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The Level Of Knowledge Of Farmers In Kirkuk Governorate On The Use And Maintenance Of Solar Energy Systems In Agriculture

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Abstract
The research aims to identify the level of knowledge of farmers in Kirkuk Governorate about the use and maintenance of solar energy systems used in agriculture, as well as to identify their personal and socio-economic characteristics and their relationship with their level of knowledge about the use and maintenance of solar energy systems. The researchers used the descriptive method to achieve the research objectives, the research included all farmers who own solar energy systems for agricultural purposes in Hawija district in Kirkuk governorate, the number of farmers (514) according to the records of the owners of solar energy systems supply offices in the region, a simple random sample of them was selected by (10%), thus the number of farmers in the research sample became (52) farmers, a test consisting of 20 questions in multiple choice format was prepared to measure the level of knowledge of farmers about the use and maintenance of solar energy systems for agricultural purposes, as well as knowing their distinctive characteristics, data was collected and analyzed using a number of tools. The results showed that (71.2%) of the farmers had a high level of knowledge about the use and maintenance of solar energy systems in agriculture, the average farmers age was (44.32) years, (75%) of them are married and the average number of family members is more than (6) members, (61. It was also found that the average size of the land they own is (70.84) dunums IQ, and although the average number of years of their work in agriculture reached (21.04) years, the duration of their ownership of solar energy systems did not exceed two years, and (29.79) of them have more than two solar energy systems. The results also showed that there is no significant correlation between the level of farmers' knowledge of the use and maintenance of solar energy systems and the studied variables.
Keywords: *Solar energy, irrigation pumps, knowledge level, horsepower.*

INTRODUCTION

Sustainable development is one of the key elements of building prosperous societies that are able to meet the needs of the present without affecting the opportunities of future generations. Within this framework, agriculture stands out as a key element to achieve this goal, as its role is not only limited to ensuring food security, but also extends to increasing GDP, creating jobs, and enhancing rural livelihoods [1,2]. With the increasing challenges on natural resources and climate change, it has become necessary to adopt sustainable agricultural methods that improve resource efficiency and protect the environment. In recent years, there has been a global shift towards searching for new and sustainable energy sources to address the shortage and high cost of fossil fuels, as well as the negative environmental impact associated with their use. In this context, renewable energy sources, especially solar energy, represent an exciting strategic option, given their abundant availability in multiple regions of the world, including Iraq, which enjoys rich solar radiation throughout the year [3].

Solar energy is an attractive option for the agricultural sector, as it can be employed in irrigation systems, water pumping, greenhouse heating, and crop drying, which enhances indirect dependence on diesel and electricity from the national grid and reduces operational costs for farmers [4,5]. Solar energy systems have

undergone significant development in recent times, making them more efficient and less expensive. These systems have become an essential part of modern agricultural practices in many countries suffering from water shortages or the high cost of conventional energy [6,7]. However, the adoption of these new technologies requires the establishment of appropriate infrastructure as well as sufficient awareness among farmers on how to use and maintain these systems to ensure their effectiveness and sustainability. Kirkuk Governorate is one of the regions in Iraq that relies heavily on agriculture as its main source of income [8]. Despite the great potential of solar energy in the governorate, there is an urgent need to understand the prevailing level of knowledge among farmers on how to utilize solar energy in their agricultural activities. Farmers' knowledge of the different aspects of using and maintaining solar energy systems is an important element for the successful implementation and optimization of these systems. A widespread lack of knowledge in this area can lead to misuse or frequent breakdowns of these systems, negatively affecting economic and environmental returns [9, 10].

. In the absence of extensive agricultural extension programs focused on solar energy applications, farmers may find it difficult to understand how renewable energy systems work, how to use them effectively, and how best to maintain them [11, 12]. This lack of knowledge is a major barrier that may lead to operational issues, such as frequent breakdowns, poor performance, or not achieving the expected energy savings, which reduces the attractiveness of this technology to farmers and reduces its diffusion [13, 14]. Therefore, it becomes necessary to assess farmers' current level of knowledge and identify their weaknesses in order to design effective extension and training programs to enhance their skills in this field. Despite the growing importance of solar energy in the agricultural sector both globally and locally, and the awareness of governmental bodies and international organizations of its role in achieving sustainable agricultural development in Iraq, there are real questions about the extent to which farmers in Kirkuk Governorate understand this promising technology [15]

Recognizing the level of farmers' knowledge contributes to determining the amount of efforts that agricultural extension should prepare, and recognizing the educational levels of farmers contributes to determining the appropriate extension methods and methods [16].

