

**CYCLONE HAZARD ASSESSMENT OF THE
COASTAL COMMUNITIES OF PURBA MEDINIPUR,
WEST BENGAL, WITH SPECIAL REFERENCE TO
THE CARRYING CAPACITY OF THE
MULTIPURPOSE CYCLONE SHELTERS**

Synopsis Submitted by

SRIPURNA KANJILAL

Registration No:

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Doctor of Philosophy (Science)

Under supervision of

Dr Gupinath Bhandari

Professor, Dept of Civil

Engineering,

Jadavpur University

School of Oceanographic Studies

Faculty of Interdisciplinary Studies, Law & Management


Jadavpur University

Kolkata-700032

INDIA

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Sripurna Kanjilal


Dr. Gupinath Bhandari
Prof, Department of Civil Engineering &
Coord, Centre for Disaster Prep & Mgt.
Jadavpur University, Kolkata 700032
INDIA

List of Publications:

Journal Publications

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| 1. Kanjilal, S., & Bhandari, G. (2025). Physical Infrastructure Development in Cyclone Preparedness Strategy: An assessment in the cyclone prone blocks of West Bengal, India. <i>Regional Science Policy & Practice</i> , 100231. | Scopus, Web of Science |
| 2. Kanjilal, S., Bhandari, G., & Majumder, S. (2025). Health Vulnerability Index in Disaster Preparedness: An Analysis in the Cyclone Prone Blocks of Purba Medinipur, India. <i>Journal of Disaster Research</i> , 20(2), 233-241. | Scopus |
| 3. Kanjilal, S., & Bhandari, G. (2025). Capacity And Utilisation Of Multipurpose Cyclone Shelter As A Disaster Resilient Infrastructure In West Bengal. <i>South India Journal of Social Sciences</i> , 23(2), 21-25. | UGC CARE |

Conference proceedings

Kanjilal, S., & Bhandari, G. (2022). Role of Multipurpose Cyclone Shelter as a Disaster-Resilient Infrastructure in Digha Dadanpatrabar Coastal Belt, West Bengal. In S. A. Babu (Ed.), *Hazards, Vulnerabilities and Risks of Disasters. 1*, pp. 107-112. Mumbai: Macmillan Publishers India Private Ltd,

Accomplishments:

1. UGC-NET JRF in 2016

1.0. Introduction:

The densely populated eastern coast of India is susceptible to tropical cyclones (Ghosh & Mistri, 2023), (Kantamaneni, et al., 2022). Majority of the cyclones originate over the Bay of Bengal and impact the East coast of India. There is an increase in the incidence of tropical cyclones over Bay of Bengal owing to climate change (Singh, 2007). A recent study indicates an escalation of tropical cyclones regarding wind velocity and cyclone magnitude in the Bay of Bengal over the past few decades (Murty, et al., 2016) .

Vulnerability refers to the extent to which a community is prone to the impacts of a natural hazard. The vulnerability assessment of cyclone hazards is a thorough and dynamic process that evaluates the severity of the hazard and assesses its impact on essential infrastructure, society, economic resources, and the environment. Cyclone hazards cause substantial socioeconomic repercussions.

Resilience refers to a community's capacity to recover from and adjust to the impacts of a hazard. According to the 2011 Census conducted by the Government of India, approximately 14.2% of the population inhabits coastal districts, and the trend is currently on the rise (Sahoo & Bhaskaran, 2017).

Evaluating the level of a community's vulnerability is the initial step in mitigating the actual disaster risk.

