GEOGRAPHIES OF DISASTER RISK REDUCTION PRACTICES

Climate Disasters, Coastal Socio-Ecological Challenges, and Participatory GIS

Kousik Das Malakar

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GEOGRAPHIES OF DISASTER RISK REDUCTION PRACTICES: CLIMATE DISASTERS, COASTAL SOCIO-ECOLOGICAL CHALLENGES, AND PARTICIPATORY GIS

BY

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INVESTOR IN PEOPLE

Dedicated to young scholars in the field of hazard and disaster studies, geography, environmental science, climatology, sustainability science, social science, and policy makers.

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LIST OF ABBREVIATIONS

CBA	Community-based Adaptation
CBDRM	Community-based Disaster Risk Management
CCA	Climate Change Adaptation
CCM	Climate Change Mitigation
CES	Coastal Ecosystem Services
CVA	Coastal Vulnerability Assessment
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EWS	Early Warning System
GIS	Geographic Information System
HVR	Hazard, Vulnerability, and Risk
IPCC	Intergovernmental Panel on Climate Change
ITK	Indigenous Technical Knowledge
LK	Local Knowledge
PGIS	Participatory Geographic Information System
RMS	Risk Management Strategies
SDGs	Sustainable Development Goals
SES	Socio-ecological System
UNDRR	United Nations Office for Disaster Risk Reduction
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change

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ABOUT THE AUTHOR



Kousik Das Malakar is a socio-ecological geographer, GIS analyst, and researcher with a specialisation in climate change and policy. He currently holds the position of Assistant Professor in the Department of Geography, GDC Memorial College (Chaudhary Bansi Lal University), BRCM Vidyagram Campus, Haryana. He earned his PhD from the Department of Geography, Central University of Haryana. He also possesses a Master's degree in Social Science Geography from Jawaharlal Nehru University (JNU), New Delhi, and a Bachelor's degree from Vidyasagar University, Medinipur. His research interests encompass the climate crisis, socio-ecological systems, coastal environments and societies, sustainability, disaster studies, participatory policy planning, and the application of geospatial technologies. In his field of research, he has participated in over 150 academic events and has published 20 research papers, 3 authored books, 1 edited volume, 20 book chapters, and 2 conference proceedings in internationally reputed publications. He has received numerous certifications from the Indian Institute of Remote Sensing (IIRS) in Dehradun, the Geological Survey of India (GSI) in Hyderabad, and the National Institute of Disaster Management (NIDM) in New Delhi, recognising his ability to engage in and acquire research ideas and knowledge. Additionally, he actively serves as a reviewer for academic journals and books, and is a member of several academic and professional organisations, including the Human Development and Capability Association (USA), Unequal World (USA), the International Society for Urban Health (USA), the International Centre of Excellence in Engineering & Technology (Portugal), and the International Centre of Excellence in Humanities, Social Sciences, and Interdisciplinary Studies (Portugal). (ORCID: https://orcid.org/0000-0003-4498-7153).

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PREFACE

Coastal ecologies experienced a variety of socio-ecological difficulties due to the climate crisis, including sea-level rise, cyclones, floods, and the unsustainable expansion of infrastructure, which is becoming more prevalent in different regions. Understanding the geographies of disaster risk reduction in the coastal domain is critical for protecting the world's most susceptible coastal communities. Based on this context, the present book discusses contemporary socio-ecological challenges to climate disasters in the coastal research domain and presents participatory GIS approaches to coastal disaster risk reduction.

There are three parts to this book. The initial part addresses the fundamental understanding of climate disasters and coastal socio-ecological systems, including climate disaster concepts and approaches, as well as coastal risk and vulnerability geographies. The second part of this book delves deeply into the concentration on current socio-ecological challenges along coastal regions. It provides a comprehensive understanding of the challenges and possibilities surrounding nature-based and community-centred disaster risk reduction practices. Further, it explores the geographies and socio-spatial dynamics of these practices through participatory GIS, emphasising the significance and potential of incorporating local and indigenous technical knowledge into disaster risk reduction efforts. Finally, third part provides an innovative approach to representing empirical evidence through field narratives and case studies in coastal socio-ecological systems. The field narratives encompassed various themes, including climate disaster adaptation, accounts of cyclones and the coastal frontline, adaptation and resilience amidst coastal flooding, participatory mapping of sea-level rise, and climate-induced migration in coastal communities. Furthermore, the case studies examined the spatiotemporal mapping of climate variability and community perspectives, the relationship between climate disasters and community resilience, strategies for disaster risk reduction, socio-ecological vulnerability to climate change, the utilisation of indigenous technical knowledge in disaster risk reduction, nature-based solutions, and community-based management approaches.

