

Strategies To Mitigate Climate Change Risks in Agriculture of Cooch Behar District, West Bengal

Dr. Wangda Gyatso Gyana¹ and Prof. (Dr.) Ram Krishna Mandal^{2*}

¹Sr. Assistant Professor, Department of Commerce, Dera Natung Government College, Itanagar, Arunachal Pradesh, India

²Professor & HoD, Department of Economics, Cooch Behar Panchanan Barma University, Cooch Behar, West Bengal, India

*Corresponding Author: Prof. (Dr.) Ram Krishna Mandal

Professor & HoD, Department of Economics, Cooch Behar Panchanan Barma University, Cooch Behar, West Bengal, India

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Abstract: One of the major issues facing agricultural sustainability today is climate change. Cooch Behar district in West Bengal, India has a large agrarian economy, with very small land holdings, and depends on rainfall from the monsoon season. This district is highly vulnerable to climate-related stresses such as erratic rainfall, increasing temperatures, floods, and extreme weather events. The purpose of this research is to identify the nature of the threats presented by climate change to agriculture in Cooch Behar district and identify strategies for reducing the impacts of these threats through mitigation, adaptation, and resilience strategies. This research draws from a number of methods, including empirical research and research studies performed in this region, as well as climate smart agriculture frameworks. Crop diversification, water resource management, technological innovations, institutional and policy support, as well as the use of local knowledge in developing the scientific innovations needed for increasing local resilience and improving sustainable agricultural practices were highlighted as key strategies to address climate-related challenges in Cooch Behar district.

Keywords: Agricultural Sustainability, Climate Change, Agrarian Economy, Floods, Water Resource

INTRODUCTION

The part of the economy consisting of farming remains one of the most sensitive areas to climate change. This is especially true in developing countries as a significant amount of people are dependent on farming for sustenance and livelihoods. Climate change can be characterized by increasing global temperatures, changing precipitation patterns, and increasing frequency of extreme weather events. Therefore, climate change is a significant threat to sustainable agriculture. Many crops rely on rain to grow, and farming is generally underdeveloped and economically fragile. Therefore, a country has a higher risk of being affected by climate change if it is dependent on rainfall, has low levels of agricultural technology, and has an economy that is unstable. India has many areas of agricultural development, a variety of climates, and is therefore at a higher risk of being affected by climate change. The agricultural impact of climate change in India has recently begun to show itself (Baraj *et al.*, 2024). The eastern part of India, which includes West Bengal is also highly vulnerable to climate change because this area has dense population, a reliance on the monsoon rain, and is very sensitive to ecological disruptions. Cooch Behar district in West Bengal is in an especially vulnerable geographical location in regard to climate. The soils are fertile, alluvial, receive high amounts of rainfall, and the local economy is primarily based upon agriculture. Moreover, while Cooch Behar has a lot of potential for agriculture, it also faces many challenges due to climate change. Examples of these challenges facing Cooch Behar include but are not limited to: (1) erratic rainfall, (2) changing temperatures, (3) flooding that occurs repeatedly, and (4) soil degradation.

Most farmers in Cooch Behar are small and marginal landholders and have very little access to resources, technology, and institutional assistance. They continue to rely on traditional farming practices and also depend on rainfall from the monsoon for their water supply. This makes them even more vulnerable to climate risks. Farmers have also

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reported that, in recent years, there have been changes to the climate in their area, such as delayed onset of the monsoon and irregular rainfall as well as more frequent occurrences of extreme weather events (Sarkar *et al.*, 2021). Therefore, an effective strategy for addressing climate change impacts and improving agricultural resilience is essential. This chapter will present a detailed assessment of climate-related agricultural risk in Cooch Behar as well as provide recommendations for a multi-pronged approach to mitigating and adapting to climate-related risks.

OBJECTIVES OF THE STUDY

In Cooch Behar district, the main goals of this study are:

1. To identify the types of climate change risks to agriculture and analyzing them.
2. To develop comprehensive strategies to mitigate climate change risks.
3. To search the challenges and barriers to agricultural development.
4. To explore the policy advice on how to sustain agriculture will also be provided.