The current research seeks to answer the following questions:

- What is the level of knowledge of farmers in Kirkuk governorate about the use and maintenance of solar energy systems used in agriculture?
- What is the relationship among the level of knowledge of farmers in Kirkuk governorate about the use and maintenance of solar energy systems used in agriculture and their characteristics (age, marital status, number of family members, educational level, full-time agricultural work, type of farm tenure, area of agricultural land, years working in agriculture, number of years owning solar energy systems, number of systems owned by the farmer, and the horsepower of agricultural pumps).

Objectives of the study:

The research seeks to achieve the following objectives:

First: - To Identifying the level of knowledge of farmers in Kirkuk Governorate about the use and maintenance of solar energy systems used in agriculture.

Second: - To study the correlation between the level of knowledge of farmers in Kirkuk governorate about the use and maintenance of solar energy systems used in agriculture and their characteristics (age, marital status, number of family members, educational level, full-time agricultural work, type of farm tenure, area of agricultural land, years of working in agriculture, number of years owning solar energy systems, number of systems owned by the farmer, and horsepower of agricultural pumps).

Hypotheses of the study:

The study tests the research hypothesis which states that there is no significant correlation between the level of knowledge of farmers about the use and maintenance of solar energy systems in Hawija district, Kirkuk governorate and each of the following variables: Age, marital status, number of family members, educational

level, full-time employment, type of agricultural tenure, area of agricultural land, years working in agriculture, number of years owning the system, number of systems, number of systems, and pump capacity.

Procedural definitions:

1- Knowledge level: It means the amount of information that the farmer has about the use and maintenance of solar energy systems used to operate irrigation water pumps used for agricultural purposes.

2- Solar energy system: It means an integrated unit that includes solar panels, an electricity regulator (inverter), rules for installing the panels, and the agricultural pump.

3- Horsepower: It means the capacity of the agricultural irrigation water pump, which determines the number of solar panels needed to operate it and the size of the regulator (inverter).

4- Inverter: An electrical device that is one of the components of solar energy systems, whether agricultural or domestic, which works to regulate the flow of electric current from the panels to the load devices, including the irrigation water pump.

METHODOLOGY:

The study seeks to understand the truth by using the descriptive method, which is considered an effective way to obtain accurate information and facts about the perception of the target group during a certain period of time [17]. The descriptive method allows the researcher to classify, process, and analyze the data and information collected with great accuracy. The purpose of this work is to extract meanings and reach comprehensive and accurate conclusions related to the studied topic [18].

Research population and sample:

The research included all 514 farmers who own solar energy systems for agricultural purposes in Hawija district, Kirkuk governorate, according to the records of the owners of the solar energy systems supply offices in the area, a simple random sample of them was selected at a rate of (10%), making the number of farmers in the research sample (52).

Preparation of the questionnaire:

The researchers prepared a two-part questionnaire to collect the research data: The first part included some personal information about the farmers (age, marital status, number of family members, educational level, full-time agricultural work, type of farm tenure, agricultural land area, years of working in agriculture, the number of years you own solar energy systems, the number of systems owned by the farmer, and the horsepower of agricultural pumps.), while the second part included a scale consisting of (20) paragraphs developed in the form of multiple choice questions, and each question has three answers, one of which is the correct answer. After completing the preparation of the questionnaire form in its initial form, it was presented to some specialists to indicate the apparent and content validity, and after making some amendments according to the experts' point of view and in order to ensure the stability and validity of the scale, a pre-test was conducted on a sample of (10) farmers randomly selected from the research community and later excluded from the research sample, the Cronbach coefficient was used to measure stability, which reached a value of (84. 4), which means the validity of the test and the readiness of the questionnaire to collect research data.

Measuring research variables:

First: Measuring the independent variables:

1. **Age:** Measured by the number of years the respondent spent from birth until the moment of collecting the research data.
2. **Marital status:** It was measured through the levels (single, married, divorced, widowed). It was given the following weights (4, 3, 2, 1).
3. **Number of family members:** Measured by assigning one numerical value to each family member.
4. **Educational level:** Measured by levels (illiterate, reading and writing, elementary, middle school, high school, bachelor's, master's, doctorate) and given the following weights (1, 2, 3, 4, 5, 6, 7, 8).

