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

Thesis Submitted for the degree of

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by

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Dedicated to

my Parents and

my Husband

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Certificate from Supervisor

This is to certify that the thesis entitled " **CYCLONE HAZARD ASSESSMENT OF THE COASTAL COMMUNITIES OF PURBA MEDINIPUR, WEST BENGAL, WITH SPECIAL REFERENCE TO THE CARRYING CAPACITY OF THE MULTIPURPOSE CYCLONE SHELTERS"** submitted by **SRIPURNA KANJILAL**, who got registered (registration no **D-7/ ISLM/ 108 /19**, dated **31.10.2019**) her name under the Faculty of Interdisciplinary Studies, Law & Management for the award PhD (Science) degree of Jadavpur University is absolutely based upon her own work under the supervision of **DR. GUPINATH BHANDARI** and that neither her thesis nor any part of the thesis has been submitted for any degree/diploma or any other academic award anywhere before.

16/09/2025

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Statement of Originality

I, **SRIPURNA KANJILAL (REGISTRATION NO: D-7/ ISLM/ 108 /19)** registered on **31.10.2019** do hereby declare that this thesis entitled **CYCLONE HAZARD ASSESSMENT OF THE COASTAL COMMUNITIES OF PURBA MEDINIPUR, WEST BENGAL, WITH SPECIAL REFERENCE TO THE CARRYING CAPACITY OF THE MULTIPURPOSE CYCLONE SHELTERS** contains literature survey and original research work done by the undersigned candidate as part of Doctoral studies.

All information in this thesis has been obtained and presented in accordance with existing academic rules and ethical conduct. I declare that, as required by thesis rules and conduct, I have fully cited and referred all materials and results that are not original to this work.

I also declare that I have checked this thesis as per the "Policy on Anti Plagiarism, Jadavpur University, 2019", and the level of similarity as checked by iThenticate software is **9%.**

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The papers below are based on the current Doctoral work which has been published in Scopus indexed, peer reviewed Journals and an International Conference Proceeding

i) Kanjilal, S., & Bhandari, G. (2025). Physical infrastructure development in cyclone preparedness strategy: An assessment in the cyclone prone blocks of West Bengal, India. *Regional Science Policy & Practice*, *17*(11), 100231.

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i) Oral presentation on ‘Utilization of Multipurpose Cyclone Shelter as a Disaster Resilient Infrastructure in West Bengal, India’ (as Presenter) in the International Perspective of Water Resources Management and the Environment, Organized by Bangladesh University of Engineering and Technology, Bangladesh . 4-6 January 2023, held in Dhaka Bangladesh

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iii) Oral presentation on ‘Cyclone Hazard Preparedness Strategy for the Coastal Community of Mandarmani-Dadanpatrabar Coastal Belt, West Bengal’ (as Presenter) in 30th IGI conference organized by Jamia Milia Islamia University, 3-5 Oct 2018, held in New Delhi.

8. Participation in Workshops, Seminars and Symposium:

i) Participated in one week training programme for Human Resource, Capacity Enhancement & Faculty Development Programme on “Tackling Urban Flood: Exploring Synergies between Geospatial Tools & Community Based Approaches” organized by the National Institute of Disaster Management, Ministry of Home Affairs, Govt. of India in collaboration with Centre for Disaster Preparedness & Management, Jadavpur University, Kolkata during 16th – 21th March 2025 at Kolkata

ii) Participated in the Three Days Training & Field Visit at Sundarbans on “Remedy of Socio-ecological Vulnerability of Sundarbans in the Discourse of Climate Change”, held during December 15 to 17, 2022 in Sundarbans, organized by the Centre for Disaster Preparedness & Management Jadavpur University, Kolkata, in Collaboration with National Institute of Disaster Management (NIDM), Ministry of Home Affairs, Government of India.

iii) Participated as Delegate in the “National Conference on Coastal Disaster Risk Reduction and Resilience (CDRR&R) 2020" organized by National Institute of Disaster Management (NIDM), Ministry of Home Affairs, Government of India in collaboration with knowledge Partners, on February 2020, at New Delhi, India

iv) Completed a training Course on Aquifer Management and Development” held at Central Ground water Board, Eastern Region, Salt lake, Kolkata 700091 on 27 October 2021

v) Participated in one day Seminar on “ Climate Change and Water Crisis” organized by the Department of Civil engineering IIEST, Shibpur, Howrah on 21st June 2019

vi) Participated in the “Two days National Workshop on hands on training and exercise on the tools for planning sustainable Development: Arc GIS” organised by Centre for Disaster Preparedness and Management, Jadavpur University on 6 &7 September 2019

vii) Participated in three days short term course from 17-19 July 2018 on Climate Change Risk on Sustainable Development in Rural India (Fact, Friction, Policy) organised by Rural Development Centre, IIT Kharagpur, Kharagpur 721302, India.

ABSTRACT

The Bay of Bengal has experienced an increase in the intensity of tropical cyclones in terms of wind speed and cyclone size in recent decades with resultant greater vulnerability of the coastal population and threat to life and livelihood. This study set in the five cyclone prone coastal community development blocks of Purba Medinipur district of West Bengal intends to evaluate the existing structural preparedness strategies, comprehend the level of vulnerability and risk stratification of the coastal community to tropical cyclones and recommend possible adaptation for building stronger resilience of the people.

The study area was divided into grids of 4 sq. km for the purpose of survey and location of schools, MPCS, administrative offices and health centres for calculation of Nearest Neighbour Analysis and uniformity and randomness of distribution of MPCS. Road network analysis and accessibility using standard indices were done. Data was collected both from the local government office and other secondary data source available on the internet as well as primary data from field visit and local surveys. The MPCS were weighed using multi criteria decision model using Analytical Process Hierarchy (APH) and scored as per criteria to obtain weighted score and assess their disaster preparedness. Social Vulnerability Index, Health Vulnerability Index and Risk, Economic and demographic sensitivity risk and Infrastructural adaptivity risk were calculated using dimension reduction model by Principal Component Analysis of the identified indicators of the study area to elicit the more vulnerable zones for an equitable distribution of resources for a more holistic resilience building.

All the CD blocks are found to have moderately connected, moderately efficient complex road networks of varying spatial distribution and development. However, a consistent pattern is that the Gram Panchayats nearer to the coastline fare poorly with respect to the road network efficiency and accessibility (Shimbel and Detour index). The pattern of distribution of MPCS is random and clustered in Contai-I and Deshapran while it was random and uniform in Ramnagar I, random and dispersed in Ramnagar II and clustered in Khejuri II.

The study finds an unequitable distribution of MPCS, high schools and metalled roads with only 21%, 26% and 31% of the surveyed households having reliable access to these infrastructures respectively. 29.2% (n=12) of the 41 MPCS in the 5 blocks are found to be unsatisfactory in terms of maintenance and available amenities, while 26.8% (n=11) fared good in the selected criteria.

Khejuri II with the lowest number of cyclones shelters and hospitals, has the highest index of health vulnerability with a high corresponding risk. Ramnagar-I with its sprawling beachline and associated thriving economy poses the lowest Health Vulnerability Index and subsequently the lowest risk.

The GPs possessing significant demographic and economic risk to cyclone disasters in the study area include Amtalia (Deshapran CD Block), Haludbari (Khejuri II CD block), Sarada (Deshapran CD Block), Baratala (Khejuri II CD block) and Badhia (Ramnagar I). GPs possessing significant infrastructural adaptivity risk to cyclone disasters in our study area include Amtalia (Deshapran CD Block), Aurai (Deshapran CD Block), Dulalpur (Contai I CD Block), Basantia (Deshapran CD Block) and Rajpur Paschimbar (Contai I CD block).

A vertical multi-level bunk bed system is proposed for the MPCS which, apart from utilising the height of the rooms and accommodating sizable number of affected persons in reasonable living conditions, also provides for sufficiently wide corridors and empty spaces in front of doors and windows in the rooms for convenient evacuation and hygienic purposes. After discussion with the local stakeholders, a shatterproof emergency storage kit, built of impact resistant, tough, rigid and temperature proof Acrylonitrile Butadiene Styrene (ABS), measuring 35 cm (L) X 25 cm (W) X 10 cm (D) is proposed for the safe storage and carry of necessary documents and belongings during disaster periods.

The findings of the study thus obtained and the recommendations drawn may pave the way for appropriate action by the concerned authorities for a more equitable distribution of resources, thus building a more comprehensive and holistic disaster preparedness strategy.

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INTRODUCTION

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1.0. Foreground:

The terms natural hazards and natural disasters have become widely synonymous and are frequently used interchangeably. Nonetheless, a distinction exists between the two terms. Various efforts have been done to delineate the two concepts (Fritz, 1961), (Cutter , Boruff, & Shirley, 2003), (Chapman, 1999). Natural hazards are processes that affect humans as the earth is geologically dynamic and undergo continuous but gradual climatic phenomenal changes.

The Earth is geologically dynamic and undergoes gradual yet continuous climatic changes. Consequently, it is perpetually vulnerable to natural anomalies or hazards. Natural hazards are processes that can impact human populations. These processes may be triggered by hydro-meteorological, geological, or biological factors. A hazards is considered as a disaster only if it adversely effects human population. Thus it can be said in other words that hazard may be the cause of a disaster or disaster as an effect of a hazard. A natural phenomenon in how ever high velocities over a deserted geographical location is not considered a disaster. A hazard evolves into a disaster when the population is unable to cope or alleviate the ill effects of hazard resulting in loss of lives and property, damage and disruption. The concept of Vulnerability arises here. Vulnerability is the potential for these fatalities, injuries, loss or damage from hazards.

There is a subtle distinction between the concepts of hazard and risk. While hazard is the process that may incur loss or damage, risk is the probability of that hazard occurring.

Hazard remaining the same the probability of loss is the risk. (Okrent, 1980) provided a classic example of risk, where 3 men on a boat crossing the Atlantic Ocean and 300 people in a ship crossing the same stretch have different risks of drowning. The hazard here is drowning which is the same, but the risk (probability of drowning) is greater for the individuals on the boast than on the ship. Thus RISK = probability of accident occurring x hazard.

Tropical Cyclones are atmospheric disturbances formed over warm ocean water. They are rapidly spinning storms that acquire their energy from the warm tropical oceans waters beneath. Low pressure prevails in the centre which is called ‘the eye’ of the cyclone. The diameter of a cyclone usually ranges from 200 to 500 km but can reach up to 1000 km. Tropical cyclones can last for several days or even weeks (BoM, 2022). The Sea Surface Temperature (SST) is a critical factor in the formation and intensification of tropical cyclones and has been evaluated in many research studies (Emanuel,, 1987), (Saunders & Harris, 1997), (Mohan, et al., 2022) .The ocean and the cyclone interact reciprocally. During formation, the ocean provides energy to tropical cyclones, resulting in storm intensification as long as it remains over sufficiently warm seawater (Mahapatra, et al., 2007).Tropical cyclone are accompanied by high velocity violent winds, torrential rains and high waves causing storm surges and coastal flooding (WMO, 2022). The term 'Cyclone' comes from the Greek word 'Cyclos,' which refers to a snake's coils. It was coined by Henry Peddington, a British colonial officer, posted in Calcutta in 1848 (NDMA, 2022).

Cyclones are prevalent occurrences in the North Indian Ocean basin and accounts for 7% of global cyclonic events. Four times more cyclones occur in the Bay of Bengal than in the Arabian Sea (Dube, et al., 1997). Ideal sea surface temperature (SST) conditions generate upright vortex that facilitate the formation of numerous tropical cyclones (TCs) in the Bay of Bengal basin (Sahoo & Bhaskaran, 2017). Over the past five years, tropical cyclones FANI (May 2019), BULBUL (November 2019), AMPHAN (May 2020), YAAS (May 2021), REMAL (May 2024) and DANA (October 2024) have severely disrupted the social and economic structure of West Bengal's coastal areas (Mondal, et al., 2021). The people living near the coast are especially vulnerable as they are poor and lack in resources. They mainly depend on land and water for agriculture and fishing respectively.

The present study focus on five community development blocks, Ramnagar I, Ramnagar II, Contai I, Deshapran and Khejuri II of Purba Medinipur. They have been identified as cyclone prone by the district disaster management authority of West Bengal (Government of West Bengal, 2022). The occurrence and severity of cyclones are expected to escalate in the near future as a result of climate change (Mondal, et al., 2021). Several blocks in the southern region of West Bengal experienced significant impact from cyclones and floods on 15 occasions between 1995 and 2015, signifying the coastal blocks enduring frequent cyclones and floods (Government of West Bengal, 2019-2020)

This study aims in understanding the level of vulnerability of the coastal community in few aspects such as health, socioeconomic and infrastructure as well as evaluates the existing infrastructures facilities like road network and MPCSs as preparedness strategies. The government is taking initiatives for better preparedness and mitigation of cyclone disasters but there remains a gap between planning and implementation. The findings can be used for better planning and judicial allocation of the scarce funds among at risk blocks and gram panchayats of the study area.

1.1. Rationale of the study:

The Bay of Bengal has experienced an increase in the intensity of tropical cyclones in terms of wind speed and cyclone size in recent decades, as indicated by recent studies (Murty, et al., 2016). Which brings up a big question of whether the people living close to the coast prepared to tackle the cyclone hazards? It is important to understand the risk of cyclone hazards on the local coastal community and their level of vulnerability. The Government of India and all its concerning authorities are taking initiatives to make the coastal areas prepared for cyclones, but their implementation and utilization needs assessment. Thus highlighting the needs and demands of the local inhabitants to ensure judicious utilisation of limited funds is crucial.

1.2. Organisation of the chapters

Chapter 1 provides a glance into the aspects of vulnerability, disasters and briefly introduces the need for addressing the unmet need of cyclone preparedness and subjective and objective evaluation of existing infrastructure.

Chapter 2 showers light into the existing research material, the historic data of cyclones and its associated destructions, provides an overview of the government disaster mitigation projects in place and briefs about the existing vulnerability assessment measures by previous researchers and authorities alike.

Chapter 3 introduces the research gap, provides the research questions to achieve the aims and objectives of the study and briefs about the methodology adopted.

Chapter 4 introduces the study area with details about its historical background, geology, geomorphology, soil, drainage, climate, land use land cover and demographical aspect.

Chapter 5 analyses the road network connectivity of the study area using various connectivity indices as well as the transport network accessibility using Detour index and shimbel index.