2.0. Review of literature:

India has a coastline of approximately 7516 km, with 5400 km along the mainland. The Bay of Bengal experiences four times as many cyclones in the Indian subcontinent as the Arabian Sea (Rao, et al., 2020). Tropical cyclones regularly occur in May (pre-monsoon) and October (post-monsoon) (Mahapatra, et al., 2007). The destruction caused by landfall cyclones primarily results from three factors: torrential rain, high winds, and storm surges (Mahendra, et al., 2011). In 2009 Cyclone AILA has obliterated a 400 km stretch of embankment, as severe waves inundated the flood plains in West Bengal, leading to a significant disaster. The incursion of seawater during this event impacted nearly 2 million individuals stranded for several days, adversely affecting agriculture and the potable water supply. The incursion of saltwater rendered agricultural lands unproductive (Sahoo & Bhaskaran, 2017). In May 2020 a super cyclone developed on Bay of Bengal which affected West Bengal, killing 12 people

directly and many more in the aftermath, several homes were destroyed, trees uprooted, disruption of electricity for days and water logging in several parts of southern Bengal.

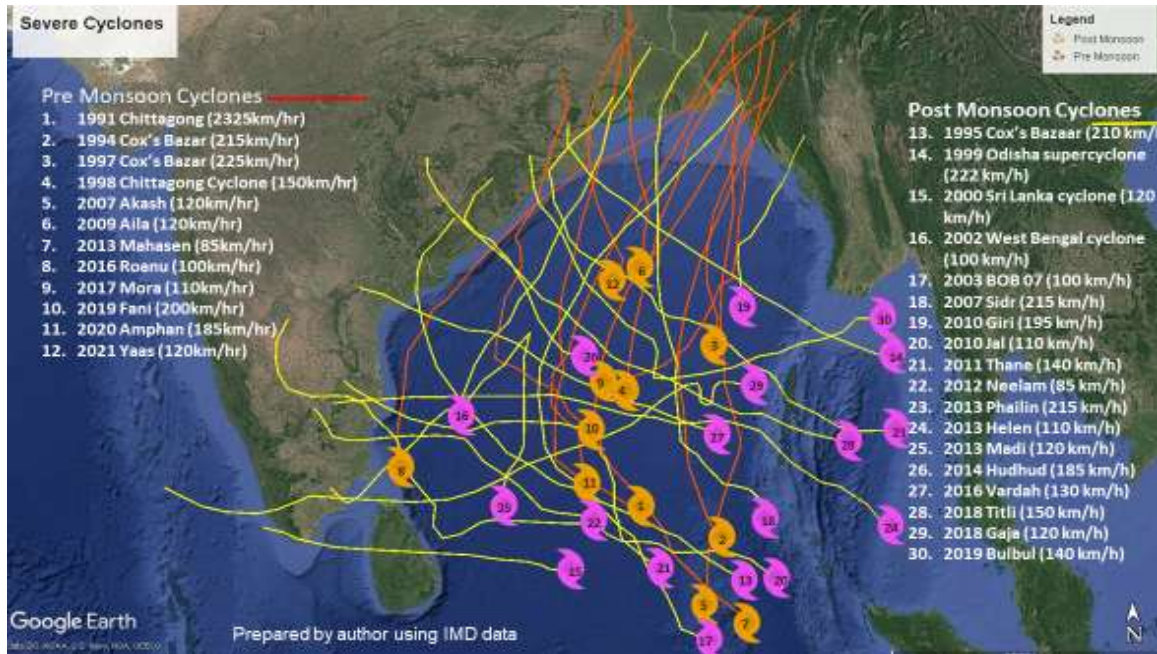


Figure 1: Severe cyclone tracks over Bay of Bengal – 30 years

(Gayathri, Bhaskaran, & Sen, 2015) examined the coastal inundation resulting from the AILA cyclone in Bengal and concluded that Bay of Bengal is highly vulnerable to tropical cyclones and catastrophic events. (Mazumdar & Paul, 2016) identifies the vulnerability of the Indian coastal districts to cyclones based on the socio-economic status and infrastructure by using statistical methods like PCA.

According to the IPCC Sixth Assessment Report (AR6) “*Vulnerability is defined as the propensity or predisposition to be adversely affected by climate change and encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt*” (IPCC, 2023). Vulnerability to climate change is mainly function of three factors, i.e. the sensitivity, adaptive capacity and the degree of the exposure of the structure to climate related hazards which has been summarized into two factors in the latest report of Sensitivity which refers to the degree to which a system is affected by a hazard and Adaptive/coping capacity which refers to the ability to adjust to potential damage or take advantage of opportunities presented by climate change (IPCC, 2023).