RESEARCH METHODOLOGY

1. Study Area: Geographical and Socioeconomic Profile: Cooch Behar District is located in the northern region of West Bengal and represents an area that is part of the Eastern Himalayan alluvial plain. The entire area of Cooch Behar District has latitude ranges from 26°00'N to 26°30'N and longitude ranges from 89°15'E to 89°30'E and its altitude is normally approximately 49 meters above sea level within a range of about six feet above or below sea level. Rivers flow throughout the district, many of which belong to the Torsa, Jaldhaka, and Raidak Basins. While these rivers enrich the surrounding area and make it fertile, the river systems also create areas with a high potential for flooding. The climate in Cooch Behar District is classified as humid subtropical, with heavy rains occurring during the monsoon season (about 3000mm per year), hot summers, and cool winter months. Cooch Behar District is heavily reliant on agriculture, with more than 80 percent of its residents engaged in agricultural production for their primary source of income. The primary crops produced within Cooch Behar District are paddy, jute, potatoes, maize and various vegetables. However, the agricultural production methods used in Cooch Behar District are dominated by small, fragmented land holdings and very low levels of mechanization, as well as very little access to irrigation. Rain-fed agriculture makes Cooch Behar District very vulnerable to changes in climate. In addition, socioeconomic factors such as limited income, limited access to credit, and inadequate infrastructure only make the community more vulnerable to change.

2. Research Design: The present research accommodates a mixed-method research design which combines both qualitative and quantitative methods in order to provide a more thorough assessment of the risks of climate change, as well as options for mitigating the effects of climate change on agriculture in Cooch Behar district. The rationale for using a mixed-method approach is that climate change is multifaceted and has many dimensions, including environmental dimensions (such as atmospheric and climatic conditions); socio-economic dimensions (such as farm productivity and income); and institutional (or bureaucratic) dimensions (such as government support to farmers and the legal framework that involves supporting farmers). While quantitative methods provide measurements of climate variability (e.g., rainfall and temperature variability), agricultural productivity, as well as socio-economic indicators, qualitative methods provide insight into farmers' perceptions of climate change; their adaptive behaviours regarding responding to climate change; and the institutional dynamics that affect climate change. Overall, the study is descriptive, analytical and exploratory. The study is descriptive because it provides a description of the climatic and agricultural characteristics of the Cooch Behar district; the study is analytical because it examines how changes in climate variables relate to agricultural outcomes in the Cooch Behar district; the study is exploratory because it identifies potential mitigation and adaptation strategies.

3. Data Sources: The study makes use of secondary data sources to provide another layer of robustness and validation to the research findings. Secondary data sources utilized in the research are drawn from several credible sources and include: - Indian Meteorological Department - Government Reports - Farm Productivity Statistics - Research Journals/Books/FAO/IPCC Publications - District-Level Agricultural Database. Secondary data sources will provide a basis on which to conduct trend analyses and to assist in understanding the context of climate change.

4. Variables and Measurement: There are two types of variables: 1) dependent; and 2) independent; both types of variables will be examined in relation to each other. The dependent variables are as follows: agricultural productivity; farm income; and adoption of climate-resilient agriculture; while the independent variables used in evaluating the dependent variables include: temperature; rainfall variability; access to irrigation; education level; size of farm; and support of government agencies/institutions to assist farmers. In order to evaluate climate variability; rainfall deviation; and temperature anomaly; historical records will be used to calculate climate variability indicators.

5. Analytical Methods: The methods used in this study are a mixture of quantitative (statistical and econometrics) and qualitative analysis.

5.1 Descriptive Statistics: Statistical measures such as means (averages), percentages, and standard deviations will be used to describe the socio-economic characteristics, climate trends, and ways farmers have adopted to adapt to climate change.

5.2 Trend Analyses: Time-series data of rainfall and temperature will be analyzed to identify long term climatic trends and variability patterns affecting agriculture.