Chapter 6 assesses the utilisation, maintenance and suitability of the MPCS during disaster periods by a weighted scoring model using AHP methodology and also assesses their upkeeping during fair weather periods. Local respondents were also interviewed to ascertain their knowledge about the cyclone shelters.

Chapter 7 assesses the locational suitability of the MPCS with respect to the mean centre of population and analyses their degree of demand. It also introduces the concept of uniformity of distribution and randomness in the locations of MPCS.

Chapter 8 assesses the health vulnerability of the population at risk using a dimension reduction model by principal component analysis of the identified 9 health indicators pertaining to vaccination coverage, infrastructural preparedness, vulnerability burden and socio-economic status.

Chapter 9 assesses the demographic and economic risk and the infrastructural adaptivity risk of each Gram Panchayat of the study area using a similar methodology of dimension reduction model by principal component analysis of the identified indicators.

Chapter 10 recommends measures to enhance the carrying capacity of the MPCS in a humane manner which increases efficiency. An emergency storage kit for all necessary important documents (like certificates, deeds, etc) for easy carry during relocation as this was felt to be the unmet need by the researcher during focused group discussions and interview with the local respondents.

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CHAPTER TWO

REVIEW OF LITERATURE

CHAPTER TWO

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2.0. Foreground:

The eastern coast of India is susceptible to tropical cyclones (Ghosh & Mistri, 2023). These coastal regions are densely populated (Kantamaneni, et al., 2022). The majority of 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 indicate an escalation of tropical cyclones regarding wind velocity and cyclone size 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 process that evaluates the severity of the hazard and assesses its impacts 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 in India.

2.1. Cyclone hazards in the Bay of Bengal:

India has a coastline of approximately 7516 km, with 5400 km along the mainland. TCs affect the entire coast at varying frequencies and intensities (Mohapatra, 2015). Tropical cyclones affect 13 coastal states and Union Territories (UTs) of the country. There are four states (Tamil Nadu, Andhra Pradesh, Odisha, and West Bengal) and one union territory (Puducherry) on the east coast and Gujarat on the west coast are susceptible to cyclones (Mohapatra, et al., 2012). 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, several homes were destroyed, trees uprooted, disruption of electricity for days and water logging in several parts of southern Bengal.

(Dube, Mazumder, & Das, 2006) In their paper focused on a comprehensive composite vulnerability assessment framework has been worked out in the study to identify the cyclone prone vulnerable blocks of Sundarbans in West Bengal

(Rao, et al., 2007) showed physical and social vulnerabilities of Andhra Pradesh coast are map and assessed considering several physical and socio economic parameters.

(Sharma & Patwardhan, 2008) In their research did a cluster analysis-based alternative method for locating hotspots that aims to solve this issue by taking into account the various aspects of vulnerability independently.

(Kumar, et al., 2010) analysed the effects of tsunami on the coastal areas of Chennai, using inundation map. The total inundation threshold and total submerged areas of the coast of Tamil Nadu have been assessed by them.

(Chand & Acharya, 2010) Evaluated the shoreline alterations from sea level rise in Bhitarkanika Wildlife Sanctuary of Odisha. The used satellite images of temporal scales to analyse the shorelines changes and their threat to human settlements.

(Alam & Collins, 2010) aimed to understand through primary survey how the poor households in Bangladesh cope up in regards to food and water during cyclones

(Krishnamurthy, Fisher, & Johnson, 2011) worked on vulnerability and capacity assessment. That has been carried out using a GIS based Model by locating the areas with vulnerable housing and infrastructure.

(Das S. , 2012) calculates the likelihood of expected human fatalities from severe cyclones for 262 villages located within 10 km of the coast in one of India's most cyclone-prone districts. The odds are calculated using a cyclone impact (mortality) function that considers exposure and the village's adaptive capacity through various factors, including natural ecosystems.

(Poompavai & Ramalingam, 2013) in their research integrated a Coastal Risk index that has been computed with parameters like Environmental Vulnerability Index, VI Social Vulnerability Index, HPI Hazard Potential Index, and MCI Mitigation Capacity Index in the coast of Tamil Nadu.

(Kulatunga, et al., 2014) showed how socioeconomic factors like social status, political influences, and economic conditions have made the community even more vulnerable to cyclones. The majority of the Patua-Khali community has been "knowingly" at risk of cyclone disasters due to a lack of alternatives, particularly with regard to their patterns of livelihood.

(Jana, et al., 2014) evaluated the shoreline alterations that are a result of sea level rise along the Digha Coast of West Bengal India. The significant concerns the physical environment as we as the human settlements. They attempted to monitor shoreline change with remote sensing and established a correlation between sea level rise and shoreline alterations.

(Mallick & Vogt, 2015) showed an intricate interaction between cyclone-induced vulnerable livelihood management. Which serves as the foundation for developing strategies and policies for disaster risk reduction that are sustainable has been shown through different indices such as social supremacy index etc.

(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.

(Ghorai, Devulapalli, & Paul, 2017) prepared a cyclone Vulnerability map using RS GIS with weighted sum Model to indicate the areas of Andhra Pradesh that are susceptible to cyclones.

(Yadav & Barve, 2017) put forward a Social vulnerability Index has been applied to understand the level of vulnerability for the cyclone affected coastal communities of Odisha.

(Sahoo & Bhaskaran, 2017) calculated, Odisha coast's Coastal Vulnerability Index (CVI) indicates how vulnerable it is to cyclone. Study aimed to examine the effects of coastal vulnerability on the physical, environmental, social, and economic levels. The study also looks into how vulnerable this region's coastlines would be in the future under a changing climate scenario.

(Paul & Chowdhury, 2021) studied the after math of cyclone and did a inundation mapping using MNDWI for the cyclone effected blocks of West Bengal.

(Kantamaneni, et al., 2022) focuses on the coastal vulnerability and its impact on the Coastal region of Andhra Pradesh. The study assesses the drivers and effects of cyclone hazards and vulnerabilities on coastal Andhra Pradesh. A CVI index has been formulated to identify the risk zones.

(Sahana, et al., 2019) analysed the socio economic vulnerability of the blocks of Indian Sundarbans using a pragmatic approach.

Table 1: List of Cyclones in the Bay of Bengal from 1970-2024

SL NO	NAME	DATE	WIND SPEED	CATEGORY OF CYCLONIC DISTURBANCE	STATES	DISTRICTS	CASUALTY AND ECONOMIC LOSS
1	Cyclone Dana landfall near Habalikhati Nature Camp (Bhitarkanika)	Oct 24 2024	100-110 kmph	SCS	Odisha	Bhadrak, Kendrapara Baleshwar Jagatsinghpur	Impacting over 10 lakh people and a loss of 72 Million Dollars
2	Cyclone Remal	May 26 2024	110-120 kmph	SCS	West Bengal	South 24 Parganas North 24 Parganas	No casualty reported

SL NO	NAME	DATE	WIND SPEED	CATEGORY OF CYCLONIC DISTURBANCE	STATES	DISTRICTS	CASUALTY AND ECONOMIC LOSS
3	Cyclone Sitrang	Oct 24 2023	80-90 kmph	CS	Bangladesh	Barisal	No casualties reported
4	Cyclone Asani	May 9 2023	110-120 kmph	SCS	Andhra Pradesh	Machlipattam	No casualties reported
5	Cyclone Yaas made landfall near south of Balasore, Odisha	May 26 2021	155-165 kmph	VSCS	West Bengal	Purba Medinipur South 24 Parganas North 24 Parganas Haora	2 deaths, 10 Million people affected, 300,000 Houses damaged
					Odisha	Baleshwar Bhadrak Jagatsinghapur Kendrapara	2 Human lives lost 128 Villages severely impacted in 10 districts
6	Cyclone Amphan	May 21 2020	155 – 165 kmph gusting upto 185 kmph	SuCS	West Bengal	East & West Medinipur, south & north 24 Parganas, Howrah, Hoogli, Kolkata Districts	Killed 12 people and ravaged Kolkata and several parts of West Bengal uprooted trees, disruption of electricity, thousands of homes were destroyed and water logging in different low-lying parts of the state
					Odisha	Puri, Khordha, Cuttack, Jajpur	
7	Cyclone Bulbul	November 9 2019	110-120 kmph gusting to	VSCS	West Bengal	East & West Medinipur, south & north 24 Parganas,	Total 13 casualties, 4,65,000 people affected, disruption of electricity,uproo

SL NO	NAME	DATE	WIND SPEED	CATEGORY OF CYCLONIC DISTURBANCE	STATES	DISTRICTS	CASUALTY AND ECONOMIC LOSS
			135 kmph			Kolkata, East Burdwan	ting of electric poles, waterlogging and mobile towers disfunctional
					Odisha	Jagatsinghpur, Kendrapada, Bhadrak Balasore and Mayurbhanj	
8	Cyclone Fani	May 3 2019	175-185 kmph 205 kmph	ESCS	Odisha	Puri, Kendrapada, Jajpur, Cuttack, Khordha	64 lives lost. NO casualties in West Bengal.
					West Bengal	East Medinipur, south & north 24 Parganas	
9	Cyclone Titli	October 11 2018	140-150 kmph gusting to 165 kmph	VSCS	Odisha	Gajapati, Ganjam, Kandhamal, Keonjhor, Nayagarh, Angul, Cuttack	77 casualties. 16 districts were affected, landslide in Gajapati district. 20000 houses were destroyed, Several fishing boats were lost
					Andhra Pradesh	Srikakulam, Vizianagaram	40000 houses were damaged. 16 people lost their lives.
10	Cyclone Hudhud	October 12 2014	170 kmph gusting to 180 kmph.	VSCS	Andhra Pradesh	Visakhapatnam, Srikakulam, Vijaynagaram, East Godavari	
					Odisha	Ganjam, Gajapati	
11	Cyclone Phailin	October	210-220 kmph	ESCS	Odisha	Ganjam, Puri, Khordha	44 fatalities in Odisha. Estimated loss

SL NO	NAME	DATE	WIND SPEED	CATEGORY OF CYCLONIC DISTURBANCE	STATES	DISTRICTS	CASUALTY AND ECONOMIC LOSS
		12 2013				and Chilika area	of crops of 394 million dollars. 1 death in Andhra Pradesh
					Andhra Pradesh	Srikakulam	
12	Cyclone Nilam	October 31 2012	80-90 kmph gusting upto 100 kmph	CS	Tamil Nadu	Trivallur, Nagapattinam, Chennai, Cuddalore	Total death of 21 lives and total damage approximately 1040 million INR
					Andhra Pradesh	Nellore, Chittoor, Prakasham, Visakhapatnam	
13	cyclone Thane	December 31, 2011	145 kmph	SCS	Tamil Nadu	Trivallur, Nagapattinam, Chennai, Cuddalore	46 deaths and 12,925 million INR damage
					Andhra Pradesh	Nellore, Chittoor, Prakasham, Visakhapatnam	
14	Cyclone Aila	May 25 2009	110 kmph	SCS	West Bengal	North & South 24 Parganas, Howrah, Hoogly, Kolkata, East & West Midnapur, Darjeeling	2.2 million people affected. 61,000 houses collapsed and 1,32,000 houses were damaged. About 100 people died in the WB.In Orissa Numerous trees were uprooted and power lines were down . High waves produced by the storm inundated coastal villages,
15	Cyclone Nisha	Novemb	40-50 kmph gustin	CS	Tamil Nadu	Tirivur, Nagapattinam,	Over 800,000 people affected s more than

SL NO	NAME	DATE	WIND SPEED	CATEGORY OF CYCLONIC DISTURBANCE	STATES	DISTRICTS	CASUALTY AND ECONOMIC LOSS
		er 27 2008	g upto 60 kmph			Cuddalore, Ramanathan puram, Villupuram, Tirunelvelli	50,000 houses were inundated, paddy and sugarcane crops raised on 200,000 acres were submerged and electric supply crippled
					Puducherry	Karaikal	
16	Cyclone Sidr	November 15 2007	215 kmph	ESCS	West Bengal	South 24 Parganas	The cyclone passed mainly over Bangladesh however.thousands were effected in WB, crops were damaged. Disruption of power supply. Failure of Bidyadhari dam causing flood.
17	Cyclone Ogni	October 30 2006	65 kmph	Ds	Andhra Pradesh	Prkasam, Guntur and Krishna districts	It caused widespread rainfall with scattered heavy to very heavy falls and isolated extremely heavy falls over coastal Andhra Pradesh leading to flash flood over the region and hence loss of life and property.
18	Cyclone Baaz	November 28 2005	84 kmph	CS	Andhra Pradesh	Nellore. Chittoor and Cuddapah	11 fatalities
19	Severe Cyclonic	December	100 kmph	SCS	Andhra Pradesh	Machilipatnam	81 people dead in Andhra

SL NO	NAME	DATE	WIND SPEED	CATEGORY OF CYCLONIC DISTURBANCE	STATES	DISTRICTS	CASUALTY AND ECONOMIC LOSS
	Storm over Bay of Bengal	11-16, 2003					Pradesh, 1637 Building destroyed completely, 7453 Building partially damaged 61898.5 hectares of Agricultural land damaged. Loss of property to the tuneof Rs.23903.13 Lakh. No of villages electric failure are 2000 and telecommunication disruption are in 41 villages.
20	West Bengal Cyclone	November 10-12, 2002	100 kmph	SCS	West Bengal	Purba Medinipur South 24 Parganas North 24 Parganas Nadiya	2 trawlers went missing 48 fishermen died and 111 went missing
21	Cyclonic Storm over Bay of Bengal	October 14-17, 2001	65-75 kmph	CS	Andhra Pradesh	Nellore, Cuddapah, Karnool, Ananthapur and Chitoor	108 casualties, damage to crops about 125000 Hectares and 55747 house damaged in Andhra Pradesh.
22	Very severe Cyclonic Storm over the bay of Bengal	December 23-28, 2000	165 kmph	ESCS	Tamil Nadu	Ramnathan puram Thirunelveli . Tutocorin	Above 100 houses were damaged 318, Fishing boats lost - 95, 281 hectares of loss of crops paddy, 650 hectares of

SL NO	NAME	DATE	WIND SPEED	CATEGORY OF CYCLONIC DISTURBANCE	STATES	DISTRICTS	CASUALTY AND ECONOMIC LOSS
							plantation destroyed Acres of betal fields destroyed in Tamil Nadu.
23	Gopalpur Cyclone (Orissa)	October 15-19, 1999	220 kmph	Sucs	Odisha	Jagatsinghpur, Kendrapada, Cuttack, Puri, Jajpur, Bhadrak, Keonjhar, Balasore, Khurda, Dhenkanal, Mayurbhanj, Nayagarh	8243 human lives were lost, 4.45 lakh livestock perished. Crops in 18.43 lakh hectare damaged. The total loss of infrastructure was estimated to be Rs.6243.96 cr
24	Machilipatnam cyclone	May 4-9, 1990	110 kmph	SCS	Andhra Pradesh	Nellore, Ongole, Gannavaram, Macchilipatnam, Vishakapatnam	967 fatalities
25	Kavali Cyclone	November 1-9, 1989	142 kmph	VSCS	Andhra Pradesh	Vishakapatnam Srikakulam	69 casualties in India
26	Indo-Bangladesh Border	November 24-30, 1988	125 kmph	ESCS	West Bengal	South and North 24 Parganas Kolkata	
27	Sri Harikota Cyclone	November 9-14, 1984	65-75 kmph	CS	Andhra Pradesh	Nellore, Prakasam, Sri harikota	604 people lost their lives
28	Andhra Cyclone	Novemb	205 kmph	ESCS	Andhra Pradesh	Nellore, Prakasam,	10000 people lost lives,

SL NO	NAME	DATE	WIND SPEED	CATEGORY OF CYCLONIC DISTURBANCE	STATES	DISTRICTS	CASUALTY AND ECONOMIC LOSS
		er 14-20, 1977				Guntur, West Godavari to Visakhapatnam districts	3400000 people became homeless, over 100 villages were washed away
29	Balassore Cyclone	October 26-31, 1971	175 kmph	VSCS	Odisha	Bhadrak, Balasore, Cuttack and Jagatsinghpur	10,000 people died and 1 million people Were homeless.
30	Bangladesh(bhola)	November 12-13, 1970	185 kmph	VSCS	West Bengal Andaman and nicobar islands	Coastal Bengal and the Sundarbans	300000 people died

(Source: compiled by author from different sources like IMD reports, WMO reports, Mausam journals, state government reports, Unicef reports etc.)

