



Community Resilience and Disaster Management: A Study of the Cyclone-Prone Indian Sundarban

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Abstract: *The Indian Sundarban is one of the most environmentally vulnerable coastal regions of India, frequently affected by cyclones, flooding, embankment breaches and salinity intrusion. The present study examines disaster management and community resilience in the cyclone-prone Sundarban region based on household-level analysis. The study is based on both primary and secondary data. Primary data were collected through a field survey conducted during January and February 2026 from 150 households in selected villages of the Indian Sundarban. The findings reveal that recurrent cyclones such as Aila, Amphan and Yaas have significantly affected local livelihoods, housing, agriculture and infrastructure. Agriculture and fishing were found to be the most vulnerable livelihood sectors due to repeated flooding and salinity intrusion. The study further shows that although local communities face severe environmental and economic stress, they have developed several coping and adaptation strategies, including livelihood diversification, community cooperation, use of cyclone shelters and participation in Self-Help Groups. The Community Resilience Index indicates that most households belong to the medium resilience category, while economically weaker households remain highly vulnerable due to limited resources and inadequate recovery capacity. The study also identifies several challenges, including weak embankments, infrastructure limitations, inadequate preparedness and institutional gaps in disaster management. The paper suggests that strengthening local infrastructure, improving disaster preparedness, promoting sustainable livelihoods and encouraging community participation are essential for enhancing resilience in the Sundarban region.*

Keywords: *Community Resilience; Disaster Management; Indian Sundarban; Cyclones; Climate Vulnerability; Coastal Hazards; Livelihood Insecurity; Adaptation Strategies*

1. Introduction

Disasters have become a major challenge to sustainable development, particularly in coastal regions where environmental vulnerability and population pressure are high. In recent decades, the frequency and intensity of hydro-meteorological disasters such as cyclones, storm surges, floods and coastal erosion have increased significantly due to climate change and environmental degradation. These disasters not only damage infrastructure and livelihoods but also affect the social and economic stability of vulnerable communities. As a result, disaster management and community resilience have gained increasing importance in academic and policy discussions.

Community resilience refers to the ability of individuals and communities to prepare for, respond to and recover from disasters while maintaining their basic functions and livelihoods. In disaster-prone regions, resilience depends on factors such as livelihood security, social networks, awareness, institutional support and access to resources (Adger, 2000). In the Indian context, coastal populations are particularly vulnerable because of poverty, dependence on natural resources and weak infrastructure.

The Indian Sundarban represents one of the most climate-sensitive and hazard-prone regions of the country. Located in the lower Gangetic delta, the region is characterised by low-lying islands, tidal rivers, mud embankments and fragile ecological conditions. The area experiences recurrent cyclones, flooding, embankment breaches, salinity intrusion and riverbank erosion. Major cyclones such as Aila (2009), Amphan (2020) and Yaas (2021) caused severe damage to lives, livelihoods, agriculture and infrastructure across the Sundarban region (Hazra et al., 2020).

The livelihood structure of the Sundarban is highly dependent on climate-sensitive sectors, including agriculture, fishing, forest resource collection and daily wage labour. Frequent disasters disrupt these activities and increase livelihood insecurity. In many cases, repeated disaster impacts force households to adopt coping mechanisms such as migration, borrowing, or occupational change. Women, children and economically weaker groups often face greater vulnerability during and after disasters (Banerjee, 2015).

Several studies have examined environmental vulnerability, climate change impacts and livelihood stress in the Sundarban region. Hazra et al. (2020) highlighted the increasing frequency of extreme climatic events and their ecological consequences. Ghosh and Boykoff (2018) discussed climate adaptation challenges in the deltaic environment, while Das (2019) examined the socio-economic vulnerability of coastal communities. These studies provide valuable insights into environmental and livelihood issues in the Sundarban. However, many existing works focus mainly on physical vulnerability or climate impacts, while fewer studies examine the role of local communities in disaster preparedness and grassroots resilience building.

This creates an important research gap. There is limited micro-level understanding of how local households cope with repeated disasters, what factors shape resilience and how institutional support influences recovery processes in the cyclone-prone Sundarban region. Understanding

these aspects is essential for developing effective disaster management strategies and climate-resilient planning.

Against this background, the present study aims to examine disaster management and community resilience in the Indian Sundarban. The study focuses on the nature of disaster vulnerability, household-level preparedness, adaptation practices and the role of institutions in enhancing resilience among local communities.

2. Study Area

The Indian Sundarbans are located in the southern part of West Bengal, within the lower Ganges delta region. It forms a part of the world's largest mangrove ecosystem and mainly covers areas of the North 24 Parganas and South 24 Parganas districts. The region consists of numerous low-lying islands, tidal rivers, creeks and mud embankments, making it environmentally fragile and highly disaster-prone.

