study Population and Sample

The descriptive approach was adopted for this research as it is suitable for identifying the factors associated with the level of application of climate-smart agricultural techniques for adapting to climate change in the Sheikhan district, Nineveh Governorate. The study population consisted of all farmers in the Sheikhan district, numbering (300) farmers (Elsahookie and Dawood, 2024). A total of 30 farmers were excluded to measure the scale's reliability, and a proportional random sample (40%) was selected, resulting in a sample size of 120 farmers. To collect data, a questionnaire was designed to measure the application of climate-smart agricultural techniques for adapting to climate change in the Sheikhan district. The questionnaire was divided into three sections:

- The first section aimed to gather personal characteristics such as age, education level, land area, land ownership type, and training courses.
- The second section included 50 items to measure the application level using a three-point scale. Three alternatives were assigned to each item: "Applied to a large extent," "Applied to a moderate extent," and "Not applied," with corresponding weights of (1, 2, 3), respectively. The overall score for this scale ranged from 50 to 150 points (Ali and Fayyadh, 2025).
- The third section aimed to identify the main problems hindering the application of climate-smart agricultural techniques for adaptation to climate change in the Sheikhan district. For this section, the following alternatives were provided to measure the severity of these problems: "Major problem," "Moderate problem," "Minor problem," with weights of (3, 2, 1), respectively.

Variables and Measurement

Age: Measured in terms of the number of years the respondent lived during data collection.

Education Level: Measured by categorizing respondents as (illiterate, can read and write, primary school graduate, intermediate school graduate, secondary school graduate, technical institute graduate, college graduate) with the following assigned values: (1, 2, 3, 4, 5, 6). (Hasan, 2021)

Land Ownership Type: Measured by categorizing the type of land ownership as (ownership, contract, rental, partnership) with the following assigned values: (1, 2, 3, 4).

Towards the application of smart agriculture technologies: This variable was measured using eight items, divided into positive and negative statements, with alternatives such as (Agree, Neutral, Disagree). The following weights were assigned: (1, 2, 3), with a theoretical range for the attitude variable between (8,24).

Exposure to Information Sources: This variable was measured by identifying 11 sources of information related to climate-smart agriculture. Alternatives such as (Always, Sometimes, Rarely) were provided, with numerical values of (1, 2, 3), respectively. Identifying Barriers. The third section focused on identifying the barriers to applying climate-smart agricultural techniques in adapting to climate change in the Sheikhan district. A list of (10) potential barriers was provided, with the following alternatives to measure their severity: "Very large problem," "Large problem," "Moderate problem," "Minor problem," "No problem." Numerical values of (1, 2, 3, 4) were assigned to these alternatives.

RESULTS AND DISCUSSION

Objective 1: Identify the application level of growers to smart farming techniques to confront climate change.

The results showed that the application level of climate-smart agricultural techniques among farmers ranged from 65 to 124, with a mean of 106.4 and a standard deviation 10.8. The respondents were distributed according to the age variable. The highest percentage of respondents fell into the "low" category (Eskander *et al.*, 2023).

Table (1): Distribution of sample members according to Categories of Application Level of -Smart Agricultural.

Category	Number	Percentage (%)	Mean
Low (65-85)	85	69.2	111.3
Medium (86-106)	34	28.3	96.3
High (107 and above)	3	2.5	71.7
Total	120	100%	10.76 SD

As shown in the table, 69.2% of the respondents fell into the low category, while 28.3% fell into the medium category. Thus, (97.5%) they fall within the low and medium application levels, possibly due to respondents' lack of awareness of the importance of implementing smart agriculture in their fields and its high economic impact.

Objective 2: To identify the relationship between the level of application of growers to smart farming techniques to confront climate change and the independent variables .

The ages of the respondents ranged between 18 and 65 years, with an average of 37.56 years and a standard deviation of 12.40. The respondents were distributed according to the age groups ،with the highest percentage falling into the "high" category.

Table (2): Distribution of respondents according to Age Variable

Category	Number	Percentage (%)	Mean	r Value
Low (18-33)	40	33	108.61	-0.15
Medium (34-49)	12	10	109.59	
High (50 and above)	50	57	104.56	
Total	120	100%		

The correlation between the level of application of climate-smart agriculture and age was calculated using Pearson's correlation coefficient, which yielded a value of (-0.15), indicating no significant correlation. Therefore, the null hypothesis is accepted, suggesting that age does not influence the application level. This result is consistent with the findings of (Daqdoqa *et al*., 2013), (Talal *et al*., 2025). It does not agree with what he has reached (Hameed *et al*., 2025; Kadem, 2022).

