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The Role of Participatory Agricultural Extension in Mitigating the Adverse Effects of Climate Change on Agricultural Production

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Abstract: Climate changes pose significant challenges to agricultural production systems, necessitating the adoption of the effective extension approaches that enhance farmers' adaptive ability. This study evaluates the role of participatory agricultural extension in addressing the adverse impacts of climate change on agricultural production from farmers' perspective. Data were collected through a structured questionnaire and analyzed using descriptive and inferential statistical methods to examine the relationship between farmers' characteristics and their perception of participatory agricultural extension. Data were collected from simple random sample of 128 farmers (25% of the target population of 512 farmers) distributed across 12 villages in Sulaymaniyah Governorate. The findings revealed a limited implementation of participatory agricultural extension within agricultural extension centers in the centers in the study area, with 56.3% of respondents reporting low levels of participatory communication. Correlation analyses (Pearson and spearman) indicate significant negative relationships between participatory agricultural extension and farmers' age, education level, farm size, farm type, farming experience. Significant positive relationships were found with educational level, participation in training programs, and level of communication with information sources. In contrast, no significant relationship was found between farmers' attitudes toward climate change and their perceptions of participatory agricultural extension. Despite the weak implementation of participatory extension approaches, respondents demonstrated moderate to high adoption levels of climate-smart agricultural practices, accounting for 62.5% and 32.0% of the sample, respectively. Farmers identified three major constraints hindering the effective implementation of participatory agricultural extension. The predominance of conventional extension approaches among extension (92.29), prevailing social and cultural norms (92.45%). And insufficient governmental support for participatory extension programs (92.19%). The study highlights the urgent need to strengthen participatory agricultural extension systems through capacity building, modernization of extension methodologies, and increase institutional and financial support, enhancing participatory approaches can improve farmers resilience and adaptive capacity, thereby contributing to more sustainable agricultural systems under changing climatic conditions.

Keywords: Agricultural sustainability, Climate change mitigation, Farmers' perceptions, Participatory agricultural extension.

Introduction

Climate change and the need for environmental protection are global issues and call for an awareness response from all nations to be effectively mitigated (Houghton and WMO, 2002). The unpleasant reality of global warming and the human activities causing it are acknowledged by both the scientific and environmental sectors.

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The environment is being impacted by the quick rise in greenhouse gases more quickly than many living things can adjust, which is worrisome. All kinds of life face enormous hurdles in this ever-evolving and increasingly complicated environment (Hassan, 2024). Climate change is significantly impacting global agriculture, which is upsetting conventional agricultural practices and creating serious problems for food security.

Global food production systems are greatly influenced by the complex interactions between rising temperatures, changing patterns of precipitation, and an increase in the frequency of extreme weather events (Prajapati et al., 2024). North of Iraq is presently experiencing numerous issues related to climate change and agricultural deterioration, such as increasing temperatures, altered precipitation patterns, heightened drought conditions, escalating water shortages, and more frequent sand and dust storms. The absence of targeted data and analysis on the Kurdistan Region of Iraq has hindered comprehension of the unique challenges the region faces, given its different climate, terrain, and customs in comparison to central and southern Iraq (Iraq, 2022).

For the crucial development of rural areas through agricultural extension services in rural communities, some countries do not pay enough attention, which is significant, as agricultural extension workers can establish and formulate an active strategy and develop programs for transferring information (Hamasali and Layeeq, 2023). The agriculture, biodiversity, natural resources, and practices that are harmful to human beings should be accepted as moral and human issues. It is necessary to make use of agricultural extension, which is a magic tool that helps bring a change in incorrect attitudes and notions. It has to be kept in mind that it should be used with perfectly correct and proper approaches, as helpful for farmers' problem-solving and participation (Özcatalbas et al., 2017). The integration of different extension approaches, including both established and contemporary techniques, can improve the spread of innovation. Combining the traditional top-down approach with modern pluralistic and participatory approaches is likely to result in more favorable outcomes (Adefalu et al., 2023). Participatory approach in farming has proven to be transformative for agricultural practices in rural areas, significantly enhancing both productivity and sustainability. By actively participating in decision-making processes and leveraging local knowledge, this strategy has led to improved crop yields, helped with better water and soil management, and diversification of adopted cropping systems. However, it strengthened resilience to climate change impacts and restored degraded farmlands, boosting the long-term sustainability of agricultural practices (Sharma, 2017).