5. **Full-time agricultural work:** It was measured through two levels (full-time, part-time) and was given the following weights (1, 2)
6. **Type of agricultural tenure:** Measured through the levels (ownership, contract, participation, lease, rent, investment) and given the following weights (5, 4, 3, 2, 1)
7. **Agricultural land area:** Measured by giving one numerical value for each dunum IQ of agricultural land owned by the farmer.
8. **Years of work in agriculture:** Measured by assigning a numeric value to each of the years the farmer has been farming.
9. **Number of years of system ownership:** Measured by giving one numeric value for each year of ownership of the system.
10. **Number of solar energy systems:** Measured by giving one numeric value for each system owned by the farmer.
11. **Horsepower of operational pumps:** Measured by giving one numeric value for each horsepower of agricultural pump capacity.

Second: Measuring the dependent variable (the level of farmers' knowledge about the use and maintenance of solar energy systems used in agriculture)

A test was designed consisting of 20 paragraphs formulated in the form of multiple choice questions, and for each question, three alternatives for answering, one of which represents the correct answer, and one score was given for each question answered correctly, which means that the theoretical range of the degree of knowledge level that a farmer can achieve ranges between (0-20) degrees.

Data collection and analysis:

After completing the form, the data was collected by personal interview with farmers for the period from (15/12/2024 to 26/01/2025), after which it was transcribed and classified and then analyzed using a number of statistical methods (range, arithmetic mean, Pearson's simple correlation coefficient, Spearman's correlation coefficient, and (t) test, using the SPSS statistical analysis program (Statistical Package for Social Science).

RESULTS AND DISCUSSION

First: Identifying the level of knowledge of farmers in Kirkuk Governorate about the use and maintenance of solar energy systems used in agriculture.

The results showed that the lowest numerical value of the level of knowledge of farmers in Kirkuk Governorate about the use and maintenance of solar energy systems used in agriculture was (12) degrees, while the highest numerical value was (18) degrees on a scale ranging from (0-20), with an overall mean of (16) and a standard deviation of (1.25).

The respondents were divided into three categories and the results were as shown in Table (1)

Table (1): Distribution of respondents according to their level of knowledge of the use and maintenance of solar energy systems used in agriculture.

Knowledge categories	N	%	Average knowledge
(12-13) little knowledge	2	3.8	12.5
(15-14) middle knowledge	13	25	14.8
(16 -or more) Highknowledge	37	71.2	16.6
Total	52	100	
General average = 16		Standard deviation = 1.25	

The results shown in Table (1) indicate that the highest percentage of the respondents amounted to (71.2%) of the total respondents and fell within the category of high knowledge level with an average score of (16.6), and the category of medium knowledge level came in second place with (25%) of the total respondents and an average score of (14.8), while the lowest percentage of the respondents was within the category of low knowledge level with (3.8%) of the total respondents and an average knowledge level score of (12.5). This

means that the majority of the respondents (96.2%) had a medium to high level of knowledge about the use and maintenance of solar energy systems used in agriculture, which means that solar energy system technology can be quickly spread among farmers in Hawija district if the means of spreading it, such as reducing the costs of spreading it, are available.

Second: - To study the correlation between the level of knowledge of farmers in Kirkuk governorate about the use and maintenance of solar energy systems used in agriculture and their characteristics (age, marital status, number of family members, educational level, full-time agricultural work, type of farm tenure, area of agricultural land, years of working in agriculture, number of years owning solar energy systems, number of systems owned by the farmer, and horsepower of agricultural pumps).

1- Age:

The results showed that the oldest respondent was (73) years, while the youngest respondent was (24) years old, with a mean of (44.32) years and a standard deviation of (1.26). The respondents were divided according to the laws of range and category length into three categories, and the results were as shown in Table 2.

Table (2): Distribution of respondents according to their age and its relationship with their level of knowledge about the use and maintenance of solar energy systems in agriculture.

Age categories (year)	N	%	Average knowledge	r value	calculated t value	Sig
(24-39) Small	22	42.3	15.68	0.218	1.58	NS
(40-55) young	19	36.53	16.26			
(56 -or more) High old	11	21.15	16.18			
Total	52	100				
		General average = 44.32			Standard deviation = 1.25	

The results in Table 2 show that (42.3%) of the respondents are of young ages ranging from (24-39) years with an average knowledge level of (15.68) degrees for the use and maintenance of solar energy systems, while the middle age group was in the second place with a percentage of (36.53%) and an average knowledge level of (16.26) degrees. This means that the majority of those who own a solar energy system within the research sample are from young age groups and those who did not exceed the age of 55 years. This means that the majority of those who own a solar energy system within the research sample are from young age groups who did not exceed the age of 55 years.

