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CLIMATE CHANGE PROMPTED PERILS AND LOCAL SMART ADAPTATION STRATEGIES IN AGRICULTURE: EVIDENCE FROM PAKISTAN

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Abstract:
Purpose: *Climate change refers to long-term shifts in weather patterns and global temperatures due to human-activities, primarily the emission of greenhouse gases into the atmosphere. Climate change has numerous impacts, including rising temperatures, extreme weather events, changes in precipitation patterns, intense heatwaves, droughts and floods. Farmers are significantly impacted by climate change as their livelihoods depend on the environmental conditions.*
Research Method: *The study used a binary logistic regression model to assess the factors influencing the adoption of smart climate adaptation strategies by farmers. It also included an examination of farmers' awareness, perceptions of climatic hazards, and changes in cultivation patterns due to climate change.*
Findings: *Results of the analysis shows that factors including family size, dependency ratio, land size, access to credit and extension services and distance to market have positive impacts on farmer's smart adaptation strategies. However, age, education, off-farm income and raising livestock have negative influence on farmer's smart adaptation strategies. The output of the farm and non-farm operations can be used to control the risk posed by climate change and implement as many smart adaption techniques as possible. As a result, policies, methods, and resources should be developed and made available to farmers so that they can quickly adopt effective climate change adaptation measures.*
Keywords: *Smart adaptation strategies, climate change, logistic model, agriculture, Pakistan.*

Introduction

Extreme weather events including hurricanes, cyclones, droughts, floods, and wildfires are becoming more frequent and more severe as a result of climate change. These incidents seriously harm the environment, residential structures, and livelihoods, causing relocation, fatalities, economic disruptions, and increased social vulnerability. In recent times, the phenomenon of climate change is widespread, meaning that its impacts are not confined to specific regions or countries. Greenhouse gas emissions and other human activities that contribute to climate change occur worldwide, and the resulting changes in climate patterns affect the entire planet. Indeed, the negative impacts of climate change on both natural and human systems are generally more apparent and well-documented than the positive impacts (Karl et al. 2009; IPCC, 2014; Ojo and Baiyegunhi, 2020 and Pedersen et al., 2021).

Many people in low income countries countries rely upon climate-sensitive sectors for their livelihoods. The sectors include forestry, agriculture, and fisheries. By causing extreme weather

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CJSSR
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
Vol.04 No.01 (2026)

events, changing growing seasons, and altering precipitation patterns, climate change disrupts these industries and generates lower yields of crops, diminished fisheries, and degraded forests. Poor households' access to food and money are directly impacted by this matter (Maskrey et al. 2007). Even though they only contribute 10% of the world's annual carbon dioxide emissions, developing nations are the most vulnerable to climate change (Maskrey et al. 2007). Agriculture is a vital sector in South Asian countries, employing a substantial portion of the population and contributing significantly to their economies. Climate change-induced shifts in temperature, rainfall patterns, and extreme weather events directly affect agricultural productivity, leading to reduced crop yields, food insecurity, and economic losses. Small-scale farmers, who form a significant portion of the rural population, are particularly vulnerable due to limited resources and adaptive capacity (Zhuang 2009; Mirza 2011).

The 21st century's agricultural industry in underdeveloped nations faces serious hazards from predicted climate change. Although significant technological breakthroughs, improved agriculture productivity is not achievable without favorable weather (IPCC 2014). Rainfall and temperature are two environmental factors that can be used to estimate crop yields. Crop farming is significantly impacted by global climate change of varying intensities (Ullah et al, 2018).

Climate change has had a severe impact on Pakistan, one of the ten most susceptible nations in the world. The agricultural industry accounts for 22.7% of Pakistan's GDP and is very important to the country's economy. Historically, different climatic pressures, such as floods, droughts, unpredictable rainfall, and heat waves, have an impact on Pakistan. Pakistan glaciers means Himalayas are melting very rapidly due to accelerating temperatures, there's a chance of reduced water availability in the future. Given that a sizable section of the population works in agriculture, it poses a serious danger to livelihoods, food security, and other aspects of the agricultural sector (Kreft et al. 2017; GDP, 2021).

The most destructive floods in Pakistan's history occurred in 2010 and 2014, while the country also had severe droughts from 1999 to 2003. Over the past 20 years, these events have had a substantial impact on the yield of important crops like wheat, rice, sugarcane, and cotton (Abid et al., 2015). Therefore, adaptation methods are required and is essential to minimizing the consequences of climate change. Crop dates can be changed, livestock can be used in mixed cropping systems, crops can be modified, irrigation systems can be changed, and contemporary varieties that are adapted to drier conditions can be used, according to Nhemachena and Hassan (2007) and Kurukulasuriya and Mendelsohn (2008). Additionally, some nations are putting their adaptation tactics to use on farms to help alleviate climate change. These differences in adaptation techniques depend on the type of farm, the climate, as well as the political, institutional, and economic variables of the farmers. Additionally, the farmers' choice of adaptation tactics depends on their geographic and temporal circumstances (Bryan et al., 2009, Deressa et al., 2009, Hisali et al., 2011).

Adaptation strategies for agriculture can lessen the effects of climate change, but they are insufficient to solve the problem on their own. The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as the process of changing natural and human systems in response to past, present, and future climate change, as well as its effects, in order to lessen or neutralize harm or increase opportunities to resist climate change (IPCC, 2014). Furthermore, there is a critical need for adaptation techniques, in the case of Pakistan. Farmers must have access to current, accurate, and comprehensive knowledge about climate change in order to effectively handle this major issue. Additionally, farmers would be better able to lessen the harmful consequences of the

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CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
CJSSR
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
Vol.04 No.01 (2026)

climatic issues issue with the use of adaptation tactics such changes to socioeconomic and agronomic practices (Nhemachena and Hassan, 2007).

