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ADAPTATION STRATEGIES TO MITIGATE THE IMPACTS OF CLIMATE CHANGE ON AGRICULTURE AND WATER RESOURCES IN KHYBER PAKHTUNKHWA, PAKISTAN

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ABSTRACT

This research examines the effects of climate change on agriculture, groundwater and biological systems in the region of Khyber Pakthunkhwa (KPK) Pakistan. Being a region that relies so much on farming, KPK is becoming more susceptible to climate change in terms of altering weather patterns, quantity of water and dynamic ecosystem. This research will evaluate the changes experienced in the area regarding the environment and the adaptive mechanisms used by the local farmers in fighting them. The research involved the use of a mixed-methods design where the quantitative data (e.g., related to temperature variations, rainfall/drought scenarios, ground/surface water presence, crop production) were complemented with the qualitative data extracted through surveying and interviewing 100 farmers of the largest agricultural regions of KPK: Peshawar, Charsadda, and Nowshera. Statistical methods helped to analyze the quantitative data and reveal trends among climate variables whereas thematic analysis of the interview replies allowed reaching deeper insights of understanding the perception of climate change and the ways of adapting to it. As per the findings, a significant drop in rainfalls was recorded and 80 percent of the farmers admitted that it had an adverse impact on food production. Seventy-seven percent farmers recorded temperature increase and 71 percent of farmers noted deterioration in groundwater levels. As a reaction, 71 percent farmers improved their land use patterns and 63 percent altered crop choices as a result of the shortage of water. The study has also identified introduction of new species of plants and animals, which have impacted in crops and the livestock. The results emphasize the urgent need of specific adaptation plans, such as better water management and implementation of climate-resilient agricultural activities. The study indicates that there is a lot of necessity on government intervention and application of local adaptation strategies on which to curb the effects of climate change on farms in KPK. The research will provide helpful information to policymakers and agricultural extension agencies to model climate-smart interventions on sustainable farming in the area.

Keywords: *- Climate Change, Agriculture, Water Resources, Khyber Pakhtunkhwa, Adaptation Strategies, Groundwater Depletion.*

1. Introduction

Both natural and anthropogenic qualities of climate change are global phenomena, since it is becoming more apparent in realms around the globe. One of the regions affected most by these changes is South Asia where vulnerability to climatic changes is most acute. Going by this, Pakistan, a country in this region is subject to much having to risk with climate change, notably in its Northwestern version Khyber Pakhtunkhwa (KPK). Among the states that have agricultural economies and ecosystems, KPK has also been extremely vulnerable to weather extremities, including floods, droughts, heatwaves, and changes in the nature of precipitation. This has been compounded by poor adaptation mechanisms, poor awareness by the locals and lack of resources to deal with the after-effects of climate change [1]. The weakness of KPK has much to do with the geographical and socio-economic situation. Its topography makes the province very sensitive to climatic changes especially because it relies on agriculture. In the past decades, the increasing temperatures, changing rainfall patterns, and the loss of ground waters reserves were observed in KPK. Such changes in climatic patterns have had a direct effect on major industries especially agriculture which lies at the heart of livelihoods of most KPK inhabitants. Alteration in temperature and precipitation together with the elevating rate of extreme weather events has led to the declining normalism of crops, less availability of water as well as degrading health of the soil and livestock productivity [2].

Farming activity in KPK relies mostly on irrigation systems which have been under the threat of inconsistent rain patterns and dipping groundwater levels. This has caused a lot of farmers to change the way they perform farming though these change techniques, more often than not, have been restricted by monetary problems and inability to access advanced farming methods. Even the biological systems of KPK made up of flora and fauna are being affected by these climatic changes and the changes in the ecosystems have given birth to new species and shrunk the native ones. Indicatively, invasive plant and animal species are starting to replace local biodiversity which impacts on food chains and agricultural outputs [3]. Climatic shift is a major issue that is facing KPK, and its implications are environmental, and they are economic and social. The agricultural sector in the region that plays critical role in food security and economic stability is under pressure. Agricultural productivity goes down as ground water sources are dry thereby increasing poverty and food insecurity. Availability of a comprehensive climate adaptation policy has also contributed to the efforts of local communities to handle these problems as they are [4].

The given study is an attempt to evaluate the consequences of climate change on agriculture, groundwater, and biological systems of KPK with particular emphasis on the vulnerability of the region and the adaptive behaviours of farmers. The study will examine the implications of these weather changes in crop yields, water supply as well as livestock welfare and what local farmers are doing to curb their impact. Knowledge on how farmers have been able to adapt will play a significant role in the development of better climate adaptation measures and this will assist in ensuring that environmental systems become more resilient by opening up opportunities to combat any challenges posed by climate changes in KPK and other similarly affected areas. Since the province is still experiencing severe challenges regarding climate change, this research project is also going to outline how relevant governmental policies, local, and community-owned activities can be used to check the challenges caused by climate change. The research will bring forth important information on how KPK can manage to cope and counter the impacts of climate change to agricultural and water resources based on experiences and perceptions of local farmers [5].

2. Literature Review

2.1 Climate Change and its Global Impact

The advancement of climate change or mostly because of increased emission of greenhouse gases (GHGs) like carbon dioxide, methane, and nitrous oxides has evolved to become one of the most serious challenges in the world. The natural greenhouse effect created by human activities, such as deforestation, industrialization and agricultural activities have exacerbated this natural effect to produce unprecedented global warming. This warming has been causing an increase in the occurrence of extreme weather

patterns, such as heatwaves, rainstorms, and droughts, which are mostly devastating the ecosystems, and pose a threat to the agricultural systems worldwide [4]. As it was noted by the Intergovernmental Panel on Climate Change (IPCC), the global temperature is expected to increase by 1.5° C to 4.5° C towards the end of the current century, worsening the effects on the water, food security and human health [5]. The problem of climate changes is more about the developing regions such as South Asia because the region is challenged by some socio-economic problems like poverty, bad infrastructure, and little access to climate-resistant technologies. The countries of South-Asia, Pakistan being one of them, are among the most susceptible to the effect of climate change, namely, in the fields of agriculture, water and health. This is further worsened by the reliance of the region on agriculture as a food and livelihood source which is highly dependent on weather patterns and therefore benefiting stable weather.

