Climate Change and the Changing Dynamics of the Sundarban Region of West Bengal: Socio-Economic and Environmental Impacts in the Context of Sustainable Development Goals (SDGs)

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***Abstract*—The Sundarbans of West Bengal, one of the world's largest mangrove ecosystems and a UNESCO World Heritage Site, are increasingly experiencing severe environmental and socio-economic transformations due to climate change. Rising sea levels, salinity intrusion, frequent cyclonic disturbances, coastal erosion, and biodiversity degradation have altered both ecological balance and human livelihoods in the region. This study examines the changing dynamics of the Indian Sundarbans with special emphasis on environmental degradation, livelihood vulnerability, migration, gender inequality, and sustainable development challenges. The paper adopts an interdisciplinary approach integrating climate science, socio-economic analysis, and Sustainable Development Goals (SDGs) frameworks to understand regional vulnerability and resilience. Secondary data from government reports, scientific literature, satellite observations, and climate databases are utilized to analyze recent environmental trends and socio-economic impacts. The study finds that climate change has intensified poverty, reduced agricultural productivity, increased displacement, and weakened ecosystem sustainability in the Sundarbans. The research further identifies critical linkages between climate vulnerability and SDGs such as No Poverty (SDG 1), Climate Action (SDG 13), Life Below Water (SDG 14), and Life on Land (SDG 15). The paper argues that sustainable adaptation strategies, community participation, mangrove restoration, and climate-resilient governance are essential for long-term sustainability in the Sundarbans region.**

***Index Terms*—Climate Change, Sundarbans, West Bengal, SDGs, Environmental Vulnerability, Coastal Erosion, Mangrove Ecosystem, Sustainable Development**

I. INTRODUCTION

Climate change has emerged as one of the most pressing environmental challenges of the twenty-first century. Coastal ecosystems across the world are increasingly exposed to sea-level rise, extreme weather events, salinity intrusion, biodiversity loss, and ecological instability. Among these vulnerable regions, the Sundarbans of West Bengal occupy a unique position due to their ecological richness and socio-economic fragility. Situated in the deltaic region formed by the Ganga, Brahmaputra, and Meghna river systems, the Sundarbans constitute the largest mangrove forest ecosystem in the world and provide ecological, economic, and climatic services to millions of people.

The Indian Sundarbans are highly sensitive to climatic variations because of their low elevation, fragile geomorphology, and dependence on natural-resource-based livelihoods. Over the last two decades, the region has experienced increasing climatic uncertainties including cyclones such as Aila, Amphan, Bulbul, and Yaas, along with severe coastal erosion and saline water intrusion. These processes have significantly transformed land-use patterns, agricultural systems, fisheries, settlement structures, and ecosystem functions. (Springer)

Recent scientific studies indicate substantial shoreline changes, degradation of mangrove vegetation, and rising ecological vulnerability in the Sundarbans due to anthropogenic and climatic stressors. (ResearchGate) The socio-economic consequences are equally alarming, particularly among marginalized

communities dependent on agriculture, fishing, forest resources, and informal labour sectors. Climate-induced migration, food insecurity, health risks, and gender inequality have become increasingly prominent in the region. (Scholar Cave)

This study aims to examine the changing environmental and socio-economic dynamics of the Sundarbans in the context of climate change while integrating the framework of Sustainable Development Goals (SDGs). The research emphasizes the urgent need for climate-resilient planning, ecological restoration, and sustainable development policies in the Sundarbans region.

II. OBJECTIVES OF THE STUDY

a) To analyze the environmental impacts of climate change in the Sundarbans region of West Bengal.
b) To examine socio-economic transformations and livelihood vulnerabilities among coastal communities.
c) To assess the relationship between climate change and Sustainable Development Goals (SDGs).
d) To evaluate adaptation and resilience strategies for sustainable regional development.

III. RESEARCH METHODOLOGY

The study is based on qualitative and quantitative secondary data analysis. Data have been collected from:

- Government reports and census publications
- IPCC climate reports
- Scientific journals and satellite imagery
- Research databases and environmental assessments
- Sustainable Development Goal reports

The study applies an interdisciplinary analytical framework combining climate vulnerability assessment, socio-economic analysis, and SDG integration models. GIS-based findings from recent studies are also incorporated to evaluate land-use changes and environmental degradation.

