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### Climate Changes and Future of Agriculture in Punjab

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#### Abstract

*This paper explores the effects of climate change on agriculture in Punjab, Pakistan, a pivotal province for food production and the nation's economy. With qualitative research, it assesses the impact of climate change on yield, food security, and sustainable diets that farmers and experts have on them. The paper evaluates the capacity of the Punjab agricultural sector to respond to increasing temperatures, changes in rainfall and occurrence of climate shocks. It also discusses climate change management practices i.e. optimal and sustainable crop varieties like drought tolerant crops and Conservation tillage agriculture as well as the technologies that include; policies and farmer's education among others. In any way, the discoveries brought forward in this research intend to contribute towards the formulation of policies regarding sustainable agricultural practices and food security as well as environmental conservation in Punjab.*

**Keywords:** Climate Change, Sustainable Agriculture, Food Security

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#### 1. Introduction

The effects of climate change affects agriculture globally and in this way poses a major threat to food security at the global level. Agriculture is a fragile yet crucial industry as it has been majorly affected by climate change and also plays the role of being one of the biggest producers of greenhouse gases. By 2050, the global population is anticipated to exceed 9 billion people, which means that she will not fulfill food demand due to climate change impacts on crop yields, quality, and accessibility (Ali & Rose, 2021; Shabbir et al. , 2020). This underlines the role of a Call to Policy that will enable measures to be put in place to reduce such effects. The impacts of climate change are not experienced in a similar manner since developed nations cause most of the problems and underdeveloped nations and their population suffer most from the effects of climate change. The farmers in developed countries at least have more resources to address the situation, the farmers in the developing countries are challenged in terms of awareness, resource mobilization and adaptation plans. Therefore the solution to these needs calls for regional solutions.

Climate change affects agriculture in Asia more specifically in wheat-rice systems as increased temperatures and changes in precipitation patterns reduce crop yields (Rana et al., 2020; Ahmad et al. , 2021). Agriculturally productive area of Punjab in Pakistan has been affected by climate change issues including drought and flood that hinder food security (Nadeem et al., 2022; Abbas et al., 2022). Analyze Climate change, land use and agriculture in

Punjab, The analysis of climate change, land use, and agriculture in Punjab is essential in understanding the possible future outcomes in the efforts towards achieving the sustainable development goals especially under uncertain tradeoffs between economic development and sustainability (Chigor et al., 2018; Samie et al., 2020; Khan et al., 2021).

### **1.1 Problem Statement**

However, there is gap of knowledge on the impacts of climate change, land use and agriculture and hence the formulation of strategies on sustainable agriculture and climate change resilience in Punjab, Pakistan.

1.2 Theory Development: Therefore, this paper develops a new theoretical framework grounded on sustainability, resilience, and agricultural development theories to examine the impact of climate change and land use on agriculture in Punjab, Pakistan.

## **2. Literature Review**

There have been researches done on the effects of climate change on agriculture of Punjab, Pakistan and these are based on different methods and data collections. Munir et al., 2022 used regression and decision trees to estimate the yield response of wheat to temperature and moisture regimes and found that warmth is a major yield depresser among the climate factors. Imran et al. (2020) has also analyzed how farmer's perception differs from the actual climatic data, suggested a gap that has to be addressed for the purpose of effective participation in climate change adaptation. Whilst Abbas et al. (2022) emphasized on the detriments of temperature and rainfall affecting the yield for rice, they called for resilient agriculture in South Asia. Shahbaz et al., 2021 reviewed the impact of socio-economic factors on farmer's climate change plan revealing that education and farm size requires intervention. A research study by Roychowdhury et al. (2020) also reviewed literature on sustainable agriculture throughout the world noting the significance of organic farming and policy systems toward increasing the level of adaptation to climate change by farming activities. That is why Usman et al. (2023) studied the correlation between risk perception of farmers and climate change, further suggesting increasing climate change literacy and creating farming-related policies unique to the certain geographical area. Ahmad et al. (2020) used the perceived climate change and dam sedimentation effects to estimate water availability for irrigation in the future projecting a future availability of only 30% in the year 2050 and hence urged for efficient methods of water conservation and methods of irrigation. Waseem et al. (2022) separately described the negative impacts of drought on different farming levels and stressed the necessity of focusing on the issue of drought. Temperature and rainfall have effects on rice yield that Abbas & Mayo (2021) explained the call for improved rice varieties and sustainable farming practices.