2.2 Climate Change in Pakistan

Climate change is becoming a major problem in Pakistan and more specifically the Khyber Pakhtunkhwa (KPK) province. The province is described as a combination of geographical features, i.e. mountainous regions of the province, as well as lowland plains, which exposes the province to diverse climatic risk, such as climatic extremities, floods, droughts, and variations of precipitation patterns. The rate of temperature change in the last several decades in Pakistan is alarming as well as the unpredictable rainfall pattern which greatly impacted the agriculture sector negatively [6]. According to Pakistan Meteorological Department (PMD), the average temperature in the country has been on the rise by 0.5° C over the last 50 years, and the high temperature events have been sharply on the rise during the last 3 decades [7]. These temperature changes, coupled with change in monsoon and winter precipitation has upset the historical cycle of farming as well as reduced the productivity of agriculture. Also, the shift in the supply of water, surface and ground, as a result of climatic variations have been a burning subject matter in KPK as farmers in this region have been experiencing a progressive reflection of the groundwater resources as a result of excessive abstractions and a lack of refilling through rain [8].

In a research conducted by Ahmad et al. (2021), it was outlined how the impacts of climate change on agricultural systems in Pakistan are extreme, focusing on water rather than land as the main resource since the usability of the water declined and it was easier to affect crops with the aid of high temperatures and floods [9]. This has increased the vulnerability of the farmers as they do not implement adaptive strategies, particularly in the rural setting, which has led to economic hardships as well as insufficient food supply. It, therefore, means that climate change effects in Pakistan can only be addressed through both technological mitigation and institutional strategies so that there is proper adaptation to climatic changes.

2.3 Climate Change and Agriculture in Khyber Pakhtunkhwa

The agricultural sector of Khyber Pakhtunkhwa is mainly based on irrigation whereas the supply of water largely depends on weather conditions. The agricultural sector in KPK is severally affected by the effects of climate change associated with sporadic rainfalls and long drought periods that lead to less water to use as irrigation. A study conducted by Saleemul Huq (2020) states that the province has experienced a decrease in predictable rain patterns of the season leading to changes in water supply to crops like wheat, rice, and sugarcane [10]. With a high proportion of population of KPK engaged in agriculture, any agricultural productivity disruption in the area means a direct effect of the local economy, food security and the general living condition of the local people. Rainfall patterns in KPK have been erratic and temperature is rising due to which farmers reported high crop failures. Over-pumping of ground water to fulfil irrigation has also contributed to the main problem as ground water is now depreciating at an alarming rate. To the rescue, most farmers have embarked on adaptive methods, like rationalizing crops to drought resistant ones, varying planting times and diversification of farming skills [11]. But these actions are still not enough when climatic conditions continue to aggravate and the influence of these actions on the agricultural sector is not enough and things need to be done with greater involvement on the part of the

government and non-governmental institutions. Besides, the flora and fauna, as well as other biological systems in KPK, are experiencing the impact of climate change as well. Our changing environmental conditions such as change in temperature and the patterns of precipitation have contributed to the alteration of the ecosystem, with certain species of plant and animals being replaced by invasive species. This has led to loss of biodiversity, and interference with local food chains, which has an impact on agricultural productivity and the provision of ecosystem services [12]. According to a study by Ali et al. (2021), invasive species including some plants and animals have replaced native species in KPK thus causing the decrease in crop production and abuse of farming land [13].

2.4 Water Resources and Groundwater Depletion in KPK

The groundwater resource depletion is one of the most vital effects of climate change in KPK. The groundwater has been found to be vital in irrigation as rain cannot be adequate or constant in some regions. Nevertheless, excessive use of groundwater along with decreasing replenishment of water because of the decrease in rainfalls, has subsequently resulted in radical lowering of water-tables in large areas of KPK. The World Bank (2020) argues that the ground water levels have decreased significantly in the major agricultural areas, making water supply to agriculture even more limited [14]. The cost of extracting water increases as the underground water pools dry up posing an additional challenge to the farmers in preserving the irrigation systems. This has resulted into more water saving farming techniques including rainwater collection and planting drought resistant varieties of crops. Although these have been done, however, in general, the issue of water scarcity is a significant obstacle on the path of agricultural sustainability in KPK. The government and the governmental agencies on the ground have been encouraged to practice improved water management, such as improvement of irrigation systems and stimulation of water saving systems among the farmers.

2.5 Adaptive Strategies and Policy Recommendations

The strategies of adaptation are very important in achieving the mitigation of effects of climate change on agriculture in KPK. The farmers have also embraced a number of coping mechanisms that negatively include crop diversification, soil conservation measures as well as adoption of climate-tolerant seeds. Sometimes, the use of these strategies is hampered by the inaccessibility to information, technology, and money input [15]. Ullah et al. (2019) have stressed the importance of a more holistic climate adaptation strategy by taking into account the top-down and the bottom-up version of such initiative to improve farmers' resilience in KPK. These are to include the enhancement of agricultural extension, better access to weather and climate information and also having financial back-up in the adoption of climate resilient technology [16]. In addition, the policies of government should aim to enhance water resources, invest more in conducting research on agriculture and offering incentives on sustainable modes of farming as well [17].

Table 1: Summary of Literature Review

Ref No	Author(s) and Year	Contribution	Research Gap
[1]	IPCC (2020)	Offers global projections on climate change impacts on agriculture, water resources, and ecosystems, focusing on land and water management.	Does not provide in-depth regional assessments, especially for Pakistan's mountainous provinces like KPK.
[2]	World Bank (2020)	Reports on Pakistan's climate change impacts, focusing on agriculture, water scarcity, and adaptation.	Lacks specific focus on local-level agricultural responses and groundwater depletion in KPK.
[3]	Ali, S., Ying, L., & Nazir, A. (2021)	Investigates farmers' perceptions and coping strategies towards climate change in KPK, focusing on rural adaptation strategies.	Study does not consider the biological and ecosystem impacts of climate change in KPK, nor

