

## Original Research Article

# Impact of Resilience of Land Productivity on Climate Change: A Study in Cooch Behar District

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**Abstract:** The capacity of land to produce food without destroying itself has become a vital factor for sustainable development in the agricultural world. This study investigates how the capacity of agricultural producers' land to resist degradation and maintain productivity affects their ability to adapt to climate change in Cooch Behar District of West Bengal, India. Using a combination of secondary data and indices developed by farmers to measure their perceptions of various adaptive agricultural practices, as well as econometric modeling, this research explores how different types of adaptive agriculture practices help producers mitigate the risks associated with climate-induced change on their farms. The results of this study show that adaptive agricultural practices (e.g., crop diversification, integrated nutrient management, and utilizing climate-resilient varieties) increase the stability of crop yields in West Bengal despite increasing temperature variability and irregular precipitation. While many producers are able to successfully implement these adaptive practices, the small size of most producers' landholdings, the degradation of soils in many areas, and the limited access to government programs that assist farmers in adapting to climate change all serve as major barriers to achieving optimal adaptation. The results also demonstrate that strengthening the resilience of land productivity is one of the most important factors in providing for sustainable agricultural development, food security, and livelihoods of rural communities in areas impacted by climate change, such as Cooch Behar District.

**Keywords:** Land Productivity, Resilience, Adaptation, Sustainable Agriculture, Climate Change.

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## INTRODUCTION

Despite technological advances and significant interventions through policy towards developing resilient agricultural systems based on climate variability, India's agriculture system remains very sensitive to weather patterns. Increased occurrences of extreme weather conditions, unpredictable precipitation trends, higher temperature ranges make it difficult to consider agriculture sustainable. Ortiz-Bobea *et al.* (2021) indicated that climate change has diminished global agriculture output by nearly 21% since 1961 due to the considerable effects of climatic issues on productivity and output of land. Therefore, the idea of resilience relates to understanding the ways in which an agricultural system can deal with and adjust/cope with environmental change. The definition of Holling (1973) describes resilience as the ability for a system to have disturbance in form of disturbance from a disturbance and then continue to carry out its necessary functions

and maintain its structure after experiencing an event such as this. In agriculture, this means that land can hold its productivity or recover normal levels of productivity after experiencing climatic conditions. According to Walker *et al.* (2004), resilience refers to having the ability of a system to withstand and reorganize after experiencing an event that disrupts or affects its functioning. With regard to agricultural systems, this will refer to achieving and maintaining productivity levels after having been exposed to climatic conditions or unexpected events. Folke (2006) noted that resilience does not just mean resist or hold up against; but also to have an ability to adapt to change and/or transform to meet current needs after the event has occurred. Adaptability refers to how well a farmer can make modifications to their behaviour in response to new circumstances while transformability measures changes that will occur with an agricultural system if the traditional way of doing things no longer works.

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Cooch Behar District of West Bengal is a great opportunity to see this relationship due to Issues with Agro-Climatic Vulnerability and Dependence on Agriculture. The economy of this district is mostly based on Agriculture, for example, the majority of farm income in rural areas comes from the sale of crops (Paddy, Jute and Vegetables etc.) but as a result of increasing Climate Variability we have seen variability in production and income stability and therefore Food Security is affected. The resilience of Agricultural land productivity is defined as the ability of Agricultural Land to produce regardless of how Climate Change Stressors such as variable precipitation and rising temperatures affect the productive capacity of agricultural land (Lal, 2015; Pimentel and Burgess, 2013). The role of Land Productivity Resilience (LPR) in Cooch Behar District of West Bengal is very important as it has helped insulate farmers from the negative effects of Climate Change on their farming systems resulting in Agricultural Products continuing to be produced even though Farmers face many Climate Change Vulnerabilities (Saha and Hazra, 2016). Agricultural Productivity and Climate Change: There has been much research about the relationship between Agricultural Productivity and Climate Change in the literature. In an analysis by Lobell *et al.* (2007) the authors found that as temperatures increase and precipitation pattern changes, this can impact crop growth and especially in the Tropical and Subtropical regions. In addition, according to the IPCC (2022), Climate Change will reduce South Asia's Agricultural Productivity. Increased Heat Stress and Diminished Water Resources will lead to reduced Agricultural Productivity for farmers. Increased temperatures will speed up the time on maturity of crops to flower and therefore reduce the time for grain filling which will lead to producing lower yields (Porter *et al.*, 2014). Furthermore, variable patterns of Rainfall will create difficulties for when to plant crops and increase the risk of Crop Failure. These Risks will be greatly increased for Flood Prone Areas, like Cooch Behar, because of Excessive Rainfall leading to Water logged fields; Soil Erosion; and Nutrient Loss due to Leaching.