As best to the extent that we are aware of and comprehend, this study would be a valuable addition to the scientific research because few researchers have performed similar research in Pakistan. As agriculture is a vital sector in Pakistan's economy, and climate change impacts, including erratic rainfall, increased temperatures, and pests and diseases, have adverse effects on crop yields and livestock productivity. This affects food security, rural livelihoods, and the overall economy. Moreover, Pakistan has been taking steps to address climate change impacts through national policies, disaster management strategies, and efforts to promote climate resilience. Despite of these vulnerabilities, still research is required to fill the literature breach. The current study examines the degree of climate change comprehension and how farmers perceive it, what they know, and how they are aware prompted perils related vulnerabilities. This study would offer adequate justification for the various types of agricultural risks and depending on the farmer's home, the farmer chooses the right farm adaptation measures. Following is the breakdown of the remaining portions of an article. The methodology is followed by results and discussion portions. The study's conclusion and its policy implications were presented in the final section.

Methodology

The province of Khyber Pakhtunkhwa (KP) is geographically separated into two zones: the northern zone and the southern zone. The northern zone stretches from the Hindu Kush to the edges of the Peshawar basin. The northern zone has a chilly, snowy environment with significant winter precipitation. Apart for the capital Peshawar, which gets hot in the summer, it has pleasant summers with modest rainfall. Peshawar to the Derajat basin are included in the southern zone. It features dry winters and scorching summers with little rainfall (GoKP, 2023). A total of 1.65 million hectares are cultivated in the KP province, which occupies 12.77 percent of Pakistan's total land area. Both some of the steep sections and its plain regions have excellent soil fertility (GoKP, 2023).

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CJSSR
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
Vol.04 No.01 (2026)