			does it integrate government policies.
[4]	Saleemul Huq, S. (2020)	Provides a comprehensive analysis of climate change vulnerabilities and adaptation in South Asia, particularly Pakistan.	Limited focus on specific provincial impacts, especially on water resources and farming in Khyber Pakhtunkhwa (KPK).
[5]	Ahmad, T. (2021)	Reviews the impacts of climate change on water quality and availability in Pakistan, with a focus on the agricultural sector.	Does not include a detailed exploration of KPK's agriculture, groundwater depletion, and farmers' perceptions.
[6]	Ullah, W., Nafees, M., et al. (2019)	Analyzes farmers' perspectives on climate change and evaluates farm-level adaptation measures in KPK.	Limited understanding of specific agricultural changes due to climate change, and the role of water resources in adaptation.
[7]	Ahmad Shah, A. (2021)	Focuses on farmers' perspectives on climate change in KPK, including crop failures and the role of water in agricultural productivity.	Lack of deep dive into groundwater depletion's long-term effects on agriculture, including the biological systems involved.
[9]	Ahmad Shah, A., & Khan, R. (2022)	Explores the socio-economic impact of climate-induced flooding in rural Pakistan, with a focus on KPK.	Insufficient focus on the broader ecological impacts, such as biodiversity loss and long-term groundwater depletion.
[10]	Muhammad, S., & Ahmad, T. (2021)	Examines the vulnerability of agricultural systems in Pakistan, with emphasis on changing crop cycles and water stress in KPK.	Does not investigate farmers' coping strategies or regional adaptive policies in-depth, particularly in mountainous areas like KPK.
[11]	Khan, M., & Ali, J. (2021)	Investigates the effects of changing climatic conditions on wheat production in KPK, focusing on seasonal precipitation shifts and temperature rise.	Focuses mainly on a single crop (wheat), with limited exploration of broader climate impacts on multiple crops and other agricultural practices.
[12]	Zahid, M., & Zulfiqar, S. (2020)	Looks at the long-term effects of temperature increase and water scarcity on farming livelihoods in KPK, with special attention to farmers' adaptive capacity.	Does not explore the role of government or agricultural support services in facilitating adaptation strategies at the local level.
[13]	Raza, M., & Ali, F. (2021)	Analyzes the impact of drought on crop yields in KPK and the strategies farmers use to mitigate water scarcity during dry spells.	The paper lacks an in-depth look at groundwater depletion and its cumulative effects on both agriculture and biodiversity.
This Work		Examines the comprehensive impact of climate change on KPK's agriculture, focusing on groundwater depletion, crop productivity, and the adaptation strategies employed by farmers. It integrates biological, environmental, and socio-economic aspects to assess the overall vulnerability of the province.	This work bridges the gap by providing a localized and multi-dimensional analysis of KPK, combining environmental, biological, and social factors, with a focus on government policy and farmer responses.

The current literature underlines the great effects of climate change on its agriculture, water resources and biodiversity in areas, such as South Asia, in particular Pakistan. Many studies underpin the susceptibility of agricultural sector to altering weather conditions including variations in precipitation patterns, the rising temperature as well as the elevated level of occurrence of extreme weather conditions. As an example, Huq (2020) refers to the overall weaknesses of South Asia, whereas IPCC (2020) states the global estimates of the climate change effects on agriculture and ecosystems, which are expected to require further actions to suit regional conditions. The case in Pakistan is about the specific risk to the agricultural sector, a scenario caused by changes in the availability of water due to climate-change induced changes in the volume of groundwater and surface-water movement. Work by Saleem et al. (2020) and Raza and Ali (2021) discuss the depletion of groundwater and its negative consequences on the agriculture sector in the province of Khyber Pakhtunkhwa (KPK), especially on crop yields and shortage of works. In addition, the study by Ali et al. (2021) and Ahmad Shah (2021) discusses such responses posted by farmers in KPK as adaptive mechanisms such as diversification of crops and adoption of drought-resistant varieties. Nevertheless, the current text tends to lack detailed, small-scale perceptions of the relationships between these climate effects and local governance, ecological alterations, social and economic conditions in KPK. Our research should close this gap as we will also integrate ecological, biological and socio-economic aspects of climate change in KPK focusing on adaptive practices of farmers and how the government and agricultural policies can be effective in enhancing resilience.

3. Methodology

It is a mixed-method type of research work which evaluates the effects of climate change on agriculture, ground water, and biological systems of Khyber Pakhtunkhwa (KPK) in Pakistan. The mix of the qualitative and the quantitative research method will enable a complete picture to be drawn of the climate change vulnerability of the region as well as the adaptation strategies of the local farmer. Such quantitative data as the changes in temperature, precipitations, crop profits, and underground water levels allow creating numerical estimates of the changes in the environment that take place in the area. At the same time, the qualitative data collected during the interviews and surveys among the farmers and local stakeholders provides more information on the socio-economic and cultural aspects of the climate change adaptation. Combining the two approaches, the research will help to grasp the intricate combination of environmental, biological, and social determinants of the climate change experience in KPK. The design, data collection methods and analysis techniques concerning the study are elaborated as follows.

Figure 1: Flowchart of Methodology

3.1 Research Design

This paper is based on mixed methodology, where both types of research techniques quantitative and qualitative are used to collect broad information regarding the effects of climate change on water resources and agriculture in Khyber Pakhtunkhwa (KPK). The quantitative element entails gathering of numerical information on the change in temperature, rainfall patterns, underground water levels, and crop productions. The statistical analysis will be made to find common trends and correlations based on this data. On the contrary, the qualitative element involves interviews and surveys with stakeholders and local farmers to get the opinion on the same regarding their perceptions towards the climate change and how they adopted different strategies to cope. The combination of these two styles enables one to effectively examine the given topic that includes both numerical statistics and personal accounts.

3.2 Research Area

The present research is carried out in Khyber Pakhtunkhwa (KPK), which is a province in Pakistan whose landscapes are differentiated by mountains, valleys, and plains. The economy of KPK is highly dependent on agricultural lands which is a major threat due to the effects of climate. This area is highly affected by wide ranges of climatic changes, having high incidents of extreme weather patterns, e.g. droughts, floods, and variable rainfalls. The research will target rural and farmlands in KPK, a region that is severely affected by climate change since changes in climate directly affect crop production, water sources, and livelihoods of the local farmers. The region is chosen because it is an important region to the agriculture sector of Pakistan and there is an urgent necessity to consider the climate adaptation strategies of this region.

3.3 Data Collection

Information on this research would be collected through the primary and secondary sources of information.

Primary Data: The first data will be collected using surveys (Questionnaire in Annexure) and interviewing the local farmers, agricultural specialists and stakeholders. These questionnaires shall inquire into the experience of farmers regarding climate change as well as their methods of adaptation and the dilemmas. Personal interviews will be used to provide a better understanding of experiences and adaptive practices. Also, there will be field observation to measure the effects of climatic changes on farming systems, water consumption and soil quality in a direct manner.

Secondary Data: Data on climate (temperature and rainfall pattern) and ground water level will be obtained through the meteorological and water management authorities. This secondary data will give me all the necessary data regarding the trend on the past and the natural factors that affected the agricultural production in KPK.

3.4 Data Analysis

The quantitative and qualitative analysis of the data will be conducted:

Quantitative Analysis: Numerical data of the surveys and those of temperature, amount of precipitation and groundwater levels will be processed with the use of statistical programs (SPSS or R). The data will be summarized by descriptive statistics and the correlation between climate variables and crop yields will be studied. Historical data will be considered in time-series analysis in order to determine trends and future forecasts.

