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EXPLORING THE STATISTICAL ANALYSIS OF THE EFFECT OF CLIMATE CHANGE IN THE OKARA DISTRICT OF CENTRAL PUNJAB

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ABSTRACT

This thesis examines the effect of climate change on Central Punjab District, specifically focusing on the district of Okara. The study investigates the impact of changing climatic variables on agricultural outcomes and draws upon previous research to provide comprehensive insights into the subject. Through descriptive statistics, regression analysis, and ANOVA, the study identifies key factors such as temperature, pesticide usage, rainfall, and technological advancements that significantly influence crop production in Okara. The findings highlight the adverse effects of climate change on agricultural productivity, emphasizing the need for targeted interventions and adaptive strategies. The research contributes to the existing literature by providing localized insights specific to Central Punjab District, offering valuable information for policymakers and stakeholders to develop effective climate change mitigation and adaptation measures in the agricultural sector. Further research is recommended to explore additional dimensions of climate change and its long-term consequences on the region's socio-economic and environmental aspects.

INTRODUCTION

Climate change is one of the most significant challenges of our time, affecting every aspect of our lives, including agriculture. In Pakistan, the agricultural sector plays a crucial role in the economy, employing around 40% of the country's workforce and contributing around 20% of its GDP. However, climate change is posing a severe threat to this sector, jeopardizing the country's food security and rural livelihoods. Pakistan is a country with a diverse climate, ranging from arid to humid and from cold to hot. The country relies heavily on irrigation for its agriculture, with more than 90% of the irrigated land being used for crops. Climate change has already started to affect the water supply, with many regions facing water scarcity due to the melting of glaciers, reduced rainfall, and increasing demand from urbanization and industrialization. This has led to reduced crop yields, loss of biodiversity, and increased poverty in rural areas(Ahmed and Schmitz 2011).

BACKGROUD ON PAKISTAN AGRICULTIURE

The agricultural sector in Pakistan is diverse, with a range of crops grown across different regions of the country. The major crops include wheat, rice, sugarcane, cotton, maize, and fruits and vegetables. These crops are grown on both irrigated and rain-fed land, with irrigated land accounting for more than 90% of the total cultivated area. The major irrigation sources include rivers, canals, and groundwater. Pakistan has a varied climate, ranging from arid and semi-arid to

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humid and sub-tropical. The climate is influenced by the monsoon winds, which bring rainfall from June to September. The northern areas of Pakistan, including the Himalayan and Karakoram mountain ranges, experience cold temperatures and heavy snowfall in winter(Chandio, Jiang et al. 2020).

The agricultural practices in Pakistan vary according to the region and the crops grown. The majority of small-scale farmers in Pakistan practice traditional farming methods, using simple tools and techniques. They rely on family labor and draft animals for cultivation, with limited access to modern technologies and inputs. In contrast, large-scale farmers and agribusinesses use modern technologies, including tractors, seed drills, fertilizers, and pesticides. The agricultural sector in Pakistan faces several challenges, including water scarcity, soil degradation, low productivity, and market access. The water resources in Pakistan are limited and unevenly distributed, with increasing demand from urbanization and industrialization. This has led to over-exploitation of groundwater and reduced river flows, affecting crop yields and water availability for livestock. Soil degradation is also a significant issue, with soil erosion, nutrient depletion, and salinity affecting crop yields and soil fertility(Gul, Ahmed et al. 2020).

EVIDENCE FOR CLIMATE CHANGE IN PAKISTAN

Temperature

The increase in temperature in Pakistan is one of the most significant impacts of climate change. The average temperature in Pakistan has increased by 0.6°C since 1960, which is consistent with global warming trends. This rise in temperature has led to more frequent and prolonged heat waves, which have had devastating impacts on human health, agriculture, and ecosystems Ali, G. (2018). According to the Pakistan Meteorological Department, the number of hot days in Pakistan has increased over the past few decades, with temperatures regularly reaching over 40°C in many parts of the country. This increase in temperature has led to heat stress and heatstroke, particularly in urban areas where the heat island effect exacerbates the problem. The 2015 heat wave in Karachi, for example, resulted in over 1,000 deaths (Khan, Tahir et al. 2020).

In addition to the immediate health impacts of heat waves, high temperatures can also affect agriculture, causing crop failures and reduced yields. Crops such as wheat, rice, and maize are particularly vulnerable to high temperatures, which can affect both their growth and their ability to produce viable seeds Bocchiola, D., & Diolaiuti, G. (2013). The livestock sector is also affected, with animals suffering from heat stress and reduced milk production. The rise in temperature can also have long-term impacts on ecosystems, leading to changes in plant and animal distributions and disruptions to food webs. For example, the range of the Himalayan brown bear, a threatened species in Pakistan, is shifting to higher altitudes due to the loss of suitable habitat at lower elevations(Malhi, Kaur et al. 2021).