In order to identify the relationship between the level of knowledge of farmers in Kirkuk governorate towards the use and maintenance of solar energy system and their age, the Pearson correlation coefficient was used and the r value was (0.218), which means that the correlation is positive between the two variables, and to check the significance of the relationship, the calculated t value was (1.58), which is not significant, which means that the research hypothesis that states "there is no significant correlation between the level of knowledge of farmers in Kirkuk governorate towards the use and maintenance of solar energy system and age" is accepted.

2 - Marital status:

The respondents were divided according to marital status into four categories, and the results were as shown in Table (3).

Table (3): The distribution of respondents according to marital status and its relationship with their knowledge level about the use and maintenance of solar energy systems in agriculture.

Marital status categories	N	%	Average knowledge	r value	calculated t value	Sig
Single	8	15.38	16	0.238-	1.7327-	NS
Married	39	75	15.87			
Divorced	2	3.85	16			

Widowed	3	5.77	17.66
Total	52	100	

The results in table (3) show that (75%) of the total respondents are married, with an average knowledge level of (15.87) degrees, while the percentage of single people (15.38%) of the total respondents with an average knowledge level of (16), the percentage of widows (5.77) of the total respondents with an average knowledge level of (17.66), while the percentage of divorced people (3.85) with an average knowledge level of (16), which means that most respondents in the research sample are married people, with an average knowledge level of (16).

In order to identify the correlation between the level of knowledge about the use and maintenance of solar energy systems in Kirkuk Governorate and their marital status, the correlation coefficient was used and the value of r was (0.238), and to check the significance of the relationship, the calculated t value was (1.732) degrees which is not significant at any of the two levels, which means that the research hypothesis that states "there is no significant correlation between the level of knowledge about the use and maintenance of solar energy systems in Kirkuk Governorate and marital status" is accepted.

3- Number of family members:

The results showed that the general average number of family members amounted to (6.78) with a standard deviation of (3.24) The respondents were divided according to the number of family members into three categories, and the results were as shown in Table (4).

Table (4): Distribution of respondents according to the number of family members and its relationship with their level of knowledge about the use and maintenance of solar energy systems in agriculture.

Number of family members categories	N	%	Average knowledge	r value	calculated t value	Sig
(1-4) Small	14	26.92	16	0.101	0.717	NS
(5-9) middle	27	51.92	16			
(10 or more) big	11	21.16	16			
Total	52	100				
General average = 6.78				Standard deviation = 3.24		

The results in table (4) show that (51.92%) of the total respondents are (5-9) medium-sized, with an average knowledge level of (16) degrees, (1-4) small-sized, with an average knowledge level of (16) degrees, and (10 or more), with an average knowledge level of (16) degrees, which means that most workers in solar energy systems within the research sample are medium to small-sized.

In order to determine the correlation between the level of knowledge about the use and maintenance of solar energy systems in Kirkuk governorate and the number of family members, the correlation coefficient was used and the value of r was (0.101), and to check the significance of the relationship, the calculated t value was (0.717), which is not significant at either level, which means that the research hypothesis that states "there is no significant correlation between the level of knowledge about the use and maintenance of solar energy systems in Kirkuk governorate and the number of family members" is accepted.

4- Educational level:

The results in Table (5) show that the highest percentage of the respondents are those who have a preparatory degree with (26.92%) of the total respondents and an average knowledge level of (16.14) degrees, and those with a bachelor's degree came second with (23.08%) and an average knowledge level of (16.16) degrees, while the lowest percentage of the respondents were illiterate people with (3.85%) and an average knowledge level of (15.5) degrees, while the lowest percentage of the respondents were illiterate people with a percentage of (3.85%) and an average knowledge level of (15.5) degrees.

Table (5): Distribution of respondents according to their educational level and its relationship with their level of knowledge about the use and maintenance of solar energy systems in agriculture.

Educational level	N	%	Average knowledge	r value	calculatedt value	Sig
Illiterate	2	3.85	15.5			
Reads and writes	4	7.69	15.75			
Elementary	8	15.38	15.25			
secondary	6	11.54	16.33			
Preparatory	14	26.92	16.14	0.216	1.594	NS
Bachelor's	12	23.08	16.16			
Higher degree	6	11.54	16.4			
Total	52	100				

In order to identify the correlation between the level of knowledge of farmers about the use and maintenance of the solar energy system, agricultural extension workers and educational level the Spearman's correlation coefficient was used and the value of r was (0.216). To ascertain the significance of the relationship, it was found that the calculated t value amounted to (1.594), which is not significant at either level, which means that the research hypothesis that states (there is no significant correlation between the level of farmers' knowledge about the use and maintenance of solar energy systems and educational level) is accepted.