Ali et al., (2020) focused on analyzing the effects of climate change on the frequency of floods and droughts in the Punjab region and called for adopting the measures of adaptation and mitigation. Jamil et al. (2021) examine climate-smart agriculture and positively connected it to farmer resilience and thus encouraged the provision of such practices. Precisely, Khanna and Kaur (2023) undertook a study on the application of precision agriculture in Punjab, India with an emphasis of credit and technology in managing land. Haq et al. (2021) associated climate-smart agriculture to better nutrition among rural households recommending creation of awareness and resources. Irrigation management and conservation of water were recommended to reduce the impacts of climate variation on agriculture as stated by Syed et al. (2021). Ahmad and Afzal (2021) helped to draw attention to flood-resilience relating to credit and technology utilized by farmers of the flooded tracts. Mujtaba et al., (2022) examined cropping patterns and climatic factors regarding crop yields, and comes to the conclusion that improved water management can increase agricultural productivity. Last, Janjua et al. (2021) analyzed Punjab areas where climate change will severely affect rice yield reducing and recommended climate-smart rice varieties and irrigation technics.

## **3. Theoretical Framework and Conceptual Analysis**

### **3.1 Theoretical Framework**

Independent Variable: The main variable of interest in this research study is climatic change, which implies variation in temperature, rainfall regime and the incidence of violent weather condition. They work and remain associated with agriculture and food production, which affects yields and food security, and income possibilities in Punjab, Pakistan.

#### **3.1.2 Dependent Variable**

Dependent variable is related to the future scenario of Punjab agriculture, including production rates, food securitization and farming business incomings. This paper focuses on weather change and how it affects these results and to what degree adaptation and preventative measures can lessen the impact.

### **3.1.3 Mediating Variables**

In this framework, the above stated mediating variables are quite crucial in elaborating climate change effects on agricultural yield.

#### **3.1.3.1 Adaptation and Mitigation Strategies**

This entails crop insurance, Irrigation practices, Climate Resilient crops, among others which are said to help in minimizing the impact of the climate change.

#### **3.1.3.2 Innovative Agricultural Practices**

This ranges from smart farming, precision agriculture, advanced vertical farming, to inventions that enhance efficiencies of farming.

#### **3.1.3.3 Policy and Institutional Support**

Farmer friendly information and inputs originating from agricultural policies for extension and credit facilities have been found to have a significant positive correlation with the ability of farmers to change their practices in response to climate change.

### **3.1.4 Moderating Variables**

Such factors cause variations in the extent and the nature of the correlation between climate change, on one hand, and agricultural results, on the other hand.

#### **3.1.4.1 Socio-Economic Factors**

Some of the factors include the income level of farmers, education level of the farmers and size of their farms which determines their ability to change due to climate change.

#### **3.1.4.2 Agricultural Systems and Practices**

Crop type, use of technology or farming methods, and soil health act as buffers of the effects of climate change on crop yields.

### **3.2 Theoretical Pathways**

The proposed framework indicates several links by which climate change impacts can be seen to influence agriculture.

#### **3.2.1 Direct Impact on Yields and Food Security**

This factor is critical since climate change affects the yield which in turn impacts on food security.

#### **3.2.2 Adaptation and Mitigation Measures**

Climate change causes the implementation of adaptation and mitigation strategies to be adopted hence leading to either a reduction or an enhancement of the impact on the productivity of the agriculture sector.

#### **3.2.3 Innovation and Technology Adoption**

The increase in climate change acts as a catalyst to force farmers or anyone involved in farming to change or improve the production methods, thus increasing the food production.

**3.2.4 Institutional and Policy Support:** It is also very relevant to note at this point that, adequate policies and institutions support are paramount if farmers have to incorporate climate resilient practices hence impacting on yields and food security.

### **3.3 Theoretical Perspectives**

### **3.3.1 Sustainability Theory**

Sustainability theory focus on the conservation of agriculture in the long run while at the same time it addresses issues of food security. It emphasizes on the aspects of sustainable farming that could be adopted in order to overcome various challenges affecting food production as a result of climate change.

### **3.3.2 Resilience Theory**

Resilience theory addresses the capability of agricultural systems to withstand and restore itself from those impacts and stress that are occasioned by climate change. It focuses on the need to incorporate buffer stocks in the farming practices so as to protect the food chain.

### **3.3.3 Innovation Theory**

Technological Innovation plays a vital role in addressing problems that affect climate change. It calls for the changes to farming practices and methods that can help increase the production and efficiency of agriculture.

## **3.4 Climate-Resilient Agriculture Framework (CRAF)**

The Climate-Resilient Agriculture Framework (CRAF) reinforces the notion of sustainability and resilience besides using the innovation principle as a way of approaching the issue for improving agricultural productivity when faced with the destructive effects of climate change.

