



Impact of Climate Change on the Livelihood of the People of the Bay of Bengal

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Abstract:

The existence of climate change as one of the significant phenomena in the workplace worldwide has been confirmed, mainly impacting the coastal zones in the Bay of Bengal and the socio-economic systems. Environmental changes include rising sea levels, cyclones, coastal erosion, and intrusions of saline water affecting agriculture, fisheries, and water supply. Food security, economic instability, livelihoods, and forcible migrations are impacted most, especially families whose sources of income are based on agriculture, fishing, and other natural resource revenues. This paper aims to examine the social and economic repercussions of these varied environmental transformations on the population of certain districts of Bangladesh and India. It also covers the strategies for adaptation and policies focusing on developing climate change resilience against the unsettled vulnerabilities in the region.

Keywords: Climate Change, Coastal Livelihoods, Bay of Bengal, Sea-Level Rise, Cyclones, Coastal Erosion, Adaptation Strategies, Socio-economic Vulnerability

Objective of the Study

1. This paper analyzes several environmental factors, such as sea level rise, cyclone frequency, coastal erosion, and saline water intrusion in the Bay of Bengal ecosystems.
2. It aims to study the social and economic impacts on food security and the financial status of vulnerable coastal communities residing in some selected areas of the Sundarbans region
3. The study will aim to understand how climate change impacted forcible migration, especially among families in the agricultural and fishing sectors, and by natural resource revenues.
4. Also, it will explore current adaptation practices adopted by people and authorities of affected areas to improve their stand against climate change outcomes.
5. Last, it will present policy implications for building resilience and supporting sustainable development in a context that has yet to solve the remaining structural margin of insecurity endured by these societies.

Introduction:

A productive and wealthy area with biodiversity that sustains millions of people, particularly in the bordering countries such as Bangladesh and India, the Bay of Bengal. However, these communities' presence in the region is, over time, coming under pressure as a result of the intensification of the impacts of climate change. The population living in this region occupies the floodplains of large rivers, river deltas, and mangrove forests. It is at a high risk of adverse impacts of environmental changes such as sea level rise, increase in cyclone frequency and intensity, and intrusion of saline water. These phenomena are changing the built, human, and natural environment with a developmental impact in terms of physical infrastructure and challenges for the people who depend on agriculture, fishing, and other forms of natural resource use for their livelihoods. As climate change deepens, it has become one of the greatest threats affecting food insecurity and poor coastal households' livelihoods in this part of the world.

Bangladesh and the low-lying areas on the coast of the Indian state of West Bengal are the most vulnerable. Bangladesh is one of the most threatened countries due to climate change, having one of the most enormous deltas and high population density (IPCC, 2021). The Sundarbans, the world's largest mangrove forest, is a World Heritage Site located at the mouth of the Ganges and Brahmaputra at the head of the Bay of Bengal; it is a Biodiversity and livelihood-sensitive area. After reaching a climax in economic production, the region's natural environment is at risk due to increased sea levels and salinity, negatively impacting the natural ecosystem and those residing nearby. Moreover, the further prediction is that one in every seven people in Bangladesh can be displaced from their homes because of climate change around 2050 (World Bank, 2022).

Climate change impacts on the region and the environment have already tipped the Bay of Bengal into the very high bracket of environmental pollution. Among a list of global warming repercussions, sea levels' emergence as a crucial topic can be cited, and this type of problem is especially catastrophic herein." As per the survey of IPCC 2021, the water level of the Bay of Bengal is rising day by day more than the world average, and the prediction of sea-level rise is approximately ninety centimeters by 2100. This puts vast extents of the coastal region at risk, effectively washing away homes, agricultural lands, and critical infrastructure. The effect of a rise in sea level is made worse because Bangladesh and the Sundarbans in West Bengal are flat and quickly flooded and eroded.

Cyclones and storm surges are an added factor here Stowers et al., (2011). Alerts for cyclones have increased in the Bay of Bengal due to the rising effects of climate change, such as Cyclone Aila in 2009, Cyclone Sidr in 2007, and Cyclone Amphan in 2020. These cyclones cause loss of life among people, but they also cause loss of property and affect infrastructure, homes, and people's sources of earning a living. The agricultural sector, which comprises the main economic activity along the coastal regions, is severely affected. Habits are rendered unproductive, resulting in severe economic instabilities, crops are destroyed, farmland becomes unsuitable for cultivation because of saltwater intrusion and fishing activities are affected.