5- Full-time agricultural work:

The respondents were divided according to availability into two categories, and the results were as shown in Table (6).

Table (6): Distribution of respondents according to their full-time agricultural work and its relationship with their level of knowledge about the use and maintenance of solar energy systems in agriculture.

Full-time agricultural workcategories	N	%	Average knowledge	r value	calculated t value	Sig
Part–time	14	26.92	16.28			
Full–time	38	73.08	15.89	0.139–	–0.992	N.S
Total	52	100				

The results in Table (6) show that (73.08%) of the total respondents are full-time agricultural workers with an average knowledge level of (15.89) degrees and (44.45) degrees, while (26.92%) of the total respondents are non-full-time workers with an average knowledge level of (16.28) degrees, which means that more than half of the agricultural workers in the research sample are full-time agricultural workers.

In order to identify the correlation between the level of their knowledge about the use and maintenance of solar energy systems and full-time agricultural work, the correlation coefficient was used and the value of r was (0.139-), and to confirm the significance of the relationship, the calculated t value was found to be (0. 992-), which is not significant at the two levels and (0.01) (0.05), which means that the research hypothesis is accepted, which states (there is no significant correlation between the level of knowledge of farmers about the use and maintenance of solar energy systems in Hawija district of Kirkuk province and full-time agricultural work).

6- Type of agricultural tenure:

The respondents were divided according to agricultural tenure into 5 categories, and the results were as shown in Table (7)

Table (7): The distribution of respondents according to the type of agricultural tenure and its relationship with their level of knowledge about the use and maintenance of solar energy systems.

Type of agricultural tenure categories	N	%	Average knowledge	r value	calculatedt value	Sig

Ownership	4	7.69	15.75	0.192-	-1.383	NS
Acontract	28	53.85	15.78			
participation	3	5.77	16.33			
Rent	11	21.15	15.45			
Investment	6	11.54	16.16			
Total	52	100				

The results in table (7) show that (53.85%) of the total respondents' tenure type is a contract with an average knowledge level of (15.78), while the percentage of rent (21.15%) of the total respondents with an average knowledge level of (15.45), the percentage of investment (11.54%) of the total respondents with an average knowledge level of (16.16), and the percentage of ownership (7.69%) of the total respondents with an average knowledge level of (15.75), and the percentage of participation (5.77%) of the total respondents with an average knowledge level of (16.33). (7.69%) of the total respondents with an average knowledge level (15.75), and the participation rate (5.77%) of the total respondents with an average knowledge level (16.33), which means that more than half of the agricultural workers in the research sample are owners of agricultural tenure type agricultural contract, which is related to their level of knowledge about the use and maintenance of solar energy systems.

In order to identify the correlation between the level of knowledge of farmers about the use and maintenance of solar energy systems and the type of agricultural tenure, the correlation coefficient was used and the value of r was (0.192-), and to confirm the significance of the relationship it was found that the calculated t value amounted to (1. 383-) which is not significant at (0.01) and (0.05) levels, which means accepting the research hypothesis which states (there is no significant correlation between their level of knowledge about the use and maintenance of solar energy systems in Hawija district, Kirkuk governorate and the type of agricultural tenure).

7- Agricultural land area:

The results showed that the overall mean of the land area was (70.84) and the standard deviation was (40.98) and the respondents were divided according to the land area into three categories, and the results were as shown in Table (8).

Table (8): The distribution of respondents according to land area and its relationship with their knowledge level about the use and maintenance of solar energy systems in agriculture.

Type of agricultural tenure categories	N	%	Average knowledge	r value	calculated t value	Sig
(20-79) small	32	61.53	15.9	0.04	0.283	NS
(80-139) middle	16	30.77	16.12			
(140-200) large	4	7.7	16.25			
Total	52	100				
General average = 70.84				Standard deviation = 40.98		

The results in table (8) show that (61.53%) of the total respondents own a small area, with an average knowledge level of (15.9) degrees, while (30.77%) of the total respondents own a medium area, with an average knowledge level of (16.12) degrees, and those who own a large area (4%) of the total respondents, with an average knowledge level of (7.7) degrees, meaning that almost half of the respondents are owners of small areas.

In order to identify the correlation between the level of their knowledge about the use and maintenance of solar energy systems and land area, the correlation coefficient was used and the r value was (0.04), and to check the significance of the relationship, the calculated t value was (0.283) which is not significant at any of the two levels, which means that the research hypothesis that states (there is no significant correlation between

the level of their knowledge about the use and maintenance of solar energy systems in Hawija district, Kirkuk governorate and agricultural land area) is accepted.