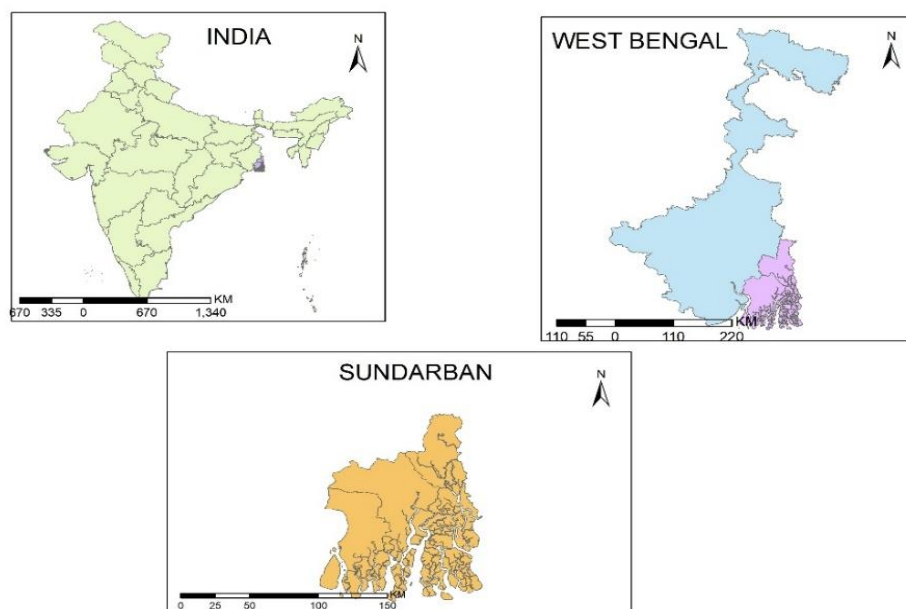


Fig. 1: Location Map of the Study Area

The climate is tropical and humid with heavy monsoonal rainfall and frequent cyclones originating from the Bay of Bengal. Major cyclones such as Aila (2009), Amphan (2020) and Yaas (2021) caused severe damage to houses, embankments, agriculture and livelihoods across the region (Hazra et al., 2020). Riverbank erosion, tidal flooding and salinity intrusion are also common environmental problems.

The economy of the Sundarban is mainly based on agriculture, fishing, forest resource collection and daily wage labour. Since these activities are highly dependent on climate conditions, local communities remain vulnerable to repeated disasters. Poor infrastructure, weak embankments, limited healthcare and inadequate transport facilities further increase disaster risk and livelihood insecurity (Banerjee, 2015).

The Sundarban also has high ecological importance due to its mangrove forests and biodiversity. However, increasing environmental pressure and climate-related hazards have

intensified the vulnerability of both ecosystems and local communities. Therefore, the region provides an important setting for studying disaster management and community resilience in a cyclone-prone coastal environment.

3. Data and Methodology

The present study is based on both primary and secondary data to examine disaster management and community resilience in the cyclone-prone Indian Sundarban. Primary data were collected through a household survey conducted during January and February 2026 in selected villages of the Sundarban region. The survey focused on disaster experience, livelihood loss, preparedness measures, adaptation practices and recovery strategies adopted by local households.

A multi-stage sampling method was used for selecting the respondents. At first, a few cyclone-affected villages were selected from the Indian Sundarban region. From these villages, households were chosen randomly for the survey. A total of 150 households were surveyed to understand community-level patterns of vulnerability and resilience.

Data were collected through structured questionnaires, personal interviews and field observations. Questions were asked regarding cyclone impacts, damage to livelihood and property, access to relief measures, preparedness practices and community support systems. Informal discussions with local residents were also conducted to understand local coping mechanisms and disaster experiences.

Secondary data were collected from government reports, Census publications, disaster management documents and published research articles related to climate change, cyclones and the Sundarban region.

For the analysis, different indicators related to disaster resilience were considered. These included housing condition, livelihood security, awareness level, access to cyclone shelters, early warning response, social participation and recovery capacity. Simple statistical methods such as percentage analysis and comparative interpretation were used to examine the data.

A Community Resilience Index (CRI) was also prepared by combining selected socio-economic and preparedness indicators. Based on the calculated values, households were grouped into low, medium and high resilience categories. This helped to assess the variation in resilience levels among surveyed households.