Participatory agricultural extension encompasses adaptation, mitigation, and various agricultural practices that enhance the system's ability to cope with different climate-related disruptions by minimizing damage and facilitating rapid recovery. In essence, it refers to the system's capacity to rebound. This approach fundamentally entails the careful and enhanced management of natural resources, such as land, water, soil, and genetic resources, through the implementation of optimal practices (Sulaiman, 2024). To facilitate the upscaling and integration of local knowledge systems in climate-smart agriculture (CSA), the political narratives surrounding CSA must ensure the representation of smallholder farmers in agricultural policy and decision-making processes, rather than allowing dominant development partners to dictate the discourse. Achieving the successful upscaling of the mitigation of climate change impacts requires a more equitable distribution of power and a commitment to social justice, thereby amplifying the voices of smallholder farmers. This process of inclusion should adopt a participatory, bottom-up approach within CSA initiatives. We propose that methods such as farmer-led knowledge creation and farmer school programs offer valuable production. Such a bottom-up model can help prevent development partners and national governments from imposing technocratic agendas, ensuring that the interests and insights of smallholder farmers remain central to the design of practices and technologies aimed at mitigating climate change (Ogunyiola et al., 2022; Mansour et al., 2026).

Future strategies should prioritize inclusive, decentralized, and community-driven methodologies to guarantee equitable access to programs designed for building climate resilience. Emphasizing farmer-led innovation, participatory approaches, and institutional reforms will be essential for fostering long-term sustainability. Enhancing the connections between research, extension services, and farmers, as well as integrating climate resilience into agricultural policies, can significantly improve food security, enhance rural livelihoods, and promote overall agricultural sustainability in the context of climate-related challenges (Priya et al., 2025).

To establish this approach, which integrates farmers into agricultural extension programs, the current research aimed to explore the significance of participatory agricultural extension in mitigating climate change impacts on agriculture, particularly through the lens of farmers in the Kurdistan Region of Iraq. By analyzing the relationship between various independent factors and farmers' assessments of the effectiveness of participatory extension methods, the researcher sought to identify key strategies and practices employed by farmers to adapt to climate challenges. Additionally, the research will reveal the primary challenges encountered in implementing the participatory agricultural extension approach, providing valuable insights into farmers' perspectives.

Ultimately, the findings will contribute to the development of more effective agricultural policies that prioritize farmers' needs and enhance resilience against climate impacts.

Therefore, this research attempts to answer the following questions:

1. How highly do farmers evaluate the role of participatory extension in mitigating the negative impacts of climate change on agriculture in general?
2. Do farmers' evaluations of the role of participatory extension vary according to their individual characteristics?
3. What are the strategies and practices employed by farmers to mitigate the negative impacts of climate change on agriculture in the Suleymani governorate, from the farmers' point of view?
4. What are the primary challenges faced in implementing the participatory agricultural extension approach from the farmers' point of view?

Objectives

1. Evaluating the role of participatory agricultural extension in mitigating the negative impacts of climate change on agriculture from the farmers' point of view.
2. Identifying the correlation between independent variables and the farmers' evaluation of the role of participatory agricultural extension in mitigating the climate change impacts on agriculture in the Soleymani governorate.
3. Identifying the strategies and practices employed by farmers to mitigate the negative impacts of climate change on agriculture in the Soleymani governorate, from the farmers' point of view.
4. Identifying the primary challenges faced in implementing the participatory agricultural extension approach from the farmers' point of view.

Research Hypotheses

To achieve the objective of the study, there is no significant relationship between the role of participatory agricultural extension approach in addressing the negative impacts of climate change on agriculture and each variable:

There is no statistically significant correlation between farmers' evaluation of the role of participatory agricultural extension in mitigating the negative effects of climate change on agriculture and some of their characteristics such as: age, educational level, farm size, type of farm, experience in agriculture, participation in training courses, attitudes toward climate change, and level of communication with information sources.