8- years working in agriculture

The research results showed that the longest period of service in agriculture for the respondents was (50) years, while the shortest period of service in agriculture for the respondents was two years with a mean of (21.04) years and a standard deviation of (10.54). The respondents were divided according to the laws of range and length into three categories, and the results were as shown in Table (9).

Table (9): Distribution of respondents according to the number of years working in agriculture and its relationship with their level of knowledge about the use and maintenance of solar energy systems in agriculture.

number of years working in agriculture categories	N	%	Average knowledge	r value	calculated t value	Sig
(2-17) Few	21	40.38	15.80	0.205	1.48	NS
(18-33) Middle	25	48.08	15.96			
(34-50) Long time	6	11.54	16.83			
Total	52	100				
General average = 21.04				Standard deviation = 10.54		

The results in Table 9 indicate that (40.38%) of the respondents are in the short service category in the second rank with an average knowledge level of (15.80), and the medium service category in the first rank of the total respondents between (18-33) years with an average knowledge level of (48.08). (08%), while the percentage of respondents within the category of long service duration in the third rank, which ranges between (34-50) years with (11.54%) of the total respondents, and an average knowledge level of (16.83) degrees, this means that the majority of respondents working in agriculture within the research sample have a medium to short service. In order to identify the correlation between the level of knowledge of agricultural workers about the use and maintenance of solar energy systems and their length of agricultural service, the Pearson correlation coefficient was used and the r value was (0.205), and to check the significance of the relationship, the calculated t value was (1.48) which is not significant at both levels, which means accepting the research hypothesis that states (there is no significant correlation between the level of knowledge of agricultural workers about the use and maintenance of solar systems in Kirkuk governorate and their length of service). The alternative hypothesis is rejected.

9- Number of years of system ownership

The results of the research showed that the average year of the respondents is (1.923) and the standard deviation is (1.202). The respondents were divided according to the laws of range and length into three categories, and the results were as shown in Table (10).

Table (10): Distribution of respondents according to the number of years of owning the system and its relationship with their level of knowledge about the use and maintenance of solar energy systems in agriculture.

Number of years of system ownership categories	N	%	Average knowledge	r value	calculated t value	Sig
(1-2) Few	40	76.92	16.15	0.130−	−0.927	NS
(3-4) middle	10	19.23	15.3			
(5 or more) Long time	2	0.85	16.5			
Total	52	100				
General average = 1.923				Standard deviation = 1.202		

The results in table (10) indicate that (76.92%) of the respondents are in the low ownership category, which ranges between (1-2) years, with an average knowledge level of (16.15), and the medium ownership category

came second with (19.23%) of the total respondents, which ranges between (3-4) years, with an average knowledge level of (15.3), while (0.85%) are in the high ownership category, which ranges between (5 or more) years, with an average knowledge level of (16.5), which means that the majority of the respondents who own the system in the research sample have few to medium years of ownership. This means that the majority of the respondents who own the system in the research sample have few to medium years of ownership, with an average knowledge level of (16.5) degrees.

In order to identify the correlation between the level of knowledge about the use and maintenance of solar energy systems in Hawija district, Kirkuk governorate and the years of ownership of the system, the Pearson correlation coefficient was used and the value of r was (0.130-), and to confirm the significance of the relationship, the calculated t value was (0. (2.787) and (927), which is not significant at (0.05) and (0.01) levels, which means that the research hypothesis that states (there is no significant correlation between the level of understanding about the use and maintenance of solar energy systems in Hawija district in Kirkuk Governorate and the number of years of ownership of the system) is accepted and the alternative hypothesis is rejected.

10- Number of solar energy systems:

The results of the research showed that the respondents' use of one system is more (37) users and the use of two systems comes second with (12) users, while the least amount of use of three systems is (3) users with an overall mean of (0.067) and a standard deviation of (0.66). The respondents were divided according to the laws of range and length into three categories, and the results were as shown in Table 11.

Table (11): Distribution of respondents according to the number of solar energy systems and its relationship with their level of knowledge about the use and maintenance of solar energy systems in agriculture.

Number of solar energy systems categories	N	%	Average knowledge	r value	calculated t value	Sig
1 system	37	71.15	15.92	0.067	0.47	NS
2 systems	12	24	16			
3 or more	3	5.79	16.33			
Total	52	100				
General average = 1.38				Standard deviation = 0.66		

The results in table (11) indicate that (71.15%) of the respondents (37 farmers) use one system, with an average knowledge level of (15.92) degrees, and the category of using two systems came in second place with (24%) and an average knowledge level of (16), while the percentage of respondents who use three or more systems is (5.79), with an average knowledge level of (16.33) degrees, this means that the majority of respondents who use solar energy systems within the research sample have one to two systems, and the average knowledge level is (16.33) degrees, which means that the majority of respondents who use solar energy systems within the sample.