Education Level

The respondents were categorized into six educational levels. The highest percentage of respondents fell into the "secondary school graduate" category.

Table (3): Distribution of Respondents According to Education Level

Category	Number	Percentage (%)	Mean	r Value
Illiterate	16	13.4	103.6	0.13
Can read and write	10	8.4	103.9	
Primary school	27	22.5	107.3	
Intermediate school	17	14.1	105.1	
Secondary school	39	32.5	110.03	
Bachelor's degree	11	9.1	100.7	
Total	120	100%		

Pearson's correlation coefficient was used to determine the correlation between the level of application and education level, yielding a value of 0.13, which is insignificant. Thus, the null hypothesis is accepted, meaning there is no significant relationship between the application and educational levels. This result may be explained by the fact that information about climate-smart agriculture is accessible to all farmers regardless of their education level. This finding is in line with (Kadhim, 2023), (Ahmed *et al*., 2021) and (Talal *et al*.,2024).

Type of Ownership

This variable was distributed into four categories, with the highest percentage falling under the "Lease" category, as shown in Table (4).

Table (4): Distribution of Respondents by Type of Ownership

No.	Categories	Number	Percentage (%)	Mean	r Value
1	Ownership	25	21	106	0.55
2	Lease	61	51	108	
3	Contract	28	23	102	
4	Partnership	6	5	111	
Total		120	100%		Non-significant

There was no significant correlation between the ownership type and the application level of smart agricultural technologies for climate change adaptation. Spearman's rank correlation coefficient was 0.55, indicating no significant relationship. This is because the ownership type does not significantly affect farmers' adoption of smart agriculture technologies.

Attitude Toward the Application of Smart Agriculture

The research findings revealed that the respondents' attitudes ranged between 8 and 24, with a mean of 18 and a standard deviation of 3.95. Using the range law, the respondents were classified into three categories, with the highest percentage falling within the positive attitude category, as shown in Table (5).

Table (5): Classification of Respondents by Attitude Toward Smart Agriculture

No.	Categories	Number	Percentage (%)	Mean	r Value
1	Negative (8-12)	10	8	87.24	0.40
2	Neutral (13-17)	20	17	102.13	
3	Positive (18 and above)	90	75	109.54	
Total		120	100%		Significant*

Pearson's correlation was used to examine the correlation between the attitude toward smart agriculture and the application level of smart agricultural technologies for climate change adaptation, yielding a value of 0.40. Indicates a relationship at the (0.01) level, leading to the rejection of the null hypothesis and the acceptance of the alternative hypothesis. This is because respondents with a positive attitude are more likely to seek knowledge and information about smart agriculture, thus increasing their awareness. This result aligns with the findings of (Al-Mufreji, 2018) and (Talal *et al.*, 2023).

Exposure to Information Sources

The results showed that the respondents were exposed to 15 to 29 information sources, with a mean of 20.5. Using the range law, the respondents were classified into three categories, with the highest percentage falling within the medium category, as shown in Table (6).

Table (6): Distribution of Respondents by Exposure to Information Sources

No.	Categories	Number	Percentage (%)	Mean	r Value
1	Low (15-20)	25	12.5	105	0.42
2	Medium (21-26)	64	61.7	107.7	
3	High (27and above)	31	25.8	111.8	
Total		120	100%		Significant*

To examine the correlation between exposure to information sources and the level of application of smart agricultural technologies for climate change adaptation, Pearson's correlation coefficient was used, yielding a value of 0.42. This indicates a significant relationship at the 0.01 level, leading to the acceptance of the alternative hypothesis and the rejection of the null hypothesis. The findings suggest that the information sources exposed to the farmers have substantially impacted their adoption of modern agricultural practices, which contradicts the findings of (Talal and Mohammed, 2022). And it agrees with what he reached (Mijda *et al.*, 2022) and (Hameed and Sawicka, 2023).

Participation in Extension Activities

The results showed that the values for participation in extension activities ranged from 0 to 24, with a mean of 7.87. The respondents were distributed into three categories, with the highest percentage in the moderate participation category, as shown in Table (7).

The table indicates a significant correlation between participation in extension activities and the application level of smart agricultural technologies for climate change adaptation ($p < 0.01$). As a result, the null hypothesis is rejected, and the research hypothesis is accepted. This suggests that as respondents' participation in extension activities increases, their knowledge and ability to adopt and implement modern agricultural technologies also improve. this agrees with (Hameed and Abd AlFaraje, 2024).