From a socio-economic perspective, climate change means significant changes. Due to centralized population, low technological infrastructure, and livelihoods fixed on agricultural land/ livestock, pastoral and fisheries resources, many coastal communities are sensitive to environmental change. Deterioration in the quality of soil and water is due to rising sea levels, which poses a significant challenge to agriculture, a staple source of income for many families in the area. Rice, mainly in Bangladesh and West Bengal, is susceptible to salinity. According to the FAO (2022), Bangladesh has experienced soil salinity problems, where over one million hectares of agricultural land and rice production are also affected. These adverse effects are a decline in agricultural output, thus further worsening food insecurity and poverty – which is felt most seriously in rural areas that depend on farming.

The fisheries sector, another essential part of supporting the livelihood of the most affected coastal populations, is also in danger. The increase in sea temperature and the changes in currents affect the movement of fish, and traditional fishing methods are no longer effective. According to the World Fish Center (2021), the fish stock has reduced by 25% in the last twenty years in the Bay of Bengal due to a range of environmental

changes associated implicitly with climate change. This decline adversely affects food security and income point source dependencies, especially for artisanal fishers who cannot afford such risks.

Moreover, these groups of people live in regions characterized by poverty and poor resource endowment, which has increased their socio-economic risk. There is still a high poverty level in many coastal districts of Bangladesh and West Bengal, where households depend on climate-vulnerable activities. Using the Livelihood Vulnerability Index (LVI), moderate to high vulnerability ratings include islands like that of Hatiya in Bangladesh, where natural disasters, including floods and cyclones, have, for instance, destroyed the livelihood base (Chowdhury et al., 2024). For these households, poverty and vulnerability are explained by the fact that they cannot accumulate and access financial and social capital that would allow them to rebound after experiencing climate-related shocks. Sustainable development is challenged by significant inequalities and increasing vulnerability because vulnerable people who are damaged the most have more minor abilities and strengths to face these changes.

Despite these challenges, communities in the Bay of Bengal area have undertaken new adaptation strategies. For instance, rice growers in Bangladesh have switched to fish farming since growing rice in saline regions only does not make sense. The impacted industry is aquaculture, especially shrimp and crab farming, which has developed into another source of revenue after the community can no longer depend on livestock farming (Dasgupta, 2021). Besides, the cultivation of resistant fishes in aquaculture, the planting of salt-tolerant crop varieties, and the initiative to take back the lost mangrove forest of the Sundarbans are considered two valuable approaches to rise against the challenges brought by climate change.

The policymakers in both Bangladesh and India have also realized the importance of effective climate adaptation policies. As reported in Bangladesh's climate change strategy and action plan, BCCSA hopes the country will focus on enhancing strategy food security, managing disaster risks, and creating infrastructures (Government of Bangladesh, 2022). India introduced the National Action Plan on Climate Change (NAPCC), which targets climate change adaptation measures for infrastructure and improving coast management systems (Government of India, 2021). Still, there are many barriers in any of these policy areas, and the major problems are in implementation and access to minorities who dwell in the far-off coastal regions.

Increased partnership between Bangladesh and India is essential in managing the disaster implications of climate change in the Bay of Bengal. Intersectoral approaches in risk reduction, water resources, and restoration of damaged ecological systems could significantly improve the living standards of people living in the coastal areas. Nevertheless, political rivalry and different sovereign interests occasionally delay bilateral and multilateral cooperation adapting to climate change (Islam & Rehman, 2019). However, without the synergistic approach, there are few chances to reduce vulnerability and inequality, and the further impact of climate change will exacerbate multiple socio-economic risks for the most affected population.

Literature Review

Climate change severely threatens coastal people in the Bay of Bengal countries, especially Bangladesh and India. This region is vulnerable to environmental shocks, including sea level rise, cyclones, and coastal erosion, bearing implications for valuable economic activities such as agriculture and fisheries. The following review captures the principal effects of these changes and contextualizes existing mitigation measures and governmental actions.