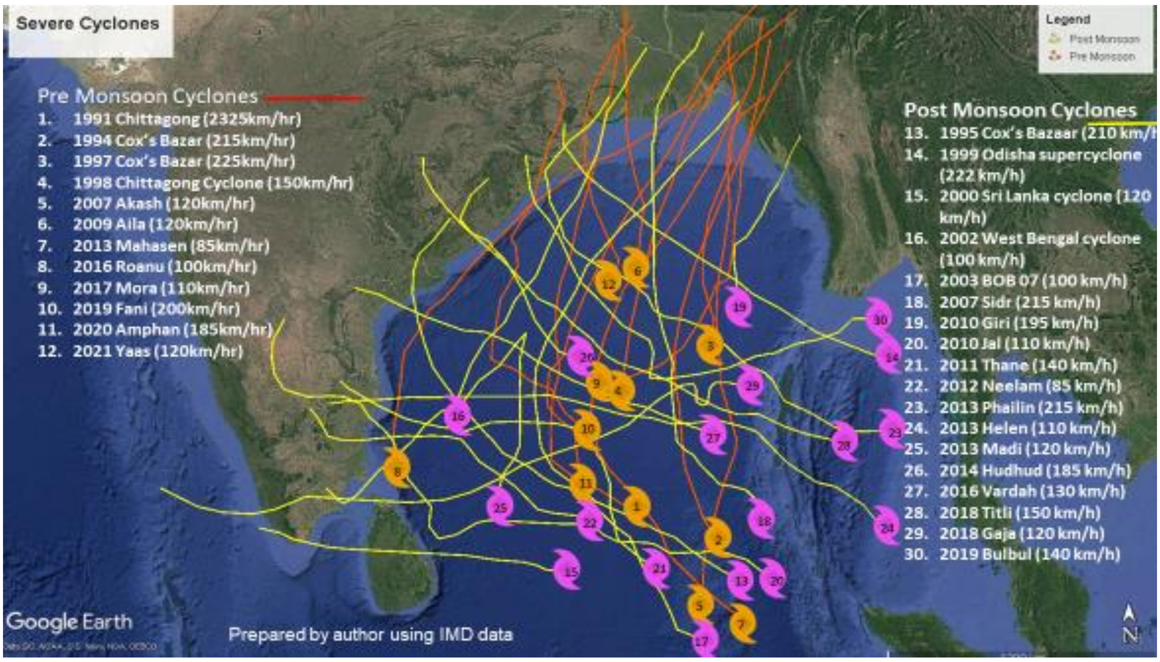

Figure 1: Path of Severe Cyclones over Bay of Bengal from 1991-2019

2.2. Concept of Vulnerability:

Since the 1990s the concept of vulnerability was being cultivated by different academicians (Chambers, 1994). Vulnerability often refers to the propensity to damage or harm, but it has two perspectives. One being the risk and shocks the individual is susceptible to and on the other hand the powerlessness or lack of coping mechanism without incurring loss. Vulnerability has been defined as "Vulnerability means not lack or want but defencelessness, insecurity and exposure to risks shocks and stress" by (Chambers, 1994). A hazard negatively impacts both the environment and socioeconomic conditions (UNISDR;, 2011). Vulnerability refers to an individual or community's ability to anticipate, manage, withstand, and recover from the effects of a natural hazard (Sahoo & Bhaskaran, 2017), (Cutter, et al., 2009). According to the scholars, vulnerability is a multifaceted concept that is influenced by people's abilities to affect institutional, political, and economic capacities (Bohle, Downing, & Watts, 1994). Over the past three decades, a significant number of definitions of vulnerability have emerged.

The concept of Vulnerability and disaster is interlinked. The concept gained momentum when linked with climate change related research. The Intergovernmental Panel on Climate Change's Third Assessment Report (AR3) provides a formal definition and an empirical assessment methodology. IPCC defined vulnerability as *"the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity"* (IPCC, 2001) . 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).Throughout the majority of the twentieth century, disaster management concentrated on the physical environment, prioritizing infrastructure and technology. The notion of social vulnerability in disaster management emerged in the 1970s when researchers acknowledged that socioeconomic factors also influence community resilience (Juntunen, 2005). The likelihood of a disaster depends on the level of the exposure and the intensity of a hazards. An event is termed as a disaster only if it causes damage to human lives and settlement. A hazard passing over a uninhabited land shall not be considered as a disaster. Risk is the probability of that event or hazard causing destruction and preparedness refers to actions taken by individuals, communities, and administrative bodies to reduce loss of life and property during hazard events. This includes early warning systems, rescue, relief, and rehabilitation efforts.

Vulnerability to hazards is affected by various factors, such as age, gender, income, physical disability, the reliability of social networks etc. Individuals residing in disaster-affected regions experience varying impacts. Evidence demonstrates that the people belonging to the lower economic strata are more susceptible during and after a disaster occurs (Kanjilal & Bhandari, 2025).

2.3. Vulnerability assessment:

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. While assessing the vulnerability of a community, economic structure if the residents, perspectives of the stakeholders, livelihood of the inhabitants along with the existing preparedness strategies have to be considered. Another method to maintain focus on the vulnerability assessment is to rank or prioritize the types of vulnerabilities that require attention. Various methods exist to prioritize or rank the pertinent vulnerabilities, with the chosen approach relying upon the specific requirements of the community. Vulnerability assessment does not highlight the impact of a hazard on a community but the highlights the community's status in coping with a hazard which in turn helps in planning of community's need specific resilience.

Most vulnerability measures and indices focus on social and economic vulnerability, frequently neglecting the intricate dimensions of 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).

Vulnerability has been assessed in different methods. Vulnerability assessment techniques can be broadly divided into four categories: model-based techniques, GIS and remote sensing-based techniques, indicator-based techniques, and stakeholders' or participatory techniques. Physical vulnerability, Social Vulnerability and in the recent health vulnerability is an addition. (Gayen, Villalta, & Haque, 2020) Employed various standardization techniques for data transformation, including Z-score, maximum value normalization, and min-max rescaling, to analyse and assess the social vulnerability of an area. Vincent's National Adaptive Capacity Index, (Brooks, Adger, & Kelly , 2005)'s Predictive Indicators of Vulnerability (2005), and the (UNDP, 2007)'s Disaster Risk Index. (Cutter, et al., 2003) proposed the Social Vulnerability Index. These indices, which use biophysical, socioeconomic, and climatic indicators, have been used to compute different levels of vulnerability at different scales.

The IPCC's pragmatic approach was employed to develop a composite socio-economic vulnerability index (SeVI), analysing the components and sub-components of exposure, sensitivity, and adaptation, which were initially standardized and weighted according to their significance. This method has been used by (Sahana, Rehman, Paul, & Sajjad, 2019). (Mondal, et al., 2020) applied an integrated methodology combining principal component analysis and correlation of historical disaster events with fuzzy logic. They did their analysis by assigning equal weight to each indicator, as the validity of assigning weights remains questionable due to the absence of a standardized weighting method for evaluating the precision Due to the indicators being measured in disparate units, a normalization method was employed to consolidate them into a singular value. An 'integrated approach' was employed to evaluate vulnerability, defined as a function of exposure, sensitivity, and adaptive capacity.

(Bahinipati, 2014), (Hoque, et al., 2021) applied the Fuzzy Analytical Hierarchy Process (FAHP) to assign weights to the criteria, as FAHP aids decision-makers in mitigating uncertainty while evaluating alternative preferences in the decision-making process for assessing cyclone hazards vulnerability.

Cyclone hazard maps are created using the multi-criteria analysis technique and are based on spatio-multi-temporal satellite data sets such as Sentinel-1A SAR and RADARSAT SAR. Flood hazard layers are produced using microwave satellite imagery to illustrate the cyclones PHAILIN and TITLI'S varying social vulnerability in the Bhadrak district by (Jaman, Dharanirajan, & Sharma, 2021)

The analysis employs factor analysis, specifically principal component analysis, to condense numerous variables into a limited number of factors that illustrate socioeconomic and infrastructural vulnerability to potential cyclones. Subsequently, the factor scores have been delineated for spatial analysis employing Jenk's natural break method (Mazumdar & Paul, 2016). A composite vulnerability Index of the Sundarbans to cyclone hazards have been prepared by (Dube, Mazumder, & Das, 2006) and (Ahammed & Pandey, 2019) used the Coastal Social Vulnerability Index (CoSVI) developed by (Cutter, et al., 2003). (Khan, Chatterjee, & Bisai, 2013) applied the methodology used in UNDP's Human Development Index (HDI) Health Vulnerability Assessment is a comparatively new addition to the vulnerability assessments. (Chan, et al., 2019) used principal component analysis to compose health vulnerability Index for the Belt and Road Initiative (BRI) countries. (Shultz, Russell, & Espinel, 2005) focused on the epidemiological studies of tropical cyclones generally entailing swift health-needs evaluations performed shortly after the event's impact.

2.4. Cyclone mitigation and adaptation:

The first step in reducing the risk of a disaster in 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. Cyclone

Detection Radars and the Doppler Weather Radars along with the polar-orbiting satellites of the United States and the Soviet Union are providing satellite images of the cyclones to satellite picture receiving equipment Since the Indian Geo-Stationary Satellite INSAT-LB's Meteorological application program went live in October 1983, there have been additional advancements in cyclone tracking and forecasting (GSDMA, 2014). The forecaster's ability to provide the public with timely warnings has improved as a result of monitoring the cyclone with hourly photos (Amssdelhi, 2017) 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.

In 1969, the Government of India recommended that the maritime states establish a "Cyclone Distress Mitigation Committee" (CDMC) to prevent loss of life and minimize property damage. CDMCs are tasked with planning the communication systems within the state for the rapid dissemination of meteorological warnings and preventive measures (Amssdelhi, 2017). The concept of Community Based Disaster Risk Management (CBDRM) has been introduced. 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). It has four components of a) Early Warning Dissemination System (EWDS), b) Cyclone Risk Mitigation Infrastructure (CRMI), c) Technical Assistance for Capacity Building on Disaster Risk Management (CBT and SLT) and d) Project Management and Monitoring through Web-based Dynamic Composite Risk Atlas (Web-DCRA) and Decision Support System (DSS) Tool (Sharma S. K., 2023).

Mitigation of cyclone risk through is been approached through building infrastructure including cyclone shelters, connecting roads and bridges, saline embankments, underground electrical cabling, and early warning dissemination systems. The World Bank is providing financial support (NDMA, 2022).

In August 2019, the Ministry of Environment, Forests, and Climate Change (MoEF & CC) released a draft of the Environmental and Social Management Framework (ESMF) for integrated coastal management and put forward the Integrated Coastal Zone Management

(ICZM) Project. For sustainable development of the coastal areas the Coastal Regulation Zones (CRZ) were also put in action.

Every State is required by Section 14 of the DM Act 2005 to create a State Disaster Management Authority (SDMA). The Chief Minister leads the State Disaster Management Authority (SDMA) at the state level. Disaster Management Act of 2005 The National Disaster Response Force (NDRF) was established by the Government of India to provide specialized assistance during disaster events. According to Section 3.4.5 of the National Policy on Disaster Management, 2009, the State Disaster Response Force (SDRF) was established to facilitate rapid disaster response (Government of West Bengal, 2023). According to Section 25 of the Disaster Management Act 2005, each district within a state shall establish a District Disaster Management Authority. Each DDMA will be led by the respective District Magistrate, District Collector (DC), or Deputy Commissioner, as applicable, with the elected representative of the Local Authority serving as Co-Chairperson. The DDMA will serve as the planning, coordinating, and implementing authority for disaster management at the district level and will undertake all requisite actions (Government of West Bengal, 2023).

2.4.1 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.

(Mallick, Rahaman, & Vogt, 2011) shares the consequences of the victims of cyclone Aila in Bangladesh after the unavailability of cyclone shelters has been talked about in this paper. Recommendations on equitable location of cyclone shelter for their optimum use has been put forward.

(Nirupama, 2013) placed recommendation of vertical evacuation so that maximum people may be rescued in times of a cyclone.

(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 either 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.

(Faruk, Ashraf, & Ferdaus, 2017) assessed inclusiveness of the shelters have been assessed. It is concluded that the shelters were unfit for older population, physically disabled and lack some basic requirements of local farmers. Gender discrimination is also seen.