5.3 Econometric Models: To analyze the factors affecting the adoption of climate-resilient strategies, a variety of regression models will be used including: • Multiple Linear Regression (performing productivity/income analysis) • Logit/Probit (for analyzing the adoption behaviour of farmers towards climate-smart practices).

5.4 Climate Vulnerability Index (CVI): A composite index measuring Climate Vulnerability, based on indicator values that measure vulnerability (based on how exposed, sensitive and adaptive people are), will help identify the most vulnerable areas and people.

5.5 Qualitative Analysis: Qualitative data (collected through FGDs and interviews) will be analysed to identify key themes using a thematic analysis approach. This will assist the researcher in identifying key themes (or patterns) with respect to institutional challenges, local knowledge, and farmer adaptation strategies.

RESULT AND DISCUSSION

1. Types of Climate Change Vulnerabilities

1.1 Temperature Variability & Heat Stress: The first major climate change vulnerability within the region is an increase in temperature over time. Increasing temperatures have many consequences for agricultural production. The rise in temperatures decreases the time needed for crops to mature and results in short periods of grain filling and lower yields. Heat stress also affects the physiological processes of crops through photosynthesis and respiration resulting in lower productivity. In crops such as rice which have a high sensitivity to temperature changes, even the smallest increase in temperature during flowering can produce a substantial yield loss. Furthermore, increasing temperatures also result in increased rates of water loss through evapotranspiration causing depletion of soil moisture and increasing irrigation demand (Haque, 2024a).

1.2 Rainfall Variability & Water Stress: Rainfall variability is the second most important climate change vulnerability impacting agriculture in Cooch Behar. Agriculture in the region has historically relied on monsoon rains for crop production. Rainfall variability is one of the most obvious effects of climate change affecting agriculture in the region. The delayed onset of the monsoon; uneven rainfall distribution; and prolonged dry periods have all had serious impacts on the ability of farmers to conduct the agricultural practices of sowing, transplanting and harvesting. Furthermore, rainfall variability has increased the risk of crop failures and negatively impacts overall agricultural production (Haque, 2024b).

1.3 River Flooding: The river-based landform of Cooch Behar makes it easy for the area to flood. The heavy rains that accompany monsoons often result in overflowing rivers flooding agricultural land. When standing crops are damaged as a result of flooding there is also an additional time delay for the planting of crops again on the land that has been flooded.

1.4 Decreasing Soil Quality: The impact of climate change has caused soil degradation processes to accelerate or occur more frequently. Soil is degraded by erosion, loss of nutrients, and loss of organic matter. The result of increased intensity of rainfall is a greater amount of soil loss due to erosion. A prolonged period of time without rain decreases soil health and results in a decrease in soil quality and therefore limits the sustainability of agricultural production in those areas by limiting the capacity of the land to produce new produce.

1.5 Increased Pest and Disease Infestations - The change in climate has created conditions which allow for increased populations of pests and diseases to spread further than previously thought able to sustain their populations. Warmer temperatures and increased humidity produce a more rapid cycle of reproduction and allow for larger geographical distribution of pest populations. Many of the farmers are responding to the challenges with pest and/or disease infestation by using more pesticides, which may result in decreased environmental quality and may create potential human health issues.

COMPREHENSIVE STRATEGIES TO MITIGATE CLIMATE CHANGE RISKS

1. Climate-Smart Agriculture (CSA) is a holistic and integrated approach designed to increase agricultural productivity, improve resilience to climate variability, and assist in mitigating greenhouse gas emissions at the same time (FAO, 2013; Lipper *et al.*, 2014). In the context of Cooch Behar's agro-ecosystem, CSA will play an especially important role because of the extreme variability of rainfall, periodic flooding, and excessive waterlogging conditions. These issues cause major problems for the sustainability of agriculture in the Cooch Behar area (Gbegbelegbe *et al.*, 2014).