Materials & Methods

Methodology of Research

The study employed the descriptive research approach to evaluate the role of participatory agricultural extension, the strategies and practices employed by farmers, and primary challenges faced by implementing the role of participatory agricultural extension approach in Soleymani Governorate to mitigate the negative climate change impacts on agriculture product. It is considered an appropriate approach for evaluating the existing situation by collecting, analyzing, and interpreting data related to the characteristics, perceptions, and experiences of the selected population. This is also emphasized by previous studies, the situation in the study area is unstable, as suffering from climate change impacts on farmlands and water resources, which were conducted by all of (Grimes and Schulz (2002). Therefore, this approach was adopted in this research because it is suitable for the nature of the research topic and achieves its objectives scientifically and systematically.

Study Area

The study was conducted in the Governorate of Soleymani, located in the Kurdistan Region of Iraq. The area is famous for multiple agricultural practices, with a large number of farmers working in plant and animal production, and all those farmers are under the supervision of agricultural extension centers. For each of the mentioned sub-districts in Table 1, there is one directorate of the agricultural extension center, and the

agricultural extension agents have roles to support farmers in their diverse agricultural extension methods, including the participatory approach.

Population and Sample of Research

The research population included 512 farmers distributed across 12 villages in four sub-districts and two districts in Soleymani governorate. To achieve the research objectives, a simple random sample of 25% was selected, and thus the research sample size reached 128 farmers, as shown in Table 1.

Table 1. The population and sample of research.

No.	Governorate	Districts	Sub-districts	Villages	Population	Size of sample 25%
1.	Sulaymaniyah	Center	Tanjro	Qaraly	76	19
2.				Qaragul	24	6
3.			Bazyan	Arbati-kon	40	10
4.				Halla	36	9
5.		Zerayan	Lazyan	68	17	
6.				Khaldan	64	16
7.			Deskera	32	8	
8.				Kelakawy	44	11
9.		Bazyan	Alan	24	6	
10.				Kani-Kewa	28	7
11.			center	Mahmod-Khane	36	9
12.				Kani-Meel	40	10
Total					512	128

Materials

The questionnaire was the primary data collection tool used by the researcher, as it facilitated obtaining accurate responses aligned with the research objectives through one-on-one personal interviews with farmers.

Data Collection

The role of participatory agricultural extension agents in facing the impacts of climate change on agriculture in the Soleymani governorate, comprises a set of questions to know the role of participatory agricultural extension approach in point of the farmers' view; it means the role of agricultural extension agents by using participatory agricultural extension approach in conducting and transferring the information to farmers about climate change impacts and the degree of their participation in agricultural extension activities such as "planning, program evaluation, field visits, training sessions, etc.". The 35 items were measured on a three-point Likert scale as follows: (Always = 3, Sometimes = 2, Never = 1). Correspondingly, the scores ranged theoretically from 35 to 105.

Personal characteristics include a set of questions to recognize the characteristics of farmers as follows: (age, educational background, area used for agricultural production in dunums, type of farmland possession, agriculture experience, participation in climate change sessions, farmers' trend towards climate change, and knowledge level of connecting to the information on climate change resources). Age, this variable was measured by the raw number of the respondent's age, considered from his/her birthday date to the time of data collection. Educational background, the level of education of the respondent was reached at the time of data collection, and it was measured by the following scales: illiterate = 1, read and write = 2, primary school = 3, intermediate school = 4, high school = 5, diploma = 6, bachelor = 7, and higher educational = 8., Area used for agricultural production in Dunums, this variable was measured by the raw number of donums that the farmer cultivated at the time of data collection.

Type of farmland possession, this variable refers to the type of production that farmers practice at the time of data collection, which is divided into three types: plant production, animal production, and mixed farm of plant and animal, and it was measured by the following scales: plant production = 1, animal production = 2, mixed farm = 3. Agriculture Experience: This variable refers to the number of years a farmer has spent in agricultural

practices, measured by the raw number of years spent in agriculture. Participation in climate change sessions: This variable refers to the farmer's participation in training sessions on the impacts of climate change on agriculture.

