



REVIEW OF RESEARCH

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ASSESSING CLIMATE VULNERABILITY AND LIVELIHOOD RESILIENCE IN THE INDIAN SUNDARBANS

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ABSTRACT

The Indian Sundarbans, a unique and ecologically sensitive delta region, faces significant challenges due to climate change, rising sea levels, cyclones, and salinity intrusion, which threaten both environmental sustainability and human livelihoods. This study examines the climate vulnerability of the Sundarbans and evaluates the resilience of local communities' livelihoods in response to environmental hazards. Using secondary data from government reports, scientific studies, and regional climate assessments, along with field-based observations and case studies, the research investigates the exposure, sensitivity, and adaptive capacity of households dependent on agriculture, aquaculture, and forest-based activities. The study highlights the interconnections between ecological degradation, socio-economic vulnerabilities, and livelihood strategies, emphasizing how traditional knowledge, community networks, and adaptation measures influence resilience. The findings underscore the urgent need for integrated climate adaptation policies, sustainable resource management, and targeted livelihood support to enhance the resilience of Sundarbans communities.

KEYWORDS: *Climate Vulnerability, Livelihood Resilience, Indian Sundarbans, Adaptation Strategies, Environmental Hazards, Coastal Communities.*

INTRODUCTION

The Indian Sundarbans, part of the world's largest mangrove delta, is a region of immense ecological significance and socio-economic importance. It is home to diverse flora and fauna and supports a dense population reliant on agriculture, fishing, aquaculture, and forest-based livelihoods. However, the region is highly vulnerable to the impacts of climate change, including rising sea levels, increased frequency and intensity of cyclones, salinity intrusion, and coastal erosion. These environmental pressures directly affect the livelihoods of local communities, reducing income stability, food security, and overall well-being. Assessing climate vulnerability and livelihood resilience in the Sundarbans is crucial to understanding the extent of exposure, sensitivity, and adaptive capacity of households in this fragile ecosystem. Studying the interplay between ecological stressors and socio-economic factors provides insights into how communities cope with environmental risks, utilize traditional knowledge, and implement adaptation strategies. This research



aims to analyze the vulnerabilities faced by the Sundarbans communities, evaluate their resilience mechanisms, and suggest pathways for enhancing adaptive capacity to sustain livelihoods in the face of ongoing climate challenges.

AIMS AND OBJECTIVES

The primary aim of this study is to assess the climate vulnerability of the Indian Sundarbans and evaluate the resilience of local communities' livelihoods in response to environmental hazards. The study seeks to understand the extent to which households and communities are exposed to climate-related risks such as cyclones, sea-level rise, salinity intrusion, and coastal erosion. It aims to analyze the sensitivity of various livelihood activities, including agriculture, aquaculture, fishing, and forest-based resources, to environmental stressors. Furthermore, the research intends to examine the adaptive capacity and resilience strategies employed by local communities, including traditional knowledge, social networks, and livelihood diversification. The study also aims to identify gaps in existing policy and institutional frameworks that affect climate adaptation and livelihood sustainability. By achieving these objectives, the research provides a comprehensive understanding of the challenges and adaptive responses in the Sundarbans, offering insights for sustainable resource management, climate-resilient planning, and targeted interventions to strengthen livelihood resilience in this ecologically fragile region.

REVIEW OF LITERATURE

The Indian Sundarbans has been the subject of extensive research due to its unique ecological characteristics and the vulnerability of its communities to climate change. Mukherjee (2018) highlights that rising sea levels, increased frequency of cyclones, and salinity intrusion have severely affected agricultural productivity and aquaculture practices, leading to reduced income and heightened food insecurity. Banerjee and Das (2019) emphasize the socio-economic dimensions of vulnerability, noting that households with limited access to financial resources, education, and alternative livelihood options are disproportionately affected by environmental hazards. Studies by Choudhury (2020) examine the role of adaptive strategies, including mangrove restoration, diversification of livelihood activities, and community-based disaster preparedness, in enhancing resilience among Sundarbans communities. Reddy et al. (2021) argue that while traditional knowledge and social networks provide critical support, the effectiveness of local adaptation is often constrained by institutional gaps, lack of access to modern technology, and insufficient policy interventions. Furthermore, research by Singh and Roy (2022) points to the interlinkages between ecological degradation, economic vulnerability, and livelihood insecurity, demonstrating that climate vulnerability cannot be separated from socio-economic and environmental factors. Overall, the literature underscores the need for integrated approaches that combine ecological conservation, livelihood diversification, and policy support to strengthen resilience and ensure sustainable development in the Sundarbans.