(Islam & Khatun, 2018) states that women are the most vulnerable, yet they face discrimination. Women have adapted several coping strategies. This paper tries to find vulnerable the women are in case of a cyclone

(Dash & Walia, 2020) aims to understand the utility and usability of a cyclone shelter after major cyclones. Absence of clarity over the usefulness and condition of the shelters has led to over emphasis of shelter construction in proportion to the population size.

(Shahin, et al., 2020) evaluates a questionnaire survey points about the lacunae of the existing cyclone shelters in Bangladesh and why they are being avoided by some people.

(Miyaji, Okazaki, & Ochiai, 2020) The assessment of Bangladesh's BRAC University's proposal of Mini cyclone shelters and their acceptance among the locals.

(Hadi, et al., 2021) talks about the wait and see approach due to the fear of losing one's property and all the other reasons why people delay of refuse to relocate to cyclone shelters

(Hasan , et al., 2024) identified and delineated suitable locations for cyclone shelters through the application of GIS, AHP, Hotspot Analysis, and Remote Sensing methodologies.

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CHAPTER THREE

OBJECTIVES, SCOPE & METHODOLOGY OF THE STUDY

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3.0. Foreground:

Coastal zone is the region where the land and sea interacts. It encompasses both terrestrial and marine resources, which may either be renewable or non-renewable. Coastal communities exhibit higher vulnerability to climate change due to their susceptibility to both meteorological and oceanic parameters, particularly rising sea levels and increasing wave heights, which may significantly result in physical, social and economic repercussions. In a world of booming population, competing desperately for resources and sustenance, a catastrophe invariably introduces an element of uncertainty into the fundamental nature of our existence. Consequently, the most enduring inquiry is how individuals, subjected to constant fear, interpret a catastrophe.

The Bay of Bengal has experienced an increase in the intensity of tropical cyclones in terms of wind speed and cyclone size in recent decades, as indicated by recent studies (Murty, et al., 2016). West Bengal on the other hand possesses an extensive coastline of nearly 100 kilometres (including islands), distinguished by significant floral and faunal biodiversity, varied geomorphic features, and anthropogenic influences (Bhattacharya A. , 2002), (Bhattacharya, Sarkar, & Bhattacharya , 2003) and is hit by cyclones in varied intensities throughout the year. Regardless of the origin of the disasters the consequences will be influenced not only by the underlying severity and intensity of the hazard but also by the vulnerability of individuals and their socio-economic resilience to violent and unforeseen events (Mazumdar & Paul, 2016). Understanding the factors influencing the impacts of a disaster on human welfare for assessing and planning of preventive measures for better development of preparedness strategies are important.

3.1. Research Gap:

Research gap describes the area that has not been adequately explored or resolved in prior investigations. The areas in the present study that require additional research to enhance the existing knowledge and comprehension of a specific topic. The research gap has been identified from literature review.

- 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 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 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. Scope of Work:

This study mainly focuses on the assessing of vulnerability of the coastal community to cyclone hazards and recommendations for better preparedness. The scope of work in this regard are as follows

a) Preparation of a database of tropical cyclones impacting the study area.

b) Analyse the road network accessibility for expedited evacuation during a disaster

c) Evaluating the utilization of MPCS and other public infrastructure for disaster mitigation

d) Comprehend the public response about MPCS to recommend holistic upliftment measures and increased capacity building

e) Assessing the Health Vulnerability of study area based on chronic disease Burden. This may be used as a pilot model for other such vulnerable population.

f) Enumeration of social, economic and infrastructural Vulnerability for more judicious allocation of funds for the population at need

g) Blue print of emergency storage kit that maybe distributed among all vulnerable households for safe storage of important documents and belongings

3.5. Overall Methodology:

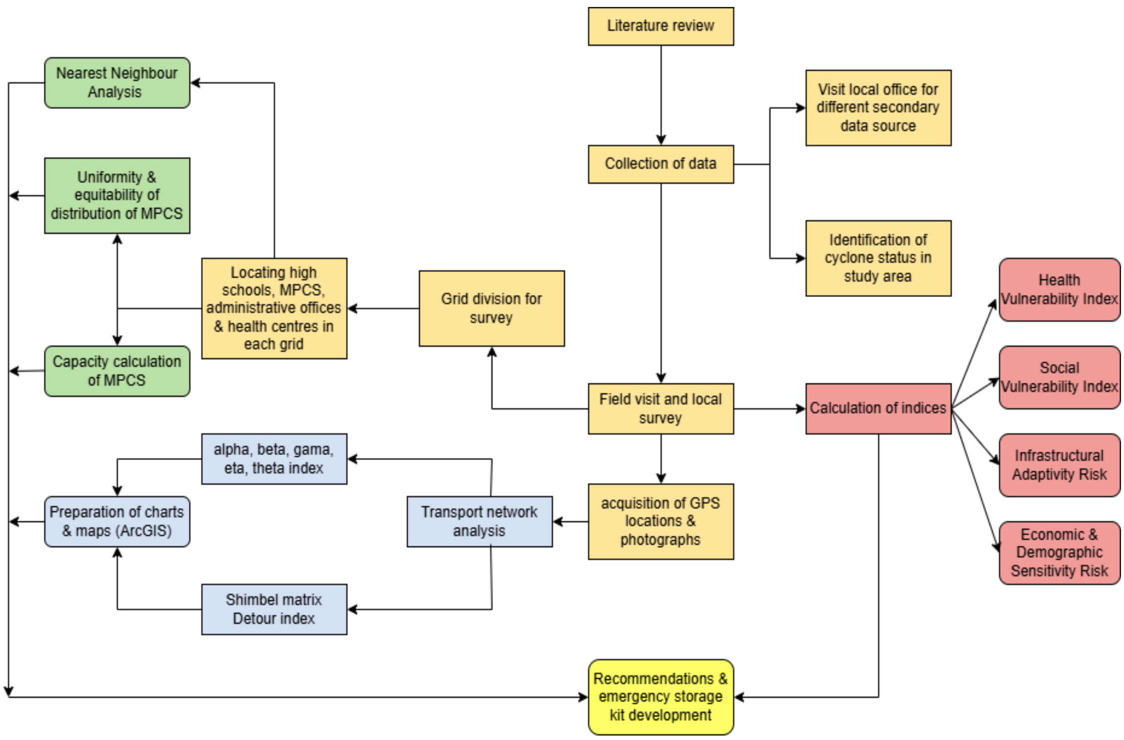

Figure 2: Flow Chart showing the overall Methodology

Thorough literature review was done to identify the study area of the five cyclone prone blocks of Purba Medinipur district of West Bengal, India and understand the cyclone scenario in the past and ascertain its impact on the study area. Data was collected both from the local government office and other secondary data source available on the internet as well as primary data from field visit and local surveys. The GPS location of each MPCS in the study area was acquired and necessary photographs were taken.

The study area was divided into grids of 4 sq. km for the purpose of survey and location of schools, MPCS, administrative offices and health centres for calculation of Nearest Neighbour Analysis and uniformity and randomness of distribution of MPCS. Road network analysis and accessibility using standard indices were done.

Social Vulnerability Index, Health Vulnerability Index and Risk, Economic and demographic sensitivity risk and Infrastructural Adaptivity risk were calculated using dimension reduction model by Principal component analysis 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 are drawn with respect to better, humane and hygienic carrying capacity modulation of MPCS and development of an emergency storage kit in lines with the need of the hour as envisioned by the author in consultation with the local respondents.

Individual methodologies are more elaborately described in the corresponding sections.

3.6. Data Source:

Table 2: Sources of the Data used

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

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CHAPTER FOUR

STUDY AREA

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4.0. Location of 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 3) have been chosen as the area of interest. This area extends within the coordinates of 21°36'39.85''N, 87°29'0.87''E and 21°54'19.39''N, 88° 0'7.86''E.

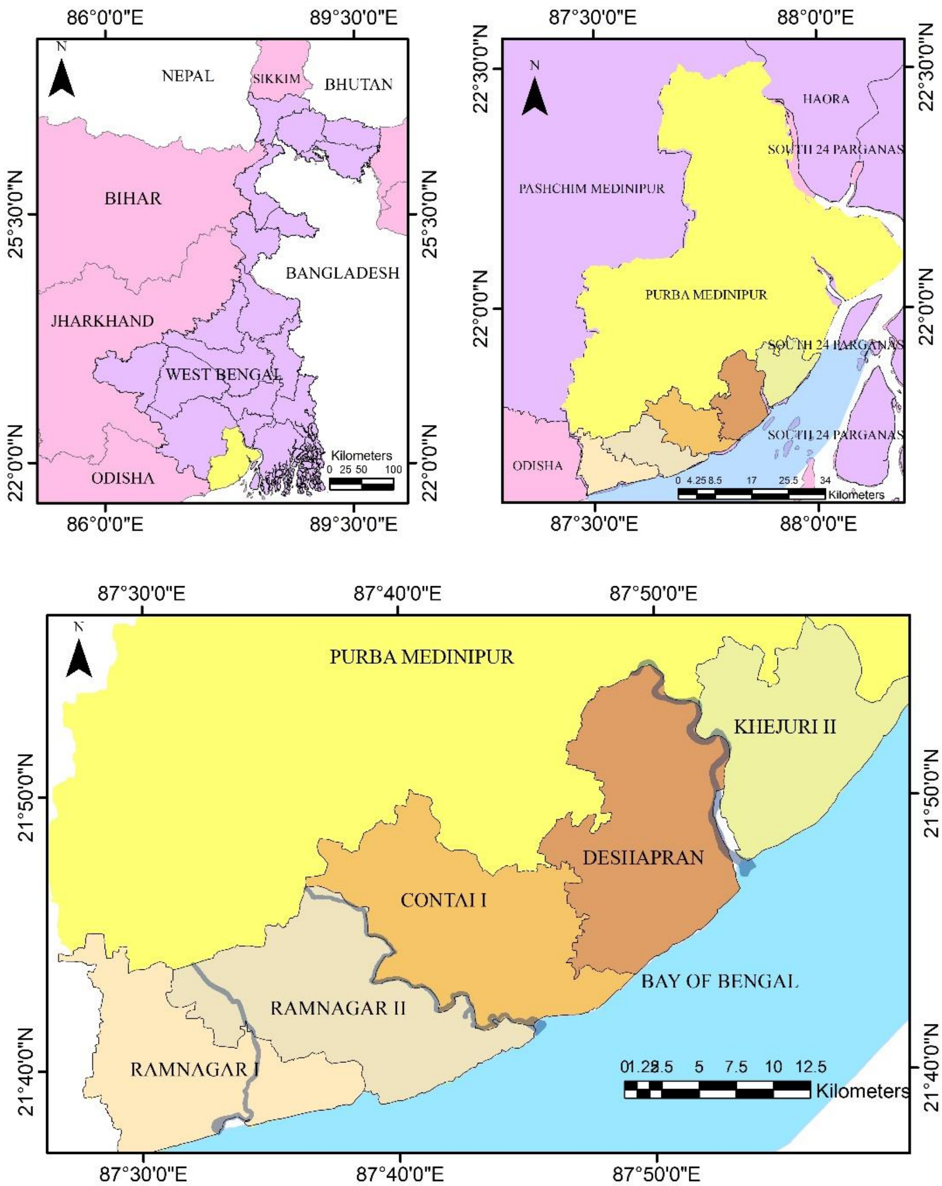

Figure 3: Map of the Study Area

4.1. Historical Background of the Study area:

The history of Purba Medinipur district can be associated with the ancient port city of *Tamtralipta Or Tamralipiti*. It has references in the great epic Mahabharata, where Tamralipta has been mentioned as a territory in the North, Eastern and Central Bengal. It has mentions in the Jain Prajnapana as a part of Vanga and in Dasakumaracharita as a part of Suhma. (Duari , 2018). It also has mentions in the writings of Ptolemy. Reference of Tamtralipta can also be cited in the travelogues of famous traveller Hiuen Tsang during his visit to India. The district was of immense importance during the Mauryan Empire. During the reign of Emperor Ashoka (circa 260 B.C.) Tamralipta was the principal port on the Bay of Bengal. Records of a Buddhist Stupa built by Emperor Ashoka in Tamralipta can be found in several Buddhist legends. Later on Ashoka commenced on his journey towards Ceylon from here. The Gupta Empire succeeded the Mauryan Empire during which traveller Fa- Hien visited the area. From his writings and drawings a lot can be deduced about the area during the period of 405-411 A.D. (Duari , 2018). After the fall of the Gupta dynasty, King Sasanka ruled over Bengal in the 7th Century A.D. when slowly it started losing its grandeur from the reign of King Chodaganga Deva.

During the medieval times Medinipur was under Muslim rule. For several years this land was the battlefield for the Mughals and Afghans and the wrath of the common has been depicted in the novel '*Chandimangal*' by Mukundaram Chakraborty. When the Mughals ruled India Medinipur was a part of Orissa. British Merchant Ralph Fitch described Hijli as a great trade centre of the east. In 1760 A.D. the Marathas invaded Medinipur. The then nawab was deceived by a close friend and consequently Medinipur was surrendered to the British through a treaty in 1760 A.D. the district of Medinipur didn't have distinct boundaries at first. But later on the British formed a Revenue committee where Hoogly collectorate comprised of Hijli, Tamluk and Mahisadal of Medinipur. In 1773 Bengal was divided into 28 districts or provinces. In 1780 A.D., Warren Hastings in one of his letters to his wife described Digha as "Brightons of the East". It was a small village which served as a holiday destination for the British. (Patra, et al., 2021) After the independence of India in 1947 Digha has been gradually developed and flourished as popular tourist destination and in recent time it is one of the most visited tourist attractions in West Bengal (Mandal, Dandapath, & Shukla, 2013).