Disaster risk refers to the connection between vulnerabilities and hazards (Brooks, Adger, & Kelly , 2005). Hazard, exposure, and vulnerability can all be thought of as components of disaster risk. (Kron, 2005), (Kelman, 2018).

A vulnerability assessment serves as a valuable framework for enhancing the community's resilience and mitigating hazard risks (Adger, 2006). When understanding vulnerability, we need to address two major questions of who is vulnerable? and to what? Vulnerability assessment refers to the assessment of the effects of natural hazards on the infrastructure, businesses social systems and services, as well as the natural environment, taking into account the community's preparedness and its capacity to respond to and recover from a disaster.

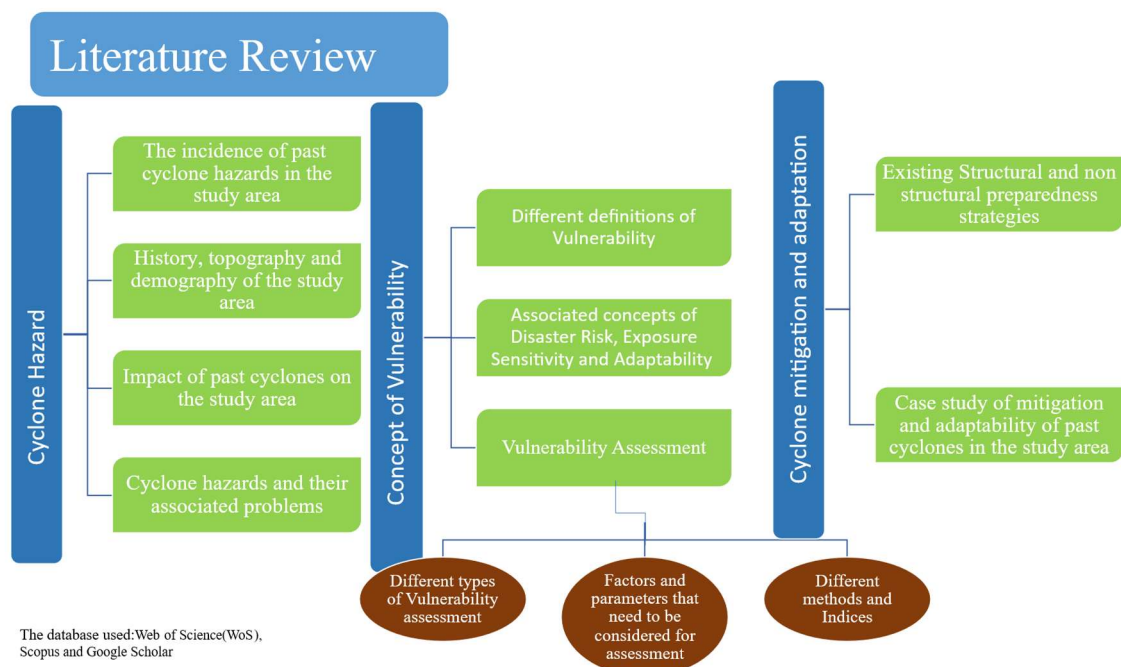


Figure 2: Format of literature review

Most vulnerability measures and indices focus on economic vulnerability, frequently neglecting the intricate dimensions of social and health vulnerability in the formulation of a comprehensive vulnerability assessment index (Khan, Chatterjee, & Bisai, 2013), (Chan, et al., 2019), (Brooks, Adger, & Kelly , 2005). Post-cyclone health issues of concern encompass diarrhoea—stemming from viral and bacterial origins (such as cholera), pneumonia, measles outbreaks, tuberculosis, and typhoid, all exacerbated by overcrowding and inadequate sanitation (Huang, et al., 2023).