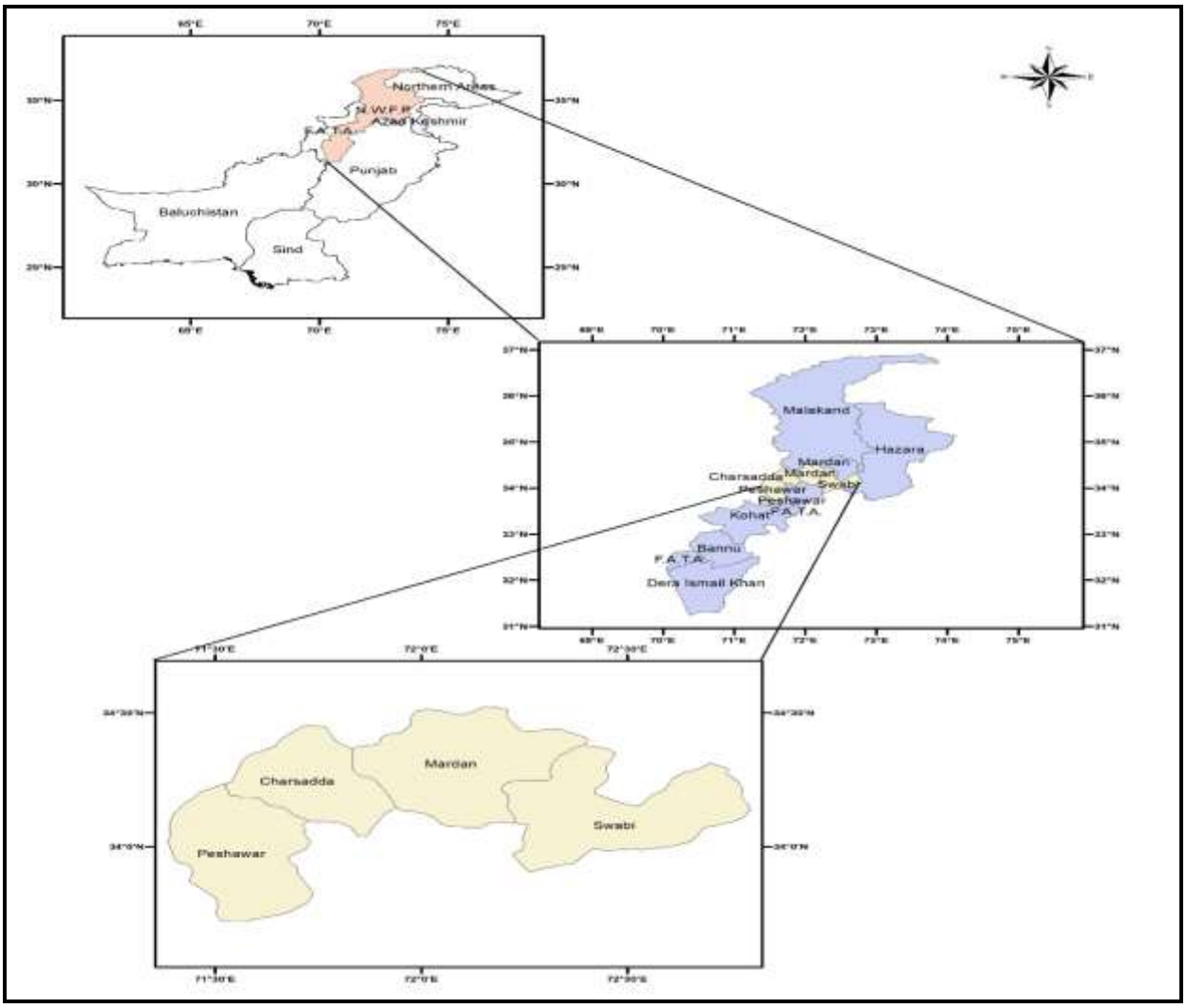

Figure 1. Map of the study area

This study was carried in 4 districts of Khyber Pakhtunkhwa. Figure 1 presents the map of the study area. This study area was selected purposively because these districts are considered as the green built of the province. Mostly livelihood in this areas depends on agriculture. The primary data information was gathered, based on the local farmer's thoughts, perceptions, experience and various climate factors and risk they faced in the area. In addition, the first identification of exposed and vulnerable places was done with the assistance and advice of educated, experienced, competent, and knowledgeable villagers. In the same context, a consultation with the skillful farmers in the villages was determined which regions were utmost disposed to major issue which is climate change. In these parts of KP, where the majority of the population is Pashtun, women cannot be interviewed by strangers (Qasim et al., 2015). The fieldwork research's respondents received adequate information about the survey's objectives, which were to fulfil the program's educational objectives. They were therefore free to respond honestly to the surveys without any restrictions (McCusker and Gunaydin, 2015). Hence, only male farmers participated in the data collection. As a result of interview total number of 478 respondent's data was collected and complied in the field survey area. For this purpose, a structured and pre-tested questionnaire was

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CJSSR
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
Vol.04 No.01 (2026)

developed and data was collected. The primary need to pretest the questionnaire was satisfied before to the physical survey, ensuring that any errors wouldn't occur during fieldwork. As a result, it was possible to identify the responders who weren't willing to fill out the questionnaire, and those people were replaced with new survey respondents.

To calculate the likelihood of the binary result, the logistic regression model employs the logistic function. The logistic function is used by the model to convert the probability's log odds (logit) back into a probability. The model's result is an estimation of the likelihood that the event will occur.

$$P_i = E(Y = 1|\mathrm{X_i}) = \frac{1}{1 + e^{-(\alpha+\beta iXi)}}$$

α is a constant, Xi is a vector of independent variables, βi is a vector of independent variable coefficients, and Pi denotes the probability of adopting an adaptive action. To make this equation simpler, we will write it as

$$Pi = \frac{1}{1 + e^{-Zi}} = \frac{e^{Zi}}{1 + e^{Zi}}$$

Where

$$Zi = \alpha + \beta iXi$$

The probability of avoiding taking an adaptive action is (1-P*i*).

$$1 - Pi = \frac{1}{1 + e^{Zi}}$$

$$\frac{Pi}{1 - Pi} = \frac{1 + e^{Zi}}{1 + e^{-Zi}} = e^{Zi}$$

The most significant socioeconomic characteristics within the framework of this study were identified through literature research to assure the correctness of the estimates.

Table 1 Socioeconomic characteristics of the variables

Variables	Descriptions	Classification	Expected Sign
Age	≤18 = 0, ≤ 30 = 1, ≤ 45 = 2, ≤ = 2, ≥ 60 = 4	Categories	±
Education	≤ 0 = 1, ≤ 5 = 2, ≤ 10 = 3, ≤ 12 = 4, ≥ 14 = 5	Categories	+
Family size	Number of the household of the farmer (Number)	Continuous	±
Dependency ratio	Number of the household of the farmer (Number)	Continuous	-
Land size	Land under cultivation size in hectares	Continuous	+
Access to extension services	Access to extension services = 1, Otherwise = 0	Dummy	+
Access to credit services	Access to credit services = 1, Otherwise = 0	Dummy	+
Off farm income	Off farm income have =1, Otherwise = 0	Dummy	+
Livestock raising	Numbers	Continuous	+
Distance to market	Kilometers	Continuous	±

Source: Author calculation

Table 1 shows the socioeconomic variables, description, classification and expected sign of the variables. A farmer's selection of an adaptable course of action may be significantly influenced by a variety of circumstances, including household age measured taken as categories, family size measured in number, dependency ratio measured in number, land size taken in hectares, off-farm income, access to extension and credit services taken as dummy variables, distance to market measured in kilometers and livestock raising taken in number.

ISSN E: 3006-1466
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CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
CJSSR
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
Vol.04 No.01 (2026)

Results and Discussions

Socioeconomic factors are very important in determining how households behave and their capacity to implement adaption measures to climate change. Table 1 presents the results for all socioeconomic characteristics for the households. Farmers' ability to adapt to climate change can vary greatly depending on their age. Older farmers often have more experience and traditional knowledge related to farming practices. They may have observed and dealt with various climatic variations throughout their lives, enabling them to draw on their experience to adapt their farming methods. Their accumulated knowledge can be valuable in implementing adaptive measures. The average age of the households was categories 2.46. The major portions of the households age were determined 45 years. Education level and, awareness of climate change issues can influence households' understanding of the risks and the importance of adaptation. Well-informed households are more likely to adopt adaptive measures and make knowledgeable choices regarding their consumption patterns and resource management. The average household's education category was considered 1.45. This shows that most of the farmers slightly above the illiteracy category. A larger family size can provide more labor resources for agricultural activities, including implementing climate change adaptation measures. With more family members available to work on the farm, farmers may have a greater capacity to carry out labor-intensive tasks associated with adaptation, such as crop diversification, soil conservation, or water management. The average family size of the households was figured out 6.56 with the minimum 2 and maximum of 11. Almost 6 peoples made up the typical household. The average dependency ratio of the households was 1.34. This portrait that dependency ratio of the farmers was not too much high around the surveyed locality. The usual and average size of the land was 3.82 hectares. Social networks, extension services and community-based institutions can be quite helpful in promoting climate change adaption. Strong social networks provide access to information, resources, and support systems that can help households cope with climate-related challenges. The households' usage of credit and extension services indicates that most farmers have access to these services. Further, the average figures of livestock raising shows that the majority of farmers preferred to raise livestock along with agricultural cultivations. Higher income and wealth levels generally provide households with more resources to invest in climate change adaptation measures. Wealthier households may have access to technologies, insurance, and financial resources that enable them to implement adaptation strategies more effectively. Therefore, the high of-farm income of the farmer would play a critical role to adopt adaptation to climate changes. Further, households that are located far away from markets and therefore resources might not be readily available such as food, water, and energy. This can exacerbate changes in climate's effects, particularly in cases where climate change reduces the availability of these resources. The average distance to market was figured out 12.31 kilometers.