Rainfall

Changing rainfall patterns are another impact of climate change in Pakistan. Pakistan heavily relies on monsoon rains for its agricultural productivity, and any changes in the timing and intensity of these rains can have severe consequences (Mendelsohn 2009). In recent years, Pakistan has experienced both droughts and floods, leading to crop failures and displacement of populations. For example, in 2010, Pakistan faced its worst floods in history, which affected over 20 million people, causing extensive damage to infrastructure and crops. The floods caused an

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estimated loss of $10 billion, and over 2 million hectares of land were destroyed. Conversely, in recent years, Pakistan has also faced droughts, which have affected the livelihoods of farmers and led to food insecurity in some regions of the country. Climate change is expected to exacerbate these extreme weather events, leading to more frequent and severe floods and droughts. The Intergovernmental Panel on Climate Change (IPCC) predicts that Pakistan will experience both heavier rainfall events and longer periods of drought in the future (Skendžić, Zovko et al. 2021).

Glacier melt

Glacier melt is another major impact of climate change in Pakistan. Pakistan is home to some of the world's highest mountain ranges, including the Karakoram, the Hindu Kush, and the Himalayas. These mountain ranges are covered with glaciers, which act as a crucial source of freshwater for the country's rivers, especially during the dry season. However, rising temperatures are causing the glaciers to melt at an alarming rate. According to a study by the Pakistan Meteorological Department, the rate of glacier melt in Pakistan has doubled over the past three decades. The melting of glaciers has led to a reduction in the amount of freshwater available for agriculture, domestic use, and hydropower generation(Abbas 2022).

IMPACTS OF CLIMATE CHANGE ON CROP PRODUCTION IN PAKISTAN

Climate change has significant impacts on crop production in Pakistan. Changes in temperature and precipitation patterns can lead to reduced crop yields, increased pest infestations, and reduced crop quality. Rising temperatures can cause heat stress in crops, affecting their growth and development. In Pakistan, crops such as wheat, rice, and maize are particularly vulnerable to heat stress. High temperatures can also affect the timing of crop growth and development, causing crops to mature earlier or later than usual, which can affect crop quality and market prices(Chandio, Magsi et al. 2020).

Changes in precipitation patterns can also have a significant impact on crop production. Excessive rainfall can lead to waterlogging, which affects the availability of oxygen in the soil and can cause crop roots to rot. On the other hand, droughts can lead to water scarcity and reduced crop yields. In addition, changes in precipitation patterns can affect the timing of planting and harvesting, leading to a mismatch between the optimal growths stages of crops and the availability of water. Pest infestations are another significant impact of climate change on crop production in Pakistan. Rising temperatures can lead to an increase in the population and distribution of pests, such as aphids, mites, and caterpillars. These pests can cause significant damage to crops, reducing yields and quality(Fahad and Wang 2020).

Climate Changes Impact on Maize and Rice

Rice, on the other hand, is more sensitive to changes in precipitation patterns. Increased flooding and waterlogging due to heavy rains can cause crop damage and reduce the quality and quantity of rice. Warmer temperatures and longer growing seasons can also lead to the proliferation of pests and diseases that can affect rice yields and quality Ajani, A., & van der Geest, K. (2021). The impacts of climate change on maize and rice have significant implications for food security, economic viability, and poverty reduction in Pakistan. These crops are essential sources of food and income for farmers and communities in the country. Reduced crop yields and quality can lead to food shortages and higher food prices, which can have severe impacts on the most vulnerable populations (Khan, Bin et al. 2019).

To address the impacts of climate change on maize and rice production, Pakistan needs to adopt climate-smart agricultural practices. These practices include the use of resistant crop varieties that can tolerate drought and other environmental stresses, water-efficient irrigation systems, and integrated pest management practices that reduce the need for harmful pesticides and fertilizers. Investing in research and development is also crucial to develop crop varieties that can thrive under changing climate conditions. By adopting climate-smart agricultural practices, Pakistan can ensure the long-term sustainability and productivity of these crops, reduce the vulnerability of farmers to climate change impacts, and ensure food security and poverty reduction for its people(Khan, Bin et al. 2019).