4.2. Geology:

The study area's geological formation was created between the Late Pleistocene and Late Holocene periods. The southernmost region of Purba Medinipur is primarily made up of coastal marine deposits and is still under development (Chakrabarti, 2005). Of these, the majority of the regions were formed during the Middle Holocene with the Panskura formation (Figure 4) using elements including fine sand, silt, and clay. The urban areas of Contai and Digha are located over the parallel dune ridges, which were produced as a recent dune sand deposit during the Late Holocene period and are composed of semi-compact medium-grained grey sands. The contain town is a part of the Panskura formation. The Basudebpur formation, which is composed of dark grey to black clay and mudflats deposited during the

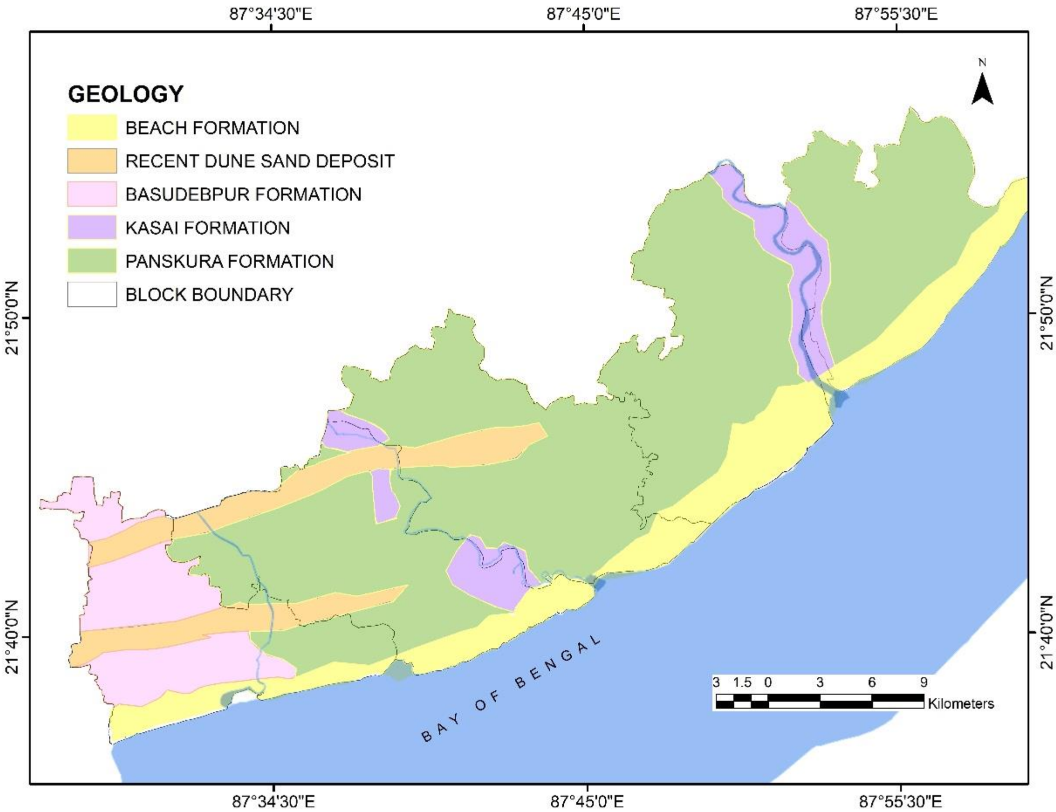

Figure 4: Geological Setup of the Study Area

Middle to Late Holocene period, underlies a portion of the Digha metropolitan centre. The Late Holocene Beach formation is made up of very fine, white to grey sands mixed with clay near the shorefront area (Mondal D. , 2021). Unoxidized sand and silt from the palaeo and modern river courses (Kasai, Rupnarayan, Rasulpur, and Subarnarekha) and their surrounds produced the Kasai formation during the Late Holocene epoch (Jana & Paul, 2018). Younger, unconsolidated alluviums from Holocene to recent deposits are found along the Bay of

Bengal. Holocene to Late Holocene beach ridges and sand dunes are divided by palaeo tidal basins in parts of Ramnagar and Contai blocks (Bandyopadhyay, 2007), (Paul, 2002)

Table 3: Geological formations with material type of the study area

GEOLOGICAL PERIOD	*GEOLOGICAL FORMATION*
Late Holocene	*Beach formation* *Recent dune sand deposit*
Middle to Late *Holocene*	*Kasai formation* *Basudebpur formation*
Middle holocene	*Panskura formation*

Source: Quaternary map of Purba Medinipur of geological Survey of India ((Duari , 2018) (Mondal D. , 2021)

4.3. Geomorphology:

The district can be divided into two sections topographically. (a) Mostly level plains to the east, west, and north. (b) The southern Contai coastal plain (Mondal M. , 2012) . The study area, which is in the district's southern region, is a representation of coastal topography (Figure 5). Sand dunes are present in this area. The sand dunes represent the area's former coastline. The shoreline is mostly straight, with shallow creeks caused by waves cutting through mudflats and deposits. In between the sand dunes some alluvial plains are present. Ancient and contemporary shorelines' sandy platforms support a unique coastal environment characterised by Cashewnut trees, Pandanus shrubs, scrubs, and long-rooted tussock grasses due to its sandy composition and the availability of subsurface moisture (Mondal D. , 2021) (Das, Das, & Pahari, 2017). Before the growth of cities, the topographic unit was heavily vegetated and served as a reliable barrier against storm surges and tidal waves in the area (Paul, 2002). Sand dunes that line the shore are connected to the open marine habitats via tidal inlets or channels. Rising tides flood them twice daily, and tidal creeks cut across them to support a community of halophytic grasslands and mangroves.

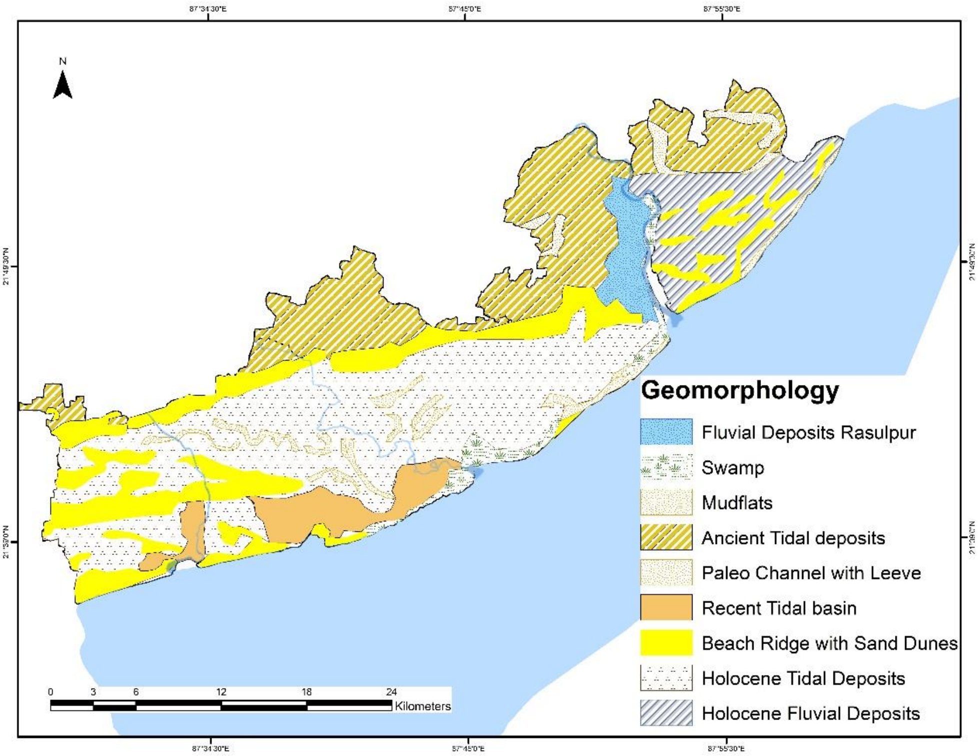

Figure 5: Geomorphological setup of the study area

4.4. Soil :

The study area mainly has undisturbed layers of recent geological sediments. The thickness varying from deep to very deep. A vast area of Purba Medinipur district has younger alluvial soils. Vindhyan alluvium and coastal alluvium are the major types found. The areas near Rupnarayan and Hugli Rivers are composed of Entisols. The southern coastal strip consists of coastal alluvium belonging to the Entisols group. A narrow strip of Saline alkaline soil of the Aridisols group can be noticed. The Western portions of the district comprises of older alluvium of Alfisols group (Sahu, 2014).

The study area mainly exhibits six major soil types (Figure 6, Table 4) out of the ten soil types classified by National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) that are usually seen in Purba Medinipur district.

Table 4: Soil types of the study area

Soil Taxonomic Name	***Description***	***Area in km2***
Aquic ustipsamments	*Very deep, moderately well drained, sandy soils occurring on gently sloping dunes in coastal plain with sandy surface, severe erosion and strong salinity*	*61.5*
Fine aerichaplaquepts	*Very deep, poorly/imperfectly drained, fine soil occurring on level to nearly level marshes in coastal plain with clayey surface and moderate flooding and salinity Associated with deep, well drained sandy soils*	*48.5*
Fine vertichaplaquepts	*Very deep, poorly drained, fine cracking soils occurring on nearly level to very gently sloping coastal plain with clayey surface, moderate flooding and moderate salinity (moderate extent) Associated with deep, poorly drained, file soils*	*425*
Typichaplaquepts	*Very deep, poorly/imperfectly drained, fine soils occurring on level to nearly level marshes in coastal plain with clayey surface, moderate flooding and salinity Associated with very deep, well drained, sandy soils*	*171.13*
Typicustipsamments	*very deep, well drained, sandy soils occurring on moderately sloping coastal plain with sandy surface severe erosion and slight salinity erosion. Slightly saline.*	*50.7*
Very fine vertichaplaquepts	*Very deep, inadequately drained soil found near the low lying lluvial palians. Has a clayey surface.*	*5*

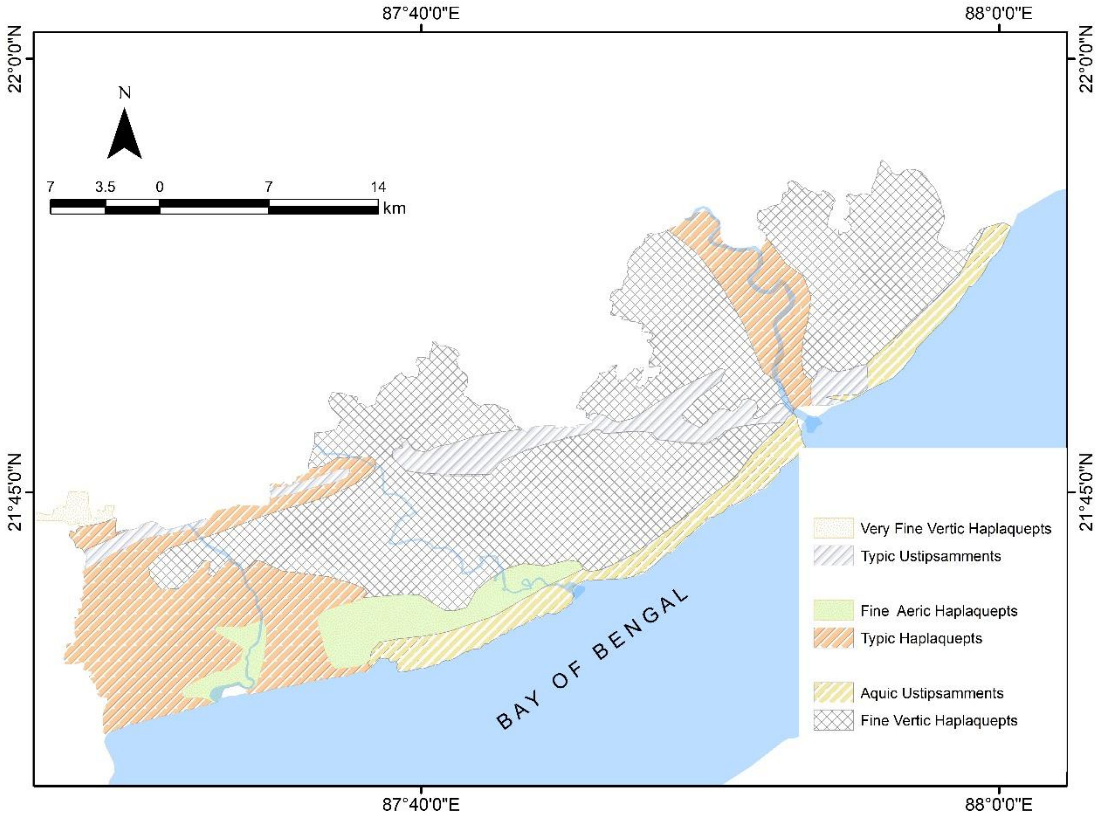

Figure 6: Soil Types of the Study Area

The physical properties of the soil belonging to the study area indicates that soils of Ramnagar-I, Ramnagar-II and Contai-I have loam, sandy clay to clay loam type of soil. Presence of sand in the soil profile is mainly due to deposition of sand from the coastal areas and adjoinging sand dunes bye easterly winds (Duari , 2018). The soils of Deshapran and Khejuri-II are clayey in nature. As per the chemical propertis of soil, Khejuri-II, Ramnagar-II and Deshapran have slightly acidic soil with pH values varies between 5-5.9 Medium acidic soils are seen in Contai-I and Ramnagar-I (Duari , 2018).