The following scales measured it: participated "Yes" = 2, not participated "No" = 1. Farmers' attitudes toward climate change, this variable was measured by using 12 statements, and 3 alternatives were used for each statement as scales (Agree, Average, and Disagree): Agree = 3, Average = 2, Disagree = 1. Knowledge level of connecting to the information on climate change resources, this variable was assessed using a set of 12 statements, each measured on a four-point Likert scale. The response options included: (Always, Sometimes, Rarely, and Never), corresponding to the numerical values of: Always = 4, Sometimes = 3, Rarely = 2, Never = 1.

The strategies and practices employed by farmers to mitigate the negative impacts of climate change on agriculture in the Soleymani governorate, Includes a set of strategies and practices that help farmers to face the current situation of climate conditions in the Kurdistan region, and then to identify the preferred degree of each one from the farmer's point of view; all strategies and practices were measured in four scales as follow, high = 4, medium = 3, low = 2, little = 1. Challenges faced in implementing the participatory agricultural extension approach from the farmers' point of view, comprise a set of challenges that are suggested to the farmers in the targeted area to know the extent of importance of challenges from the farmers' point of view; all items were measured on three scales to identify their importance to farmers as follows: big = 3, medium = 2, and few = 1.

Data Collection and Analysis

Data were collected during the period from 7 July 2025 to 25 September 2025, and were statistically analyzed using SPSS software, with the use of methods appropriate to the research objectives, which included frequencies, percentile weight, weighted mean, Pearson and Spearman correlation coefficients to study the relationship between the independent variables and the farmers' evaluation of the effectiveness of the role of participatory agricultural extension in combating the climate change impacts on agriculture in the Soleymani governorate

Reliability and Validity

Validity: This was achieved by presenting the questionnaire to several experts and specialists in agricultural extension. The necessary modifications were made to the items included in the form to make them more effective in achieving the desired objective.

Reliability: To examine the role of participatory agricultural extension in mitigating the negative impacts of climate change on agriculture, Cronbach's Alpha was used to assess the reliability of the measurement instrument based on the relationship between the items representing the independent and dependent variables. The analysis of the 35 – item scale produced a Cronbach's Alpha value of 0.73. This result indicates an acceptable to good level of internal consistency, suggesting that the items are sufficiently correlated and collectively measure the intended construct in a reliable manner.

Results and Discussion

1. Evaluate the role of participatory agricultural extension in mitigating the negative impacts of climate change on agriculture from the farmers' point of view

Table 2. Distribution of respondents by the role of participatory agricultural extension in mitigating the negative impacts of climate change on agriculture

Classes	Frequency	Percentage %	Mean	Std. Deviation
41 – 59 Low	72	56.3	57.111	18.2011
60 – 78 Medium	42	32.8	71.500	8.5290
79 – 97 High	14	10.9	87.142	4.5039
Total	128	100.0	65.117	17.7216

The results revealed that more than half of the respondents were within the low category with the ration 56.3%. In comparison, the high category only scored 10.9% of respondents, indicating a weak role of participatory agricultural extension in the study area.

2. To identify the correlation between independent variables and the farmers' evaluation of the role of participatory agricultural extension in mitigating the climate change impacts on agriculture in the Soleymani governorate.

Table 3. Distribution of respondents by personal and functional characteristics.

Variables	Classes	Frequency	Percent age (%)	Mean	Std. Deviation	Pearson/ Spearman (r/rs)	Sig.
Age	26 – 39 Low	23	18.0	33.782	3.716	r = -0.383**	Sig
	40 – 53 Medium	47	36.7	47.042	4.085		
	54 – 67 High	58	45.3	61.465	3.992		
	Total	128	100	51.195	11.182		
Educational Level	1 Illiterate	24	18.8			rs = 0.454**	Sig
	2 read and write	26	20.3				
	3 Primary school	31	24.2				
	4 Middle school	17	13.3				
	5 High school	7	5.5				
	6 Bachelor's Degree	11	8.6				
	7 Diploma	9	7.0				
	8 Higher certificates	3	2.3				
Farm Size	Total	128	100			rs = -0.213*	Sig
	6 – 70 Small	109	85.2	27.889	17.093		
	71 – 135 Medium	14	10.9	95.000	13.008		
	136 – 200 Large	5	3.9	184.000	23.021		
Type of Farm	Total	128	100	41.328	39.451	rs = 0.212*	Sig
	Plant production	93	72.7				
	Animal Production	18	14.1				
	Mixed farming	17	13.3				
Experience in Agriculture	Total	128	100			r = -0.424**	Sig
	5 – 18 Low	35	27.3	11.000	3.903		
	19 – 32 Medium	48	37.5	25.166	4.022		
	33 – 46 high	45	35.2	40.022	4.147		
Participation in Training Courses	Total	128	100	26.515	12.153	rs = 0.290**	Sig
	1 Participated	92	71.9				
	2 Not Participated	36	28.1				
	Total	128	100				
Attitudes Toward Climate Change	21 – 25 Low	25	19.5	23.280	1.242	r = 0.019	ns
	26 – 30 Medium	58	45.3	28.517	1.327		
	31 – 35 High	45	35.2	32.266	1.095		
	Total	128	100	28.8125	3.433		
Level of Communication with Information Sources	13 – 21 Low	64	50.0	17.578	1.933	r = 0.345**	Sig
	22 – 30 Medium	45	35.2	26.355	2.739		
	31 – 49 High	19	14.8	33.842	2.500		
	Total	128	100	23.078	6.459		