Table 2 Descriptive statistics of the variables

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
Age	2.46	3.00	4.00	0.00	0.86	478
Education	1.45	1.00	5.00	0.00	1.36	478
Family size	6.56	6.00	11.00	2.00	1.94	478
Dependency ratio	1.34	1.00	4.00	0.00	1.05	478
Land size	3.82	3.64	11.33	0.81	1.75	478

ISSN E: 3006-1466
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CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
CJSSR
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
Vol.04 No.01 (2026)

Access to extension services	0.76	1.00	1.00	0.00	0.43	478
Access to credit	0.71	1.00	1.00	0.00	0.45	478
Of farm income	1.00	1.00	1.00	0.00	0.42	478
Livestock raising	0.78	1.00	1.00	0.00	0.41	478
Distance to market	12.31	12.00	28.00	3.00	5.49	478

Source: Author calculation

Farmers' estimations of their exposure to climate change are given significant weight in the study's conclusions and the methods they feel will work best in these conditions. Cross-sectional data from 478 household's farms in KP, Pakistan, were collected for the project. The information was taken to represent the 2020–2021 agricultural production season. In order to gather data based on the farmers' perspective and opinions regarding the temperature and precipitation patterns in the research area, 478 growers were interviewed. We have however briefly examined how farm households view climate change and the many tactics they have adopted over the past few decades. In light of this, we have briefly examined farm households' views on climate change as well as the varied measures they have adopted over the past few decades. The awareness of the farmer on long-term changes in natural catastrophe, precipitation and temperature during the last 20 years are shown in Figure 2. The study's findings indicate that in the survey area, 82% of farm households were aware about the changes in climate over the past 20 years. Further, 74.1% of the farm households were aware about the irregular temperature pattern, 66.1% of the farm households were aware about the irregular precipitation pattern. In addition, 66.5% of the farm households were aware about the irregular natural catastrophe during that same period.

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CJSSR
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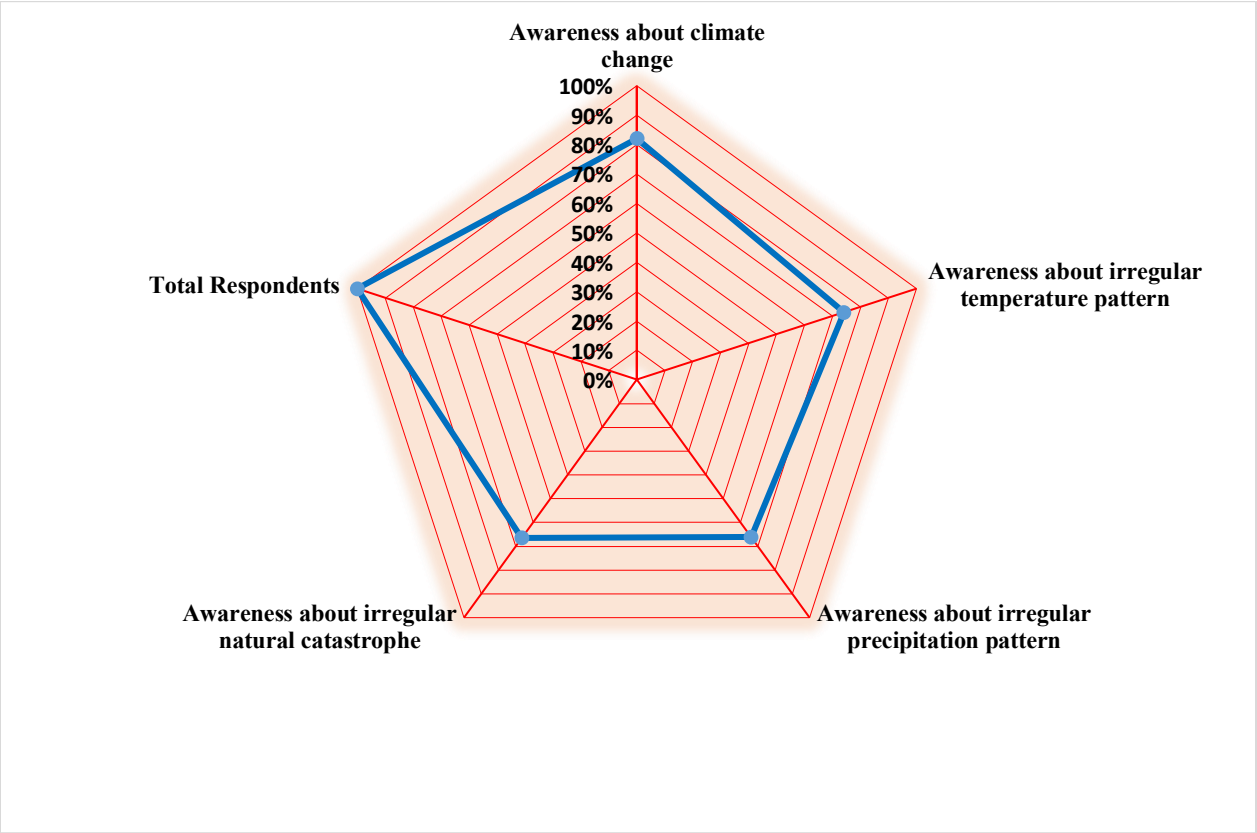