REVIEW OF LITERATURE

Malhi, G.S.; Kaur, M.; Kaushik, P (2021) Climate change was a global threat to the food and nutritional security of the world. As greenhouse-gas emissions in the atmosphere increased, the temperature also rose due to the greenhouse effect. The average global temperature increased continuously and was predicted to rise by 2 ◦C until 2100, which would cause substantial economic losses at the global level. The concentration of CO2, which accounted for a major proportion of greenhouse gases, increased at an alarming rate and led to higher growth and plant productivity due to increased photosynthesis. However, the increased temperature offset this effect as it led to increased crop respiration rate and evapotranspiration, higher pest infestation, a shift in weed flora, and reduced crop duration. Climate change also affected the microbial population and their enzymatic activities in soil.

Houcine Brougham (2020) this research combined global climate, crop, and economic models to examine the economic impact of climate change-induced loss of agricultural productivity in Pakistan. Previous studies had conducted systematic model inter-comparisons, but results varied widely due to differences in model approaches, research scenarios, and input data. The results showed that climate change-induced loss of wheat and rice crop production by 2050 would be 19.5 billion dollars on Pakistan's Real Gross Domestic Product, coupled with an increase in commodity prices followed by a notable decrease in domestic private consumption.

Muhammad Akbar Anjum on 27 March (2021) The phonological changes of a long-term observed rice-wheat system (RWS) were used to determine the relationships among management practices, climate change, and crop phenology to devise adaptation strategies for RWS to mitigate the potential impact of climate change. The study comprised 10 sites of observed and simulated rice-wheat system phonological data for the historical period from 1980 to 2014 in Punjab, Pakistan. The use of the CSMCERES-Rice and CSM-CERES-Wheat models for standard, field-tested cultivars of rice and wheat for all locations for the 35-year period showed that the simulated phenology stages were earlier with climate warming compared to the observed phenology stages.

Abbasi, Z.A.K. and A. Nawaz (2020) this studied contributed to the local responses to address the impact of climate change in the agriculture sector in the context of Khyber Pakhtunkhwa and Punjab provinces of Pakistan. Pakistan's agriculture was vulnerable to the cataclysmic transformations in the climate system, causing productivity loss, soil degradation, water scarcity, resource depletion, etc. Climate change awareness empowered the farming communities to take appropriate measures to mitigate the negative consequences of this phenomenon, but the responses were not necessarily identical in scale and form. In developed countries, climate change awareness was much more advanced, and therefore their climate change adaptations were also far better than those employed by farmers in developing countries like Pakistan.

RESEARCH METHODOLOGY

The research methodology section outlines the steps taken to ensure valid and reliable results in the study on the effect of climate change in Central Punjab District Okara. This section provides information on the revised population, target population, sample selection, revised sample size,

Population

The population is defined as the total number of individuals or characteristics of interest in the study area. In this case, the population is revised to be the total number of farmers cultivating maize and rice in Central Punjab District Okara.

Target Population

The target population represents the specific group of individuals from which inferences are made about the entire population. In this study, the target population is revised to be the total number of farmers cultivating maize and rice in Central Punjab District Okara who are affected by climate change.

Sample

A sample is a representative subset of the population that allows for drawing inferences about the entire population. It is crucial that the sample accurately represents the population under observation. In this study, the sample is selected from the pool of farmers cultivating maize and rice in Central Punjab District Okara.

Sample Size

The revised sample size for this study is determined to be n=205. The sample is collected through a survey questionnaire using appropriate sampling techniques to ensure representativeness. The questionnaire is filled out by the selected farmers in Central Punjab District Okara.

Data Type

The primary data collected from the survey questionnaire is used for this research study. The questionnaire includes 16 questions related to the impact of temperature, rainfall, and pesticide usage on maize and rice cultivation in Central Punjab District Okara.

Sampling Area

The sampling area refers to Central Punjab District Okara, which serves as the geographical scope of the study. It includes the specific regions where maize and rice cultivation is prevalent.

Data Management

Data collected from the survey questionnaire is managed and analyzed using appropriate statistical software, such as IBM SPSS Statistics or Excel. These tools assist in organizing, analyzing, and interpreting the collected data.

Data Analysis Techniques

Following statistical data analysis techniques will be used in this study:

Descriptive Statistics:

- Mean, Standard deviation,
- Skewness and Kurtosis,

Testing of hypothesis:

- F-Test, Two-Way ANOVA

Multivariate test:

- Regression
- General Linear model (multivariate)

Table 1: Descriptive Statistics.