2.1. Cyclone mitigation and adaptation:

The first step in reducing the risk of a disaster is by evaluating the resilience of the community (Burton, 2014). To protect the lives and property of the citizens the government and policy makers have a crucial duty to develop policy and preparedness strategies to deal with natural disasters (Yum, 2024). The Government of India has taken some steps by installing Cyclone Surveillance Radars in Calcutta, Paradeep, Visakhapatnam, Machilipatnam, Madras, and Karaikal on the east coast and in Cochin, Goa, Bombay, and Bhuj on the west coast. The most basic information for preventing and mitigating cyclone distress is cyclone warnings sent to the Chief Secretaries, Relief Commissioners, and District Collectors of the maritime states. The "Cyclone Alert" is the initial warning stage, and it is issued 48 hours before the predicted start of the unfavourable weather conditions over the coastal regions. The "Cyclone Warning" is the second stage warning, and it is sent out 24 hours beforehand. The AIR stations receive both "Alert" and "Warning" cyclone messages for recurrent broadcasting.

The National Cyclone Risk Mitigation Project (NCRMP) implemented by the National Disaster Management Authority (NDMA) in 2011 and executes the Project in collaboration with the relevant State Governments and the National Institute for Disaster Management (NIDM). (Sharma S. K., 2023). Mitigation of cyclone risk is been approached through building infrastructure including cyclone shelters, connecting roads and bridges, saline embankments, underground electrical cabling, and early warning dissemination systems. (NDMA, 2022).

2.1.1 Multipurpose Cyclone Shelters:

(Dalal, Mohapatra, & Mitra, 2007) focuses on the optimal location sites are identified using a algorithm called Elzinga-Hearn. Where the villages are divided into clusters and a best suitable location for construction of shelters have been calculated.

(Chowdhury, et al., 2015) studied the cyclone shelters in Bangladesh and found they face gender discrimination. Cases of Sexual harassment, lack of privacy are the main reasons why women fear taking refuge in the shelters hence making them vulnerable both ways. (Amin, Shil, & Hasan, 2016) focused on the facilities available in the cyclone shelters in Bangladesh and the willingness of the villagers to relocate in times of need.

3.1. Research Gap:

Research gap describes the area that has not been adequately explored or resolved in prior investigations.

- There is an unmet need for assessment of utilisation of MPCs in the study area for the recommendation on enhanced capacity building.
- Gap in infrastructural vulnerability and socio-demographic stratification which is required to ensure equitable funds allocation to enhance disaster preparedness
- Lacunae of incorporation of chronic health burden to assess vulnerability and improve resilience
- Absence of any concept of household emergency storage kit for the secure preservation and carry along of essential documents and possessions.

3.2. Objectives of the present study:

Assessing the vulnerability of the local coastal community to cyclone hazards and devising strategies for preparedness and mitigation is crucial to ensure the safety of the affected individuals. The objectives of the present study are:

1. To evaluate the existing Structural Preparedness Strategies.
2. To comprehend the level of Vulnerability of the coastal community to tropical cyclones.
3. Recommend possible adaptation for building stronger resilience of the people.

3.3. Research questions and approach:

1. To evaluate the existing Structural Preparedness Strategies.
 - How efficient is the existing road network connectivity w.r.t the standard indices?
 - Which part of the study area needs remedial measures?

Approach: Road Network Analysis

- Are the existing MPCs uniformly located?
- Are the infrastructural assets accessible to the vulnerable population?

Approach: Uniformity and equitability of distribution of MPCs

- Are the existing MPCs sustainable?
- Are the conditions at MPCs humane to carry the vulnerable population?
- What are the local responders' opinions about the utilisation of MPCs?

Approach: Evaluation of existing MPCs

2. To comprehend the level of Vulnerability of the coastal community to tropical cyclones.

- How does chronic disease burden affect the vulnerability?
- Which CD blocks need special attention?
- Which health dimension needs special intervention?

Approach: Health Vulnerability Index

- How does infrastructure and socio-economic burden affect the vulnerability?
- Which GPs need special attention?
- Which aspect of social vulnerability needs special intervention?