## OBJECTIVES OF THE STUDY

1. Evaluate how changes in climate are impacting agricultural productivity in Cooch Behar district.
2. Understand what resilience in land productivity is and how it can reduce the effects of climate change on agriculture.
3. Identify and assess the characteristics of adaptive agricultural practices (e.g. crop diversification, soil management & climate-resilient varieties) that farmers use.
4. Use econometric models to analyze the relationships between climatic variables (e.g. temperature & rainfall) and crop productivity.

5. Investigate farmers' attitudes, level of knowledge and the adaptation strategies they have towards climate change.
6. Identify institutional, technical and financial barriers that prevent farmers from adopting resilient practices.
7. Provide recommendations for a policy framework that will improve the sustainability and resilience of agriculture in the region.

## METHOD AND MATERIALS

### Study Area: Agro-Ecological Context of Cooch Behar

The Cooch Behar district is in northeastern West Bengal, which is considered to be part of the eastern Himalayan foothills. There are many fertile alluvial soils and ample water, and Cooch Behar has a humid subtropical climate. The climate makes it very susceptible to climate-related risks, including flooding and water logging, due to its location. Most agricultural activity in Cooch Behar relies on rainfall, and hence, the farming system has a heavy dependence on the monsoon. Cooch Behar has mostly paddy as its main crop. Other crops grown are jute, potatoes and vegetables. The high number of small and marginal farmers adds to their risk since they don't have the resources to invest in more advanced technology. Some studies have reported that a number of farmers in this area have reported many changes in climate, such as: delayed start of the monsoon; increased temperatures of 35-36°C; and erratic rainfall (Sarkar *et al.*, 2021). These climatic changes will have a significant effect on farmers' crop production and agricultural incomes.

Cooch Behar is situated in northern West Bengal and covers an area of approximately 3,387 square kilometers. It has highly fertile alluvial soils which support the growing of rice, jute and various vegetables. Over seventy per cent of the population works in Cooch Behar district in agriculture; the primary agricultural crop across the 12 administrative blocks of the district is paddy (Government of West Bengal, 2021; NABARD, 2019). Cooch Behar is characterized as having a humid subtropical climate. Annual precipitation averages between 250 and 300 centimetres and is concentrated mainly during the monsoon months from June through August; however, over the Past few years, the trend has been declining precipitation and an increasing variability in temperatures (Das & Sarkar, 2016; Saha & Hazra, 2016). The flatness of the landscape enables a high degree of cropping intensity, but also makes it especially vulnerable to both floods and droughts (NABARD, 2019).

### Design of Research

The study utilized a mixed-methods research design that incorporated both quantitative and qualitative approaches to provide an overall understanding of the research issue. The quantitative aspect used statistical and econometric methods to

determine the level of land productivity, the degree of climate variability and the resilience of farmers. The qualitative aspect focused on farmers' perceptions of climate change, their experiences and adaptation strategies. Using a mixed method approach was particularly relevant to this study because resilience is not only a measurable economic variable but also a social-ecological variable. Therefore, in creating an understanding of the phenomenon of resilience, the research study considers behavioural, institutional and environmental variables affecting resilience in addition to measuring economic data. By collecting both numeric data, as well as data on the perceptions of farmers, the research study has increased both the depth and relevance of its findings.

### Sources & Types of Data

The research employs both primary and secondary data to build a strong empirical foundation.

### Secondary Data

The collection of secondary data is from various reputable sources (government documents, publications from institutions, and literature written by academics). Key sources of secondary data for the study include the District Statistical Handbook of Cooch Behar, National Bank of Agriculture and Rural Development (NABARD) publications, and Food and Agriculture Organization (FAO) publications, along with long-term meteorological records for historical climate variability analysis (temperature & rain). The use of secondary data enables the study to create a macro-analytic understanding of the continually changing climate and its effect on agricultural productivity.

### Variable Specification

There is a set of dependent and independent variables used in analyzing agricultural productivity as well as composite indicators of resilience and adaptation.

### Dependent Variable

The dependent variable of this study is land productivity (crop yield/hectare and output index); thus, it reflects the efficiency of land used for crops under different climatic and agronomic conditions.