This book advances scientific and practical knowledge to reduce coastal disaster risks. It enriches disaster policy planning by incorporating remote community attitudes into geographic space. It provides benefits to planners, scientists, researchers, professionals, officials, students, and disaster study enthusiasts.

Kousik Das Malakar
New Delhi

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FOREWORD



Disaster studies play a crucial role in equipping communities and stakeholders with the knowledge necessary to address contemporary challenges and engage effectively with Disaster Risk Reduction (DRR) processes within the socio-environmental context. In an era characterised by intensifying environmental threats and rapid social change, the demand for innovative strategies in disaster risk management has become increasingly urgent. In this context, the forthcoming book *Geographies of Disaster Risk Reduction Practices: Climate Disasters, Coastal Socio-ecological Challenges and Participatory GIS* by Dr Kousik Das Malakar, to be published by Emerald Publishing (UK), is both timely and highly pertinent.

The chapters included in this volume represent exemplary contributions of advanced research and applied practice, offering valuable insights into climate-induced disasters, contemporary socio-ecological challenges in coastal regions, and the application of participatory GIS in disaster risk reduction. Drawing on interdisciplinary approaches and grounded in diverse coastal contexts, this volume delves into the complex interplay between climate-induced disasters and socio-ecological systems. It interrogates the evolving geographies of coastal risk and vulnerability, bringing to light both systemic challenges and innovative responses across multiple scales. Through detailed mapping, participatory methodologies, and rich field narratives, the chapters offer critical insights into nature-based and community-driven disaster risk reduction practices. Emphasising the significance of local and Indigenous knowledge systems, the volume advances the discourse on inclusive and place-based resilience strategies. As the impacts of climate change intensify, this collection serves not only as a reflection of current scholarship but also as a forward-looking contribution that encourages collaboration, grounded adaptation, and transformative action in disaster-prone coastal regions.

I congratulate the author for his commendable initiative in producing this valuable and timely volume of contemporary significance. This book makes a significant contribution to the existing body of knowledge and is particularly intended for students and researchers engaged in disaster studies, community-based research, and sustainable development. It is my hope that the work will

be widely recognised and appreciated by geographers, environmental scientists, climate practitioners, policy planners, and decision-makers involved in disaster risk reduction efforts.

Dr S. K. Sinha
Director, BRCM Education Society, and Principal,
GDC Memorial College, Bahal, Bhiwani (HR), India

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With sincere appreciation, I extend my gratitude to the survey participants from the coastal region of Bengal (India), whose knowledge, lived experiences, and perspectives have been pivotal in shaping this book, *Geographies of Disaster Risk Reduction Practices: Climate Disasters, Coastal Socio-ecological Challenges and Participatory GIS*. Their valuable contributions have enriched the case study sections, offering critical insights into the complex interactions between communities and their environment. Appreciation is also due to the vast body of literature that has guided and informed this work, offering a strong theoretical and empirical foundation. The publication of this book *as part of* the Community, Environment, and Disaster Risk Management (Emerald) series is an honour, and sincere thanks go to the editors and publishers for their dedication to advancing research on socio-environmental issues. Their efforts in fostering academic dialogue have significantly contributed to the dissemination of knowledge in this field. Deep gratitude extends to mentors, colleagues, and family, whose continuous support and encouragement have been invaluable throughout this journey. Their insights and guidance have helped refine ideas, making this book possible.

Finally, heartfelt appreciation is extended to the series editor, Prof William L. Waugh, Jr, and the acquisitions editor, Dr Daniel Ridge, for their insightful evaluations and invaluable guidance in bringing this book project to completion. Their support has been instrumental in refining the work, and their facilitation of this opportunity with Emerald Publishing (UK) is deeply appreciated.

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New Delhi

CONFLICT OF INTEREST

The author has declared no potential conflicts of interest.