Table (7): Distribution of Respondents by Participation in Extension Activities

No.	Categories	Percentage (%)	Mean	r Value
1	Low (0-8)	31	26	0.41
2	Medium (9-17)	66	55	
3	High (18 and above)	23	19	
Total		120	100%	Significant*

Objective 3: To identify the problems faced by growers during the implementation of smart agriculture techniques.

Table (8) Arranges farmers' problems when applying smart agriculture techniques to confront climate change.

Table (8): Problems Faced by Farmers in Applying Smart Agriculture Technologies for Climate Change Adaptation

No.	problems	Size of the Problem	Very Large	Large	Medium	None	Mean Value	Rank
1	High Costs	18	50	44	6	4	2.63	1
2	Lack of Raw Materials	36	17	37	27	3	1.64	5
3	Lack of Information	10	36	46	23	5	1.52	7
4	Weak Extension Services	19	20	50	18	13	2.46	2
5	Lack of Government Support	2	18	55	25	20	1.59	6
6	Weak Financial Resources	2	28	31	37	22	1.13	9
7	Low Awareness of Climate Variables	8	26	29	15	41	2.19	3
8	Weak Agricultural Loans	2	20	37	35	26	2.11	4
9	Lack of Experience with Technology	10	8	21	30	51	1.48	8
10	Difficulty in Adapting to Rapid Climate Change	4	16	16	20	64	0.97	10

The table above shows that the most significant challenge was high costs, with a mean score of 4, indicating that this obstacle is the most critical barrier to adopting smart agriculture technologies. On the other hand, difficulty in adapting to rapid climate changes ranked last with a mean score of 8, suggesting that it is considered less of an obstacle.

CONCLUSIONS

Respondents generally applied climate-smart agriculture less frequently. High financial costs were a key barrier to adoption. Greater reliance on agricultural information sources improves awareness and knowledge, leading to faster and more effective application.

Recommendations

1. Attract investment in smart agriculture and create special communication channels with the food security.
2. It is essential to establish a department within agricultural offices that focuses on applying technology and artificial intelligence systems in agriculture.
3. Continue conducting research and studies on smart agriculture to improve the agricultural sector in Iraq.
4. Suggesting the need for government support to encourage adoption.

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CONFLICT OF INTEREST

The authors state that there are no conflicts of interest with the publication of this work.

مستوى تطبيق المزارعين لتقنيات الزراعة الذكية لمواجهة تغيّر المناخ في نينوى

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الخلاصة

هدفت الدراسة إلى قياس مستوى تطبيق المزارعين لتقنيات الزراعة الذكية لمواجهة التغيرات المناخية. شملت الدراسة جميع المزارعين في قضاء الشيخان، وعددهم 300 مزارع، وتم اختيار عينة عشوائية بنسبة 40%، أي 120 مزارعًا. تم إعداد استبيان مكون من ثلاثة أجزاء: الجزء الأول يتضمن المتغيرات المستقلة مثل العمر، التحصيل العلمي، مساحة الأرض، نوع الملكية، والمشاركة في الدورات التدريبية. الجزء الثاني يتكون من 50 بندًا لقياس مستوى التطبيق باستخدام مقياس ثلاثي الخيارات (مطبق بشكل كبير، معتدل، غير مطبق) مع أوزان (3، 2، 1). الجزء الثالث يهدف إلى تحديد المشكلات التي تعيق تطبيق تقنيات الزراعة الذكية، وجُمعت البيانات عبر مقابلات شخصية، ثم تم معالجتها إحصائيًا باستخدام برنامج SPSS. أظهرت النتائج أن 69.2% من المزارعين يمتلكون مستوى ضعيف في التطبيق. كما أظهرت النتائج وجود علاقة دالة إحصائيًا بين المتغيرات المستقلة (الموقف تجاه الزراعة الذكية، مصادر المعلومات، المشاركة في أنشطة التوعية) ومستوى التطبيق، في حين لم توجد علاقة ذات دلالة إحصائية بين العمر أو التحصيل العلمي ومستوى التطبيق. وتصدرت مشكلة التكاليف العالية المشكلات بنسبة أعلى بلغت 2.63%. يوصي الباحث بجذب الاستثمارات المالية نحو مجال الزراعة الذكية وتطوير قنوات اتصال مخصصة مع صناعة الأغذية لضمان الأمن الغذائي.

الكلمات المفتاحية: مستوى التطبيق، الزراعة الذكية، التنمية المستدامة، التغير المناخي.

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