### Independent Variables

The independent variables include climatic (temperature and rainfall), agronomic (soil quality, availability of irrigation, and input use, i.e., fertilizers & seeds), and socio-economic (access to credit/extension services/institutional support) factors.

### Indicators of Resilience

Resilience is defined by the combination of multiple indicators into a single index. These indicators can be; crop diversification, soil health management, water conservation, and climate resilient technologies.

The use of multiple criteria in defining resilience allows for the comprehensive assessment of resilience as a whole rather than as one measurable variable.

## RESULT AND DISCUSSION

### Climate Change in Cooch Behar

The District of Cooch Behar has experienced several changes in climatic patterns, with a recurring theme of increased temperature; much of this increase is notably during the pre-monsoon period. According to studies available from the farmer perception studies conducted by Das & Sarkar (2016), the increase in temperature reflects a significant rise in daytime temperatures (an average of 0.95), the shorter length of time that rain occurs (0.85), the increasing uncertainty of when rain will actually occur (0.87), and an increase in the amount of time between events of dryness (0.86). The long-standing climatic data (1901-2019) suggests an increase in yearly maximum temperature and a decrease in yearly rainfall (Saha & Hazra, 2016). Blocks showing the highest levels of vulnerability, such as Tufanganj, have the least amount of adaptive capacity (NABARD, 2019); therefore, these changes in climate, including an increase in the intensity of monsoon rains and an increase in the number of extreme weather events/droughts, pose a serious threat to the survival of a rain-fed agricultural system (Rahaman *et al.*, 2013).

### Agricultural Productivity in Cooch Behar

Land productivity resilience refers to the ability of a piece of agricultural land to remain productive in the face of the numerous climate-related stresses associated with the variability in the amount of rainfall received and the increasing air temperatures. Cooch Behar District's land productivity resilience acts as a buffer against the impacts of climate change on agricultural productivity, even while the land's productivity is at risk for agriculture. As evidenced by the cropping patterns of the lands of Cooch Behar, the growing concern over land productivity is due to the fact that the area's soils have experienced increased soil degradation. Within the alluvial soils, nutrient imbalance, soil acidity, and loss of organic matter have increased in recent times (Kundu *et al.*, 2017; Das & Sarkar, 2016). Another concern is how the development of boron deficiency has been the most significant limiting factor resulting in high reductions of grain yield in Cooch Behar and how the excessive application of chemical fertilizers has made the soil unproductive (Ghosh & Dey, 2020).

Spatial variation has resulted in significant differences in crop productivity. For example, while some pressure blocks (like Sitai) have increased cereal yields by 47%, others (like Cooch Behar II) are experiencing a 54% reduction. The historical increase in the use of fertilizers has contributed to the increased pressure on land productivity and the decreased marginal rate of return on such usage (Roy & Mandal

2022). A number of factors influence land productivity, including soil type, availability of water, crop management practices and technological advancements. Pingali (2012) points out that both technological innovations and institutional support play an instrumental role in increasing land productivity. Each of these factors is adversely affected by climate change through a change in weather patterns, thus creating a need for resilience to maintain productivity during shifts in the climate.

## **EFFECTS OF CLIMATE CHANGE ON PRODUCTIVITY OF LAND**

### **The Impact of Higher Temperatures on Crop Production**

Higher average seasonal temperatures, especially during critical times for growing crops, negatively impact crop yields. For instance, Lobbell *et al.* (2011) found that an increase in temperature of just 1 degree Celsius can cause significant decreases in yield of important crops - such as wheat and rice. The increase in temperature around Cooch Behar has caused heat-related stress in crops, and has greatly negatively impacted crop production and productivity.

### **The Impact of Changes in Rainfall Patterns on Water Availability**

One of the most significant impacts of climate change in the region is variability of rainfall patterns. Drought and flooding have both increasingly occurred, resulting in uncertainty in agricultural production. Rosenzweig *et al.* (2014) argue that water availability is one of the most significant constraints on agriculture production with climate change.

### **The Impact of Climate Change on Soil Degeneration**

Climate Change has made soil degeneration worse through many processes including soil erosion, nutrient depletion, and reduction in organic matter. Flooding, a regular occurrence in Cooch Behar, will only worsen soil erosion and reduce the fertility of these soils.