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PART I

FUNDAMENTALS OF CLIMATE DISASTERS AND COASTAL SOCIO-ECOLOGICAL SYSTEMS

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CHAPTER 1

INTRODUCTION TO CLIMATE DISASTERS AND COASTAL SOCIO-ECOLOGICAL SYSTEMS

ABSTRACT

This chapter discusses the complex relationship between climate disasters and coastal socio-ecological systems, stressing the urgent need for integrated and sustainability-oriented risk reduction. It begins by unpacking the concept, causes, and drivers of climate disasters, highlighting that such events are not purely natural but are socially mediated and exacerbated by anthropogenic pressures. The discussion then turns to the functioning of coastal socio-ecological systems, emphasising their ecological value, socio-cultural diversity, and vulnerability to hazards such as cyclones, sea-level rise, and erosion. The analysis explores coastal hazards and risks, outlining their typologies, underlying drivers, and diverse impacts. Ecological consequences such as mangrove degradation, coral bleaching, and wetland loss are examined alongside social outcomes including displacement, livelihood insecurity, and the erosion of cultural heritage. The chapter argues that climate disasters produce cascading and interlinked effects that destabilise both ecosystems and human communities, particularly in marginalised regions. In response, a comprehensive framework for coastal risk reduction is advanced, grounded in community participation, ecosystem restoration, and policy integration. Hard, soft, and hybrid protective strategies are evaluated, with particular emphasis on ecosystem-based approaches that promote equity and integrate local and traditional knowledge. The chapter concludes by highlighting key arguments and future research directions, including the need for gender-sensitive perspectives, migration and resettlement studies, and participatory governance.

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By adopting an interdisciplinary and systems-based approach, it offers critical insights into building resilient and sustainable coastal futures amidst intensifying climate uncertainty.

Keywords: Coastal socio-ecological systems; climate disasters; risk reduction practices; ecosystem-based adaptation; social vulnerability; sustainability and resilience

This chapter foregrounds the intricate interplay between climate disasters and coastal socio-ecological systems, situating them within the broader debates on risk, vulnerability, and sustainability. It underscores how climate hazards are not solely natural occurrences but are deeply shaped by social, economic, and ecological conditions that amplify their impacts. By weaving together ecological insights and social realities, the chapter emphasises the urgent need for integrated strategies that combine science, policy, and community perspectives. Ultimately, it seeks to illuminate pathways towards resilience and justice in the face of escalating coastal risks.

Key points of the chapter:

- Climate disasters are socially mediated and intensified by human-driven environmental pressures.
- Coastal socio-ecological systems hold ecological and cultural value yet remain highly vulnerable to hazards.
- Disasters create cascading impacts, destabilising ecosystems and livelihoods, especially in marginalised regions.
- Effective risk reduction requires community participation, ecosystem restoration, and integrated policy action.
- Future resilience depends on ecosystem-based solutions, gender-sensitive perspectives, and participatory governance.

1.1. UNDERSTANDING CLIMATE DISASTERS

1.1.1. Concepts

Climate disasters refer to extreme weather and climate-related events that profoundly disrupt ecological systems, cause extensive damage to property and infrastructure, and endanger human health, livelihoods, and survival. Unlike broader categories of natural disasters, which encompass geological phenomena such as earthquakes and volcanic eruptions, climate disasters are specifically linked to atmospheric, hydrological, and climatological processes, many of which are intensifying as a consequence of global climate change. These events emerge from the interplay between natural climate variability and longer-term shifts in climate patterns, processes that are increasingly shaped by anthropogenic

influences. Crucially, the concept of climate disasters extends beyond the physical event itself to include the vulnerability and exposure of human and ecological systems, recognising that an event becomes a disaster only when it overwhelms the adaptive capacity of affected communities and environments. In this sense, climate disasters are not purely natural phenomena but outcomes of dynamic interactions between environmental processes and human decisions, behaviours, and socio-economic structures (Kafi & Ponrahono, 2024; Malakar et al., 2023a; Nagaraju & Bala, 2025).