1.1 Crop Diversification Mechanisms As a vital risk management technique, crop diversification allows for the agricultural distribution of climatic risks via a variety of different crop species with differing levels of tolerance to these risks within Cooch Behar (as opposed to the current predominance of rice monocultures, creating an extremely high level of vulnerability) (Birthal *et al.*, 2015). Introduction of new crops, such as maize and pulses (e.g., lentils and grams), as well as oilseeds (e.g., mustard) and many varieties of vegetables can improve resiliency and reduce dependence on a single crop (Pingali, 2012). Intercropping systems provide income security (e.g., rice-fish-vegetable integrated systems) while maintaining ecological balance (Edwards, 2015). Empirical studies have shown that crop diversification has the potential to reduce crop yield variability due to climatic stress by approximately 20 to 30 percent (Lin, 2011).

1.2 Integrated Farming Systems (IFS) Integrated Farming Systems (IFS) is the strategic mixing together of crops, livestock, fish, and horticulture into a cohesive whole. The integrated nature of systems allows nutrient recycling to take place more effectively, decreases the amount of waste created. Also, by distributing risk across more than one production sector, IFS helps create an uninterrupted flow of income throughout the year, thereby contributing to improving people's ability to provide for themselves (Pretty *et al.*, 2011). An example of this would be the paddy-cum-fish model being used in agricultural areas that have excessive amounts of water, which increases both productivity and ecological sustainability (FAO, 2016).

1.3 Climate-Resilient Technologies Climate-resilient technology is another factor that helps to increase adaptive capacity by reducing the adverse impact on the environment. Examples include laser land leveling which improves water use efficiency, and zero-till methods preserve moisture in the soil by disturbing the soil as little as possible (Jat *et al.*, 2014). Another example would be how ICT-based agro-advisory systems can provide farmers with immediate information on climate and the management of their crops, which will help them make informed decisions about how to manage their farms (Aker, 2011). Climate-resilient technologies support both adaptation purposes as well as mitigation purposes.

2. Effective Water Management: Detailed Assessment: Water management (as an agricultural practice) is one of the major factors that determine agricultural sustainability when considering climatic changes, specifically in areas that experience flooding and drought (Rockström *et al.*, 2010; Pandey *et al.*, 2003).

2.1 Collection of Rainwater: Some collection structures such as farm ponds, check dams, and community tanks enable farmers to collect surplus rainwater during the monsoon season. Therefore, rainwater collection systems help to reduce the intensity of floods, while at the same time storing water for irrigation during dry spells; thus, helping to improve the cropping intensity and productivity of agricultural lands (Kumar *et al.*, 2016; Narayanamoorthy, 2007).

2.2 Micro-Irrigation: The use of micro-irrigation systems (e.g., drip and sprinkler irrigation) improves water-use efficiency tremendously. Drip irrigation is most effective for horticulture crops, whereas sprinkler irrigation is more beneficial for field crops (Postel *et al.*, 2001). Micro-irrigation systems can also reduce overall water usage within 40 per cent and 60 per cent and improve crop yield (Narayanamoorthy, 2007).

2.3 Managing Drainage: Drainage management is also essential for flood-prone regions such as Cooch Behar. Both surface drainage and subsurface drainage systems can help reduce prolonged waterlogging of crop roots and loss of nutrients from the soil (Skaggs *et al.*, 2012).

3. Crop Enhancement and Genetic Modification

3.1 Varieties that Can Withstand Stress: The creation and use of crop varieties that are able to endure stress represents a significant method of adapting to climate change (Ceccarelli *et al.*, 2010). Varieties of rice that can endure flooding such as Swarna-Sub1 are capable of withstanding being under water for periods of up to 14 days, and as such, they are able to greatly reduce the impact of flooding-related losses to rice crops (Septiningsih *et al.*, 2009).

3.2 Varieties that are of Short Duration: Creating and using short-duration varieties of crops reduces the risk of being affected by climatic conditions and allows for the possibility of multiple crops in one season, which in turn makes for farming being more resilient to climate change (Erenstein *et al.*, 2012).

