

**VULNERABILITY ASSESSMENT OF MANGROVES AND
CORALS TO CLIMATE CHANGE AND ITS IMPACT
IN ANDAMAN ISLANDS**

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SAYANI DATTA MAJUMDAR

Under supervision of Prof. Sugata Hazra

School of Oceanographic Studies

Faculty of Interdisciplinary Studies Law and Management

Jadavpur University

INTRODUCTION

Corals and mangroves, are one of the most productive and bio-diverse ecosystems of the world. These ecosystems, flourishing in the tropics and sub-tropics are experiencing persistent degradation throughout the world due to the climatic unpredictability and detrimental anthropogenic activities. Andaman Island is a rich abode of both coral and mangrove ecosystems. Coupled with climate change, the adjoining coastal waters of Andaman Island are increasingly being affected by climatic, non climatic and anthropogenic changes. On one hand the anthropogenic activities like unsustainable felling, encroachment for settlement; pollution, coastal development activities, conversion to agriculture and aquaculture ponds is causing a huge damage to these ecosystems. On the other hand, climate change related phenomenon like short term impact of the El Niño-Southern Oscillation (ENSO), rising sea level, altered discharge are hampering the subtle balance of these ecosystems. Given the nature and extent of the degradation of these mangrove and coral ecosystems in Andaman it is important to understand the several economic benefits and values of these ecosystems and how such environmental changes might affect the ecosystem services like fishery, tourism and other provisioning and regulating services and how such potential impacts can be ameliorated.

The coastal livelihood of the Andaman Islands is facing significant challenges due to the impact of global climate change. Their vulnerability is exacerbated by limited adaptation options, including restricted natural areas for migration and recolonization, an economy heavily dependent on external resources, inadequate infrastructure, and a large rural population. These factors lead to high transportation costs and delays in receiving external supplies, further increasing the region's vulnerability. However, by conducting risk assessments and developing comprehensive mitigation plans, the Andaman Islands can better protect their coastal areas and work towards sustainable solutions for their environmental and economic challenges.

RESEARCH PROBLEM

The present study aimed to identify the unique characteristics of the mangroves and corals of the Andaman Islands and document the prominent threats that make these marine ecosystems vulnerable to climate change. The degradation of the mangrove and coral ecosystems in the Andaman Islands can be attributed to human activities, including unsustainable logging, settlement encroachment, pollution, coastal development, and the conversion of land for agriculture and aquaculture. Additionally, climate change-related phenomena, such as the short-term impacts of the El Niño-Southern Oscillation (ENSO), rising sea levels, and altered water discharge, are disrupting the delicate balance of these ecosystems. Understanding the economic benefits and values of these ecosystems is crucial, as is assessing how environmental changes may affect ecosystem services, including fisheries and tourism, as well as other provisioning and regulating services. It is essential to explore mitigation strategies for these potential impacts. To analyze vulnerability, spatial models based on biophysical parameters were developed for the mangroves and corals of the Andaman Islands. An integrated vulnerability framework approach was adopted to assess the exposure of coastal communities to climate change risks and their capacity to cope with such risks. This assessment considered social dynamics, institutional characteristics, and the economic and political status of the communities involved. (Fussel & Klein, 2005).

CENTRAL QUERIES OF THE PRESENT RESEARCH

- ❖ What factors are responsible for the vulnerability of the mangrove-alone ecosystem?
- ❖ What are the factors responsible for the social vulnerability of Andaman communities?
- ❖ How does the present environmental changes affect the provisioning and regulating ecosystem services like fishery, tourism
- ❖ How can such potential impacts be ameliorated?

BROAD OBJECTIVES OF THE STUDY

- ❖ To develop an idea about the state of health of the mangrove–coral ecosystem services in the study region
- ❖ To generate bio-physical vulnerability assessment models of the mangrove-coral ecosystem services to environmental changes
- ❖ To generate a social vulnerability assessment model of communities of Andaman to climate and environmental changes
- ❖ To develop policy options to manage the degradation of these ecosystems from environmental changes.

RESEARCH METHODOLOGY

- The methodological frameworks of biophysical and social vulnerability have been designed based on the IPCC AR4 working definitions where, vulnerability is the function of three factors which are exposure (E), sensitivity (S) and adaptive capacity (AC). Seventeen biophysical components and twenty-four theoretically significant and pertinent physical and socioeconomic variables were selected and categorized into three factors - Exposure, Sensitivity, and Adaptive Capacity - according to the IPCC AR4 framework) based on a thorough analysis of the literature and secondary data sets.

Using min–max rescaling approaches, the respective vulnerability variables, were standardized in a way, so that they are independent of the number of variables included in the computation and range from 0 to 1.

$$• M_i^{index} = \frac{M_{max} - M_i}{M_{max} - M_{min}}$$

Where M_i is the value of the major component i , and M_{min} and M_{max} are the minimum and maximum values, respectively, for each component. The contributing factors (CFs), of both biophysical and social vulnerabilities assessed on various scales were normalized for all variables, and then integrated using the following equation:

$$VI = (E - AC) * S$$

were,

VI= Vulnerability Index, E= Exposure, S= Sensitivity, AC= Adaptive Capacity.

The final products were displayed as a vulnerability index map within a particular GIS environment, with the tehsils arranged from highest to lowest in terms of the vulnerability ranking of mangroves and corals as well as communities.