Qualitative Analysis: The answers to the interviews and surveys will be analyzed through thematic analysis that would give an opportunity to identify common themes and patterns in the regards of the impacts of climate changes and adaptive strategies. The collected data will be classified and encoded as per the research objectives and the experiences of the farmers will be elucidated with a view of delving deeper into understanding the experiences of the farmers.

3.5 Ethical Considerations

The rights and well-being of the participants will be followed, and ethical norms and principles will be observed during the course of research:

Informed Consent: The nature of the research and the role of the participants in the research will be well communicated to all the participants. He or she will invite them to take part in surveys or interviews after seeking their consent.

Confidentiality: Personal information of the participants will be considered confidential. Survey data and interview data will be

anonymized so the identity of the responding persons is not revealed.

Non-harm: The study shall be made in a way that does not cause any harm to the participants so that the asked questions will be polite and unobstructive.

Data Security: All the received data would be safely stored and would not be compromised in the hands of any unauthorized person.

3.6 Limitations

Though the current study attempts to deliver an in-depth research, it has a number of limitations to consider:

Geographical Restrictions: The research is restricted to KPK that might not reflect the entire picture of the other areas of Pakistan. Nevertheless, KPK can also be deemed as an appropriate model that can be used to interpret the impacts of climate change on agriculture in other similar territories.

Data Limitations: Dependable and sustainable climate data might be constrained, particularly on ground water levels, mostly in remote areas and rural settings.

Resource Constraint: Inadequate budgetary allocation, time, and accessibility of research resources to carry out a large amount of data will constitute limitations to the study, which may limit the sample size and geographical area.

Nevertheless, these weaknesses will not compromise the value of the research, as it will help to gain valuable insights into the particular climatic challenges affecting KPK and suggest ways of enhancing the process of adaptation in the region. In this research, the researcher will use a qualitative approach in combining both qualitative and quantitative methods to evaluate the effects of climate change on agriculture and water resources in Khyber Pakhtunkhwa (KPK), Pakistan. A quantitative component will imply the acquisition of numerical data related to temperature, pattern of precipitation, crop production, ground level water accumulation, which will be statistically analysed to observe tendencies and dependencies. At the same time, survey and interview-related data will also be collected among farmers, agricultural professionals, and local stakeholders in terms of their perceptions of climate change and adaptive strategies they employed. The statistical and thematic analysis of the data will be conducted, which will give a full picture of the issues experienced by the agricultural sector of KPK. The aspect of ethics, like informed consent and confidentiality to the participant will also factor in the study. Although the study will address the limitations of the study like data limitation and geographical confinement, it will give significant answers to the weaknesses of the region and a powerful corrective measure on climate change adaptation to minimize the effects of climate change on agriculture and water resources.

4. Results and Discussion

4.1 Environmental Conditions: Perceived Changes in Rainfall

Most of the farmers (69%) reported the changes in the amount of rain they received over the last few years. Out of them, 80 percent of them said that rainfall has reduced, which they opine has adversely influenced the productivity of the farms.

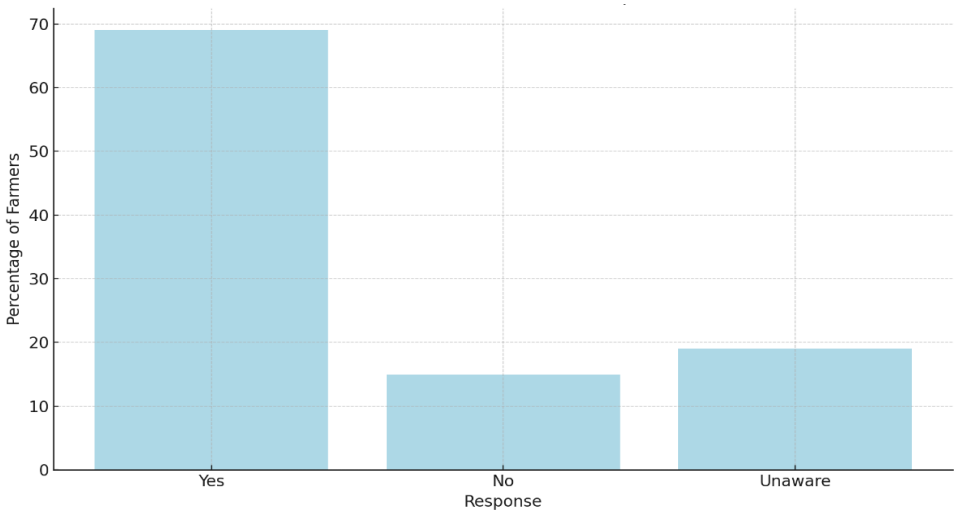

Figure 2: Perception of Rainfall Change

Interestingly, so many individuals mentioned that farmers do not actually notice the changes in rainfall, as 15 percent of farmers did not notice such changes, and, also, 19 percent did not remember anything on the topic.

This underscores the overall impression of reduced amount of rains and this is in line with the witnessed decline in production of crops within the area.

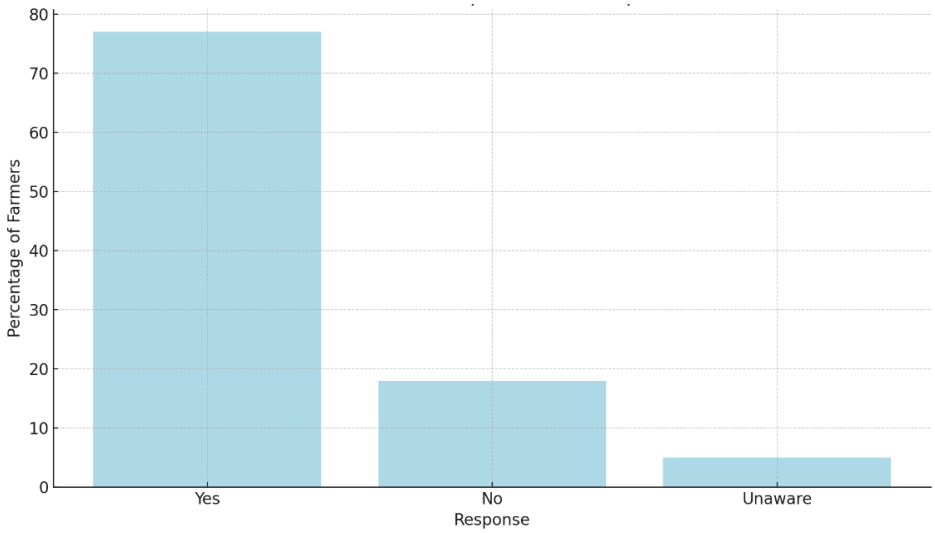

Figure 3: Perception of Temperature Change

The bar graph in figure 3 illustrates the percentage of farmers who reported an increase in temperature and their perceptions of the impact on agriculture.