3.3 Seed banks and Local Seed Systems: The use of local seed banks allows for climate-resilient varieties of indigenous plants to be held in trust and allows for timely access to these seeds during disasters (Vernooij *et al.*, 2015).

4. Soil Health Management: As Related to Science: The management of soil health is extremely important in areas that have been adversely affected by erosion caused by flooding as well as loss of nutrients from the soil (Lal, 2004).

4.1 Integrated Nutrient Management: Integrated Nutrient Management promotes the balanced use of commercial fertilizers, organic fertilizers, and bio-fertilizers, which results in improving soil fertility as well as reducing the environmental impact from farming practices (Gruhn *et al.*, 2000).

4.2 Conservation Farming: Examples of Conservation farming include but are not limited to the following practices: Minimum Tillage, Keeping Plant Material on the Soil Surface, and Rotating Different Crops. The practice of these will result in increasing soil organic content and moisture retention in the soil (Hobbs *et al.*, 2008).

4.3 Organic and Green Manure: The use of green manure crops and vermicomposting to improve soil structure and soil micro-organisms will assist with creating a sustainable soil (Palm *et al.*, 2001).

5. Disaster Risk Reduction (DRR): Structural and Non-Structural Measures

5.1 Structural Measures: Structural interventions such as embankments along rivers like Torsa and Dharla help reduce flooding (ICIMOD, 2009). **5.2** There are Early Warning Systems that give farmers the ability to make proactive decisions based on new technology (Hansen *et al.*, 2011).

5.3 The Pradhan Mantri Fasal Bima Yojana is an insurance program that will give farmers financial security and strengthen their ability to recover from disaster (GoI, 2016).

6. Livelihood Diversification: Economic Resilience: Income stability and reducing agricultural risk can occur through producing products on one's farm and creating more non-farm jobs (Ellis, 2000).

7. Ecosystem-Based Adaptation (EbA): Agroforestry, conservation of wetlands, and preservation of biodiversity increase ecosystem resilience and ability to adapt to a changing climate (Jose, 2009; CBD, 2009).

8. Institutional Framework and Policy Structure: The institutional and policy framework provides the foundation for climate change mitigation and adaptation to agricultural issues, especially in vulnerable areas such as the Cooch Behar district. The nature of the district's vulnerability to floods, unpredictable rainfall and degrading soils makes the work of institutions from local governing agencies to government entities and the use of policy tools critical for achieving sustainable developing agricultural systems that are resilient to climate change.

The subsequent sections of this report will present an overview and analysis of the significant contributions of the institutional and policy framework. A number of government programmes, such as the Soil Health Card Scheme, Pradhan Mantri Fasal Bima Yojana and Mahatma Gandhi National Rural Employment Guarantee Act, are particularly relevant to the support of farmers through the provision of financial assistance to farmers and the creation of employment opportunities (Government of India, 2015). Nationally, the National Action Plan on Climate Change continues to provide a coordinated approach to the adaptation of agriculture in response to climate change (Government of India, 2008).

8.1 Coordination of Institutions and Governance: There are various institutions that must work together to mitigate the impacts of climate variability on resources. Institutions such as governments, research institutes, extension services and local government units must cooperate on the mitigation of climate change and the adoption of climate-resilient resource management strategies to properly mitigate climate risks. To facilitate vertical (between nations, states, municipalities, and local government units) and horizontal (among different levels of government) coordination, institutional frameworks were established to facilitate policy coherence and non-duplication of efforts to successfully implement and accomplish the aims and objectives of policies.

Research has indicated that the installation of effective institutions has a positive impact on the ability of farmers and landowners to adopt climate-smart agriculture through the dissemination of knowledge and services (Patra & Babu, 2023). Coordination among various climate agencies, as well as Chhote Purush, government agricultural departments, and PRIs is necessary for the successful implementation of agricultural plans specific to the Cooch Behar district.