Descriptive Statistics	N	Range	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Temperature	205	4.00	1.00	5.00	3.1366	1.0341	-.170	.170	-.493	.338
Pesticides	205	3.00	1.00	4.00	2.1024	.97731	.493	.170	-.772	.338
Rainfall	205	4.00	1.00	5.00	2.8195	1.2763	.115	.170	-.997	.338
Techadvancement	205	2.00	1.00	3.00	2.1317	.69819	-.186	.170	-.935	.338
Maize	205	5.00	1.00	6.00	3.9366	1.3794	-.394	.170	-.364	.338
Rice	205	5.00	1.00	6.00	3.8390	1.3130	-.132	.170	-.661	.338
Valid N (listwise)	205									

The mean temperature is 3.1366 units, with a moderate negative skewness of -0.170. The average pesticide level is 2.1024 units, showing a positive skewness of 0.493. The mean rainfall is 2.8195 units, slightly right-skewed with a skewness of 0.115. The average technological advancement is 2.1317 units, featuring a slightly negative skewness of -0.186. The mean maize production is 3.9366 units, moderately negatively skewed with a skewness of -0.394. The average rice production is 3.8390 units, with a slight negative skewness of -0.132. These statistics provide an overview of the central tendencies and variability of the variables in the study.

Table 2: Regression, Dependent variable rice

Model Summary

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.934[a]	.872	.869	.47461

a. Predictors: (Constant), tech advancement, temperature, pesticide, rainfall

The model demonstrates a strong fit with an R-squared of 0.872, indicating that 87.2% of the variance in the dependent variable is explained by the predictors. The adjusted R-squared of 0.869 accounts for the number of predictors. The standard error of the estimate is 0.47461, reflecting the average difference between observed and predicted values. The significant predictors in the model include the constant term, technological advancement, temperature, pesticide, and rainfall.

Table 3 : ANOVA[a], (a. Dependent Variable: rice)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	306.638	4	76.659	340.329	.000[b]
	Residual	45.050	200	.225		
	Total	351.688	204			

a. Dependent Variable: rice

b. Predictors: (Constant), tech advancement, temperature, pesticide, rainfall

The regression component explains a significant amount of variance in the dependent variable "rice," with a sum of squares of 306.638 and an F-statistic of 340.329 ($p < 0.001$). The residual component has a sum of squares of 45.050, indicating unexplained variability. Overall, the model shows a highly significant relationship between the predictors (constant term, technological advancement, temperature, pesticide, and rainfall) and the dependent variable.

Table 4: ANOVA[a], (dependent Variable: maize)

ANOVA[a]

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	320.404	4	80.101	236.384	.000[b]

Residual	67.772	200	.339
Total	388.176	204	

a. Dependent Variable: maize

b. Predictors: (Constant), tech advancement, temperature, pesticides, rainfall

The ANOVA results indicate that the regression model has a significant effect on the dependent variable "maize" ($p < 0.001$). The regression component accounts for a sum of squares of 320.404, with 4 degrees of freedom, resulting in a mean square of 80.101. The F-statistic is 236.384, demonstrating a highly significant relationship between the predictors and the dependent variable. The residual component has a sum of squares of 67.772 with 200 degrees of freedom, yielding a mean square of 0.339. Overall, the regression model significantly explains the variance in the dependent variable.

CONCLUSION

In conclusion, this study investigated the impact of climate change on Central Punjab District, specifically focusing on the district of Okara. Through an extensive analysis of various climatic variables and their effects on agricultural outcomes, valuable insights were gained. The findings of this research provide evidence of the significant influence of climate change on the agricultural sector in Okara. The results indicate that rising temperatures, changes in rainfall patterns, and the increasing frequency of extreme weather events have had profound implications for crop production in the district. The descriptive statistics revealed that temperature, pesticide usage, rainfall, and technological advancements are key factors affecting the growth and yield of major crops such as maize and rice in the region.

Moreover, the regression analysis showcased the strong relationship between these climate-related factors and agricultural outcomes, demonstrating the importance of considering climate change in policymaking and agricultural planning. The ANOVA results further confirmed the significant contribution of these factors to the variations in crop yields, emphasizing the need for targeted interventions and adaptive strategies to mitigate the adverse effects of climate change. This study builds upon previous research by providing localized insights specific to Central Punjab District, Okara. The findings align with previous studies that have emphasized the detrimental impact of climate change on agricultural productivity. However, this research adds depth and specificity by highlighting the unique challenges faced by farmers in Okara and the importance of tailored adaptation measures for the region.

This study contributes to the growing body of knowledge on climate change and its implications for agricultural systems. It provides valuable insights for policymakers, researchers, and stakeholders in Central Punjab District, Okara, to develop effective strategies for climate change mitigation and adaptation in the agricultural sector. Further research is encouraged to explore additional dimensions of climate change and its long-term consequences on the region's socio-economic and environmental aspects.

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