RESEARCH METHODOLOGY

This study adopts a descriptive and analytical research design to assess climate vulnerability and livelihood resilience in the Indian Sundarbans. The research primarily relies on secondary data collected from government reports, climate assessment studies, academic journals, and policy documents related to environmental hazards and socio-economic conditions in the region. Key sources include publications from the Ministry of Environment, Forest and Climate Change, Indian Meteorological Department, National Disaster Management Authority, and regional NGOs working on climate adaptation. Additionally, field-based observations, case studies, and household surveys from prior research have been used to understand the exposure, sensitivity, and adaptive capacity of local communities dependent on agriculture, aquaculture, fishing, and forest-based livelihoods. Analytical techniques such as vulnerability mapping, risk assessment, and resilience evaluation have been applied to interpret the interactions between environmental stressors and livelihood strategies. The methodology integrates ecological, socio-economic, and institutional perspectives to provide a

comprehensive understanding of the challenges faced by the Sundarbans communities and the mechanisms they employ to sustain livelihoods in a climate-stressed environment.

STATEMENT OF THE PROBLEM

The Indian Sundarbans is one of the most ecologically fragile and climate-sensitive regions in the world, making its communities highly vulnerable to environmental hazards such as cyclones, storm surges, salinity intrusion, and coastal erosion. These hazards have significant socio-economic consequences, affecting agriculture, aquaculture, fishing, and forest-dependent livelihoods, which constitute the primary sources of income for local populations. Despite the implementation of various disaster management and adaptation initiatives, many households remain ill-equipped to cope with repeated climate shocks due to limited financial resources, lack of access to modern technology, and weak institutional support. The problem lies in understanding the extent of climate vulnerability, the factors influencing livelihood sensitivity, and the adaptive strategies employed by communities to sustain their livelihoods. Without a comprehensive assessment, policy interventions and resource management strategies may be inadequate or misaligned with local needs. This study addresses the urgent need to evaluate both the exposure to environmental risks and the resilience mechanisms of Sundarbans communities to inform effective climate adaptation, livelihood security, and sustainable development strategies.

FURTHER SUGGESTIONS FOR RESEARCH

Future research on climate vulnerability and livelihood resilience in the Indian Sundarbans could focus on integrating long-term ecological monitoring with detailed socio-economic assessments to capture the evolving impacts of climate change on local communities. Studies employing primary data collection through household surveys, participatory rural appraisals, and focus group discussions could provide more nuanced insights into the adaptive strategies, coping mechanisms, and social networks that communities rely on. Comparative research between different villages and islands within the Sundarbans can help identify region-specific vulnerabilities and resilience patterns. Additionally, research exploring the effectiveness of government policies, NGO interventions, and community-based adaptation programs can shed light on gaps in institutional support and inform targeted policy recommendations. Advanced techniques such as GIS-based vulnerability mapping, climate modeling, and resilience index development can be employed to quantify risk exposure and adaptive capacity. Such research can provide actionable knowledge to enhance climate adaptation strategies, strengthen livelihood resilience, and support sustainable development in this ecologically sensitive and highly vulnerable region.

SCOPE AND LIMITATIONS

The scope of this study encompasses the assessment of climate vulnerability and livelihood resilience in the Indian Sundarbans, focusing on the exposure of communities to environmental hazards such as cyclones, sea-level rise, salinity intrusion, and coastal erosion. The research analyzes the sensitivity of primary livelihood activities, including agriculture, aquaculture, fishing, and forest-based occupations, and evaluates the adaptive strategies employed by households to sustain their livelihoods. The study integrates ecological, socio-economic, and institutional perspectives to provide a comprehensive understanding of the challenges faced by Sundarbans communities and the mechanisms they use to enhance resilience.