Figure 2 Awareness about climate change

The research area Firstly, the crops cultivations such as sugar cane, tobacco, and fruits such as main three category study area has the peaches, plums, apricot, apples; off-season vegetables, such as tomatoes, potatoes, peas, cabbage and cauliflower. The study also captured households' perceptions of production patterns for the main three kinds of agriculture operations concerning the effects of climate change on the last couple of decades in the study area. A substantial gap in the increase and decrease was found between the all kinds of agriculture operations production in the study area. The perception of cultivation pattern in the study area due to climate change is presented in Figure 3. Most of the farm households perceived that their winter and summer crops production increased by 72.45% and 66.64% increased respectively during the last couple of decades. Further, 66.64% summer and 74.23% winter vegetables cultivation farm households have perceived positive impact concerning the effects of climate change on the last couple of decades in the study area. Similar, the fruits production of summer and winter season of the farm households was increase by 59.61% and 68.34% respectively in the same period of time. All of the farm households reported substantial increase in the all types of agricultural operated crops, however, there is considerable decrease was reported in the particularly decrease in the summer fruits production.

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CJSSR
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
Vol.04 No.01 (2026)

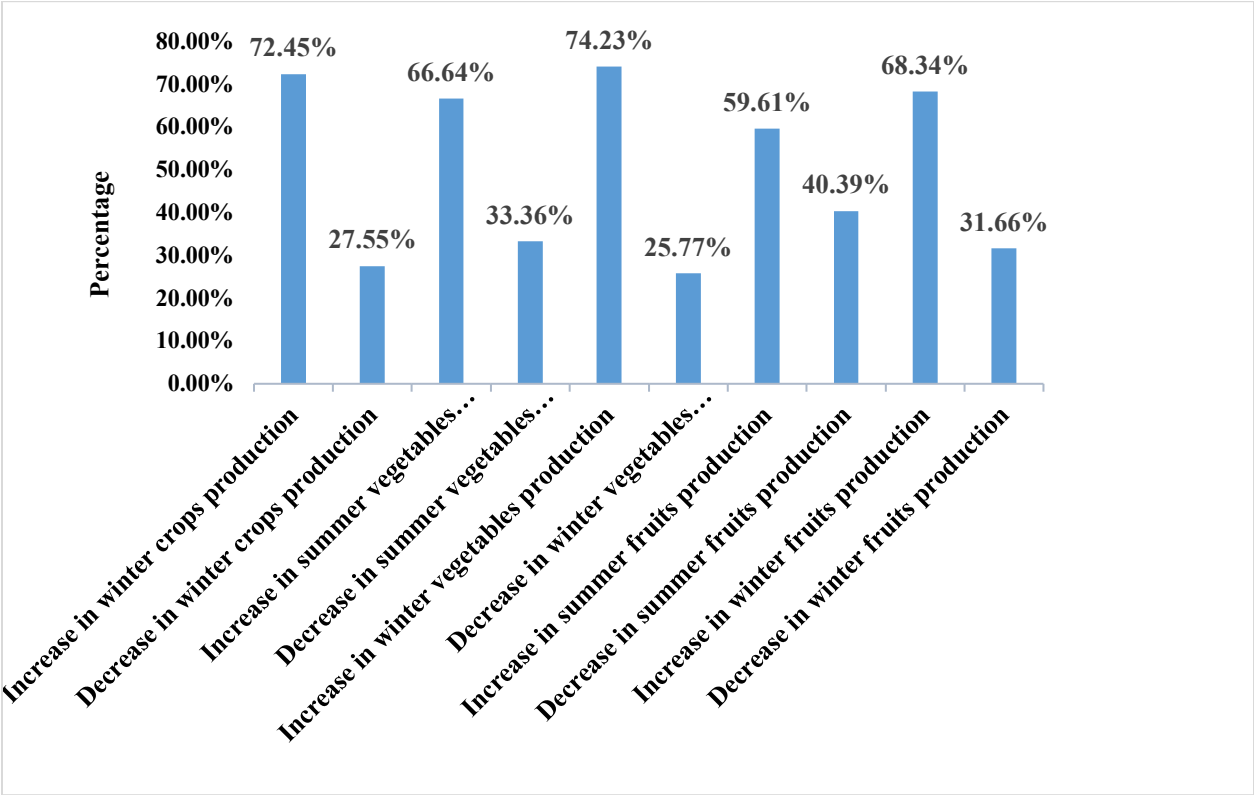

Figure 3 Perception of cultivation pattern due to climate change

The farmer's adaptation approaches to climate change are shown in Table 3. The farm household was questioned in the field study about how they felt the climate has changed over the last two decades. If the response was acceptable, we went on to inquire whether choice adaptation mechanisms had been used in the research region. The reaction was very positive, and the respondents commonly used techniques for adaption tactics to resist the consequences of climate change. The farm household's adaptations strategies to climate change presented in Table 3. The results of adaptations strategies to climate change show that 30.4% of the farm households have not used any modification techniques. The rest of the farm household's said that new crops variety (16.3%), alteration of crops timing (14.5%), alteration of farming practices (9.7%) were the highly dominants modification techniques more frequently used in the study's area.