➤ Environmental Impacts

This study reveals that in the future, climate change in the Bay of Bengal will contribute to an increase in sea level, leading to floods that will submerge large portions of the coastal land. Bangladesh is most affected by its geographical formation as a deltaic country, where a slight rise in sea level shifted millions of its population armed only with bags (Rahman & Rahman, 2020). Old projections indicate that, in the worst case of a 1-meter rise in sea level by the end of the century, as much as 17 percent of Bangladesh's land, beneficial for

agriculture, can be flooded (Chowdhury et al., 2024). Consequently, besides submerging farmland, increased seawater intrusion directly decreases soil fertility, particularly in the Sundarbans, where agriculture forms the basis of living (Ghosh et al., 2024).

Another more profound environmental degradation has been experienced in this region in recent years – cyclones. Cyclones are getting more frequent and severe. The highest frequency of cyclones is observed in the Bay of Bengal and, coupled with higher intensity, is associated with frequent loss of lives and properties among the coastal populations of India and Bangladesh, as evidenced by Cyclone Amphan in 2020 (after the writing of this chapter, Mohiuddin & Nowreen, 2024). Tropical cyclones also cause storm surges, which flood the coasts, demolish structures, contaminate freshwater sources with seawater, and escalate by salinity, affecting more crops and fishing grounds (Kofi et al., 2021).

➤ **Socio-Economic Vulnerabilities**

Climatic implications of adaptation lead to several socio-economic losses in the Bay of Bengal, especially for affected vulnerable societies engaged in climate-vulnerable activities such as farming and fishing. This means that crops are damaged, the fishing industries and structures are destroyed, and otherwise, there is instability in the economy through increased sea levels and cyclones (Chowdhury et al., 2024). Reduced incomes from crops and the catch reduce the living standards of smallholder farmers and fishermen, who are a large part of the labor force in the region, meaning they become poorer (Hossain & Das, 2022).

An analysis of the Livelihood Vulnerability Index (LVI) for areas such as Hatiya, Bangladesh, shows that because of restricted capacity to manage income, comprehensible network, and banking insurance, they are very much exposed to climate change (Chowdhury et al., 2024). However, women and daily wage laborers can be at significant risk of being affected as they cannot be financially secure in the worst times (Rahman et al., 2021). The economic impacts are worsened by displacement, where people are forced to look for means of living from cities after their farms or fish resources are washed away by climatic-related disasters (Rahman & Rahman, 2020).

➤ **Adaptation Strategies**

In the Bay of Bengal region, different measures have to be taken by people to change their lifestyles with the changing climate. Some changes include A switch from crop farming to fish farming or growing crops resistant to salinity. For instance, the Sundarbans' farmers only cultivate high-salinity rice varieties (Hossain et al., 2023). Also, fish farming in brackish water has been adopted as a source of income for people who can no longer dress from freshwater fishing grounds (Das et al., 2022).

Other adaptation strategies include engineering measures, such as reconstructed mangrove wetland areas in the Sundarbans to shield the coastlines from storm surges and prevent further coastal erosion (Ghosh et al., 2024). These mangroves also play an essential role in the availability of fish in fish ponds and fishing companies. These strategies have been equally beneficial but need government and NGO support to work optimally.

➤ **Government Policies & Response**

Bangladesh and India have incorporated policies concerning climate change and its consequent adaptations. The BCCSAP for Bangladesh centers on infrastructure adaptation, preparedness for climate events, and short and long-term business development (Rahman & Rahman, 2020). Consequently, India's NAPCC addresses the necessary actions to protect the coastlines and climate-proofing (Chowdhury et al., 2024). However, these policies are less likely to attain sufficient financing and have a slow pace of implementation, especially in targeting relatively marginalized groups (Mohiuddin & Nowreen, 2024).

Methodology

This research uses secondary data and a qualitative method to assess climate change's social and economic effects on people's livelihoods in coastal areas in some of the selected districts of Bangladesh and India. The study focuses on the climatic impacts, including rising sea levels, cyclones, and Shoreline erosion, affecting agriculture, fishery, and daily existence. It looks into the adaptation measures for the constructed vulnerability in the region.