8.2 Institutions are accountable for establishing early warning systems, disaster preparedness strategies, and contingency strategies to deal with climate-induced hazards including flooding and droughts. In places like Cooch Behar that are prone to flooding, such as those in the Indian state of West Bengal, the establishment of institutional systems to predict weather, provide real-time advisories, and respond to emergencies plays an important role in minimising losses to the agricultural sector. They allow farmers to plan for sowing, irrigation and harvests based upon reliable data.

8.3 Information Communication Technology (ICT), Geographic Information Systems (GIS), Remote Sensing and Precision Agriculture are technologies that improve product efficiencies and therefore Climate Risk Management (Zhang *et al.*, 2002; Wolfert *et al.*, 2017).

COLLECTIONS OF CONSTRAINTS & CHALLENGES

1. The realization of many climate adaptation options is impeded by the presence of structural and institutional barriers to effective implementation of adaptation mechanisms throughout the world, including in Cooch Behar.
2. The financial condition of farmers restricts their ability to purchase either technologically advanced equipment and/or climate resilient physical installations; this effect is amplified for small and marginal landowners (Philip K. Thornton *et al.*, 2014).
3. Lack of familiarity with climate-resilient practices inhibits many farmers from being willing and/or able to adopt these new forms of adaptation to climate change.
4. Farmers' limited access to extension services means they have very limited opportunities to receive information/knowledge and technical assistance related to best farming practices (Tobias B. Below *et al.*, 2012).
5. The fragmented nature of institutional governance, and the limited level of coordination between the other policies, results in much less effective climate adaptation programmes.
6. The dominance of small, fragmented farm sizes restricts the extent of economies of scale that farmers can achieve, thus it makes it increasingly difficult for farmers to apply technologically advanced equipment and mechanisation in their farming methods (Pratap Singh Birthal *et al.*, 2015).
7. Availability of technologies which enable increased agricultural production creates potential for increased yields and positive contributions to building adaptive capacity in vulnerable agricultural systems.
8. Unreliable access to climate information systems, such as timely weather forecasts and warning systems, increases the vulnerability of farmers to the adverse effects of climate change.
9. In rural and remote areas, the above challenges are all amplified by local infrastructure and institutional support deficiencies.

POLICY FRAMEWORK FOR SUSTAINABLE AGRICULTURE

1. Creation of a policy framework for agriculture that can adapt to the changing climate of the Cooch Behar's susceptible regions is essential.
2. The implementation of Climate Smart Agricultural practices (CSA) will increase yields, enhance the ability of agriculture to adjust to the changing climate and contribute to the reduction of Greenhouse Gas emissions (Food and Agriculture Organization, 2013).
3. Strengthening agricultural research and extension services will facilitate the spread of location specific technologies, scientific knowledge, and best practices for farmers' usage.
4. Increased investment in infrastructure such as irrigation systems, transportation networks and storage facilities will reduce the effects of production risk and damage caused by climate change during and after harvest.
5. Effective climate information services will enable farmers to obtain and utilize timely and accurate data concerning climate conditions, as well as weather and climate related alerts (Surabhi Mittal & Mamta Mehar 2016).
6. The establishment of public/private partnerships will allow for:
 - More investment in the research and development of agriculture
 - Better transfer of technology
 - Increased farmers' access to markets.
7. The provision of better institutional support for managing risk (such as improved access to credit, crop insurance and subsidies, etc.) will decrease the risk associated with farming.
8. Providing farmer capacity building (i.e. education on raising crops, developing new skills, etc.) will help to increase the number of farmers adopting climate resilient crops.

9. Policy integration throughout all sectors (agriculture, water resources, rural development, and disaster management), will create a coordinated response to the changing climate.

10. A specific regional approach must be taken to achieve agricultural sustainability and equitable agricultural resilience due to the unique agro-climatic and socio-economic variables associated with the Cooch Behar area.

LIMITATIONS OF THE STUDY

1. This research was conducted only in the Cooch Behar district of West Bengal, so it wouldn't be reasonable to extrapolate results to other geographical areas (regions) with distinct agro-climatic and socio-economic conditions.