### **Increase in the Incidence of Pests and Diseases**

The changing climate has created conditions that have become good for crop pests and diseases and have led to a decrease in crop production. Gregory *et al.* (2009) showed that the prevalence of crop pests and diseases will likely increase around the world due to climate change.

### **The Concept of Resilience of Land Productivity and the Mechanisms and Processes**

Resilience in land productivity is defined as the capacity of soil and cropping systems for recovery after experiences of climatic shocks such as floods, droughts and extreme heat through adaptation practices like crop rotations, organic amendments, and use of better techniques of agriculture (Lal, 2015; Singh *et al.*, 2017). Climate-resilient agriculture (CRA) is focused

on achieving yield stability, sustainability and lowering greenhouse gas emissions (Bhattacharyya *et al.*, 2015). In Cooch Behar region, a large majority of farmers (about 84%) are classified as small- or marginal-landholders and they are experiencing moderate levels of adaptation to climate change; this is due mainly to economic and institutional constraints. Productivity has seen major increases through resilient agricultural practices. Resilient areas experience greater yield stability and higher beneficial results, while marginalized areas are more affected by climate. The climate-related stressors add to the stress on crops from the daily levels of soil recovery. Soil recovery further compounds productivity losses, as soils with less nutrients respond less to added inputs while having a greater increase in temperature and decreased level of response (Mondal and Das, 2020). On the other hand, many adaptable areas that have used resilience strategies have reported yields up to 47% higher than they would have without using resilience strategies (Govt. of West Bengal, 2021).

### **Land productivity resilience**

Land productivity resilience refers to the ability of soils and cropping systems to recover from climatic shocks such as floods, droughts, and heat waves through adaptive practices such as crop rotation, use of organic amendments, and improved agronomic practices (Lal, 2015; Singh *et al.*, 2017).

### **Variability in Rainfall and Stress on Water Resources**

Variations in rainfall levels will have a large impact due to climate change within the area. Both droughts and floods are now occurring frequently, which results in large changes in agricultural production. Rosenzweig *et al.* (2014) indicate that stresses associated with limited water are a significant limiting factor to agricultural productivity with climate change.

### **Soil Erosion**

Soil erosion due to the effects of climate change will accelerate through different processes (i.e., soil erosion caused from floods is common in Cooch Behar). As a result of flooding within this area, erosion of soils will create further agricultural issues, and result in reducing the agricultural productivity of Cooch Behar soils.

### **The Increased Number of Pests and Disease Presence**

Changes in the climate provide favourable environments for the growth of insects causing crop failure due to disease and pest infections. According to Gregory *et al.* (2009), globalisation and climate change will result in increased incidences of insect infestation/disease in agriculture throughout the world.

### **Soil Health Management**

Soil health serves as a critical aspect of productivity resilience, and sustainable agricultural practices, such as organic farming, crop rotation and bio-fertilizer use, improve soil fertility and retention capacity. Lal (2015) argues that enhancing organic carbon in soils is essential to climate resilience.

### **Water Management and Irrigation**

Water management practices, such as rainwater harvesting, can be used to mitigate variability caused by seasonal rain changes. Rockström *et al.* (2010) suggest that achieving agricultural resilience depends on sustainable water management practices.

### **Crop Diversification**

By spreading risk across several crops, crop diversification does reduce underlying risk. BIRTHAL *et al.* (2015) state that diversification leads to increase resilience through reduced dependence on a single crop and provides more stable income.

### **Technology Innovation**

Technological advances (e.g. drought-resistant and other climate-resilient crop varieties; precision agriculture) also contribute to resilience through providing means for increasing efficiency in the production process. According to Pingali (2012), technology is one of the major drivers of growth in agricultural productivity.

### **Institutional & Policy Support**

The support of institutions such as extension services, credit, and insurance programs promote the adoption of adaptation to climate variability. As we know that FAO (2013) states that the success of climate-smart agriculture depends on the support provided by policies.

### **Stabilization of Yield**

The use of resilient agricultural methods can create stabilized yields under varying climatic conditions. The area that is as reliant on weather for growing like the one in Cooch Behar will see great benefits from using these types of practices.

### **Resource Efficiency to be Improved**

Using resilient agricultural methods creates greater efficiency in the use of all agricultural inputs (water, soil, nutrients, etc.) thereby increasing productivity and sustainability of agriculture.

### **Vulnerability to be Reduced**

By diversifying their crops and using adaptive agriculture, growers are better able to reduce their vulnerability to climate shocks.