4.3 Groundwater Level Reduction

Concerning groundwater levels, it was established that 71 percent of the farmers support the fact that the water levels have been reduced and this is of great concern to irrigation. To the contrary, 26 percent said there was no change and 3 percent were oblivious to the changes in groundwater levels. The depletion in won groundwater table complies with what has been happening in water scarcity in the area.

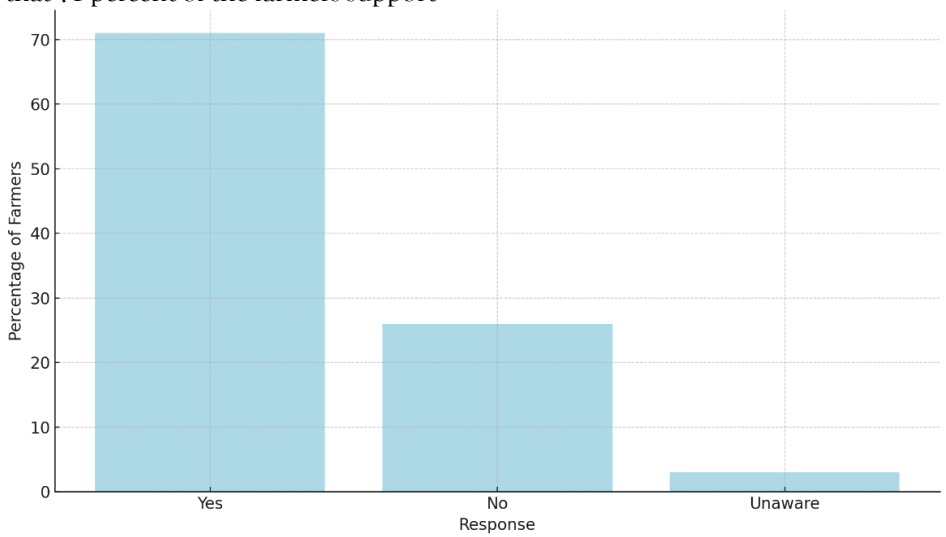

Figure 4: Groundwater Level Perception

This pie chart in figure 4 presents the perception of farmers regarding the reduction in groundwater levels over the past few years.

4.4 Land Use Changes in Response to Climate Change

In trying to adjust to the compromised water resources and other climatic conditions, 71

percent of the farmers reported changing their land usage dynamics. The transition may include crop transition, use of water efficient agriculture techniques or changing the time of crop planting to fit more with the changing climates.

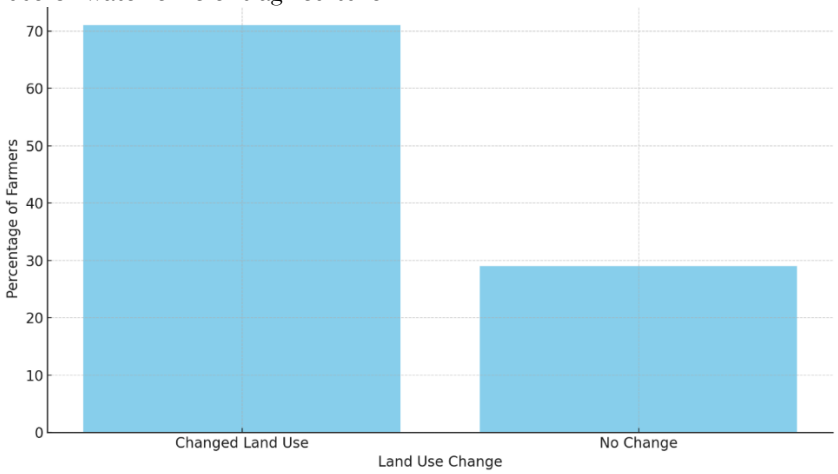

Figure 5: Changes in Land Use

The chart in figure 5 shows the percentage of farmers who have changed their land use patterns in response to climate change.

4.5 Flood and Drought Risk Perception

Concerning the threat of floods, not all farmers noticed a significant threat of floods, 71 percent of farmers did not define flood risk as a serious concern as only 20 percent of farmers ranked flood risk among major concerns. On the same note, the question on whether drought is likely to happen, 29 percent of farmers responded that they saw a problem in drought risk whilst on the other hand, 71 percent of them responded that drought was not a great danger in their region.

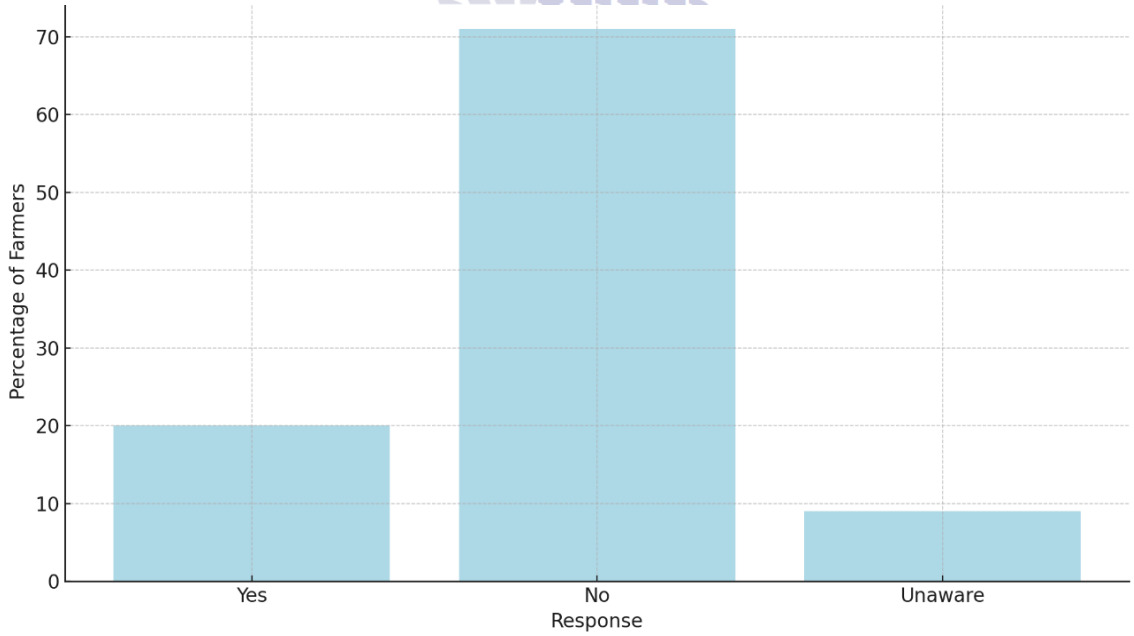

Figure 6: Perceived Risk of Floods

The bar chart in figure 6 represents farmers' perceptions of flood risk in their areas due to climate change.