Environmental Impacts of Climate Change in the Bay of Bengal

An essential water mass for several countries such as India and Bangladesh, the Bay of Bengal has been at the center of adverse environmental impacts from climate change. The significant effects include increased sea level, frequency of cyclones, loss of coasts, and increased penetration of saline water. These changes complicate the existing work as they put pressure on the dilemma of coastal populations and the more fragile ecosystems.

Rising sea levels bring permanent flooding and submergence of agricultural land, over-wetting of home gardens, and destruction of infrastructure. Data reveals that Bangladesh alone is at risk of losing 17 % of its coastlines if the sea level rises only one meter, which will lead to the displacement of millions of people (Dasgupta et al., 2014). This submersion also increases the salinity of freshwater sources for agriculture, such as water for irrigation, drinking, and fish farming.

Cyclones are frequently and intensively developed in the Bay of Bengal in recent years because ocean temperature is increasing. These cyclones include Sidr in 2007 and Amphan in 2020, significantly affecting thousands of people, farmlands, fishery, and coastal facilities (Ali, 2018). These have not only impacted the lives and properties of the people directly in Nature Serve 2002 but have also imposed long-term effects on economic stability and food security.

Coastal Erosion: As a result, it leads to the gradual withdrawal of territorial size, for example, the largest mangrove forest spread in Sundarbans. Sundarbans is a protection against storm surges and cyclones. However, it is now eroding due to rising sea levels and anthropogenic impacts, and by removing this buffer, Bangladesh is becoming more and more vulnerable.

These factors only illustrate the vulnerability of the balance in the Bay of Bengal; the environmental changes are directly related to the depletion of resources and the loss of sustainable lives for millions of people.

Socio-economic Effects on Coastal Communities

The socio-economic impacts of climate change on the coastal people of the Bay of Bengal are vast and multifaceted. Climatic shifts like rising sea levels and more frequent cyclones with enhanced coastline destruction impact more than a million people in Bangladesh, West Bengal, and neighboring areas. These are farming, fishing, and other related activities on natural resources; hence, such communities are highly affected when climate changes occur. The ripple impacts on food insecurity, economic stability, and population movement have filled a vicious poverty-displacement loop.

Agriculture, one of the primary living sources, is in a rather dangerous position. As a result of growing incidences of sea invasion of cultivable lands, saline water has affected the agricultural productivity of crops. Soil salinity affects over 53% of Bangladesh's coastal area, significantly reducing rice production and other essential foods (Hasan et al., 2021). Barren farming in coastal zones decreased by 15% in 2017 when the smallholder farmers who depend on seasonal agriculture to feed and earn incomes or livelihood sources were most affected (Rahman & Islam, 2020). The failure to grow salt-affected sensitive crops has led to numerous farmers losing their businesses, and food scarcity is rife, especially in the coastal regions of Khulna, Bagerhat, and Satkhira.

Climate change makes fishing one of the most challenging hit areas, especially for small-scale fishers, who comprise most of this industry. Due to the warming of the waters in the Bay of Bengal and the increase in salinity, there have been changes in the migration patterns of fishes and breeding grounds. Fishermen from coastal areas such as Cox's Bazar or the Sundarbans claim that their catches have decreased and, therefore, their earnings have declined due to declining fish populations. A report by Islam et al. (2018) has shown that 60% of the fishers have seen their catch decrease by more than 30% in the last decade and, on average, 30% loss per household. This decrease not only serves as a threat to their earnings but also adds to the food insecurity of the 400 million inhabitants of the Bay of Bengal region who depend on fish as their primary source of protein (World Bank, 2021).

On top of the adverse effects that climate change has on agriculture and fisheries, it has also resulted in forced migration and the existence of 'climate refugees' who are unable to live in their homes due to climate change. Bangladesh, for instance, is already on the path of a disaster, and it is expected that by 2050, around 13 million people will be displaced due to rising sea levels (Rigaud et al., 2018). Areas like Bhola and Shyamnagar are seeing more and more residents leave for fatter parts of the country, particularly the overpopulated metropolis Dhaka, to avoid flooding. Unskilled migrants, so far as they are, do not meet any requirements for urban job opportunities and are ultimately employed in bottom-tier labor-intensive informal activities, deepening their plight. Such movements also amplify the dilemmas faced by metropolitan areas already dealing with poor infrastructure and social services, leading to conflicts between the migrants and the host communities.