### **Livelihood Security to be Enhanced**

Stable cropping systems provide the basis for better incomes/livelihoods for farmers, which may alleviate poverty and improve farmers' lives.

### **Climate Resilience Using Econometric and Analysis Frameworks**

An empirical study of climate resilience is possible through an econometric regression model that accounts the role of determinants that are important in socioeconomic and institutional contexts. The model is specified in terms of functional specifications as follows:

#### **Model Specification:**

Resilience Index (RI) =  $\beta_0 + \beta_1$  (Education) +  $\beta_2$  (Farm Size) +  $\beta_3$ (Income) +  $\beta_4$  (ICT Access) +  $\beta_5$  (Irrigation Access) +  $\epsilon_t$

Where:

- RI = Composite resilience index
- $\beta$  = Coefficients
- $\epsilon_t$  = Error term

The model can be used to quantify the effect of socioeconomic and institutional factors on resilience.

### **THEORETICAL AND ECONOMIC INTERPRETATION OF THE RESILIENCE MODEL**

1. The Resilience Index (RI) is built up as a composite measure of resilience, capturing various dimensions of resilience such as adaptive capacity, exposure and sensitivity, and as such offer a comprehensive measure of the capacity of farmers to endure climate variability (Susan L. Cutter *et al.*, 2008).
2. The coefficients ( $\beta_1$  to  $\beta_5$ ) in the model indicate the marginal effects of the explanatory variables, that is, how much each factor influences the resilience level of farming households.
3. Stochastic error term ( $\epsilon$ ) represents factors and random variation that cannot be observed, and that may affect resilience, but are not explicitly defined in the model specification.
4. The model allows quantitative evaluation of the socioeconomic determinants of importance, including: Education, Farm size, Household income, Availability of Information and Communication Technologies (ICT), Irrigation infrastructure.
5. Education increases the awareness of farmers, their decision making skills, and uptake of technology, thus increasing adaptive capacity.
6. The size of a farm determines the accessibility of resources and flexibility of production that can enhance resilience to climatic stress.
7. The income level defines the investment ability of households in better inputs, diversification measure and risk management measures (Temesgen T. Deressa *et al.*, 2009).
8. Timely access to weather information and agricultural advisories through access to ICT enhances

responsiveness of farmers to risks associated with climate.

9. Irrigation infrastructures minimise reliance on rainfall and result in water security, hence reducing exposure to climate variability.

10. Empirical applications of the like econometric models have been employed extensively to study adaptation behavior and resilience specifically climate change studies (Tobias B. Below *et al.*, 2012).

11. Composite indices in combination with regression techniques offer a strong methodology that is capable of capturing the multidimensionality of resilience (Susan L. Cutter *et al.*, 2008).

## EMPIRICAL EVIDENCE IN COOCH BEHAR DISTRICT FOR RESILIENCE PRACTICES

In Cooch Behar, researchers have conducted several field-level studies to investigate different adaptation strategies that are being implemented by farmers who are affected by climate change. Examples include changes in crop types and growing season lengths, short-duration crops, and increasing use of irrigation for crop production. According to Sarkar *et al.* (2021), farmers convert to climate-resilient techniques will experience longer average yields than farmers who continue to use traditional farming techniques. Furthermore, Das *et al.* (2020) show that integrated farming systems improves farmer incomes and reduces the risk to their farms. Farmers are starting to implement some resilience practices, such as using high-yield variety (HYV) seeds and short-duration crops, and altering when they plant their crops (Das & Sarkar, 2016; Bhattacharyya *et al.*, 2015). In addition to using these cropping techniques, they are also using crop rotation and pest management techniques. On the other hand, farmers continue to have some difficulties adopting advanced techniques, such as mulching, zero tillage, and crop insurance, because of either a lack of money or understanding (Majumdar & Saha, 2019). The studies in the Cooch Behar area suggest that farmers place the greatest amount of priority on climate resilience (34.5%), followed by yield (30.4%), followed closely by a desire to reduce emissions (30.1%). Institutional support from various programmes, such as NICRA (which is executed by the Krishi Vigyan Kendras), have supported the development of climate-resilient agriculture (NABARD, 2019).