2. Much of this research's analysis was reliant on secondary (rather than primary) data sources. Thus, some important features of climate and agricultural changes at a very specific (micro-region) scale may not have been adequately captured due to the time lag of collecting and publishing secondary data.

3. Although there are many analytical diversity within this research, the research has not been sufficiently validated empirically through primary fieldwork (e.g., survey of farmers). As a result, some conclusions may be less reliable than they would have been had they been subjected to additional empirical validation through primary fieldwork before the research was finalized.

4. A highly detailed long-term time-series analysis was not included in the research; therefore, dynamic climate changes and their impacts on agriculture will not have been captured as accurately as they could have been.

5. The lack of granularity (i.e., block level) of location specific (e.g., localized) climate data (e.g., temperature/rainfall variability) limits the accuracy of climate risk assessments.

6. Climate change is a complex process, and as a result, the impact of climate change on agriculture cannot necessarily be simplified to (i.e., analysed as) separate temperature/rainfall of blocks and rather flood impact.

7. Advanced econometric models (e.g., panel data models and CGE models) were not used to a degree that could produce much more in-depth analysis of the causes for climate change.

8. Bias in Evidence from Existing Studies: Using pre-existing literature and case studies to guide inferences introduces a high degree of potential bias because results from these locations may not correspond in a meaningful and useful manner to conditions in Cooch Behar.

9. Lack of Consideration for Behaviors: Farmers' perspectives towards the climate change impacts on them, their agricultural practices, and adaptation decision-making processes have not been adequately explored; yet, they play an important role in their ability to adapt to climate change.

10. Institutional Frameworks Not Tested: The effectiveness of institutional frameworks is discussed at length; however, their performance is not measured in terms of quantifiable indicators or empirically validated field assessments.

11. Lack of Consideration for Market and Price Factors: The impact that market-related factors (e.g., price fluctuations, supply chain dynamics, market access) have on agricultural resilience in Cooch Behar were inadequately incorporated into the study.

12. Technology Adoption Factors Not Measured: The discussion of technological interventions is incomplete; there is no empirical assessment of the rate at which they are adopted, barriers to adoption, or the costs and benefits of adopting new technology.

13. Inequitable Gendered Approach: The role of gender in climate change vulnerability and adaptation strategies is inadequately emphasized; however, gender is an important component of rural agricultural systems.

14. No Prioritization of Policy Recommendations: Policy recommendations are not prioritized or ranked quantitatively with respect to their feasibility, cost, and impact.

15. Inability to Use Dynamic/Forward-Looking Analytical Frameworks: The analytical framework incorporated in the study is primarily static; therefore, dynamic and forward-looking (e.g., climate projections and scenario analysis) analyses have not been conducted.

CONCLUSION

The agricultural sector and rural economy in Cooch Behar are very vulnerable to flood risk, have a large dependence on monsoon-based agriculture, and have many of the same socioeconomic restrictions. Therefore, to mitigate climate change risks, systemic transformation of that agricultural sector and the rural economy is needed in Cooch Behar. An approach that includes climate-smart agriculture, good practices for managing water and soil, and improving institutional, technological, and community support, has the potential to greatly strengthen farm resilience in Cooch Behar (FAO, 2013; Thornton *et al.*, 2014). Over time, resilient-building strategies should focus on agricultural practices that are based on location to address agro-ecological differences and farmer-focussed approaches to ensure inclusivity and equity. To achieve sustainable results will require integrated policy development that considers multiple sectors and governance levels. Promoting resilience in agriculture is a technical, socio-economic, and institutional challenge that requires collaboration among policymakers, researchers, and communities. Climate change represents a major challenge to agriculture in Cooch Behar. However, through the use of integrated strategies which incorporate both traditional practices and modern techniques, climate change-related risks to agriculture can be successfully managed. Climate-smart agriculture, efficient resource management, technological advances, and supportive policy frameworks are critical to developing resilient and sustainable agriculture. Holistic and participatory approaches that rely on collaboration among multiple stakeholders are necessary to respond effectively to the complex challenges presented by climate change.

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