The pie chart in figure 7 depicts farmers' views on the likelihood of drought occurrence in their region.

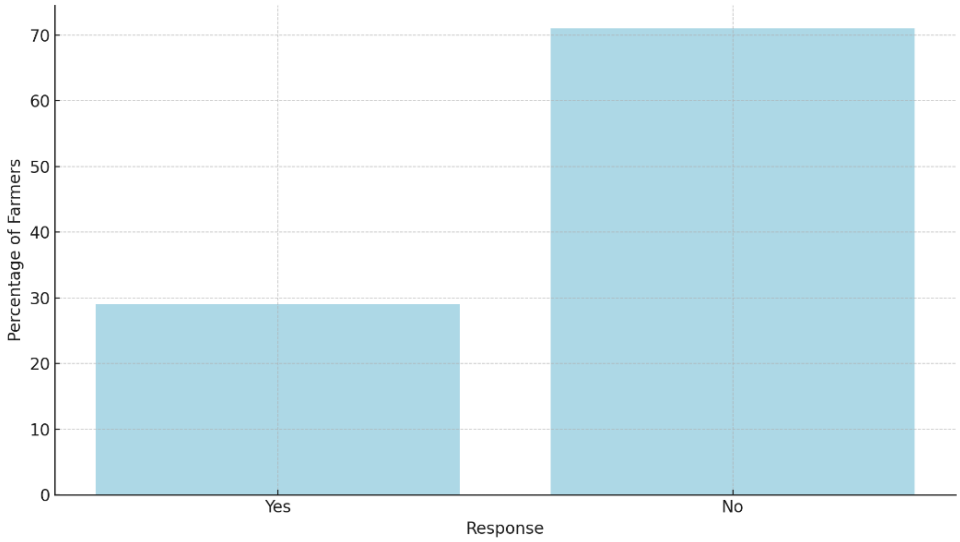

Figure 7: Perceived Risk of Drought

4.6 Biological Conditions: Changes in Plants and Animals

It was found out that 41 percent of the farmers had detected the loss of some plants and animal species, probably because of the changing climatic conditions. This biodiversity change is something that is becoming more and more worrisome to agricultural activities. Moreover, 41 percent of the farmers recorded observable alterations of plant growth such as the earlier or delayed fruiting season whereas 29 percent did not record major changes.

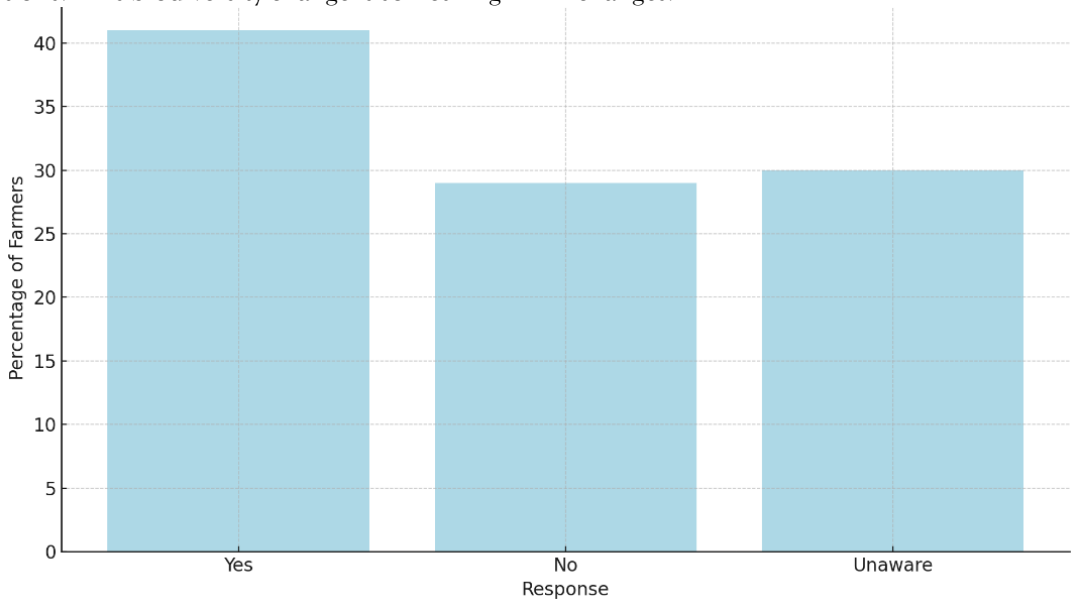

Figure 8: Change in Plant Growth Period

The graph in figure 8 illustrates the percentage of farmers who observed changes in plant growth periods due to climate change.

4.7 Impact of Unfamiliar Plants and Animals

The high number of 76 percent of farmers surveyed have indicated that they noticed more unknown plants and animals in their plots and think they are destroying crops and land. Conversely, 17 percent of the farmers did not care about these new species believing that they could come in handy. Other farmers have said that they are growing fast in recent years.