### Barriers to Resilience

While there is increasing recognition of the need to adopt resilient methods, there are many barriers to implementing these methods, including small land area, difficulties accessing new agricultural technology, lack of financial resources, and long-term soil nutrient deficiencies (especially a deficiency in the micronutrient boron) (Kundu *et al.*, 2017; Ghosh & Dey, 2020). Areas such as Cooch Behar II block are especially at risk due to low levels of adaptation and resilience (Government of West Bengal, 2021). Although resilient methods offer farmers many benefits,

they face barriers to implementing them. There is also inadequate awareness of what resilience is and how to accomplish it; farmers often struggle to access new technologies; they lack financial resources; and there is little institutional support for resilient methods. Deressa *et al.* (2009) note that socio-economic considerations greatly influence farmers' decisions to adapt.

### Farmer Awareness and Adaptation

Studies done about farmers' perceptions of climate change show that nearly 95% have observed increases in temperature and changes to climate in recent years (Das & Sarkar, 2016). The average adaptation index score (0.64) suggests that many constraints exist which hinder farmers' adaptations, including low income, lack of access to technical know-how, and lack of access to an institutional support structure (Majumdar & Saha, 2019). Farmers are more likely to adopt greenhouse gas emission-reducing methods if they know of sustainable agricultural practices that can be utilized (Bhattacharyya *et al.*, 2015).

## STRATEGIES AND POLICY DIRECTIONS

To increase resilience, policy measures should be directed toward increasing the use of climate-resilient agricultural practices by providing subsidies for drought-resistant seeds, training farmers, and increasing access to institutional finance. The adoption of organic fertilisers and integrated nutrient management would provide substantial benefits to the soil quality and sustainability of farmers (Singh *et al.*, 2017). Conservation agriculture and crop diversity are critical for developing long-term resilience to climate change and degradation (Lal, 2020). Establishing an institutional framework (e.g., Krishi Vigyan Kendras), and the implementation of locality-specific adaptation strategies will be crucial to enhancing agriculture (Mukherjee, 2021). Therefore, based on the findings of this study, there is a variety of policy options available to increase resilience in land productivity. Examples of specific programs are: Promotion of climate smart agriculture, Enhancement of extension services, Investment in irrigation infrastructure, Improvement of access to credit and insurance, and Support for research and development.

## LIMITATIONS OF THE RESEARCH

1. The restriction of having little (long-term) micro-level (farm-level) data available means that it is not possible to undertake a very detailed temporal analysis.
2. Because the farmer-reported themselves, there is potential for bias or subjectivity in the information they provide.
3. The research was restricted to Cooch Behar district, meaning it is not possible to generalise from this research to other areas.
4. The differences in climate and socio-economic conditions of the various blocks of Cooch Behar mean

they are unlikely to be captured completely in the aggregated analysis.

5. The limited access to real-time climate data makes it more difficult to precisely link climate factors to productivity.

6. Offsetting this, most institutional and policy analysis will have drawn upon much of the above while there are also however few direct policy evaluations apart from these secondary or perception-based sources.

## CONCLUSION

The study emphasizes the need for resilience in land productivity with a focus on how it helps mitigate the effects of climate change in Cooch Behar district, where the impacts of climate change on agricultural sustainability are significant challenges to long-term viability. Resilience-based practices can provide viable solutions by improving soil health, enhancing water management, and diversifying crops, thereby improving the resilience of agricultural systems to cope with the impacts of extreme climate events. To strengthen resilience for sustainable agricultural development, policies and farmer-oriented interventions need sustained commitment through advances in technology and continued policy support (Lal 2020). The findings of this study demonstrate the significant role that resilience within land productivity has as a mitigating factor to the negative impacts of climate change upon the Cooch Behar district. Areas exhibiting relatively high levels of resilience also tend to have improved yield stability and adaptive capacity and vice versa for those areas that are more vulnerable and demonstrate declining rates of productivity. Through improving and enhancing the capacities of agricultural producers to adapt and implement sustainable agricultural practices among those with some degree of resilience and/or who operate within resilient agricultural production systems, resilience provides the basis for the long-term stability of yields, and thus of food security. The conclusion of the study is that in addition to having a positive impact on agricultural productivity sustainability, increasing resilience is the key to food security and rural development of climate-impaired areas. A comprehensive approach involving technological advances, institutional processes and policies will be essential to achieving sustainable agriculture in the world of climate change. Institutions that aid resilience growth via developing integrated soil management systems, increased technology use and institutional support are essential to ensuring sustainable agricultural advancement. Future policies should be developed with a comprehensive perspective that incorporates ecological sustainability and sociocultural inclusivity.

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