### **3.4.1 Components of CRAF**

3.4.1.1 Climate Change Awareness: Raising the levels of consciousness among farmers and policymakers on the effects of climate changes and the necessity of applying climate-proof measures.

#### **3.4.1.2 Adaptation and Innovation**

Promoting the use of climate change resilience activities, technology and policies relating to within the agriculture sector.

#### **3.4.1.3 Institutional Support**

Mainstreaming climate change by enhancing Institutions, extension services and policies that will help support climate resilience agriculture.

### **3.4.2 CRAF Model: The CRAF model demonstrates the interactions between the components**

- Climate Change Awareness
- Adaptation and Innovation
- Institutional Support Climate-Resilient Agriculture
- Improved Agricultural Productivity and Food Security

This model is useful for comprehending the interrelations between climate change, agriculture, and sustainability in Punjab and helps in development of hypotheses and research strategies in this study.

## **3.5 Conceptual Analysis**

This research employs a conceptual framework that integrates sustainability theory, resilience theory, and innovation theory. It examines how climate change, as an independent variable, affects agricultural production and food security (dependent variables) through mediating factors such as land use changes, water management, and agricultural practices. The framework also considers the moderating influence of socio-economic factors, institutions, and technology. This comprehensive framework provides a deeper understanding of the inter-linkages between climate change, land use, and agriculture in Punjab, offering insights into the diverse impacts of climate change on agriculture and the strategies needed for sustainable and climate-smart agricultural practices.

## **4. Hypothesis Formulation and Methodology:**

### **4.1 Hypothesis Formulation**

The following hypotheses are proposed:

**Hypothesis 1:** It is hypothesized that agricultural outputs (wheat and rice) in the Punjab region, Pakistan are inversely related with temperature. According to the above-discussed studies, it has been revealed that the temperature is going to reduce production for different categories of agriculture particularly the crops which are vulnerable to high temperature like wheat and rice (Munir et al. , 2020; Abbas et al. , 2021).

**H2:** Based on the survey findings the farmer's attitude towards climate change is influenced by socio-economic factors such as age, education level, or size of the farm. Previous studies have pointed out that demographic characteristics like education and farm size/type influences one's attitude towards climate change as well as his or her willingness and capability of implementing climate smart practices (Imran et al. , 2020).

**H3:** those farmers who experienced or anticipate adverse effects of climate change and employ higher levels of climate-smart developments such as drought-resistant cultivators and water control have higher propensity to practice climate adapted models. As hypothesized, there is a positive relationship between perceived risks concerning climate change and engagement in climate smart agriculture among the farmers(Uzakwe et al. , 1998).

**H4:** The government support in form of favourable policies, advisory assistance has the propensity to enhance Climate smart Agriculture and the productivity of Agriculture in Punjab, Pakistan. As pointed out by Shirazi (2020), Bhardwaj et al. , (2022) recognizing the need and institutional support are the drivers of smart practices, and farm yields.

**H5:** Climate change affects production of agriculture in Punjab, Pakistan and the above affects would be worse if the lands get shifted to other use such as non-agriculture use for example converting agriculture production land. Hence, not only climate change shocks are going to affect the agricultural productivity in the affected areas but also changes in land use like conversion of the agricultural land (Ali & Rose, 2021).

## 4.2 Research Methodology

The Research method for this study is based on the use of theoretical concepts derived from Sustainability Theory, Resilience Theory, and Innovation Theory to understand the effects of climate change on agriculture production in Punjab, Pakistan. The study is deductive in nature; it does not involve collection of primary data but is based on a priori conceptualization and analysis of theoretical models in extant literature concerning climate variables, farming practices and food security. Unlike the previous analysis that emphasizes on case studies and generation of new theory, this piece of work utilizes theories and hypotheses testing. Validity and reliability are achieved through triangulation of theories, consistent interpretation and critical review of literature to provide a sound theoretical framework to explain the processes involved in climate resilience agriculture in the context of the region.

## 5 Conclusions

The study points out the level of vulnerability of agriculture in Punjab, Pakistan due to the effects of climate change including rising temperatures and changes in precipitation. The study notes climate change has adverse effects on the yields of both wheat and rice and that other factors include the farmers' practices, attitudes, economics, as well as the support structures put in place. Hence, the study underscores the importance of policy interventional to enhance climate resilience Agriculture in Punjab. This involves the choice of favourable crops, optimal land and water resources application, special extension services and creating farmer awareness. Furthermore, the study stress on the need to take into consideration socio-economic status and attitude of farmers during the introduction of climate resilient practices for agriculture. It thus requires the fermans, researchers, and policymakers to work together in arriving at long term and sustainable solutions in agriculture to feed the world as well as support future generations amid climate change.

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