In order to identify the correlation between the level of their knowledge about the use and maintenance of solar energy systems and the duration of the number of solar energy systems, the Pearson correlation coefficient was used and the value of r was (0.067), and to check the significance of the relationship, the calculated t value was (0.47), which is not significant at both levels, which means accepting the research hypothesis that states (there is no significant correlation between the level of their knowledge about the use and maintenance of solar energy systems and the number of solar energy systems) and rejecting the alternative hypothesis.

11- The horsepower of the agricultural pump:

The results of the research showed that the largest horsepower of irrigation water pumps was (50) horsepower, and the smallest pump capacity was (15), with an overall mean of (34.71) and a standard deviation of (10.49).

The respondents were divided according to the laws of range and length into three categories, and the results were as shown in Table (12).

Table (12): Distribution of respondents according to the horsepower of the agricultural pump and its relationship with their level of knowledge about the use and maintenance of solar energy systems in agriculture.

The horsepower of the agricultural pumpcategories	N	%	Average knowledge	r value	calculated t value	Sig
(15-26) small	12	23.07	16.08	0.082	0.58	N.S
(27-38) middle	16	30.76	15.63			
(39 or more) dig	24	46.15	16.21			
Total	52	100				
General average = 34.71				Standard deviation = 10.49		

The results in table (12) indicate that (46.15%) of the respondents are in the large horsepower category, which is more than (39) horsepower, with an average knowledge level of (16.21) degrees, and the medium category came second with (30.76%) between (27-38) horsepower, with an average knowledge level of (15.63), while (23.07%) of the respondents are in the small horsepower category between (15-26) horsepower, with an average knowledge level of (15.08). 63), while the percentage of respondents in the small horsepower category reached (23.07%) ranging between (15-26) horsepower, with an average knowledge level of (16.08) of the total respondents, meaning that the majority of respondents who own solar energy systems within the research sample have pumps with large to medium horsepower.

In order to identify the correlation between the level of their knowledge about the use and maintenance of solar energy systems and the horsepower of the pump, the Pearson correlation coefficient was used and the r value for the growth regulator was (0.082), and to confirm the significance of the relationship, the calculated t value was found to be (0. 58), which is insignificant at the probability level of (0.05) and (0.01) respectively, which means accepting the research hypothesis that states (there is no significant correlation between their knowledge level about the use and maintenance of solar energy systems and horsepower pump capacity) and rejecting the alternative hypothesis.

CONCLUSIONS

1. High level of farmers' knowledge: The results of the research showed that the majority of farmers in the study sample (71.2%) have a high level of knowledge about the use and maintenance of solar energy systems, which indicates a good readiness of farmers to adopt this technology in the agricultural sector.
2. No significant relationship between knowledge and demographic and social variables: Statistical analyses did not show a significant correlation between farmers' knowledge level and each of the following: Age, marital status, number of family members, educational level, full-time agricultural work, type of agricultural tenure, land area, number of years of agricultural work, number of years of owning a system, number of systems, or the capacity of agricultural pumps. This indicates that farmers' knowledge about this technology is not significantly affected by these factors.
3. Farmers have owned the systems for relatively short periods of time: The results showed that most farmers have owned solar energy systems for a short period of time ranging from one to two years, which may explain some of the knowledge gaps of a few respondents.
4. Limited variety of systems: The vast majority of farmers (71.15%) own only one system, which indicates a limited reliance on solar energy in various agricultural operations, perhaps due to economic factors or lack of sufficient technical and advisory support.
5. Weak relationship between knowledge and farm productive characteristics: The research results did not show that the area of agricultural land, number of years of agricultural experience, or type of agricultural

tenure had a significant impact on the level of knowledge, suggesting that other factors such as awareness campaigns or personal experiences may play a greater role in shaping farmers' knowledge.

6. Significant opportunities to expand the use of solar energy: Given the high level of knowledge of most farmers, there is a great opportunity to expand the use of this technology in other agricultural areas, provided that technical support, training, and the cost of acquiring these systems are available.

Recommendations

From the above, the researchers recommend the following:

1- Facilitating the procedures of owning solar energy systems for farmers by government agencies by providing them and subsidising their prices.