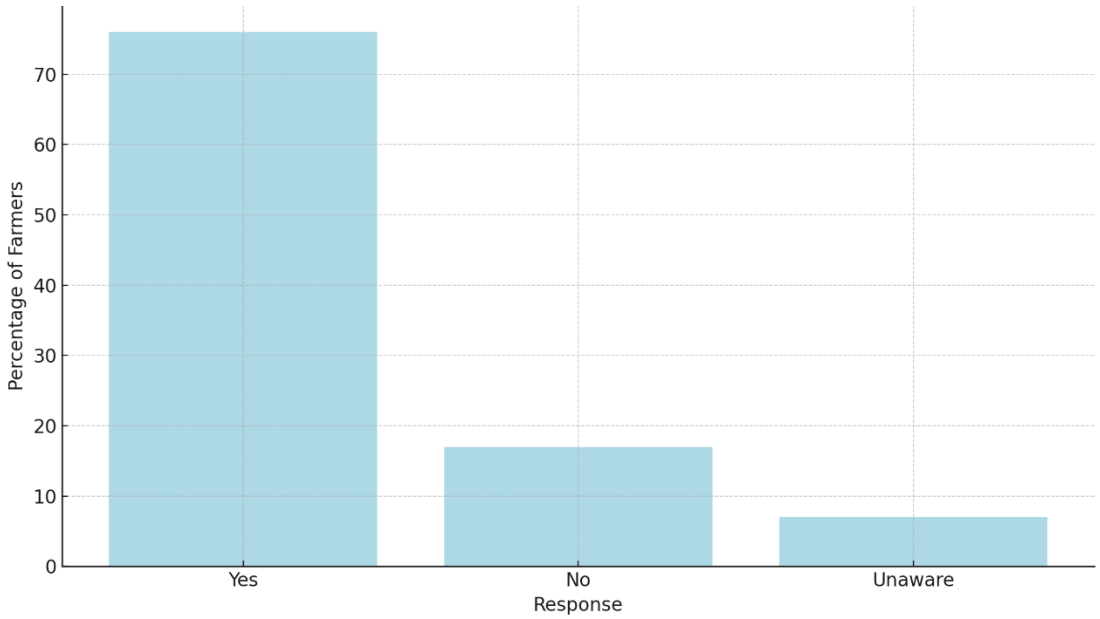

Figure 9: Presence of Unfamiliar Plants and Animals

Figure 9 chart displays the farmers' concerns about the introduction of unfamiliar plants and animals in their fields.

4.8 Livestock Health Impact

Concerning livestock, even 55% of farmers testified that they saw characteristics changes in the health of their animals, such as reduced production of milk and reproductions problems. Health reduction of the livestock associated with extreme temperatures as well as other climate-related conditions constitutes an alarming situation among farmers.

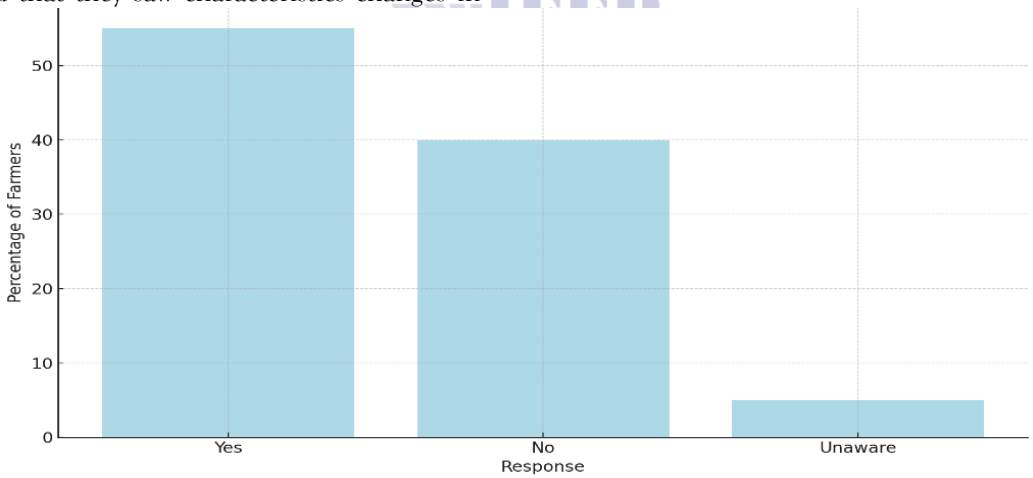

Figure 10: Livestock Health Impact

The pie chart in figure 10 presents the percentage of farmers who have noticed health issues in their livestock due to climate change.

4.9 Adaptation Strategies: Coping with Climate Change

The adaptation of farmers to climate change is taking place in Khyber Pakhtunkhwa in different ways. Due to the rising water scarcity, 63 percent of the farmers ceased to produce the crops that require much water. Also, 41 percent of farmers changed their crop production, trying hybrid crops or crops more resistant to droughts. The agricultural production under the changing climatic condition achieves these changes to sustain production.

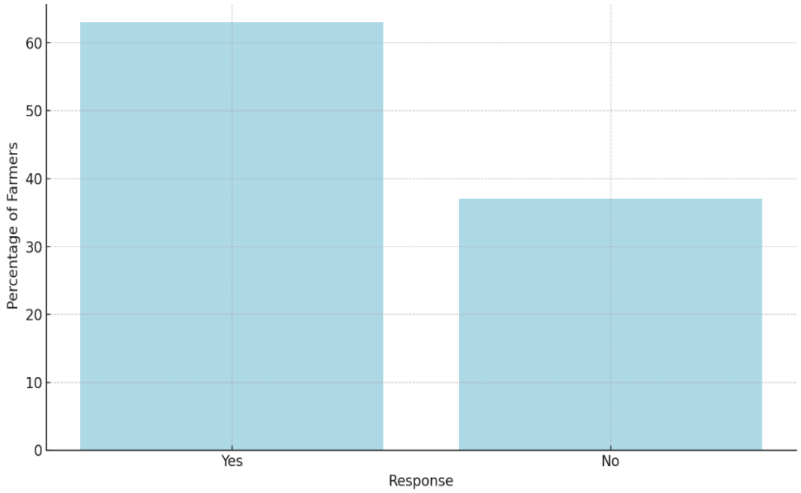

Figure 11: Crop Water Usage Adaptation

The bar chart in figure 11 shows the percentage of farmers who have adapted to water scarcity by changing their crop types.

Figure 12 graph represents the percentage of farmers who have adopted new crop types or hybridized their crops to cope with climate change.

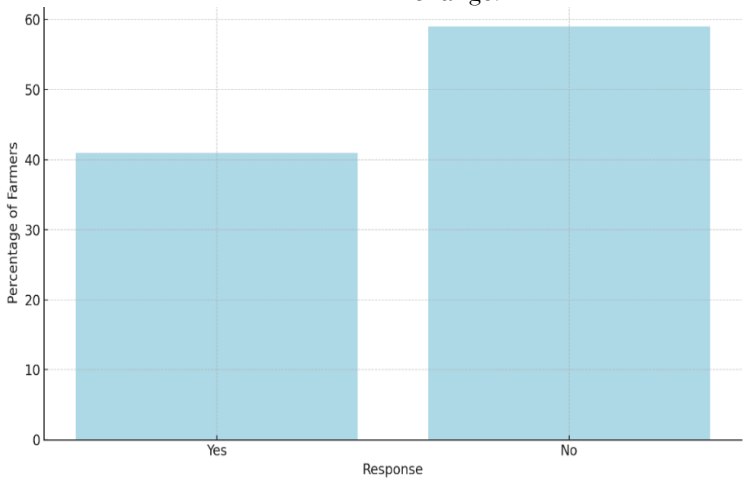

Figure 12: Adoption of New Crop Types

The combined table summarizes the responses from farmers regarding various climate-related factors, including perceived changes in rainfall, temperature, groundwater levels, and adaptation strategies.