Food insecurity is another grave problem that extends beyond the social divides. Due to declining agricultural productivity and the depletion of fish stocks, the coastal residents are gradually becoming incapable of feeding themselves. In a 2019 study, Ahmed et al. elucidated that roughly 45 percent of the households in the coastal zones of Bangladesh are affected by chronic food insecurity, and most of them suffer temporally during the Leen season when agriculture is impossible. Mothers and their kids are most susceptible to malnourishment, with indicators such as stunting and wasting being much higher in people living in cyclone-affected regions (Ahmed et al., 2019). This is compounded by the economic constraints given that most families cannot afford food after the devastation of natural calamities.

Economic hardships are rampant, particularly among these vulnerable groups' members. According to the Livelihood Vulnerability Index (LVI), Chowdhury et al. rho, p. .2014:569. Surprisingly, almost 70% of fishers and farmers are uninsured or have low savings and are the most affected by climatic catastrophes. It has been reported that thousands of families sank deeper into poverty after Cyclone Amphan in 2020, which caused \$13 billion in damages in Bangladesh and India. For example, communities in the Sundarbans are expected to rely on wage labor with insufficient employment opportunities available following the war or utilize existing resources (Asian Development Bank, 2021; Ghosh et al., 2024).

To this extent, social inequalities have also deepened due to socio-economic hardships. These factors tend to worsen the death toll as well as make it difficult for vulnerable sections such as women, children, and other minority ethnic groups to recover from climate-induced disasters. Women have a high percentage in the agricultural and fishing sectors but are mostly deprived of capital access and land ownership, which limits them to respond to environmental changes. The region's income and food security gaps are widening (Chowdhury & Haque, 2019).

Adaptation Strategies and Policies

Adaptation strategies by the Bay of Bengal involve strategies for improving infrastructural bases, livelihood diversification, and policy approaches in addressing the effects of climatic change. Coastal communities, especially in Bangladesh and India, are applying measures to cope with growing sea levels, cyclones, and salinity intrusion, among other adaptation measures. However, effective implementation poses a challenge while accessing resources.

➤ Infrastructure Development

To combat the impact of such extreme weather, cyclone shelters, flood barriers, and embankments have been created in vulnerable regions. For example, Bangladesh has constructed over 3,800 cyclone shelters and sheltered millions during storms (Rahman et al., 2019). Many of these embankments have yet to become strong due to inadequate maintenance and recurrent natural disasters, specifically in the Sundarbans region (Bhattacharya et al., 2021).

➤ Livelihood Diversification

People are diversifying their sources of income. The expansion has reduced further reliance on climate-sensitive industries like agriculture and fishing. Shrimp farming and aquaculture have become the boom, mainly due to saltwater intrusion that limits farming operations (Islam et al., 2020). More so, the restoration work on mangrove forests has assisted in suppressing erosion and generated revenue for the local economies (Chowdhury & Haque, 2019).

➤ Policy Initiatives

At the policy levels, Bangladesh and India have implemented national strategies for tackling climate change's implications. It has relied more on resilience building and looks to alleviate socio-economic vulnerabilities. Thus, Bangladesh's Climate Change Strategy and Action Plan, adopted in 2009, outlines its comprehensive adaptation approach through disaster preparedness, food security, and infrastructure development (Ministry of Environment and Forests, 2019). It incorporates agricultural practice uplifting, management of water through better systems, and promotion of renewable energy to reduce traditional, climate-vulnerable industrial inputs. In 2020, it unveiled the Mujib Climate Prosperity Plan, which will translate into economic opportunities by transforming its climate resilience by embedding investments in sustainable industries and clean energy (Rahman & Alam, 2021).

Similarly, the Indian government has initiated several state-level and national programs that focus on enhancing the ability of coastal areas to withstand dangers. National Action Plan on Climate Change, launched in 2008, lists the National Mission for Sustaining the Himalayan Ecosystem, relevant to water resources that hold critical importance to coastal agriculture, and the National Mission on Sustainable Agriculture, which promotes the adoption of climate-friendly agricultural activities (Government of India, 2020). In West Bengal, the Sundarbans Action Plan focuses on this region's vulnerabilities by emphasizing ecorestoration projects, livelihood diversification, and disaster management.