Age, respondents who are located in the high-age category (54 – 67 years) covered almost half of the population, with the ratio (45.3%), while the medium and young ages came lower with the ratios 36.7% and 18% consequently. The results indicate that agricultural activities in the study area are largely managed by individuals who are older rather than younger, and age was significantly and negatively correlated with the dependent variable ($r = -0.383$, $p < 0.01$), showing that higher age was associated with a lower extent of the outcome. *The level of education* among the respondents revealed that most farmers have a primary school certificate (24.2%), followed by the farmers who can only read and write (20.3%), and (18.8%) who are illiterate. Educational level indicated a significant positive relationship with the dependent variable ($rs = 0.454$, $P < 0.01$), which means a better educational level tends to result in higher scores on the measured outcome.

Regarding *farm size*, the findings showed the limitation in the farm size, as most of the respondents with the ratio (85.2%) owned small farms ranging from 6 to 70 dunums, opposite the medium and large farms, where the ratio 10.9% and 3.9%, respectively. It also indicated that the standard deviation was equal to 39.45, which means the farm size relationship had a negative correlation with the dependent variable ($r_s = -0.213$, at $p < 0.05$), because the variable's lower outcome scores were associated with the larger farm holdings. Concerning *the type of farm*, it showed that most of the respondents were practicing plant production, representing 72.7%, while animal production and mixed farming accounted for the ratios 14.1% and 13.3%, respectively. It indicated a positive and significant correlation with the dependent variable.

With respect to *agricultural experience*, the respondents possessed substantial agricultural experience, which was scored at ratios of about 37.5% medium levels and about 35.2% high levels of agricultural experience. As shown in the findings, the average experience was 26.52 years with $SD = 12.15$, which means that the newest in agriculture experience tended to higher scores on the outcome measure, as indicated by the relationship with a significant negative correlation with the dependent variable ($r = -0.424$, at $p < 0.01$). For the *participants in training sessions* about climate change, the results showed that a high ratio of farmers participated, about 71.9%, which was positively and significantly associated with the dependent variable, with the correlation coefficient ratio $r_s = 0.290$, at p -value 0.01, which means that the training helped to increase the measured outcome.

Concerning *attitudes toward climate change*, the respondents reported that the highest ratio was in the moderate level of attitude toward climate change, about 45.3%, then the high and low ratios displayed about 35.2% and 19.5%, respectively. Since $r = 0.019$, at $p > 0.05$, there was no significant relationship found between attitudes toward climate change and the dependent variable. Lastly, the low level was reported by half of the respondents (50%) for *communication with climate change information sources*, while medium and high levels reported lower scores (35.2% and 14.8%), respectively. The dependent variable had a positive and significant correlation with communication with climate change information sources ($r = 0.345$, $p < 0.01$), indicating that more access to information sources improved the measured outcome.

Overall, significant relationships for the previous results, as follows: There were *positive relationships* for all (educational level, type of farm, participation in training sessions, and communication with climate change information sources); on the other hand, there were *negative significant relationships* for (age, farm size, and agricultural experience), and only attitudes toward climate change had *no significant relationship*.