IV. ENVIRONMENTAL IMPACTS OF CLIMATE CHANGE IN THE SUNDARBANS

4.1 Sea-Level Rise and Coastal Erosion

Sea-level rise remains one of the most severe consequences of climate change in the Sundarbans. Due to low topography and deltaic instability, several islands in the region have experienced significant land loss and shoreline retreat. Scientific investigations reveal that many coastal zones of the Sundarbans are rapidly eroding under the combined influence of tidal action, cyclonic disturbances, and anthropogenic pressure. (Nature)

The disappearance of islands and continuous embankment failures have intensified displacement and environmental insecurity among coastal communities. Erosion not only destroys settlements and agricultural lands but also threatens biodiversity and ecosystem stability.

4.2 Salinity Intrusion and Agricultural Decline

Climate change has increased saline water intrusion into agricultural lands and freshwater sources. Rising sea levels and cyclonic storm surges have significantly altered soil chemistry and reduced agricultural productivity in the Sundarbans. Paddy cultivation, once the dominant agricultural activity, is increasingly becoming unsustainable in many areas.

Studies on land-use change and soil salinization indicate severe transformation of agricultural landscapes due to climate-induced environmental stress. (Springer) Increased salinity has also affected drinking water availability, resulting in health problems and water insecurity among rural populations.

4.3 Mangrove Degradation and Biodiversity Loss

Mangroves play a crucial role in coastal protection, carbon sequestration, and biodiversity conservation. However, climate change, pollution, deforestation, and unsustainable resource extraction have weakened mangrove ecosystems in the Sundarbans.

Recent vegetation health assessments reveal increasing vulnerability of mangrove forests under climatic stress. (Nature) Additionally, airborne microplastics have recently been detected in the Sundarbans Biosphere Reserve, indicating growing ecological contamination in even remote mangrove regions. (The Times of India)

The degradation of mangroves threatens wildlife habitats, including the habitat of the Royal Bengal Tiger, which is a globally significant species in the region.

V. SOCIO-ECONOMIC IMPACTS OF CLIMATE CHANGE

5.1 Livelihood Vulnerability

The economy of the Sundarbans is primarily dependent on agriculture, fishing, honey collection, and forest resources. Climate change has disrupted these traditional livelihood systems through cyclones, salinity intrusion, and ecosystem degradation.

Fishery resources have declined due to changes in water salinity and aquatic ecosystems. Agricultural income has reduced because of soil infertility and repeated flooding. Consequently, local communities increasingly rely on migration and informal labour opportunities for survival. (Springer)

VI. CLIMATE-INDUCED MIGRATION

Environmental degradation and economic insecurity have accelerated migration from the Sundarbans to urban centers such as Kolkata and other metropolitan regions. Many households are forced to relocate temporarily or permanently due to erosion, flooding, and loss of livelihoods.

Migration has transformed demographic structures, labour patterns, and family systems within the Sundarbans. Seasonal migration among male workers has also increased the burden on women and elderly family members.

VII. GENDER DIMENSIONS OF CLIMATE CHANGE

Women in the Sundarbans experience disproportionate impacts of climate change due to limited access to healthcare, sanitation, education, and livelihood opportunities. Salinity intrusion has intensified reproductive health problems and water-related diseases among women.

Recent socio-economic studies highlight the increasing burden of unpaid labour, domestic insecurity, and climate-related health challenges faced by women in the Sundarbans. (Scholar Cave) The intersection of environmental stress and patriarchal social structures has further deepened gender inequality in climate-vulnerable regions.

VIII. CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT GOALS (SDGS)

Climate change in the Sundarbans directly affects multiple Sustainable Development Goals adopted by the United Nations.

SDG 1: No Poverty

Environmental degradation and declining livelihoods increase rural poverty and economic insecurity.

SDG 2: Zero Hunger

Agricultural decline and fishery loss threaten food security and nutritional sustainability.

SDG 3: Good Health and Well-Being

Water contamination, salinity, and climate disasters contribute to disease outbreaks and health vulnerabilities.

SDG 6: Clean Water and Sanitation

Salinity intrusion has reduced access to freshwater and sanitation infrastructure.

SDG 8: Decent Work and Economic Growth

Climate-induced livelihood instability limits sustainable economic opportunities.

SDG 11: Sustainable Cities and Communities

Migration and displacement create pressure on urban settlements and infrastructure.

SDG 13: Climate Action

The Sundarbans represent one of the most climate-sensitive regions requiring urgent adaptation and mitigation measures.

SDG 14 and SDG 15: Life Below Water and Life on Land

Mangrove degradation, biodiversity loss, and marine ecosystem changes threaten ecological sustainability.