Approach: Infrastructural Adaptivity Risk, Social Vulnerability Index, Economic and Demographic Sensitivity Risk

3.4. Methodology:

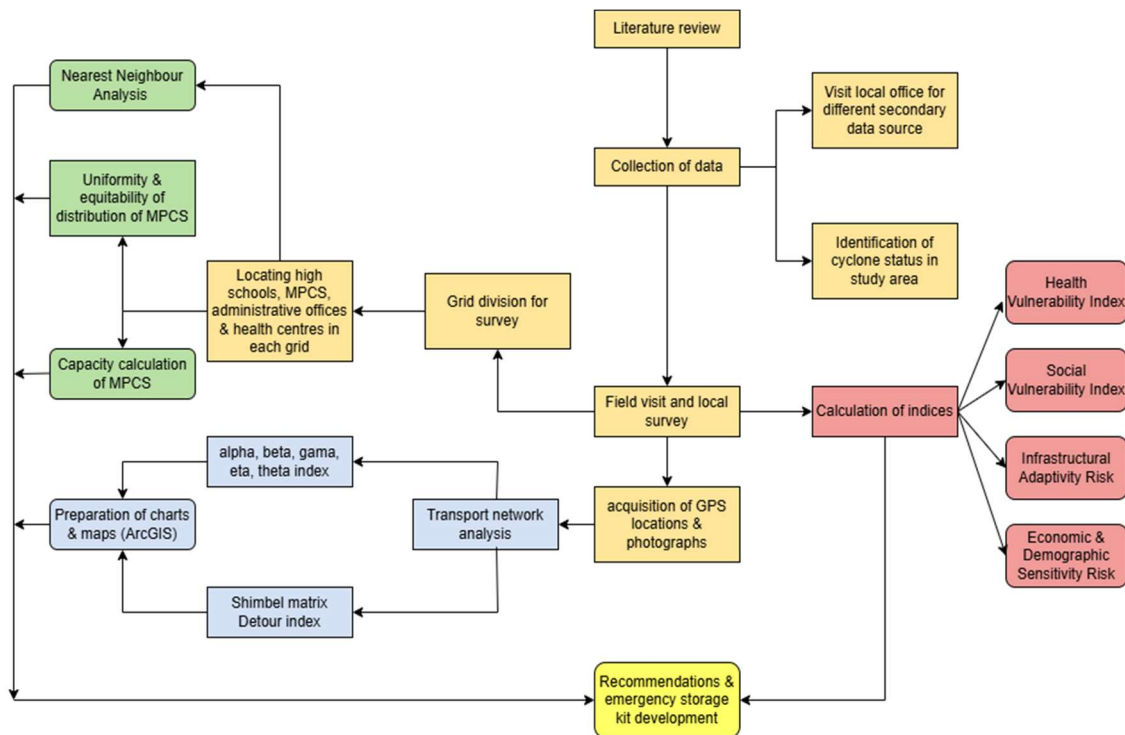


Figure 3: Proposed methodology of the study

After thorough literature review and identification of the research gap and the objectives, relevant primary data will be collected from field visit and local surveys while secondary data will be collected from the local government office and other sources available on the internet.

Sample size has been calculated as per formula for the assessment of locational suitability and degree of demand of the MPCs. (Mallick, Rahaman, & Vogt, 2011):

$$n = \frac{Z^2 p(1 - p)}{d^2}$$

Z= statistic for confidence interval;
p= expected prevalence; d= Precision

Taking

Z= 1.96 for CI 95%; p= 45%
(based on existing literature); d=
10% or 0.1

n= 96

The GPS location of each MPCS in the study area will be acquired and necessary photographs will be taken. The study area will be divided into grids of 4 sq. km for the purpose of survey. Location of schools, MPCS, administrative offices and health centres will be noted for calculation of Nearest Neighbour Analysis and uniformity and randomness of distribution of MPCS. Geographic Information system (GIS) software like Arc GIS 10.3.1 and QGIS 3.14 will be used to compute the buffer areas of each infrastructure. Road network analysis and accessibility using standard indices will be done. Cluster sampling method will be used for the selection of the respondents of a questionnaire survey. At least one *kaccha* household (non-concrete structure) will be surveyed randomly from each grid cluster.