Table 5: Texture of soils in the study area

Name of blocks	*Texture*	*Drainage*	*Percent of clay*
Ramnagar I	*Loamy Sand*	*Fairly well drained*	*25*
Ramnagar II	*Loamy Sand*	*Fairly well drained*	*60*

Contai I	*Loamy Sand*	*Fairly well drained*	*55*
Deshapran	*Silty*	*Fairly well*	*44*
Khejuri II	*Clay*	*Moderately drained*	*65*

source: (Soil survey report of state soil survey 2003-2005)

4.5. Drainage:

The major rivers of the study area are Champa, Pichaboni and Rasulpur (Figure 7). The coastal plains is divided in several small segments by drainage canals and channels like Jatra Nullah, Negua diversion canal, Jaldah estuary, Pichaboni estuary etc. All the rivers in study area are non perennial and have highest water levels during the monsoons (Government of West Bengal, 2022)

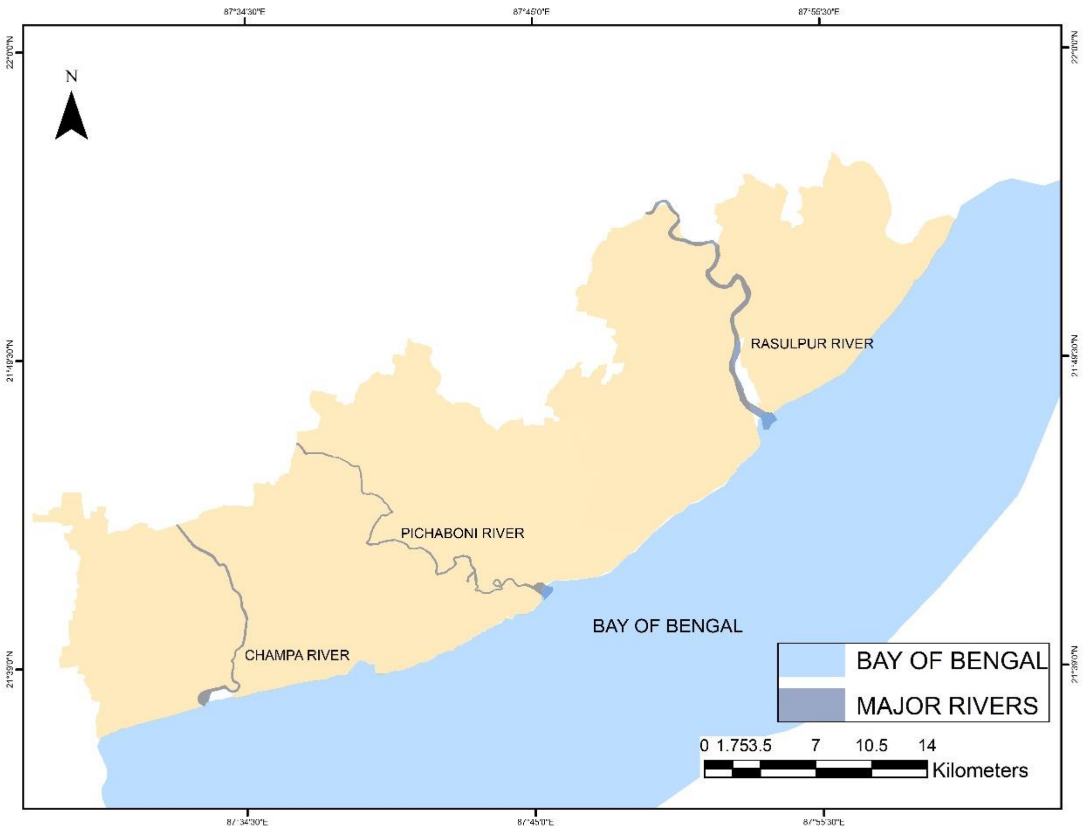

Figure 7: Major Rivers of the Study Area

4.6. Climate:

Purba Medinipur experiences humid sub-tropical climate with minimum and maximum temperatures ranging from 14 degree Celsius in the winter upto 39 degree Celsius in the summers. There are extremely high levels of humidity during the monsoons.

Depressions and cyclonic activities form in the northern bay of Bengal and cause some cyclonic activities as well as rainfall in the coastal areas.

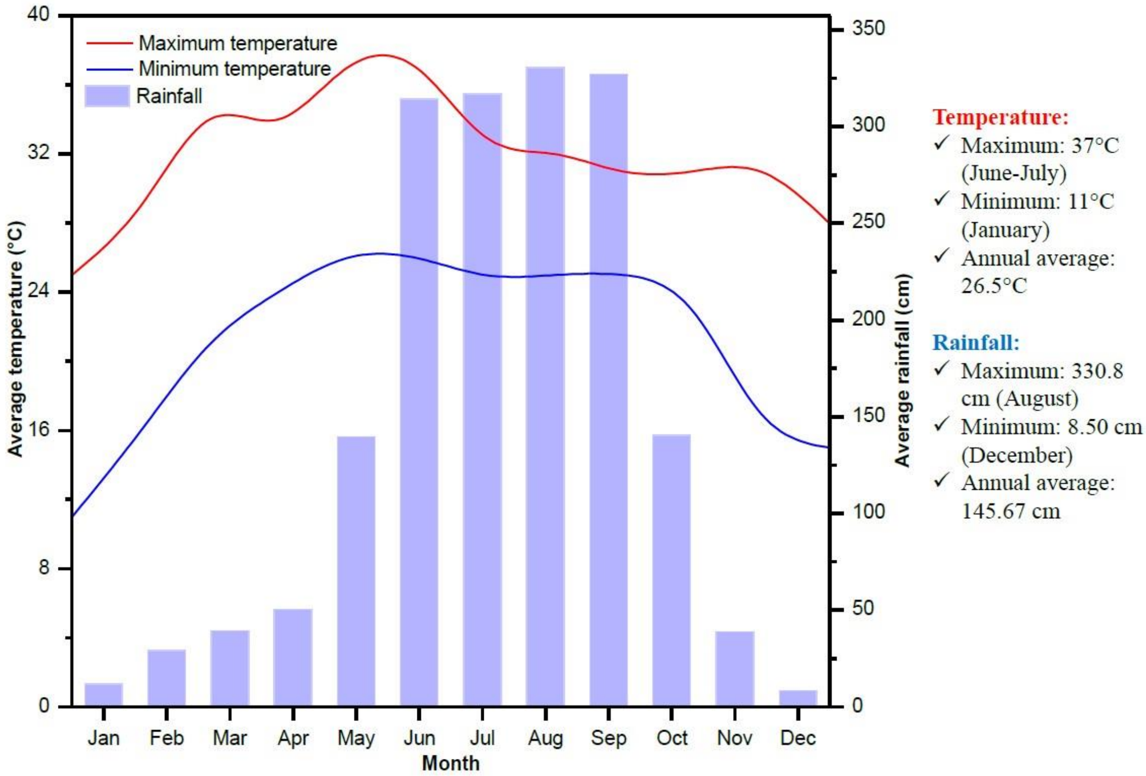

Figure 8: Temperature and rainfall graphs of the study area, source: (Government of West Bengal, 2022)

4.7. Land use and land cover:

The Land Use and Land Cover (LULC) classification of the study area demonstrates ten major classes. Vegetation cover and built-up area with settlements show the highest density. Aqua cultural ponds are also seen in the study area along with some agricultural fields. Vegetation in observed about 27% of the study area. Built up area indicated in red is seen in majority of the area which totals up to almost 31% of the area. 14% of water bodies and aqua culture ponds are present. Other classes seen are sand deposits near the coasts, bare land surface, agricultural land and agricultural fallow land.

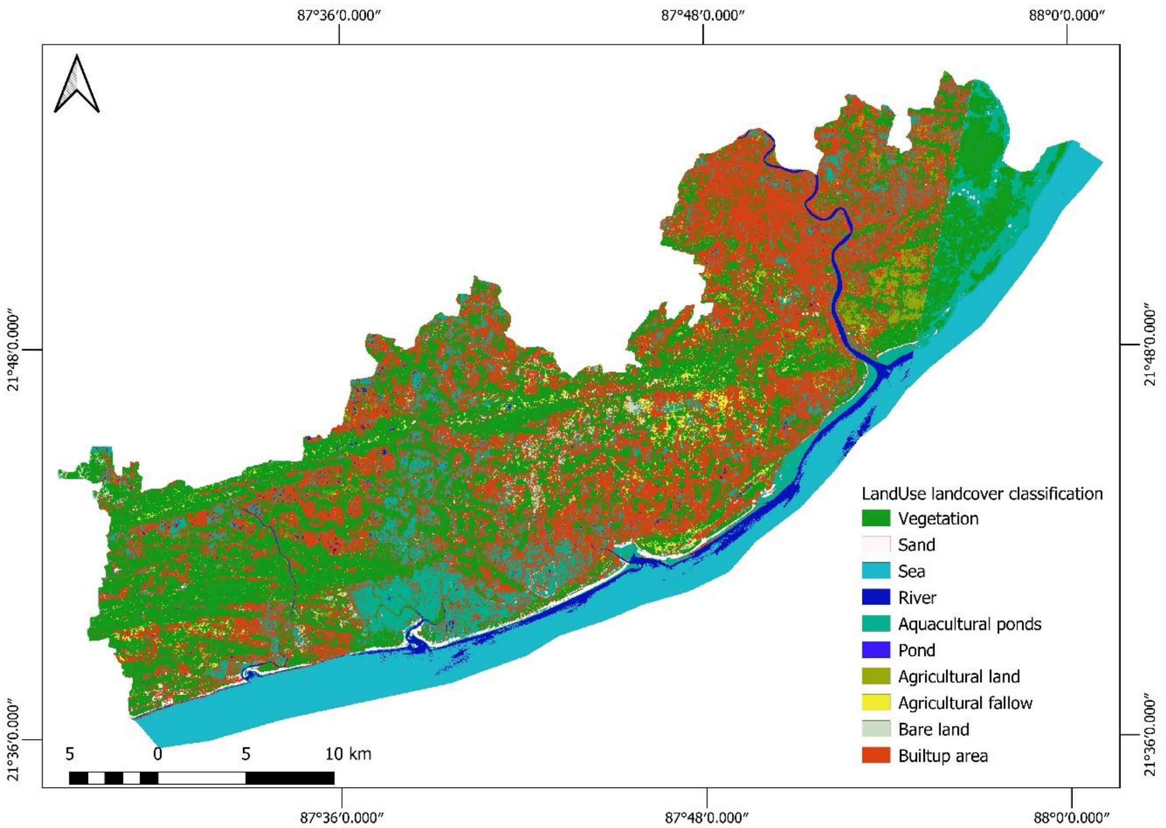

Figure 9: Land Use Land Cover map of the study area

4.8. Demography:

Purba Medinipur in 2022 has a population of about 54,26,953 (as estimated by aadhar uidai.gov.in Dec 2020 data). According to the 2011 official census reports per 2011 census of India, Purba Medinipur has a population of 50,95,875 in 2011 (Government of West Bengal, 2022). There are about 8,17,864 people living in the study area. With highest population in Deshapran followed by Contai-I and Ramnagar-I. Th Maximum population density in seen in the gram panchayats of Contai-I, Deshapran and Ramnagar-I. Maximum household distribution is also observed in Contai-I and Ramnagar-I. The majority of the workers in these blocks belong to unworking categories, with a huge share engaged in marginal works.

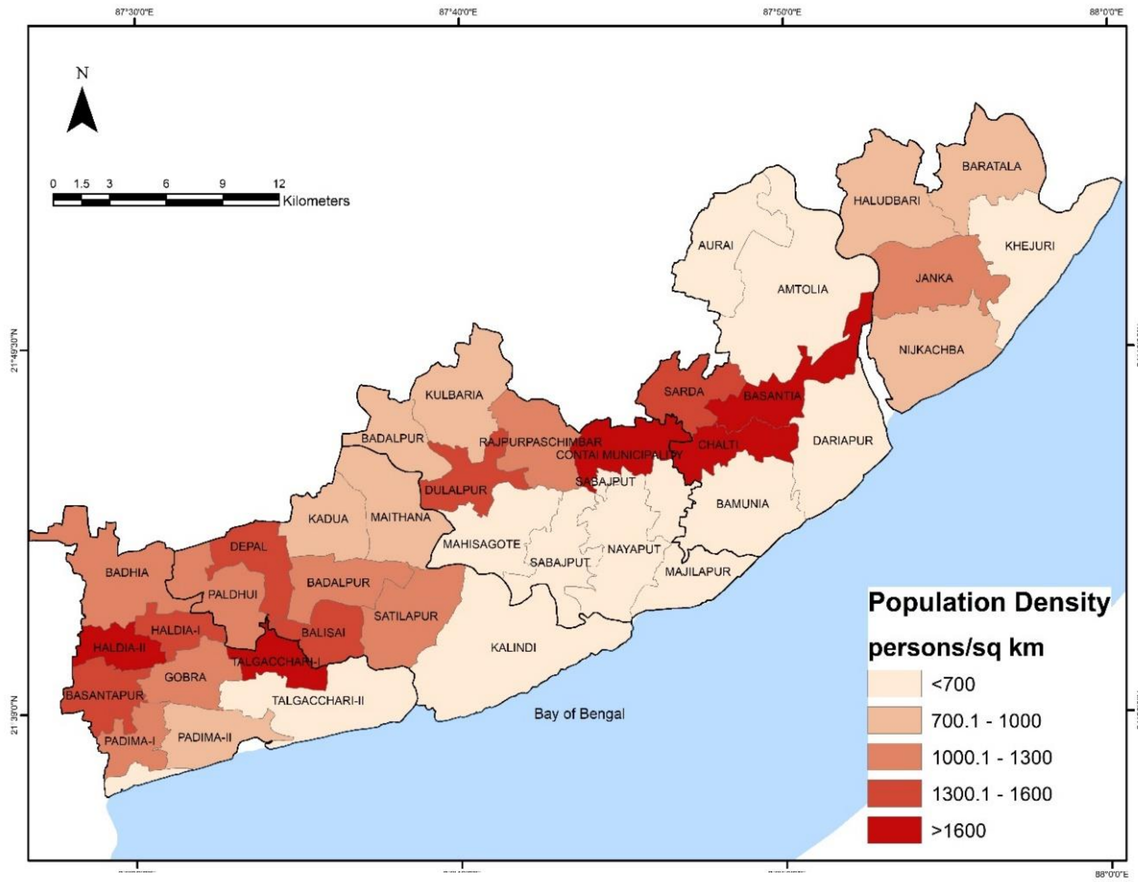

Figure 10 : Population density of the study area (Census 2011)