3. To identify the strategies and practices employed by farmers to mitigate the negative impacts of climate change on agriculture in the Soleymani governorate, from the farmers' point of view.

Table 4. Distributing the respondents according to the strategies and practices preferability

Classes	Frequency	Percentage %	Mean	Std. Deviation
Low (21-26)	7	5.5	23.86	2.12
Medium (27-32)	41	32.0	30.22	1.37
High (33-38)	80	62.5	35.94	1.86
Total	128	100	33.45	3.91

The results revealed that the majority of respondents located at the high and medium level (62.5%), and (32%) of their preferability to use new strategies and practices in agriculture in facing the climate change impacts, while only (5.5%) reported in low level, it suggesting that the farmers are open to use new techniques in their farmlands and implement strategies to mitigate the climate change impacts on their agricultural product.

4. To identify the primary challenges faced in implementing the participatory agricultural extension approach from the farmers' point of view

Respondents reported high relative importance for all items using against climate change impacts on agriculture product, the top strategies and practices were recorded with using modern irrigation systems to reduce water consumption, and employing organic farming methods to improve soil health (94.92%, and 94.14), respectively, as the area exposed more to the draught and erosion in the farmlands, farmers suffer from water scarcity and unhealthy soil for the last two decades, this is also mentioned by the (Mohammed *et al.*, 2021) in their research at Soleymani governorate about irrigation water susceptibility indexing method, and water quality, then the last item scored with 73.24% for using biotechnology to improve crop resistance to diseases and pests, this was might back to unfamiliarity about this technique. The results indicated that the farmers had very high relative importance to all strategies and practices mentioned in Table 5, but the ability of application might be limited due to some challenges as described in Table 7, which were the most familiar challenges in the study area.

Table 5. Ranking the strategies and practices according to their mean and relative importance degrees.

Methods and Strategies	Frequency	Sum	Mean	Relative Importance	Ranking
Using modern irrigation systems to reduce water consumption	128	486.0	3.796	94.92	1
Employing organic farming methods to improve soil health	128	482.0	3.765	94.14	2
Using renewable resources such as solar energy	128	450.0	3.515	87.89	3
Using modern and advanced technologies to monitor climatic conditions	128	435.0	3.398	84.96	4
Training and educating farmers on sustainable farming techniques	128	425.0	3.320	83.01	5
Developing policies and legislation to support sustainable agriculture	128	423.0	3.304	82.62	6
Using crop varieties adapted to harsh climatic conditions	128	419.0	3.273	81.84	7
Using artificial intelligence to improve the efficiency of resource utilization	128	402.0	3.140	78.52	8
Raising awareness among individuals and communities about climate change and its negative impacts on agriculture.	128	384.0	3.000	75.00	9
Using biotechnology to improve crop resistance to diseases and pests	128	375.0	2.929	73.24	10

Table 6. Distribution of respondents to challenges of implementing the participatory agricultural extension.

Classes	Frequency	Percentage %	Mean	Std. Deviation
Low (16-22)	3	2.3	16.333	0.577
Moderate (23-29)	29	22.7	27.413	1.783
High (30-36)	96	75	33.260	2.187
Total	128	100	31.539	3.984

Table 7. Ranking the challenges according to their mean and relative importance.

Challenges	Frequency	Sum	Mean	Relative Importance	Ranking
Preference of agricultural extension agents for traditional extension methods	128	357.00	2.789	92.97	1
Prevailing traditional farming culture and customs	128	355.00	2.773	92.45	2
Limited government support for implementing extension programs	128	354.00	2.765	92.19	3
Lack of funding and financial support for the extension system to improve the participatory extension approach	128	341.00	2.664	88.80	4
Lack of training capacities within the extension system in the region	128	338.00	2.640	88.02	5
Shortage of specialized extension staff in agricultural extension agents	128	337.00	2.632	87.76	6
Lack of technical expertise among farmers regarding how to apply the participatory extension approach	128	332.00	2.593	86.46	7
Weak communication and coordination between farmers and agricultural extension agents in executing extension strategies	128	328.00	2.562	85.42	8
Weak policies and legislation supporting the participatory extension approach	128	325.00	2.539	84.64	9
Low interaction between farmers and extension agents in implementing participatory programs	128	325.00	2.539	84.63	10
Lack of technical expertise among agricultural extension agents on how to implement the participatory extension approach	128	323.00	2.523	84.11	11
Limited awareness among farmers about the participatory extension approach	128	318.00	2.484	82.81	12

For the challenges that were not helpful to practice the participatory agricultural extension, it revealed that the three quarters of respondents were scored at the highest level (75%), followed by the moderate level (22.7%), of the relative importance of the mentioned challenges in the table 7, only (2.3) reported at low level, suggesting a high importance of implementing the participatory agricultural extension approach in the studied area.