Table 3 Farmer's adaptation strategies to climate change.

Farmer's adaptation strategies	Farm households (%)
No adaptation strategies	30.4
Stopped growing particular crops	6.7
Alteration of crops timing	14.5
New crops practices	16.3
Planting new tree	8.3
Alteration of farming practices	9.7
Soil management	6.7
Household invested in irrigation	5.6

ISSN E: 3006-1466
ISSN P: 3006-1458
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
CJSSR
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
Vol.04 No.01 (2026)

Other adaptation strategies	1.8
Total numbers of respondents	478

Source: Author(s) calculations

Farmers in the study area were interviewed or surveyed about climate change and climate-related threats over the past decade. This approach aimed to gather information directly from farmers to assess their viewpoints, occurrences, and observations related to vulnerability of climate change and its effects on farming practices. By querying farmers about climate change, researchers can gain insights into their knowledge, awareness, and understanding of climate-related issues. Figure 4 demonstrates how households view climatic threats and change in the climate. Most of the respondents in the study area have observed drastic fluctuations in the temperature. Almost 66% of the respondents have observed high temperature and 39% of the respondents have observed low temperature in the study area. More than 59% indicated an increase in unpredictable rainfall occurrences. A sizeable majority of respondents also reported a rise in the fluctuations in snowfall patterns occurrences as well as fluctuations in the patterns of frost and hailstorms. Almost 62% and 85% of the respondents said that droughts and dry spells were the most prevalent risk associated with climate change. This was followed by a rise in the incidence of risk in floods, occurrence of avalanches, erosion and land sliding, livestock diseases and insect assaults. Households of 52% have attributed about hazards in climate changes. Moreover, 72% of households that have adopted any coping or adapting measures and 70% have taken actions to adaptive action about climate changes.

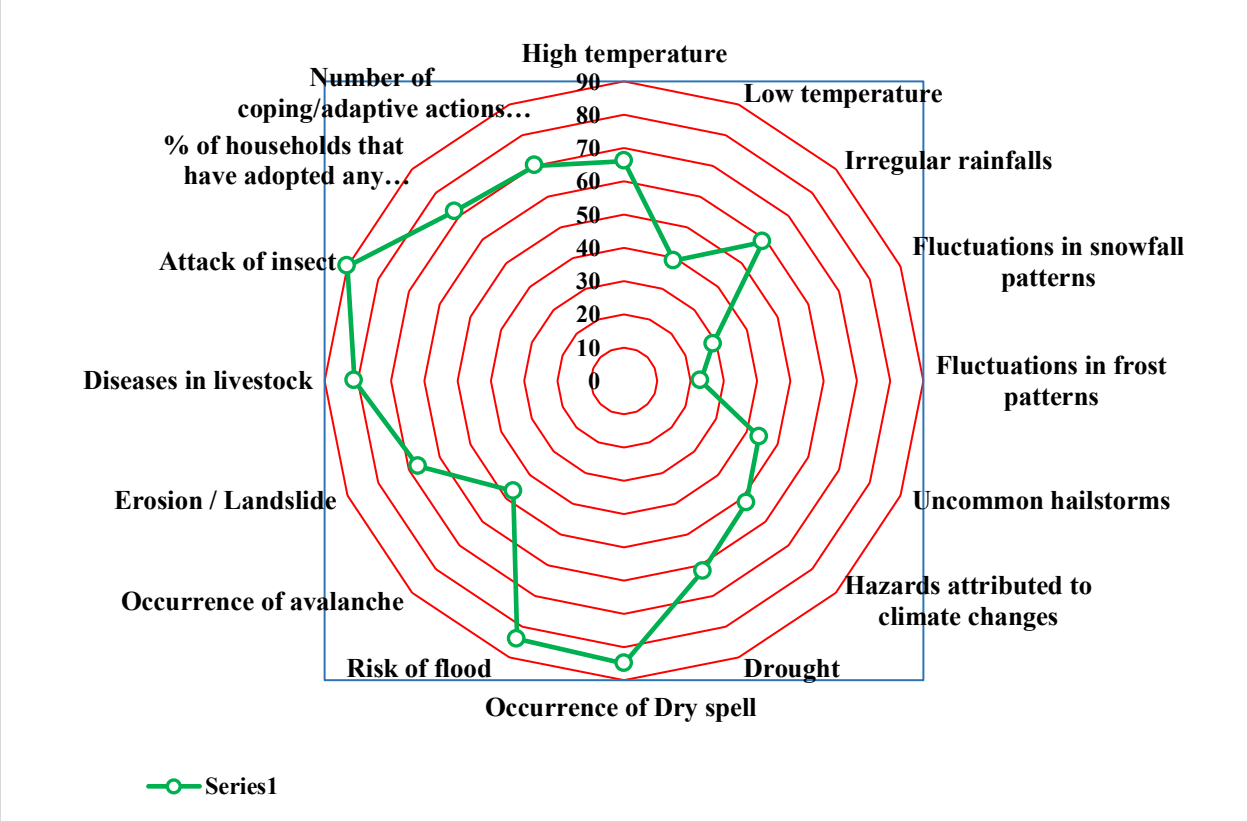

Figure 4 Household perception of changes in climate and climatic hazards

ISSN E: 3006-1466
ISSN P: 3006-1458
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
CJSSR
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
Vol.04 No.01 (2026)