1.1.2. Types

Climate disasters can be classified into distinct categories according to their underlying processes, environmental drivers, and societal consequences. Hydrological disasters include events such as floods, river overflows, and flash floods, typically triggered by intense rainfall or the sudden release of water from dams or melting glaciers. Meteorological disasters encompass phenomena like cyclones, hurricanes, typhoons, thunderstorms, hailstorms, and heatwaves, all of which are directly linked to atmospheric dynamics and rapidly shifting weather conditions. Climatological disasters, by contrast, unfold over longer timescales and include droughts, wildfires, and extended periods of extreme heat or cold that place sustained pressure on agriculture, water resources, and ecosystems. Less frequent but increasingly significant are cryosphere disasters, which occur in high-altitude or polar regions where temperature fluctuations destabilise snow and ice systems, leading to avalanches, glacial lake outburst floods (GLOFs), and ice storms. Each category exhibits unique spatial and temporal characteristics, with their manifestation shaped by climatic zones, geographical features, and patterns of human settlement and development (Sloggy et al., 2021). Climate disasters can be categorised into distinct types (Fig. 1), each defined by particular characteristics and underlying drivers:

(a) *Hydrological disasters:* such as floods and flash floods (Beran & Arnell, 1996).
(b) *Meteorological disasters:* including cyclones, hurricanes, thunderstorms, and heatwaves (Mohapatra, 2024).
(c) *Climatological disasters:* such as droughts, wildfires, and prolonged cold spells (Tschumi & Zscheischler, 2020).
(d) *Cryosphere disasters:* including events like avalanches and GLOFs (Schmidt et al., 2020).

1.1.3. Causes

The causes of climate disasters arise from both natural processes and human activities. On the natural side, interactions between the atmosphere and oceans, most notably El Nino and La Nina phenomena, disrupt global circulation patterns and often trigger droughts, floods, or storms across different regions. Seasonal monsoons and variations in solar radiation cycles similarly influence the occurrence of certain climate events. In recent decades, however,

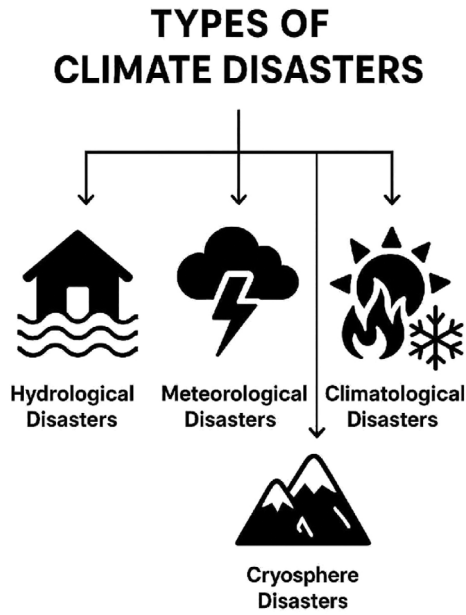


Fig. 1. Types of Climate Disasters. *Source*: Prepared by the Author.

anthropogenic drivers have become the predominant forces shaping the frequency and intensity of climate-related disasters. Rising greenhouse gas emissions from the combustion of fossil fuels, industrial activities, and transportation have accelerated global warming and destabilised climatic systems. At the same time, deforestation, land degradation, urban expansion, and the destruction of ecological buffers such as wetlands and mangroves have diminished the planet's ability to sequester carbon and regulate temperature. These alterations in land use and unsustainable resource extraction weaken environmental resilience, leaving many regions increasingly vulnerable to disaster impacts (Abbass et al., 2022; Ismail-Zadeh, 2022).

1.1.4. Drivers

The drivers of climate disasters encompass the underlying forces and processes that not only precipitate such events but also shape their magnitude and consequences. Environmental drivers include rising global temperatures, shifting precipitation regimes, retreating glaciers and ice sheets, and the increasing frequency of extreme weather phenomena, all of which are manifestations of long-term climate change. Yet, these disasters cannot be understood solely through environmental dynamics; socioeconomic and political factors play an equally decisive role. Weak governance, inadequate investment in climate-resilient infrastructure, unplanned urban expansion, and the marginalisation of vulnerable

populations amplify exposure and heighten risk. Demographic pressures, persistent poverty, inequality, and limited access to timely information and early warning systems further constrain the capacity of communities to prepare for and recover from such events. Moreover, global economic structures that privilege short-term growth over sustainability perpetuate unsustainable resource extraction, deepening environmental degradation and exacerbating climate-related hazards. Recognising the interplay of these multidimensional drivers is essential for advancing integrated strategies in disaster risk reduction, climate adaptation, and sustainable development (Das & Swain, 2024; Ohlendorf, 2019; Roukounis & Tsihrintzis, 2022).