4. Results and Discussion

4.1 Major Disasters and Environmental Vulnerability

The Indian Sundarban is highly vulnerable to different environmental hazards, particularly cyclones and tidal flooding. The field survey clearly indicates that cyclones pose the most serious environmental threat to local households. Recurrent cyclones such as Aila, Amphan and Yaas caused extensive damage to agriculture, housing, embankments and local infrastructure. In addition, riverbank erosion and salinity intrusion have increased environmental stress in several villages.

The table below shows that 88 per cent of the surveyed households identified cyclones and storm surges as the region's major environmental problems. Around 69.3 per cent reported salinity intrusion, while 64 per cent experienced riverbank erosion. Tidal flooding and waterlogging were also significant environmental issues affecting daily life and livelihood activities.

Table 1. Major Environmental Problems Faced by Households

Environmental Problem	Number of Households	Percentage (%)
Cyclone and Storm Surge	132	88.0
Riverbank Erosion	96	64.0
Salinity Intrusion	104	69.3
Tidal Flooding	89	59.3
Waterlogging	71	47.3

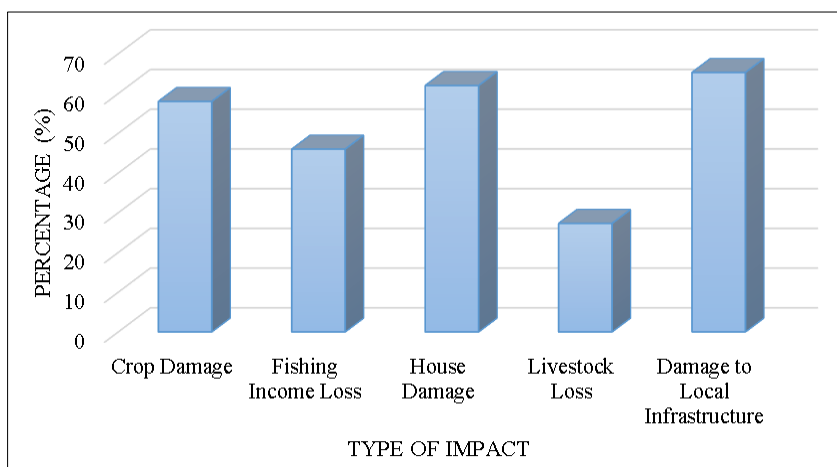
Source: Primary data

These environmental problems have increased livelihood insecurity and reduced local communities' adaptive capacity. Similar findings were also reported in earlier studies on climate vulnerability in the Sundarban region (Hazra et al., 2020).

4.2 Impact on Livelihood and Infrastructure

Disasters have significantly affected livelihood systems in the Sundarban region. Agriculture and fishing, the region's primary sources of livelihood, are highly sensitive to cyclones and salinity intrusion. Repeated disasters reduce crop productivity, damage fishing equipment and create long-term economic stress for rural households.

The figure below shows that 58 per cent of households experienced severe crop damage due to flooding and saline water intrusion. Around 46 per cent reported a decline in fishing-related income after recent cyclones. House damage was reported by 62 per cent of households, while 65.3 per cent mentioned damage to local infrastructure such as roads, embankments and transport facilities.



Source: Primary data

Fig. 2: Impact of Recent Cyclones on Livelihood and Property

The findings indicate that environmental disasters affect both household economy and community infrastructure, making recovery difficult for economically weaker households.

4.3 Household-Level Disaster Preparedness

Preparedness plays an important role in reducing disaster risk. The survey shows that awareness regarding cyclones and evacuation has improved in recent years, mainly due to government initiatives and increased exposure to repeated disasters. However, preparedness levels still vary among households.

The table below shows that 55.3 per cent of households receive early warning information via mobile phones, local announcements, or television. Around 49.3 per cent use cyclone shelters during severe weather events. However, only 38 per cent of households store emergency food and drinking water before disasters, indicating limited preparedness capacity in many villages.

Table 2: Household-Level Disaster Preparedness Measures

Preparedness Measure	Number of Households	Percentage (%)
Receive Early Warning Information	83	55.3
Store Emergency Food and Water	57	38.0
Use Cyclone Shelters	74	49.3
Keep Emergency Medicine	49	32.7
Participate in Preparedness Activities	44	29.3

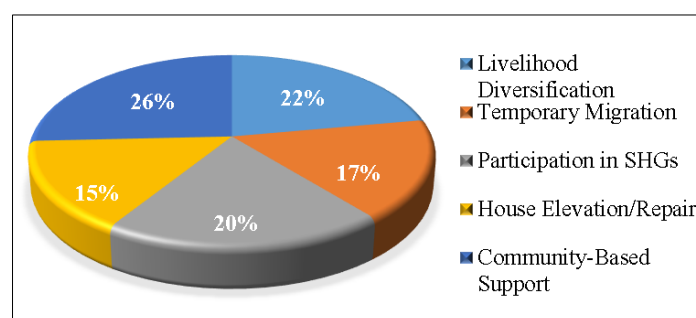
Source: Primary data

The findings suggest that although awareness has increased, resource constraints and infrastructural limitations continue to affect preparedness at the household level.