In order to investigate the nature of the link that exists between socioeconomic conditions the percentage of households that have implemented adaptation measures in order to deal with the effects of perceived changes in the climate in the agricultural production and awareness about climate change, a logistic regression model was applied. Table 4 displays the findings of the marginal effects and the binary logit predicted coefficients of the parameters. Initially, it was necessary to conduct diagnostic tests in order to examine the multicollinearity of the data. There was no indication of multicollinearity found when the Variation Inflation Factor (VIF) and Condition Indices (CI) were analyzed and compared. The results of the Wald χ^2 test show that there is a considerable degree of statistical significance at the 1% level, signifying that the independent variables equally determine the adaptation measures in order to deal with the effects of perceived changes in the climate in the agricultural production and awareness about climate change. Hensher and Johnson (1981) claim that a value for pseudo-R^2 that falls within the range of 0.20 to 0.40 is considered to be an appropriate fitting. As part of this study, the goodness-of-fit performance indicators located near the base of Table 4 and the pseudo-R^2 statistics revealed that our models aligned the data in a satisfactory manner. Furthermore, pseudo-R^2 value 24% and 20% show fascinating results. This indicates that 24% and 20% of the variation in perceived changes in the climate in the agricultural production and awareness about climate change may be attributed to socioeconomics variables. It's possible that perceived changes in the climate in the agricultural production and awareness about climate change qualities are responsible for the remaining 76% and 80% of the variation.

Table 4 presents the coefficients estimates, odds ratio, marginal effects and elasticity of the exploratory variables. Hence, this study predictor variable are dichotomous variables. Therefore, this study interprets the results with the support of odds ratio as well as with coefficients of the models. The odds ratio represents the multiplicative change in the odds of the outcome associated with a one-unit increase in the corresponding independent variable. The odds ratio is a method for comparing the probabilities of two different events. The chance that an event will take place, divided by the chance that it will not take place, is the method used to estimate the odds that an event will take place. An odds ratio greater than 1 suggests an increase in the odds of the outcome, while an odds ratio less than 1 indicates a decrease. Odds ratios that are larger than one suggest that the event will have a higher chance of occurring as the predictor's value grows. Odds ratios that are less than one imply that the event's chances of happening decrease as the predictor's level of influence rises. First this study interprets the results of the model 1. The respondents with the odds ratio of age and educations are 1.63 and 1.72 times more likely to perceived climate changes and hence implemented adaptation to climate change in the agricultural production. Further, households with the odds ratio of land size and access to extension services are 1.13 and 1.20 time more likely to perceived climate changes and hence implemented adaptation to climate change in the agricultural production respectively. Similarly, off farm income, raising livestock and distance to market are 1.33, 2.10 and 1.04 times more likely to perceived climate changes and hence implemented adaptation to climate change in the agricultural production respectively. In contrast the socioeconomic variables such as family size, dependency ratio and access to credit have less likely to perceived climate changes and hence implemented adaptation to climate change in the agricultural production.

Moreover, this study interprets the results of the Model 2 presented in Table 4. The households with the odds ratio of age and education are 1.75 and 1.80 times more likely aware to climate changes. Likewise, land size, access to credit, access to extension services are 1.24, 1.83,1.06 times

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CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
CJSSR
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
Vol.04 No.01 (2026)

more likely aware about the climate change respectively. Despite of these results Model 2 have family size, dependency ration and raising livestock have less likely aware about the climate changes in the study area.

Furthermore, the coefficient age of the households has a negative and significant relationship with the climate change adaptations strategies. Due to the fact that this association is negative, it appears that younger farmers are more likely than older farmers to select adaptive measures. This finding lends credence to the findings of Ojo and Baiyegunhi (2020) who reported that there is an inverse association between age and the mixed cropping and improved variety adaptation strategy. In the same vein of study Denkyirah et al. (2016), reveals that age of the households has negative impact on the adoption of pesticides applications in agriculture production. The coefficient of family size of the farmers positively impacted on their selection of climate change adaption techniques. These findings are consistent with those of Deressa et al. (2009) as well as Ali and Erenstein (2016). The study's findings show that larger families have more benefit to choose climate change adaption techniques. The larger family size has edge to engage extra labor with in the family for better agricultural production (Gautam and Andersen, 2016). The coefficient of land size for farming has a statistically significant positive linkage with the adoption of the adaptation strategies. This finding lent credence to prior research linking larger farms with more technological advancements (Bamire et al., 2010; Bryan et al., 2013). The households with larger land size for farming have more option for investment compared to smaller land size in the agriculture production such as using of hybrid variety.

Table 4 Results of the Binary logistic regression analysis

Variables	Adaptation to climate change			
	Coefficients Estimates	Odds Ratio	Marginal Effects	Elasticity
Age	-0.28(0.18)	1.63(0.11)**	-0.03	-0.57
Education	-0.36(0.12)**	1.72(0.09)**	-0.05***	-0.46**
Family size	0.07(0.07)	0.85(0.06)	-0.01	-0.37
Dependency ratio	0.07(0.14)	0.03(0.14)	0.01	0.07
Land size	0.12(0.08)***	1.13(0.09)	0.02**	0.38**
Access to credit	0.92(0.38)	0.04(0.71)	0.12	0.55
Access to extension services	1.27(3.04)	1.20(0.20)**	2.33	11.68
Off farm income	-17.31(3.04)	1.33(3.33)*	-2.17	-11.00
Raising livestock	-1.30(0.40)***	2.10(3.62)	-0.16***	-0.87***
Distance to market	0.13(0.08)***	1.04(0.61)	0.03**	0.37**
C	-1.33(0.79)*	0.50(0.38)	-	-
Pearson χ^2 goodness test				
Prob > χ^2 = 0.00				
Log likelihood = -194.17				
Pseudo R^2 = 0.24				