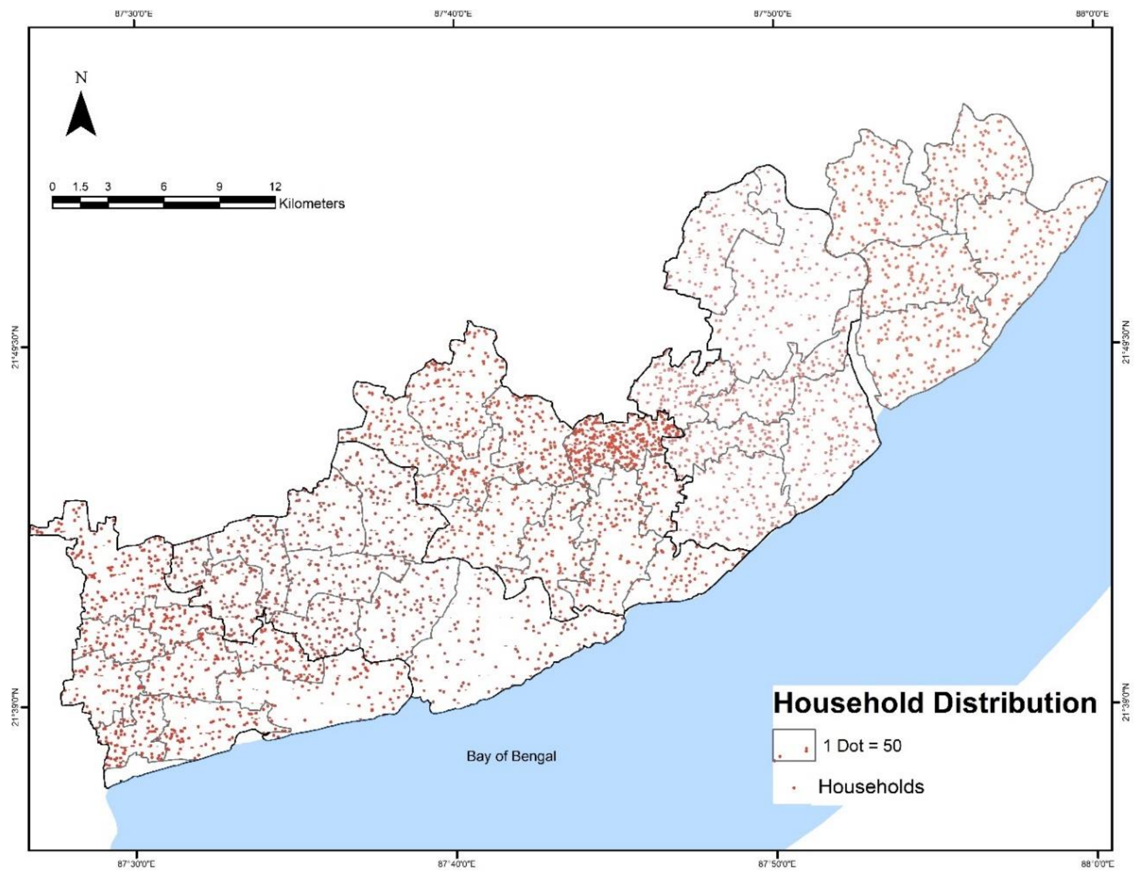

Figure 11: Household distribution of the study area

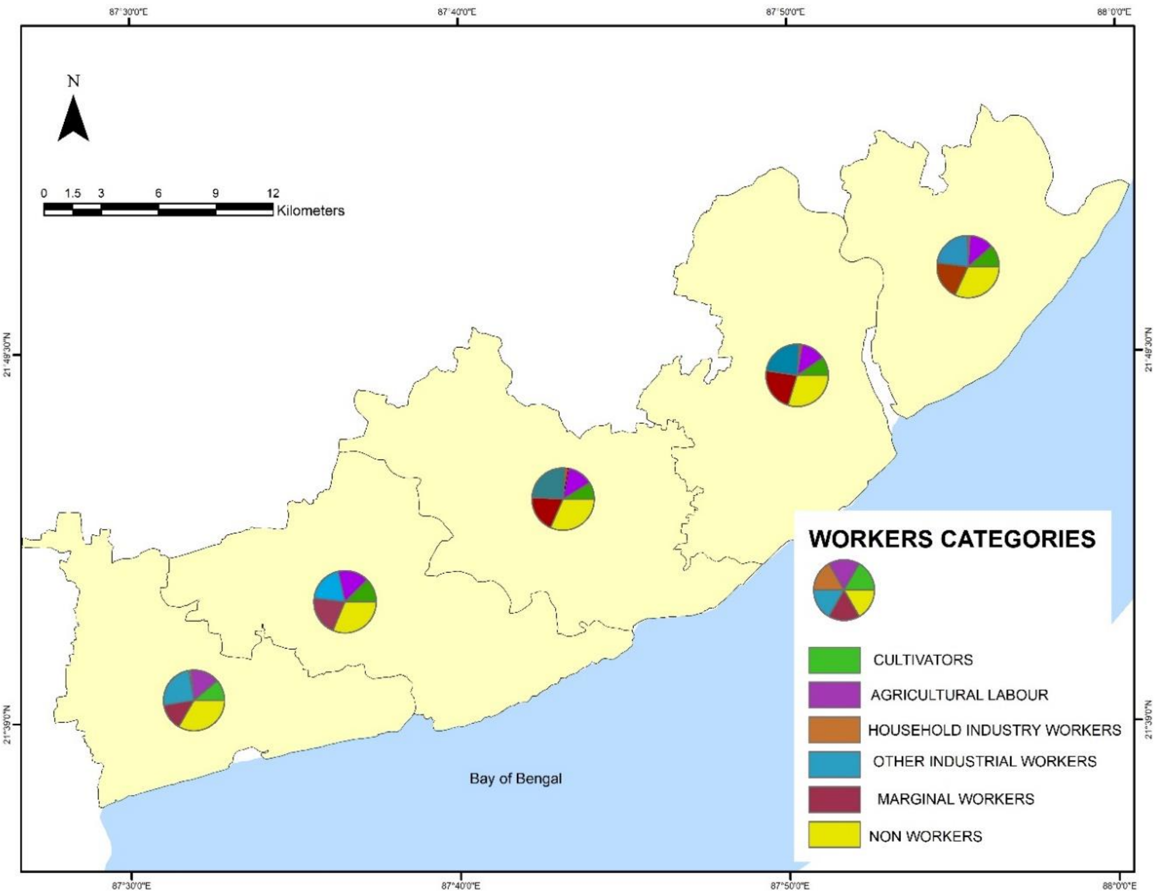

Figure 12: Workers categories of the study area

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CHAPTER FIVE

ROAD NETWORK ANALYSIS

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5.0. Foreground:

Road network analysis have been significant topic of research particularly regarding their potential application in enhancing disaster management practices. Road network and its connectivity and accessibility helps decision makers and planners to formulate disaster planning and implement a disaster response, including rescue strategies, during and after a disaster (Jenelius, et al., 2006). Road networks usually serve as infrastructure that enhances the local connectivity (Zhang & Alipour, 2019). In case of a disaster, road networks are most essential for facilitating access to emergency relief operations. Road networks are the primary resource replied upon to restore other essential infrastructure (Adikariwattage & Bandara, 2008). Roads are used to evacuate people to the shelters, they are used to get medical help as well as used to reach people in need with supplies. Roads are one of the most integral part of a society and its connectivity. In small localities road network is the only mode of connectivity. To quantitatively evaluate a road network, its accessibility and connectivity need to be calculated. To facilitate transport management, prioritize maintenance and repair and allocation of contingency funds to remove regional disparities with the help of results associated with the study of links and nodes within a network. (Jenelius, Petersen, & Mattsson, 2006).

5.1. Road Network Analysis:

Graph theory is mainly used to analyse road networks in spatial structure. Road infrastructure is a key indicator of a region's overall development and human interactions (Bhaduri, 1992). Road networks are a framework of routes that connect locations. A route is a singular connection between two points within a larger network. So in other words networks are graphs that are connected by set of vertices and edges. Graph theory can be used to represent any road network (Sarkar, 2019).

The three fundamental parameters upon which the indices are predicated are: sub-graphs, edges and vertices. The other essential components of graph theory are (Sarkar, 2019):

1. Graph: A graph is a set of links or edges and vertex or nodes

2. Vertex or Nodes (v): A node is a terminal point or an intersection point on a graph.
3. Edge or Link (e): A edge is a link between two nodes
4. Sub-graph: A subgraph is a subset of a graph. Unless we examine the global Road system in its entirety, theoretically every road network is a sub-graph of another
5. Buckle: A link that enables a node to correspond with itself

6. Planar Graph: A graph in which all interactions between two edges constitute a vertex. This graph exists within a plane, thus its topology is two-dimensional.
7. Non Planar Graph: A graph devoid of vertices at the intersection of at least two edges. This suggests a third dimension in the graph's topology due to the possibility of transit. A non-planar graph possesses a greater number of edges in comparison to a planar graph.
8. Diameter: The diameter of a graph is defined as the length of the shortest path between its most distant nodes.
9. Number of Cycles: It is defined as the maximum number of independent cycles within a graph.
10. Order: The number of connected links is defined as the order.

The graph study employs theoretic measures to elucidate a) the configuration and geometry of road networks via an analysis of individual components and attributes, and b) the efficiency of the network structure and its comparability for assessing economic development (Dayalan, 2020).

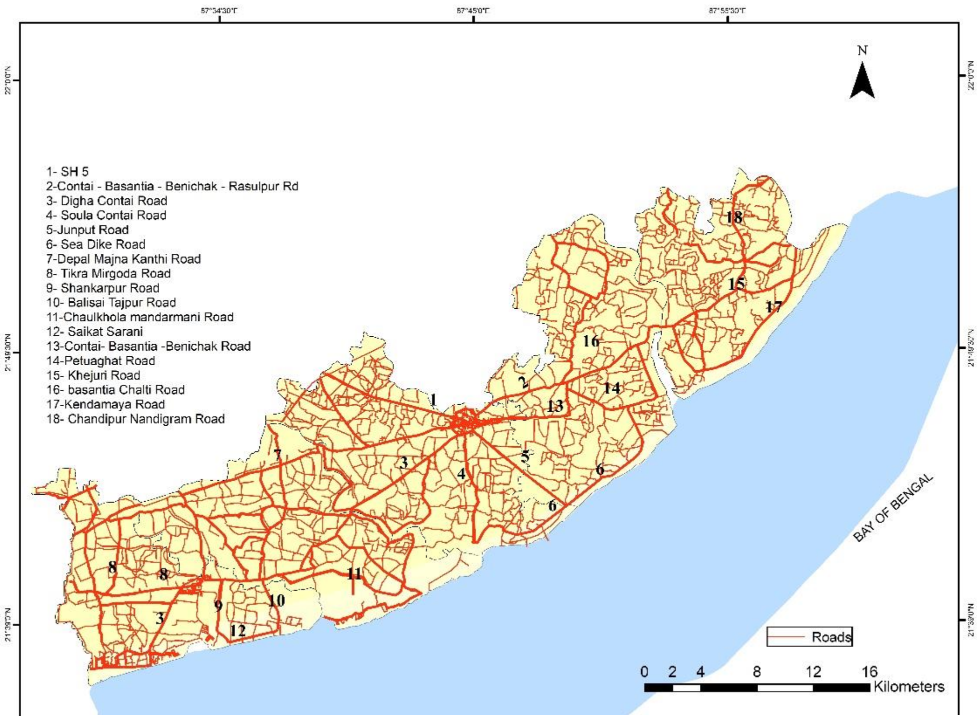

Figure 13: Road Network of the Study Area

5.1.1. Road network Connectivity:

(Kansky, 1963) Examined different road networks and formulated different descriptive indices for assessing road network connectivity, like alpha, beta, gamma among others. His method is most used to calculate network connectivity.

Table 6: Measures of Road Network Connectivity.

Connectivity Index	Description	Formula
Alpha Index (α).	It assesses connectivity by analysing the number of cycles in a graph relative to the maximum possible cycles. The greater the value, the more interconnected the network becomes.	$\alpha = \frac{e-v+1}{2v-5}$
Beta Index (β)	It quantifies the connectivity of a graph by the relation of the number of links (e) over the number of nodes (v).	$\beta = \frac{e}{v}$
Gamma Index (γ)	It quantifies connectivity by assessing the ratio of observed links to potential links.	$\gamma = \frac{e}{3(v-2)}$
Eta Index (η)	It quantifies connectivity concerning the average length (L) of the network per link.	$\eta = \frac{L}{E}$
Theta Index (θ)	It quantifies connectivity concerning the average length (L) of the network per node.	$\theta = \frac{L}{n}$

5.1.1.1. Alpha Index: The alpha index, also known as the "redundancy index," serves as a more effective measure of network connectivity. This represents the ratio of the number of cycles in a graph relative to the maximum possible cycles in a network. The alpha index (α) value ranges from 0 to 1.0, with 0 indicating a minimally connected network and 1 indicating a maximally connected network. Simple networks, such as trees, possess null values. A value of 1 signifies a thoroughly integrated network where all conceivable connections among the nodes are present.

5.1.1.2. Beta Index: It is a fundamental index of graph theory. It measures the level of connectivity by the relationship between the number of links over the number of nodes. For trees and simple networks $\beta<1$ and for a well-connected network with one cycle $\beta=1$. Complex networks have values $\beta>1$. Higher this value indicate more complex connected networks. So complex networks have a higher β value

5.1.1.3. Gamma Index: (Kansky, 1963) defines the gamma index as the ratio of edges to vertices in a road network. This is the ratio of the observed number of edges (e) to the maximum number of edges in a planar graph. The Gamma index (γ) values range between 0 and 1. γ =1 suggests a completely connected network, although practically it is almost impossible. Gamma values measure the progression of a network over time.

5.1.1.4. Eta Index: Eta index in graph theory as the ratio of total edges and vertices to observed edges. The Eta index measures the relationship between the road network, its routes, and individual elements. Higher Eta values indicates that the network is made of long individual segments whereas lower index value suggest shorter segments. Eta values are calculated to see the efficiency of the edges in a graph

5.1.1.5. Theta Index: The theta index is the ratio of the entire network to its vertices. Theoretically, Theta appears to be a more robust metric than Eta. Higher the Theta values it I signifies a more complex network, marked by increased average route length, indicating toward a enhanced spatial distribution and development.

5.1.2. Road Network Accessibility:

Accessibility is the easy by which a desired destination can be reached in a road network system. Accessibility is crucial for regional development and social welfare. The development of road infrastructure significantly affects land use and mobility (Gutiérrez, 2009). It is the ability to reach one location from one or by multiple locations. Accessibility is linked to the shortest path taken to reach a specific location. Detour Index and Shimbel Distance Matrix (or D-Matrix) are two of the most popular methods of calculating the road network accessibility.

5.1.2.1. Detour Index: The Detour Index assesses a road network's efficiency in terms of distance-overcoming capability. It compares the straight distance between two points to the corresponding road distance between those two points. The direct distance is considered to be the most optimal path between two points. In a road network the shorter direct distances between two points are considered to be more efficient. The closer the detour index value goes to 1, the network is considered more efficient. Networks have perfect detour Values of 1 are extremely rare. Even if this ever noticed, most networks would be a match for asymptomatic curve, being close to 1 but never reaching it.

5.1.2.2. Shimbel Distance Matrix (D-Matrix): Alfonso Shimbel created a method for determining the shortest route between two locations, eliminating redundancies**.** This approach computes accessibility based on the distance between vertices (nodes). A simple matrix is used to determine the shortest path between all nodes in a network. The Shimbel Index, calculated from the shortest path, indicating the number of arcs required to connect any node to all other nodes, via the shortest number of paths (Oni, Akindele, & Adedoyin, 2014). The sum of rows or columns represents the Shimbel distance for each node. Lower Shimbel values indicate higher accessibility of the network. Here only the number of edges are considered and not the actual distance between them. The Shimbel Index formula is

$$Si = \Sigma dij \quad \text{(Istrate, 2015)}$$

where *Si* represents the Shimbel index for node *i*, and *dij* denotes the distance between nodes *i* and *j* (Istrate, 2015).