1.2. COASTAL SOCIO-ECOLOGICAL SYSTEMS

1.2.1. Concept

Coastal socio-ecological systems are dynamic and interconnected assemblages of human and natural components that coexist and interact within coastal environments (Fig. 2). They include coastal communities and their economic activities, such as fishing, tourism, and aquaculture, alongside cultural practices, governance structures, and ecosystems such as mangroves, estuaries, coral reefs, wetlands, and beaches. Rooted in systems thinking, the concept highlights the mutual dependence and co-evolution of social and ecological subsystems rather

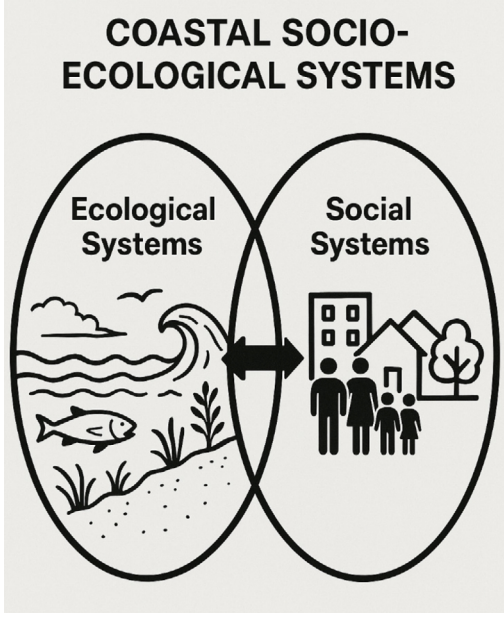


Fig. 2. Coastal Socio-ecological Systems. *Source*: Prepared by the Author.

than viewing them as separate domains. These systems are shaped by feedback loops, resilience, and adaptive capacities, yet remain highly vulnerable to both gradual changes, such as sea-level rise and coastal erosion, and sudden shocks, including cyclones and storm surges. A comprehensive understanding of coastal socio-ecological systems requires an integrative perspective that links ecological sustainability with human well-being, livelihoods, and equity, particularly in the context of intensifying environmental pressures (Malakar et al., 2023b).

1.2.2. Importance

Coastal socio-ecological systems are of profound significance, both environmentally and socioeconomically. Ecologically, they function as vital buffers that regulate climate, sequester carbon, sustain biodiversity, and mitigate the impacts of extreme weather through natural defences such as mangroves, wetlands, and coral reefs. Socioeconomically, they underpin the livelihoods of millions of people worldwide, particularly in developing regions where coastal fishing, small-scale farming, and informal economies are central to food security and income generation. Beyond material benefits, coastal zones also serve as centres of cultural identity and repositories of traditional ecological knowledge, embodying long-standing relationships between communities and their environments. From a governance standpoint, these systems highlight the importance of participatory, inclusive, and adaptive management approaches. Ensuring their sustainability is therefore critical not only for biodiversity conservation but also for advancing global development agendas and enhancing resilience to climate variability and change (Elegbede et al., 2025).

1.2.3. Interactions with Climate Disasters

Coastal socio-ecological systems occupy a frontline position in the context of climate disasters, owing to their geographical location and exposure to multiple environmental stressors. The interactions between these systems and climate hazards are highly complex and frequently intensify pre-existing vulnerabilities (Fig. 3). Sea-level rise, stronger tropical cyclones, saline water intrusion, and coastal flooding threaten ecological functions such as mangrove health and freshwater availability while simultaneously undermining human livelihoods dependent on fishing, agriculture, and stable housing. The degradation of natural protective buffers, often driven by overexploitation or unsustainable land-use practices, further magnifies the damage caused by extreme events. Socially, marginalised coastal populations, including artisanal fishers, indigenous groups, and the urban poor, face disproportionate impacts due to their limited adaptive capacity. These dynamics highlight the urgency of integrated coastal management, robust early warning systems, ecosystem-based adaptation, and community-led resilience strategies. A deeper understanding of how climate disasters interact with the socio-ecological fabric of coastal regions is essential for shaping policies that both reduce risk and promote long-term sustainability and social equity (Castro-Cadenas et al., 2022; Yanda & Mung'ong'o, 2019).