- With the aid of the bias-corrected CNRM-CM5 earth system model run of the RCP 4.5 scenario and projected bleaching frequency and intensity estimated from degree heating week (DHW), potential effects of climate change on corals in the form of probable bleaching events, their frequency and intensity, and corresponding stress on the fisheries were assessed.
- To stop the negative consequences of over-tourism, an assessment of the island's potential for sustainable development was conducted. The research was carried out in three stages to achieve the desired results: (1) an examination of the Andaman tourism development phases from 1981 to 2021 about Butler's 1980 Tourism Area Life Cycle concept; (2) a trend function exploration method was used to identify the destination's evolution from 2011 to 2051; and (3) an attempt was made to evaluate the risk of over-tourism in the island's popular beach spots in light of Tourism Carrying Capacity using the Tourist Operation Index, Tourist Density Index, and Beach Impact Index (Vandarakis et al., 2018; Kyriakou et al.,2017; Widz and Wojcik, 2020; Gore et al.,2021

IMPORTANT FINDINGS AND DISCUSSION

The biophysical vulnerability study of mangroves and corals provided a detailed overview of the potential impacts of sea level rise, coastal erosion and accretion, land subsidence, rising salinity conditions, and human pressure on mangrove species in the Andaman Islands. The analysis revealed that Mayabunder ranked with very high vulnerability, followed by Diglipur, across almost all exposure and sensitivity components. The study also highlighted the significant adaptation skills of mangroves in Ferragunj and Port Blair, as evidenced by the sufficient regeneration of new mangroves and the development of new mudflats in those areas. Additionally, the study found that North Andaman's mangroves were at greater risk due to various factors, including low species richness, logging, and slow self-regeneration potential.

Furthermore, the study emphasized the significant impact of extreme climatic events and anthropogenic factors on scleractinian corals in the Andaman Islands. It also pointed out the increasing exposure and sensitivity of reefs to climate stressors from North to South Andaman, with Port Blair and Rangat demonstrating high adaptive capacity, particularly through the presence of Marine Protected Areas and a high species recovery rate.

The study's findings highlighted the importance of religious efforts for adaptation and systematic planning in reducing social vulnerability to climate change. The research emphasized the need for continuous monitoring and proper assessment of constant climate change threats such as sea surface temperature rise, cyclones, and flooding. It underlined that the northern part of Andaman is more socio-economically vulnerable to these risks compared to the central or southern parts of the island. The study also stressed the significant threats to the biodiversity of the islands, including sea level rise and coastal flooding, and their impact on valuable ecosystem services that support the livelihoods of the islanders. The analysis revealed that areas like Diglipur, with a rural population and a primary focus on agriculture, are more susceptible to natural hazards than urbanized tehsils like Ferrargunj or Port Blair. Micro-scale analysis further illustrates limited water availability, insufficient medical and toilet facilities, and inadequate electricity infrastructure as major threats to the coastal livelihoods of specific regions. These findings tried to shed light on the complex interplay between socio-economic factors, climate vulnerabilities, and local infrastructure.

A reliable climate model was implemented for the Andaman Region to better anticipate future bleaching events. This proactive approach allowed us to effectively plan coastal and marine fisheries activities and implement necessary risk-reduction measures to address the impact of environmental changes on the reef fisheries of Andaman Island. The findings indicated a notable upward trend in sea surface temperature (SST) projections under the RCP 4.5 scenario of the CNRM-CM5 model for the 2030s, 2050s, and 2060s, which corresponds with a projected increase in the frequency of coral bleaching events during the same years. Despite previous instances of coral bleaching significantly affecting the catch of Andaman fish, particularly the perch species, there has been a steady increase in the exploitation of fish stocks. However, it's important to note that the current marine fish stock of the islands represents only 19% of the total available resources, with a production of 30,000 tonnes. As we move forward,

the management of coral reef fisheries will involve restricting fishers' access to marine resources of economic value, such as edible invertebrates, fish, ornamental fish, and decorative shells for tourists, to ensure the sustainable development of the region.

The study focused on identifying the potential for sustainable development to mitigate the negative impacts of over-tourism on the island. It found that there is a high risk of over-tourism in Port Blair and a low risk in Diglipur based on various tourism indicators, highlighting the need for targeted interventions in these areas. Additionally, the study shed light on the potential threats to the coral reef ecosystem posed by water-based tourism activities in Port Blair, emphasizing the importance of implementing responsible tourism practices to preserve the marine environment. Furthermore, the study showcased the resilience of the mangroves and corals in South Andaman in comparison to their northern counterparts, underscoring the opportunity to and enhance the adaptive capacity of these ecosystems for sustainable tourism development. In light of the findings, there is a clear need for strategic planning and proactive measures to balance tourism growth with ecological preservation, particularly in sensitive areas experiencing high tourist demand. This calls for collaboration between stakeholders to ensure that tourism development aligns with environmental conservation efforts for the long-term benefit of the region.

CONCLUSION

The focus of the present study was to gain a comprehensive understanding of the biophysical dynamics of the Andaman Islands' coastline and the physical phenomena affecting the near-shore coastal waters. This involved assessing regional sea level rise, climatic conditions, coastal erosion, cyclones, storm surges, coastal flooding, and potential changes in land use and cover. Additionally, we carefully evaluated the vulnerability of mangroves, corals, and island communities and quantified the ecosystem services provided by these habitats. Spatial vulnerability models for the mangroves and corals of Andaman Island were developed based on biophysical parameters. Furthermore, an integrated vulnerability framework approach was adopted to assess the exposure of coastal communities to climate change risks and their capacity to cope with such risks. Our study aimed to provide valuable insights that contribute to the

development of effective monitoring, management, restoration, and prevention strategies. It also sought to offer guidance for future coastal ecosystem management, particularly in the context of sustainable and environmentally conscious practices in the age of climate change.