Source: Author calculation

The coefficients of the household's regarding ability to use extension services has statistically significant and positive impact on climate change adaptation strategies. This result supported by the outcomes of prior research study performed by Adesina et al (2000). Extension services are

ISSN E: 3006-1466
ISSN P: 3006-1458
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
CJSSR
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Vol.04 No.01 (2026)

initiatives that provide farmers and rural communities with information, training, and support to improve their agricultural practices and adapt to changing conditions. Given these possible advantages, it is plausible that expanded accessibility to extension services would encourage the use of adaptation tactics. Farmers are better able to make educated decisions and put effective adaptation strategies into action when they have access to knowledge, technical assistance, and resources (Maddison, 2007). It's critical to make extension services available and easily accessible if we want to improve farmers' perceptions of and comprehension of climate change. To close the information gap and give farmers the ability to appropriately recognize and adapt to climate change in their farming practices, extension systems may be strengthened, extension agents can be given adequate training and resources, and efficient communication channels can be established (Bryan et al., 2013). The availability of credit has been found to be a significant predictor of whether or not people choose to implement techniques for adapting to climate change. The research of Kandli and Risbey (2000) and Mmbando and Baiyegunhi (2016) demonstrated that farmers' inability to afford the price of applying adaptation techniques might prevent them from making the most use of the knowledge at their disposal. The coefficient of loan availability has an optimistic impact on the selection of options for coping with climate change. Certain crops would demand the acquisition of new or enhanced planting materials and other technology, which could raise the expense of putting adaptation measures into place. So, even if farmers are aware of climate change, it might be challenging for them to put any adaptation strategies into action if they lack access to funding. This can be because they are unable to afford the necessary inputs. Access to extension services has a positive impact on strategies for climate change adaptation. The results of this study are in line with previous ones such as Aftab et al. (2021) and Ali and Rose (2021). The results of these study suggests that extension services improve the timely and regular interval climate change information provision to the local farmers. The income generated from the off-farm activities have negative impact on approaches to coping with climate change. The results support the findings of the previous study performed by Diiro and Sam (2014). This author results indicates that farmers who don't engage in off-farm activities use all of their labor resources in the farm more effectively than they do elsewhere, boosting their adoption of technology that increase production. The findings indicate that as household income rises, so do adoption and use of measures for coping with climate change. In contrast income generated from off-farm activities enhance the adoption of technology.

Conclusions

The KP province of Pakistan county-wide situated to the northwest of Pakistan, has a predominantly agricultural economy. For a sizable portion of the province's inhabitants, especially in the rural areas, agriculture serves as their primary source of income. The main crops farmed in KP include fruits such oranges, apples, and apricots, as well as wheat, maize, rice, sugarcane, and tobacco. The production of dairy and meat from livestock is a significant part of the agricultural industry in KP. The agricultural industry in KP, however, suffers a number of difficulties, including as low production brought on by poor soil fertility, insufficient water availability, out-of-date farming methods, and restricted access to loans and other resources. Additionally, the area has had numerous natural disasters, including earthquakes and floods, which have had a substantial influence on the agricultural industry. According to the study results, 82% of the participants were aware of climate change. According to the analysis's findings, farmers in the research area have seen significant variations in the production of agricultural products during the summer and winter. In addition, farmers in the area perceive dry spells, flood risk, and high temperatures, respectively,

in proportions of 85%, 84%, and 66%. The results of the binary logistic regression model showed that family size and land size have a favorable impact on climate change adaptation techniques. The research area's 0.07% and 0.12% improved climate change adaption techniques, respectively, would result from a 1% increase in family size and land size. Similarly, a 1% increase in market distance, availability to credit, and extension services would increase 0.92%, 1.2%, and 0.13%, respectively, the cost of adaption measures to climate change.

The intensity of the effects of climate change will continue to rise. Adaptation strategies can help mitigate the impact of these changes, such as planting drought-resistant crops in areas experiencing water scarcity. Developing and promoting crops that are resistant to drought, heat, and other climate-related stressors can aid in reducing how negatively the environment will affect agriculture. It is possible to help the atmosphere's ability to absorb greenhouse gases by safeguarding and restoring natural ecosystems including forests, wetlands, and oceans, as well as provide other ecosystem services like flood control and biodiversity conservation. Agroforestry integrates trees into agricultural landscapes, which can provide multiple benefits such as increased biodiversity, carbon sequestration, and improved soil health. Promoting the usage of sustainable energy in agriculture, such as solar panels or biogas digesters, can reduce emissions and dependence on fossil fuels. Encouraging knowledge sharing and education about agriculture and the effects of climate change climate can help farmers and other stakeholders adapt to changing conditions and adopt sustainable practices. Increasing public understanding of and awareness to the environment and its effects can encourage individuals and organizations to take action and support policies that address the issue. Worldwide problems like climate change need coordinated solutions. Global cooperation can help facilitate the adoption of effective policies and strategies to help impoverished nations and regions with both technical and financial support.

Competing Interests

The authors have declared that no competing interests exist.

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Ethics Statement

N/A

Data Availability

Yes - all data are fully available without restriction.

Describe where the data may be found in full sentences.

All relevant data are within the manuscript and its Supporting Information files.

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