Concerning the most effective challenges faced by agricultural extension agents from the farmers' point of view, the top three challenges displayed by farmers were as follows: preference of agricultural extension agents for traditional extension methods, prevailing traditional farming culture, and customs. Limited government support for implementing extension programs (92.97%, 92.45%, and 92.19%), respectively. On the other hand, the lowest two challenges scored by farmers were low interaction between farmers and extension agents in implementing participatory programs, and limited awareness among farmers about the participatory extension approach, with the ratios 83.63% and 82.81%. The high ratios of mentioned challenges in the study area indicated that the application of the participatory agricultural extension approach is limited in reaching out to most of the farmers; it needs to reconsideration of agricultural extension strategies by diversifying the activities in their monthly and yearly planning.

Conclusion

The study findings displayed that the farmers in the target area cannot participate in agricultural extension service, especially due to the weak strategy to implement the participatory agricultural extension approach, which is considered a core subject to participate them in agricultural extension activities. These findings suggest that the participatory approach needs to be activated in agricultural extension centers, which are considered the main responsible. As well as the activation of the participatory agricultural extension approach needs government support from the Ministry of Agriculture to face the financial and technical challenges, and at the same time, agricultural extension agents need to reconsider their yearly or monthly strategies.

In general, to get rid of the current challenges in the study area and adaptation to the new strategies to help farmers mitigate the impacts of climate change on the agricultural products requires the diversification of activities in the agricultural extension programs and encouraging them by participating in all levels of agricultural extension programs, including "planning, evaluation, and implementation.

Recommendations

1. The agricultural extension centers need to redesign the agricultural extension programs in general.
2. Enhance the participatory agricultural extension approach by the agricultural extension agents to improve effectiveness and responsiveness to farmers' needs.
3. Equipping agricultural extension programs financially and technically to reactivate the participatory agricultural extension approach
4. Supporting agricultural extension centers with the necessary training materials and aids to activate the participatory agricultural extension approach.

Study Limitations

This study has several limitations that should be considered when interpreting the findings. First, the research was conducted in selected villages in Sulaymaniyah Governorate, Kurdistan Region of Iraq, which may limit the generalizability of the results to other geographical areas with different environmental, agricultural, and socio-economic conditions. Second, the study employed a cross-sectional descriptive correlational design, which is suitable for identifying associations among variables but does not permit causal inferences. Third, the findings were based on farmers' self-reported responses to a structured questionnaire and may therefore be subject to response bias, social desirability bias, and recall bias. Finally, the study focused primarily on farmers' demographic and farm-related characteristics and did not examine broader institutional and policy dimensions that may also influence the effectiveness of participatory agricultural extension.

Future Research Directions

Future research should extend this work by including farmers from different governorates and diverse agricultural production systems to improve the external validity and generalizability of the findings. Comparative studies across regions with varying climatic, institutional, and socio-economic conditions would provide a broader understanding of the effectiveness of participatory agricultural extension.

Longitudinal, quasi-experimental, or experimental research designs are recommended to evaluate the long-term effects of participatory agricultural extension on farmers' adaptive capacity, resilience, and adoption of climate-smart agricultural practices. Future studies should also investigate the influence of institutional and policy-related factors, including extension service capacity, extension agents' competencies, governmental support, financial resources, and digital agricultural advisory services. Furthermore, integrating quantitative and qualitative approaches would provide a more comprehensive understanding of farmers' participation, decision-making processes, and the practical challenges of implementing participatory agricultural extension under changing climate conditions.

Scientific Ethics Declaration

* The author declares that the scientific, ethical, and legal responsibility for this article belongs entirely to the author.

Conflict of Interest

* The author declares that there is no conflict of interest.

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