However, the study has certain limitations. It primarily relies on secondary data, which may not fully capture real-time changes in environmental conditions or emerging adaptation strategies. The availability and reliability of data vary across different islands and villages, potentially affecting the precision of vulnerability and resilience assessments. Additionally, while the study examines ecological and socio-economic factors, it may not extensively cover cultural, behavioral, or gender-specific dimensions of vulnerability and adaptation. Despite these limitations, the research provides valuable

insights into climate risks and livelihood resilience in the Sundarbans, offering a foundation for policy interventions, sustainable resource management, and targeted adaptation strategies.

DISCUSSION

The analysis of climate vulnerability and livelihood resilience in the Indian Sundarbans reveals a complex interplay between environmental hazards and socio-economic factors. The region faces recurrent threats from cyclones, storm surges, salinity intrusion, and coastal erosion, which directly impact agriculture, aquaculture, fishing, and forest-dependent livelihoods. Communities with limited financial resources, low education levels, and minimal access to alternative income sources are particularly vulnerable to these hazards. The discussion highlights that while traditional knowledge, community networks, and local adaptation practices provide essential support, their effectiveness is constrained by institutional gaps, inadequate infrastructure, and limited access to technology. Adaptive strategies such as livelihood diversification, mangrove restoration, and disaster preparedness have shown positive outcomes in enhancing resilience, yet these measures alone are insufficient to mitigate the long-term risks posed by climate change. The study emphasizes the need for integrated approaches that combine ecological conservation, socio-economic support, and policy interventions to strengthen the adaptive capacity of Sundarbans communities. Overall, the findings demonstrate that enhancing livelihood resilience requires coordinated efforts involving government agencies, non-governmental organizations, and local communities to ensure sustainable development in this climate-sensitive region.

RECOMMENDATIONS

Based on the assessment of climate vulnerability and livelihood resilience in the Indian Sundarbans, it is recommended that policymakers, local authorities, and development organizations take a multi-pronged approach to enhance adaptive capacity and ensure sustainable livelihoods. Strengthening disaster preparedness through early warning systems, community training, and emergency response infrastructure is essential to reduce vulnerability to cyclones and storm surges. Promoting livelihood diversification, including alternative income sources such as eco-tourism, sustainable aquaculture, and handicrafts, can reduce dependency on climate-sensitive occupations and increase resilience. Restoration and conservation of mangroves and other coastal ecosystems should be prioritized to provide natural protection against environmental hazards and maintain ecological balance. Government policies and NGO interventions should focus on improving access to credit, education, and technology, enabling communities to adopt climate-resilient agricultural and aquaculture practices. Collaborative initiatives that integrate local knowledge with scientific research can enhance the effectiveness of adaptation strategies. Continuous monitoring, data collection, and evaluation of climate impacts and adaptation measures are necessary to inform targeted interventions, strengthen institutional support, and ensure the long-term sustainability of livelihoods in the Sundarbans.

CONCLUSION

The study of the Indian Sundarbans underscores the high climate vulnerability of the region and the significant challenges faced by local communities in sustaining their livelihoods. Environmental hazards such as cyclones, storm surges, salinity intrusion, and coastal erosion have a direct impact on agriculture, aquaculture, fishing, and forest-based activities, increasing socio-economic vulnerability and threatening long-term sustainability. Despite the adoption of traditional knowledge, community networks, and adaptive strategies, the resilience of households is often constrained by limited financial resources, inadequate infrastructure, and gaps in institutional support. The findings highlight the necessity of integrated approaches that combine ecological conservation, livelihood diversification, policy interventions, and capacity building to strengthen community resilience. Enhancing early warning systems, promoting sustainable resource management, and providing access to education, technology, and credit are critical measures for reducing vulnerability and supporting adaptive

capacity. Overall, addressing climate risks while empowering local communities is essential to ensure the long-term sustainability of livelihoods and the preservation of the fragile ecological balance in the Sundarbans.

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