Despite such policies, coordination, funding, and implementation still need to be addressed. Many communities need an understanding or access to resources offered through these national strategies. Already adopted policies need to be revised to enhance socio-economic resilience in the long term against climatic changes. Hossain et al. (2022) say, "Whereas on paper policies are very well-designed, their execution at the grassroots level often lags, leaving behind vulnerable populations without support."

➤ Community-Based Adaptation

One of the leading approaches for addressing the negative impacts of climate change in the Bay of Bengal region has recently been community-based adaptation (CBA). CBA places more emphasis on local communities in designing adaptation strategies and their implementation, considering the specific needs and experiences of the locality. It created resilience among socioeconomically marginalized groups, namely smallholder farmers and fishers.

A perfect example is the Building Resilience to Climate Change in Bangladesh. It has enabled local people to recognize risks and vulnerabilities, along with any problems linked to climate change, and to influence action to adapt to them. These adaptations include raised houses, rainwater harvesting, and community-managed

seed banks to protect crops from overwatering. Adaptation techniques that are culturally appropriate and sustainable are ensured through community engagement. Furthermore, social cohesion and collective action are promoted.

➤ International Cooperation

International cooperation has a vital role in enhancing adaptation efforts in the Bay of Bengal region, mainly through financial and technical support from international organizations. GCF has released more than \$256 million to Bangladesh to raise its infrastructure's resilience and prepare for disasters. GEF also provides funding to projects aiming to restore the ecosystem and sustainable livelihoods that are at risk, such as the Sundarbans area.

Bilateral and multilateral partnerships, including the Bangladesh Climate Change Resilience Fund (BCCRF), support adaptation efforts in both infrastructure and community-based areas; India, the US, and Japan focus their cooperation on climate-resilient technologies; and regional cooperation in the region through BIMSTEC has further strengthened knowledge-sharing and improved the disaster management frameworks to promote technology transfer and capacity building across the region. However, even with positive developments, other vital issues that need to be addressed for this vulnerable coastal area are more international cooperation and persistent funding for the impacts of climate change (Green et al., 2021; GEF, 2022; USAID, 2022).

Recommendations for Resilience Building

1. Improving the coastal infrastructure to protect communities from the increasing sea levels, cyclones, and erosion at the coast
2. Diversifying livelihoods through climate-resilient activities such as aquaculture or salt-tolerant crops to reduce the vulnerability of economic assets
3. Improving early warning systems to evacuate people in time, coupled with increased preparedness for climate-induced hazards
4. Facilitating community-based adaptation strategies like mangrove restoration and rainwater harvesting to raise the resilience of the local community.
5. International support for effective climate policies through building adaptation and increasing resilience in the climate.
6. Local climate education, raising climatic literacy, and awareness should be enhanced as a precondition to empower local communities to engage actively in proactive measures for climate risk mitigation.
7. Access to climate finance must be increased by developing accessible access avenues available to vulnerable people for fund access by adaptation projects.
8. Regional cooperation through BIMSTEC forums for shared knowledge and collaborative climate resilience building in the region.
9. Improve the agriculture and fisheries towards sustainable practices in mitigating salinity water intrusion and land degradation.
10. Commence technological innovation to develop climate-smart solutions through drought-tolerant crops and energy-efficient infrastructure end.

Conclusion

Climate change is a significant threat to the Bay of Bengal's coastal communities, where sea levels are increasingly rising, the cyclone will probably continue pounding it, and erosion along the coast is taking place. These environmental impacts severely devastate livelihoods based on agriculture, fisheries, and water resources. Food insecurity, economic instability, and forced migration are some of the consequences resulting from such impacts. Bangladesh and India are most vulnerable due to their climate-sensitive industries and limited adaptive capacity.

Some of the resilience-building efforts, such as infrastructure, livelihood diversification, and early warning systems, have proved promising, but the scale of the problem necessitates continued action and coordination. International support through initiatives like the Green Climate Fund and regional cooperation through BIMSTEC are also helpful, though more comprehensive strategies are needed to confront the impacts of climate change.

More to the point: more robust policies, community-driven adaptation strategies, and sustained global support will be necessary to ensure that livelihoods are safe and socio-economic disparities are reduced in the region. If such efforts are not implemented, the people's risks will continue to grow, with resilience building being important in the future.

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