The existing MPCSs will be evaluated using a weighted scoring model after finalising the measuring parameters from literature review and field survey. A multi criteria decision analysis method by Analytical Hierarchy Process (AHP) will be used.

Indicators will be identified after extensive literature review and Social Vulnerability Index, Health Vulnerability Index and Risk (based on chronic health burden of the area), Economic and Demographic Sensitivity Risk and Infrastructural Adaptivity Risk will be calculated using dimension reduction model by Principal Component Analysis (PCA) of the identified indicators of the study area to elicit the needy zones for a more equitable distribution of resources for a more holistic resilience building.

Recommendations will be drawn with respect to improved, improvised, humane and hygienic carrying capacity modification of MPCS and development of an emergency storage kit in lines with the need of the hour as envisioned by the author after discussion with the local respondents.

3.5. Data Source:

Table 1: Proposed data source to achieve the respective objectives

| Objectives | Sub-themes | Data acquired from | Software Used |
|------------|---|---|---|
| 1 | Transport Network analysis | ISGPP Panchayats & Rural Development Google Earth Pro 7.3.6 West Bengal Traffic police | ArcGIS 10.3 |
| | Uniformity and equitability of distribution of MPCs | Field survey 2021 Google Earth Pro 7.3.6 District Disaster Management plan 2022- Purba Medinipur Data provided by some Gram Panchayats within the study area | ArcGIS 10.3 |
| 2 | Health Vulnerability Index | Socio Economic and Caste Census District Statistical handbook | ArcGIS 10.3 IBM Statistics SPSS 22, MS Excel 2019 |
| | Social Vulnerability Index and Risk calculation | Socio Economic and Caste Census Census of India 2011 Field survey 2021 Google Earth Pro 7.3.6 Indian Meteorological Department (IMD) cyclone reports | ArcGIS 10.3 IBM Statistics SPSS 22 Microsoft Excel 2019 |
| 3 | Emergency storage kit | Field survey 2021 available literature | Medibang Pro |

4.0. The study area:

Purba Medinipur is a southern district of West Bengal, India. The coast adjacent cyclone prone blocks of Ramnagar-I, Ramnagar –II, Contai-I, Deshapran and Khejuri-II (Figure 4) have been chosen as the area of interest. This area extends within the coordinates of $21^{\circ}36'39.85''\text{N}$, $87^{\circ}29'0.87''\text{E}$ and $21^{\circ}54'19.39''\text{N}$, $88^{\circ}0'7.86''\text{E}$.

West Bengal, located off Bay of Bengal has seen an increasingly high incidence of severe cyclones in the recent past. While the

estuarine coastal belt of

the Sundarbans, being an UNESCO World Heritage Site has been the site of many internationally acclaimed research activities, the other coastal belt comprising mainly the five densely populated community development blocks of Ramnagar-I, Ramnagar–II, Contai-I, Deshapran and Khejuri-II of Purba Medinipur district in West Bengal India has received lesser attention and has been considered as the study area as depicted in Figure 4