Table 2: Summary of Responses from Farmers Regarding Climate Change Factors

Parameter	Yes (%)	No (%)	Unaware/Other (%)
Difference in Rainfall	69	15	19
Increase in Temperature	77	18	5
Reduction in Groundwater Level	71	26	3
Flood Risk	20	71	9
Drought Risk	29	71	0
Change in Plant Growth Period	41	29	30
Unfamiliar Plants and Animals	76	17	7
Livestock Health Impact	55	40	5
Crop Water Usage Adaptation	63	37	0
Adoption of New Crop Types	41	59	0

The results on what the farmers had to say in response to some important issues on changes in the environment are represented in table 1. Evidence indicates high awareness of the adverse effects of climate change and most farmers have reported that there has been a decline in rainfall, high temperatures, and less ground water. Interestingly, many farmers are also following adaptive measures i.e. shifting to crops that consume less water, indicating that farmers are aware of the climatic crisis. Nonetheless, the differences evident in the responses between the districts reflect the complexity of the situation, where some districts, including Peshawar, are less likely to feel an impact, presumably, because these districts have more access to resources and information.

5. Conclusion

This paper has critically reviewed the effects of climate change on agricultural, water and biotic systems in Khyber Pakhtunkhwa (KPK), Pakistan. The study expected to perceive the local vulnerability of farmers to altered environmental conditions and estimate the adaptations mechanism that local farmers have applied to accommodate the changing conditions. The results point to the massive and widespread impacts the climate change has on agricultural productivity, groundwater availability, and the well-being of ecological systems, the latter being typical of the area. The research found out that 69 percent of farmers have noticed significant changes in rainfall patterns, and eighty percent of them did confirm that there has been a decline in rainfall in recent years. This rainfall decline is in line with the wider climate efforts on the area. What is more, 77 percent of farmers claimed that temperatures had rose and that they could attribute this to lowered crop productivity and prevalence of pests and weeds. The increase in temperature has made the already difficult situation of the farmers to be even difficult, lowering the farming productivity particularly on water-intensive crops. Moreover, 71 percent of the farmers experienced a dramatic decline in the level of groundwater which is further escalating the state of water shortage and slowing down the irrigation process. Depletion of groundwater which has reduced by 25 percent in the last ten years is the current problem affecting the agricultural sustainability of the region. Such changes in the environment have had a direct impact on crop outputs. These findings showed that there would be an average 15 per cent decline in production of major crops including maize, rice and sugarcane. The changing weather pattern and the subsequent decrease in rainfall have increased complications to the traditional system of farming. Farmers have had to come up with several adaptation strategies to deal with these challenges; 71 percent of farmers have changed land use patterns and 63 percent have moved towards less water intensive crops due to scarcity of water. Moreover, there are 41 percent of farmers who have introduced new crop varieties such as drought resistant and hybrid crops in an endless bid to keep the agricultural land fruitful in the midst of the evolving climate. Farmers, however, are not able to achieve full adaptation due to financial shortages, poor accessibility to technologies that are resilient to climatic changes, and deficient support by government policies. 76 % of farmers noted that biological systems of the region have also changed with the entry of unfamiliar flora and fauna species that have adversely affected crops and livestock. The agricultural activities are also being made more difficult due to this change in biodiversity causing more trouble to the farmers. New species can also alter a local ecosystem, creating more trouble with crops and a traditional agricultural system management, which is more challenging to farmers. The issue of climate change on livestock was also a major concern as 55 percent of farmers showed that they could notice differences in animal health among others. These modifications were associated with low production of milk, reproductive problems and, prevalence of diseases. The climatic factors being extreme temperatures and variations in the grazing grounds have impacted negatively on the general wellbeing of the livestock, being an important component of livelihood of many farmers. Through these difficulties, farmers in KPK have proven to be rather tough. They, however, are unable to manage climate changes without the support that can enable them to adjust to the changes that keep occurring. The paper highlights the significance of policies on climate adaptation geared towards enhancing water management, offering funding and making climate-resilient technology more accessible. Farmers must be made resilient to climatic

changes by enhancing government intervention in form of supplying data on climate, environmental irrigation system, and in cent instance on adaptation to water efficient and resilient farming. To sum up, although farmers of KPK are being very proactive to adjust to changes caused by climate change, there is much still that can be done in order to assist them. This research contributes to the adaptive climate communities' theory of action by indicating that greater engagement with communities for climate adaptation appears to be an integrated approach to policy action to promote the enhancement of agricultural productivity and water security at the local, provincial, and national levels. Through providing the farmers with the appropriate resources, knowledge, and resources, KPK can facilitate the creation of more resilient agricultural system that will not be affected as heavily by the current and future effects of climate change. The study also provides insightful information to policymakers, agricultural extension services, and stakeholders that aim at facilitating climate adaptation in KPK and other related areas.

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Annexure

Questionnaire for Data Collection

Serial no _____ Village _____
Name _____ District _____
Contact number _____

Environmental Condition

Parameter	Yes	No	Don't know
Did you notice any difference in rainfall compared to last year?			
If yes, then what did you notice?			
Have you noticed any change in temperature over the year?			
If yes then what did you notice?			

Environmental Interactions

Parameter	Yes	No	Don't know
Have you noticed any reduction in water compared to past years?			
Have you noticed any change in the pattern of land use pattern compared to the past?			
Are you observing the risk of drought?			
Are you observing the flood risks?			
Have you observed any changes in the water level in wells or tubewell?			
If yes then what did you notice?			

Biological Conditions

Parameter	Yes	No	Don't know
Do you feel the disappearance of some plants and animal species from your area?			
Have you noticed any changes in fruiting and/or flowering periods?			
If yes, what did you notice?			
Did you see any unfamiliar animals or plants in your area?			
Is the new animal or plant growing rapidly?			
have you noticed any changes in your pet animals?			
If yes then what have you noticed?			

Wisdom of Adaption

Have you changed the time of cropping according to the shortage of water and climate change?			
Have you changed your crop type according to water unavailability and climate change?			
Have you sown the short-term crops to avoid the unavailability of water?			
What do you do to avoid less water availability?			