4.4 Community Resilience and Adaptation Practices

Communities in the Sundarban have developed various coping and adaptation strategies to address recurring environmental disasters. Livelihood diversification, temporary migration and community cooperation are some of the major strategies adopted by local households.

The figure below shows that 45.3 per cent of households adopted alternative livelihood activities to reduce dependence on climate-sensitive occupations. Around 40.7 per cent participated in Self-Help Groups, while 52.7 per cent relied on community-based support during and after disasters. Temporary migration was also reported by several households as a coping strategy during periods of economic crisis.



Source: Primary data

Fig. 3: Adaptation and Coping Strategies Adopted by Households

These adaptation practices reflect the growing importance of local resilience and collective support systems in disaster-prone regions.

4.5 Role of Government and Institutions

Government agencies and local institutions play a crucial role in disaster management and post-disaster recovery in the Sundarban. Cyclone shelters, relief distribution and warning systems have improved community response during recent disasters. However, institutional gaps still remain in several areas.

The table below indicates that 61.3 per cent of households received relief materials after major cyclones, while 48.7 per cent received shelter support. Financial assistance and healthcare support were comparatively lower. Around 18.7 per cent of respondents stated that they did not receive any significant institutional support after disasters.

Table 3: Institutional Support Received after Major Cyclones

Type of Support	Number of Households	Percentage (%)
Relief Materials	92	61.3
Financial Assistance	54	36.0
Shelter Support	73	48.7
Healthcare Assistance	39	26.0
No Significant Support	28	18.7

Source: Primary data

The findings highlight that although government interventions have increased, better coordination and faster rehabilitation measures are still needed.

4.6 Community Resilience Assessment

The Community Resilience Index (CRI) was used to assess the resilience level of surveyed households based on livelihood security, preparedness, housing condition, awareness and social participation.

The figure below shows that 50.7 per cent of households belong to the medium resilience category, while 29.3 per cent fall under low resilience. Only 20 per cent of households were found to have high resilience.



Source: Primary data

Fig. 4: Community Resilience Index (CRI) Classification

Households with diversified income sources, greater social participation and better housing conditions showed greater resilience. On the other hand, economically weaker households, mainly dependent on agriculture and fishing, remained highly vulnerable to repeated disasters.

Overall, the findings suggest that community resilience in the Sundarban is gradually improving through adaptation practices and institutional support. However, increasing environmental vulnerability and economic insecurity continue to pose major challenges to long-term resilience in the region.

5. Problems and Challenges

5.1 Weak Embankment and Infrastructure System

One of the major challenges in the Sundarban region is the fragile condition of embankments and rural infrastructure. During cyclones and high tides, embankments are frequently damaged, leading to flooding and salinity intrusion. Poor road connectivity and inadequate transport facilities further create difficulties during evacuation and relief operations. In many villages, healthcare and communication facilities remain insufficient during emergencies.

5.2 Livelihood Insecurity and Poverty

The economy of the Sundarban is highly dependent on agriculture, fishing and forest-based activities, all of which are sensitive to climatic hazards. Repeated cyclones, flooding and soil salinity reduce agricultural productivity and income opportunities. As a result, many households experience economic insecurity and seasonal unemployment. Poor households often lack the financial capacity to recover quickly after disasters.

5.3 Increasing Climate Vulnerability

Climate change has intensified environmental risks in the Sundarban region. Rising sea level, changing rainfall patterns, salinity intrusion and increasing cyclone intensity have increased the vulnerability of local communities. Frequent disasters reduce the ability of households to rebuild and adapt, particularly in economically weaker areas.

5.4 Limited Preparedness and Awareness

Although awareness regarding cyclones has improved in recent years, many households still lack adequate preparedness measures. Some families do not have access to emergency resources, secure housing, or nearby cyclone shelters. In remote villages, access to timely warning information also remains a challenge.

5.5 Institutional and Governance Issues

Government agencies and local institutions play an important role in disaster management, but several problems remain. Respondents reported delays in relief distribution, inadequate compensation and poor maintenance of embankments. Coordination among different institutions is sometimes weak, affecting the effectiveness of disaster response and recovery programmes.