2- Lifting taxes on the import of solar energy systems and providing easy interest-free loans.

3- Holding extension activities such as extension seminars, meetings and TV programmes that urge farmers to buy solar energy systems and employ them for agricultural purposes such as operating irrigation pumps, poultry halls, field crop drying plants and others.

4- Conducting studies on the obstacles to the spread of solar energy systems and proposing appropriate solutions.

REFERENCES

1- Eker, B. (2005). Solar powered water pumping systems. *Trakia Journal of Sciences*, *3*(7), 7-11.

2- Tariq, G. H., Ashraf, M., & Hasnain, U. S. (2021). Solar technology in agriculture. *Technology in agriculture*, *387*.

3- Qasim Al-Zain, & Hamad Lali, M. (2016). A simplified economic-technical comparison of a solar-powered water pumping system versus a conventional electric-powered water pumping system for agricultural purposes in the Awjila region. Solar Energy and Sustainable Development Journal, 5(1), 30-43.

4- Kata, R., Cyran, K., Dybka, S., Lechwar, M., & Pitera, R. (2021). Economic and social aspects of using energy from PV and solar installations in farmers' households in the podkarpackie region. *Energies*, *14*(11), 3158.

5- Elahi, E., Khalid, Z., & Zhang, Z. (2022). Understanding farmers' intention and willingness to install renewable energy technology: A solution to reduce the environmental emissions of agriculture. *Applied Energy*, *309*, 118459.

6- Khobkhet, A., Limnirankul, B., Kramol, P., Sirisunyaluck, R., & Chalermphol, J. (2024). Adoption Behavior of Solar Technology among Young Smart Farmers in Thailand. *The Journal of Behavioral Science*, *19*(2), 59-74.

7- Paris, B., Kanaki, V., Koutsouris, A., Balafoutis, A. T., & Papadakis, G. (2024). Farmers' needs, ideas and interests on the adoption of fossil energy free technologies and strategies in the EU. *International Journal of Sustainable Energy*, *43*(1), 2326454.

8- Mohammed, K. A., & Mahmood, E. T. (2022, July). Attitude of Al-Qasimia Village Farmers in Hawija District/Kirkuk Province Toward Cultivation and Consumption White Eggplant. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1060, No. 1, p. 012147). IOP Publishing.

9- Hahn, C., Lindkvist, E., Magnusson, D., & Johansson, M. (2025). The role of agriculture in a sustainable energy system–The farmers' perspective. *Renewable and Sustainable Energy Reviews*, *213*, 115437.

10- Kumar, V., Syan, A. S., Kaur, A., & Hundal, B. S. (2020). Determinants of farmers' decision to adopt solar powered pumps. *International Journal of Energy Sector Management*, *14*(4), 707-727.

11- Zade, P. M. (2021). *Attitude of farmers towards solar energy utilization in farming system* (Doctoral dissertation, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani).

12- Jorns, A. R. (2020). *Smallholder farmers' perceptions toward solar renewable energy technology on the island of Trinidad* (Master's thesis, The Ohio State University).

13- Elahi, E., Khalid, Z., & Zhang, Z. (2022). Understanding farmers' intention and willingness to install renewable energy technology: A solution to reduce the environmental emissions of agriculture. *Applied Energy*, *309*, 118459.

14- Jubouri, K. F. S. A. (2024, July). Farmers' Training and Knowledge Needs in the Use of Solar Power System (Photovoltaic PV) in Salah Al-Din Governorate/Al-Sharqat District. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1371, No. 10, p. 102015). IOP Publishing.

15- El-Aziem Osman, S. A., Ashour, A. K., Zied, A. W., & Mohammed, K. A. (2015). Diffusion of Agricultural Ideas among Farmers in-Contact with Extension Agents through Facebook In Kirkuk Governorate-Iraq. *Alexandria Science Exchange Journal*, *36*(JULY-SEPTEMBER), 556-574.

16- Hussein, E. A., & Mohammad, K. A. (2023, April). Diffusion of Agricultural Ideas Through the Website of the Agricultural Extension and Training Department on the Social Networking "YouTube". In *IOP Conference Series: Earth and Environmental Science* (Vol. 1158, No. 9, p. 092003). IOP Publishing.

17- Al-Asadi SJ. Creativity of a scientific researcher in the humanities and social education sciences. 2nd ed. Warith Cultural Foundation, Department of Studies and Research, Iraq; 2008.

18- Al-Rashidi BS. Educational research methods. 1st ed. College of Education, Kuwait University, Dar Al-Kutub Al-Hadithah; 2002.