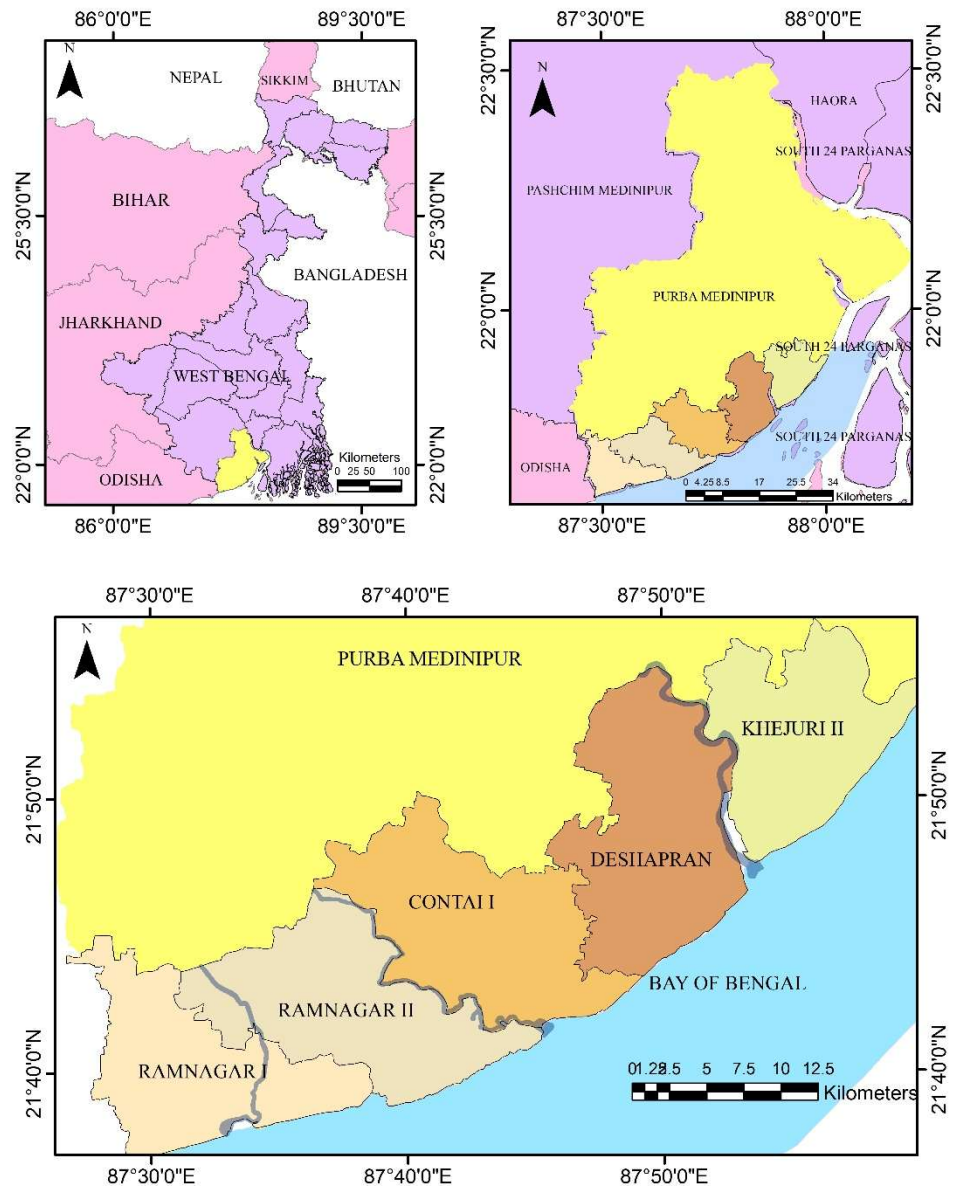


Figure 4: Study Area

5.0. Expected results:

The study will try to assess the status and upkeeping of existing infrastructural adaptive measures, including MPCs using statistical methods and try to deliver recommendations on particular areas of improvement. The locational suitability of the MPCs will also be assessed and standard indices of network connectivity and accessibility will be derived from the primary and secondary data. The chronic health burden will be taken into consideration and development of a health vulnerability index will be used to stratify the risk profile of the surveyed vulnerable area. Much emphasis has not been laid on this aspect in the existing literatures. Thus, the chronic health aspect may also be tried as a pilot in other vulnerable populations for a more holistic resilience building. Similarly, social vulnerability and infrastructural adaptivity risk stratification of the five coastal community development blocks will be done for a more equitable distribution of resources. A plan will be formulated for a more humane carrying capacity upliftment of the MPCs along with a proposal for an emergency storage kit.

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Sripurna Kanjilal