5.6 Social Vulnerability

Women, children, elderly people and economically weaker households face greater difficulties during disasters. In many cases, women have limited access to financial resources and decision-making processes, which affects their coping capacity. Repeated disasters also disrupt education, healthcare and social stability at the community level.

Overall, these challenges show that disaster vulnerability in the Sundarban is not only environmental but also socio-economic and institutional. Strengthening resilience, therefore, requires integrated planning and long-term support at both community and policy levels.

6. Recommendations

6.1 Strengthening Embankments and Rural Infrastructure

There is an urgent need to strengthen embankments across the Sundarban region to reduce flooding and salinity intrusion during cyclones. Durable, climate-resilient embankment systems should be developed through scientific planning and regular maintenance. Improvements to roads, transport facilities, communication networks and healthcare infrastructure are also necessary to support effective disaster response and recovery.

6.2 Improving Early Warning and Preparedness Systems

Early warning systems should be made more accessible at the village level. Warning messages need to reach remote households quickly through mobile communication, local volunteers and public announcement systems. Awareness programmes and mock drills should be organised regularly to better prepare local communities for disasters. Increasing the number and accessibility of cyclone shelters can also reduce disaster risk.

6.3 Promoting Sustainable Livelihood Opportunities

Livelihood diversification is important for reducing economic vulnerability. Dependence on agriculture and fishing alone increases the risk during environmental disasters. Therefore, alternative income opportunities such as poultry farming, handicrafts, eco-tourism, small

businesses and skill-based employment should be promoted. Financial assistance and training programmes can help households build more stable livelihoods.

6.4 Encouraging Community-Based Disaster Management

Local communities should be actively involved in disaster management planning and implementation. Community participation improves awareness, preparedness and collective response during emergencies. Self-Help Groups, youth groups and village committees can play an important role in relief distribution, evacuation and awareness activities. Traditional knowledge and local experiences should also be integrated into disaster management strategies.

6.5 Strengthening Institutional Coordination

Better coordination between government agencies, local administration, NGOs and community organisations is essential for effective disaster management. Relief and rehabilitation processes should become faster and more transparent. Regular monitoring of vulnerable areas and proper implementation of disaster management policies can improve long-term resilience in the region.

6.6 Climate-Resilient Development Planning

Development planning in the Sundarban should focus on long-term climate resilience. Policies related to housing, agriculture, water management and infrastructure need to consider increasing climate risks. Mangrove conservation and ecosystem restoration should also be prioritised because mangroves act as natural protective barriers against cyclones and tidal surges (Hazra et al., 2020).

Overall, these recommendations highlight that disaster resilience in the Sundarban requires a combined approach involving infrastructure development, livelihood support, community participation and climate-sensitive planning. Strengthening these aspects can reduce vulnerability and enhance local communities' adaptive capacity.

7. Conclusion

The study highlights that the Indian Sundarban is one of the most disaster-prone coastal regions of India, where environmental vulnerability and livelihood insecurity are closely interconnected. Frequent cyclones, flooding, embankment breaches, riverbank erosion and salinity intrusion have significantly affected the lives and livelihoods of local communities. The findings show that agriculture, fishing and other climate-sensitive occupations remain highly vulnerable to repeated disasters, increasing economic insecurity among rural households.

The study also reveals that local communities have developed diverse coping and adaptation strategies to address environmental stress. Community cooperation, alternative livelihood activities, the use of cyclone shelters and participation in local groups have contributed to improved household resilience. However, resilience levels vary across households depending on income, infrastructure, awareness and institutional support. Economically weaker households remain more vulnerable due to limited resources and inadequate recovery capacity.

Government agencies and local institutions play an important role in disaster management through relief distribution, early warning systems and shelter facilities. Despite these efforts, several challenges, such as weak embankments, infrastructural gaps and delays in rehabilitation, continue to affect the effectiveness of disaster management in the region.

Overall, the study suggests that strengthening community resilience in the Sundarban requires an integrated approach that combines disaster preparedness, sustainable livelihood development, infrastructure improvement and climate-resilient planning. Greater participation by local communities and stronger institutional coordination are necessary to reduce long-term disaster vulnerability in the region.

However, the study has certain limitations. The analysis is based on a limited number of surveyed households and selected villages, which may not fully represent the entire Sundarban region. The study mainly focuses on socio-economic and disaster-related aspects and does not include detailed environmental or geospatial analysis. In addition, the data were collected over a short period and may therefore not capture seasonal variations or long-term changes in resilience patterns. Future research can include larger sample sizes, advanced spatial techniques and comparative analysis across different islands of the Sundarban to provide a more comprehensive understanding of disaster resilience and climate vulnerability.

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