Research increasingly emphasizes the importance of integrating SDG frameworks into regional climate governance and adaptation planning in the Sundarbans. (arXiv)

IX. ADAPTATION AND RESILIENCE STRATEGIES

9.1 Mangrove Restoration

Mangrove restoration is essential for strengthening coastal resilience and reducing cyclone impacts. Community-based afforestation and ecosystem restoration programs can improve biodiversity conservation and carbon sequestration.

9.2 Climate-Resilient Infrastructure

Strengthening embankments, improving drainage systems, and constructing cyclone shelters are critical for reducing disaster vulnerability in the region.

9.3 Sustainable Livelihood Diversification

Alternative livelihood opportunities such as eco-tourism, handicrafts, climate-resilient agriculture, and aquaculture can reduce dependence on climate-sensitive occupations.

9.4 Community Participation and Indigenous Knowledge

Local communities possess valuable indigenous knowledge regarding tidal patterns, fishing practices, and ecological adaptation. Community participation and traditional ecological knowledge should be integrated into climate governance frameworks. (Reddit)

X. DISCUSSION

The Sundarbans represent a complex socio-ecological system where climate change interacts with poverty, environmental degradation, governance challenges, and development inequalities. The changing dynamics of the region reveal that climate vulnerability is not merely an environmental issue but also a socio-economic and political concern.

The findings indicate that environmental degradation and socio-economic insecurity are deeply interconnected. Coastal erosion, salinity intrusion, and biodiversity loss directly affect livelihoods, migration, gender relations, and regional development. Simultaneously, weak infrastructure, inadequate policy implementation, and limited adaptive capacity intensify climate vulnerability.

The integration of Sustainable Development Goals into climate adaptation planning provides an effective framework for achieving balanced ecological and socio-economic sustainability in the Sundarbans.

XI. CONCLUSION

Climate change has fundamentally altered the environmental and socio-economic landscape of the Sundarbans in West Bengal. Rising sea levels, cyclonic disturbances, salinity intrusion, and ecosystem degradation have intensified livelihood insecurity, migration, poverty, and ecological vulnerability in the region. The study demonstrates that climate change is not only an environmental crisis but also a developmental challenge affecting multiple dimensions of human well-being and sustainability.

The achievement of Sustainable Development Goals in the Sundarbans requires integrated climate governance, ecological restoration, community participation, and sustainable livelihood development. Long-term resilience in the region depends upon strengthening local adaptive capacity, protecting mangrove ecosystems, and implementing inclusive climate policies. Future research should focus on localized vulnerability mapping, climate justice frameworks, and participatory adaptation models to ensure sustainable development in the Sundarbans.

REFERENCES

[1] B. Bera, S. Bhattacharjee, N. Sengupta, *et al*., "Significant reduction of carbon stocks and changes of ecosystem service valuation of Indian Sundarban," *Scientific Reports*, vol. 12, Art. no. 7809, 2022. DOI: 10.1038/s41598-022-11716-5.

[2] S. Dutta, S. Das, S. Gorain, *et al*., "Unraveling anthropogenic and climate stressors in the Sundarbans and their ripple effects on livelihoods and ecosystems, and adaptation strategies for a sustainable future," *Environmental Development*, vol. 58, Art. no. 101410, 2025.

[3] Ghosh and P. Mondal, "Analysing the vulnerability of mangrove forest by vegetation health assessment: A study of Indian Sundarbans deltaic region," *Scientific Reports*, vol. 15, Art. no. 44250, 2025.

[4] U. K. Mandal, A. Ghosh, F. Karim, *et al*., "Land use change and soil salinization in the

Sundarbans: A machine-learning based analysis of long-term transformation and future projections," *Environmental Monitoring and Assessment*, vol. 197, Art. no. 1380, 2025.

[5] Roy and I. Guha, "Economics of climate change in the Indian Sundarbans," *Global Business Review*, vol. 18, no. 2, pp. 1–15, 2017.

[6] M. Saha, "The gendered impact of climate change: A socio-economic study of women in the Sundarbans," *International Social Research Nexus*, vol. 1, no. 3, pp. 1–11, 2025.

[7] K. Shukla, B. Ganguli, Nirwan, *et al*., "Assessing livelihood vulnerability to sea level rise: A perspective to climate vulnerability and adaptation in the context of the Indian Sundarbans delta," *Discover Sustainability*, vol. 6, Art. no. 1350, 2025.

[8] N. Suckall, E. Tompkins, R. Nicholls, *et al*., "The development of a framework for the integrated assessment of SDG trade-offs in the Sundarban Biosphere Reserve," *Water*, vol. 13, no. 4, Art. no. 528, 2021.