5.2. Methodology:

The road network has been acquired from ISGP website and (Government of West Bengal, 2019) Google Earth Pro 7.3.6. The road network is projected to the Universal Transverse Mercator (UTM) coordinate system to calculate the length of road segments. The number of nodes and edges are counted from the network dataset in Arc GIS 10.3, and the connectivity indices are calculated using

Figure 14: A concrete road in Deshapran block

network Analyst tool. A Grid matrix has been computed for each block using the number of nodes and the shimbel matrix index has been calculated.

5.4. Results and Discussions:

Analysis of the Shimbel index and detour index of the five cyclone prone coastal community development blocks of the study area reveal:

Table 7: The road network connectivity Indices

CD Blocks	Alpha (α)	Beta (β)	Gamma (γ)	Eta (η)	Theta (θ)
Ramnagar 1	**0.082**	**1.16**	**0.388**	**0.499**	**0.580**
Ramnagar 2	**0.076**	**1.15**	**0.385**	**0.898**	**1.030**
Contai 1	**0.048**	**1.09**	**0.365**	**0.630**	**0.689**
Deshapran	**0.054**	**1.11**	**0.370**	**0.771**	**0.853**
Khejuri 2	**0.073**	**1.14**	**0.383**	**0.716**	**0.819**

Ramnagar 1: GPs of Padima I, Padima II, Talgachari II and Badhia have less efficient and less accessible road networks, while GPs like Haldia I and II, Basantapur and Gobra score high.

Ramnagar 2: The coastal GPs of Balisai, Kalindi poses infrastructural problems in efficiency and accessibility of its road networks, while GPs possessing good numbers of households like Depal and Paldhui possesses road networks that are efficient but not much accessible.

Contai I: The GPs of Dulalpur, Badalpur and the coastal GP of Majilapur scores less in the efficiency and accessibility of its road networks while the bustling township of Contai Municipality possesses highly efficient and accessible road networks.

Deshapran: Road networks of GPs of Basantia and Amtalia are both effective and accessible while the effective road network of Aurai possesses inaccessibility. Road networks of all the coastal GPs are ineffective and inaccessible.

Khejuri II: Apart from part of Janka GP where road networks are effective and accessible, the whole of the community development block lacks infrastructural readiness of the road networks with respect to efficiency and accessibility.

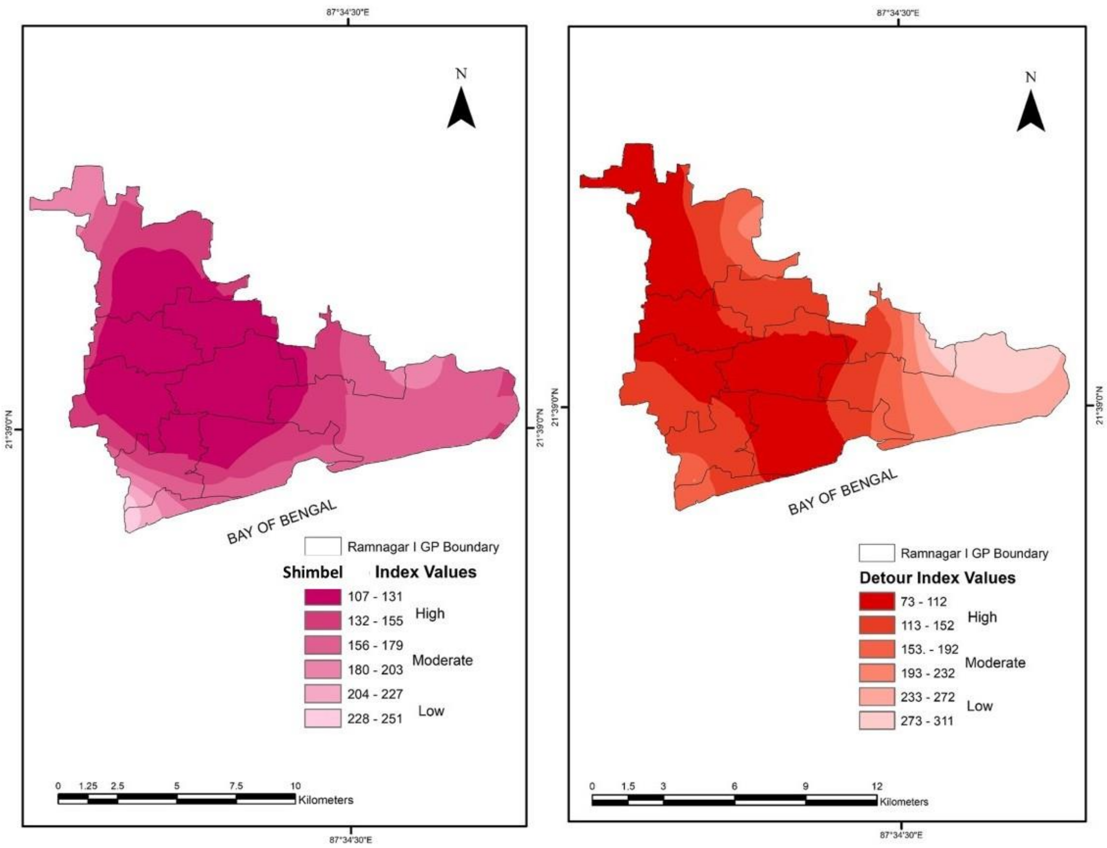

Figure 15: Shimbel and Detour Index of Ramnagar I

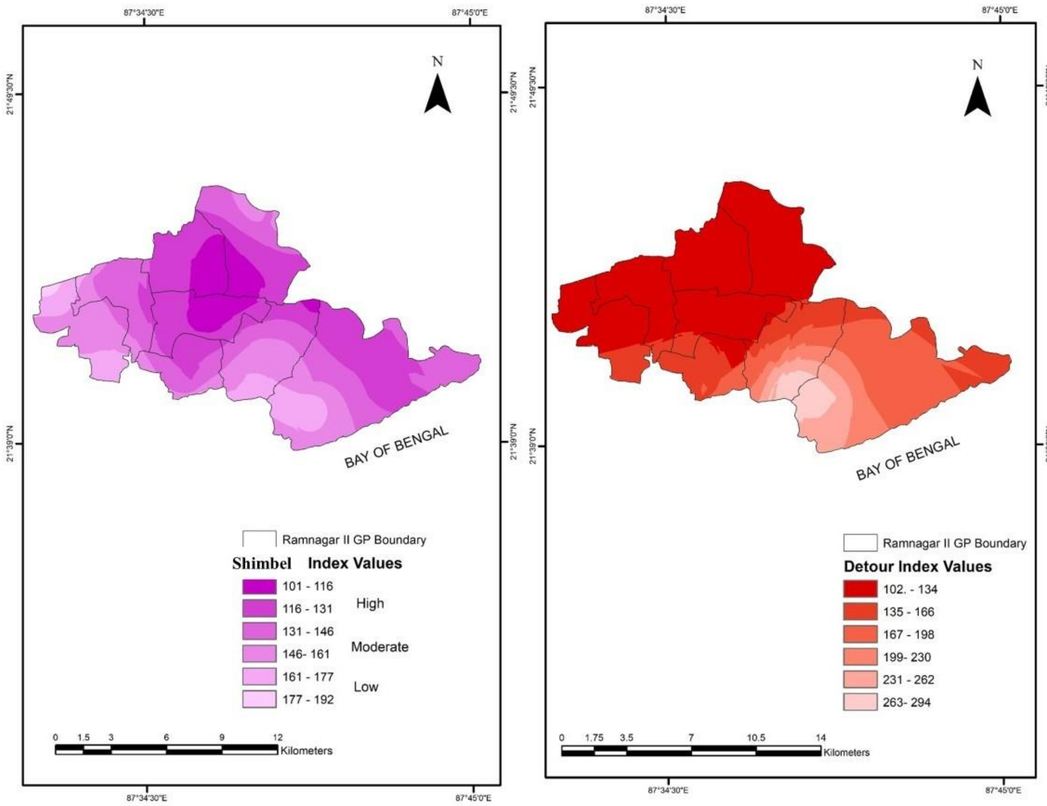

Figure 16: Shimbel and Detour Index of Ramnagar II

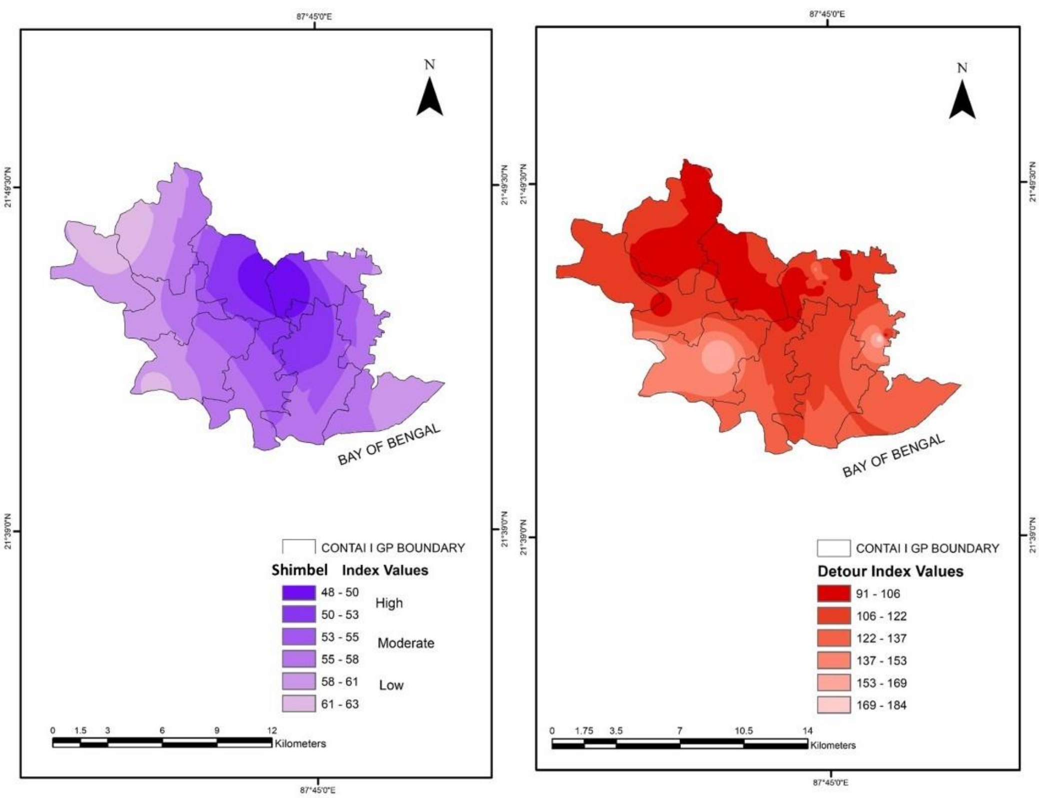

Figure 17: Shimbel and Detour Index of Contai I

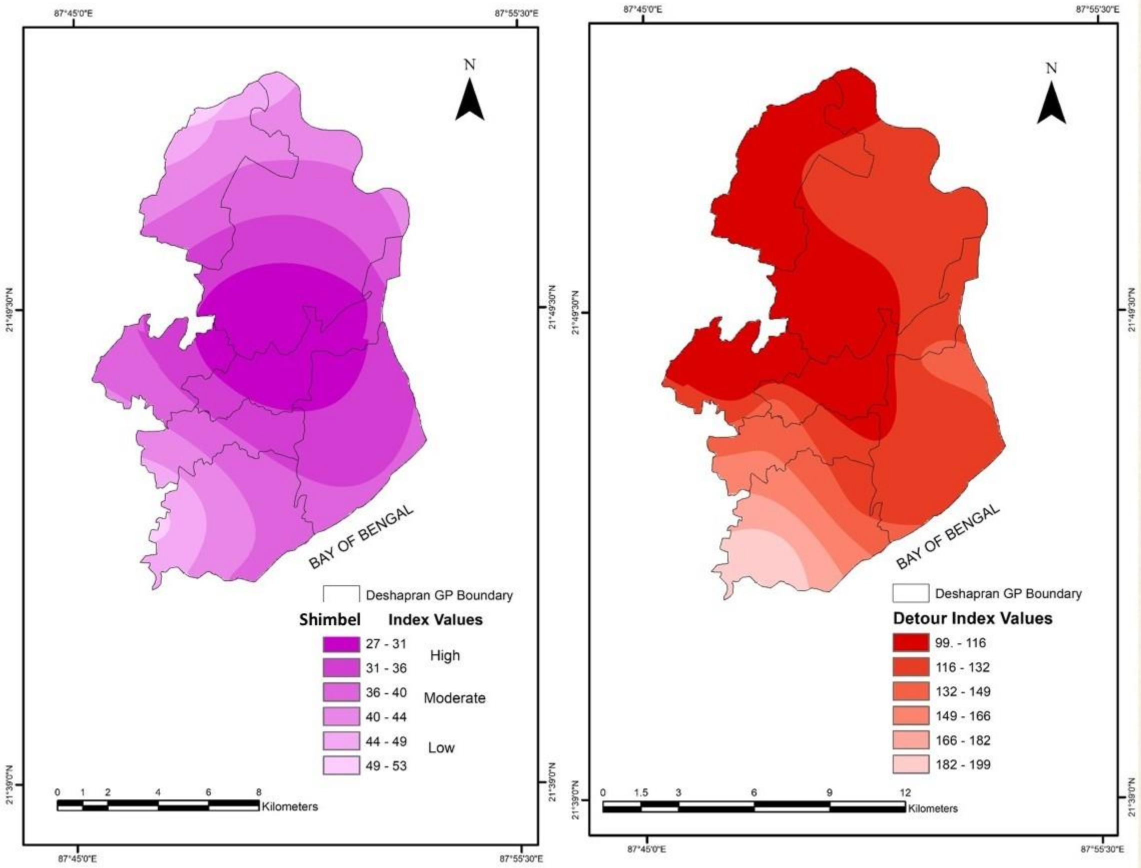

Figure 18: Shimbel and Detour Index of Deshapran

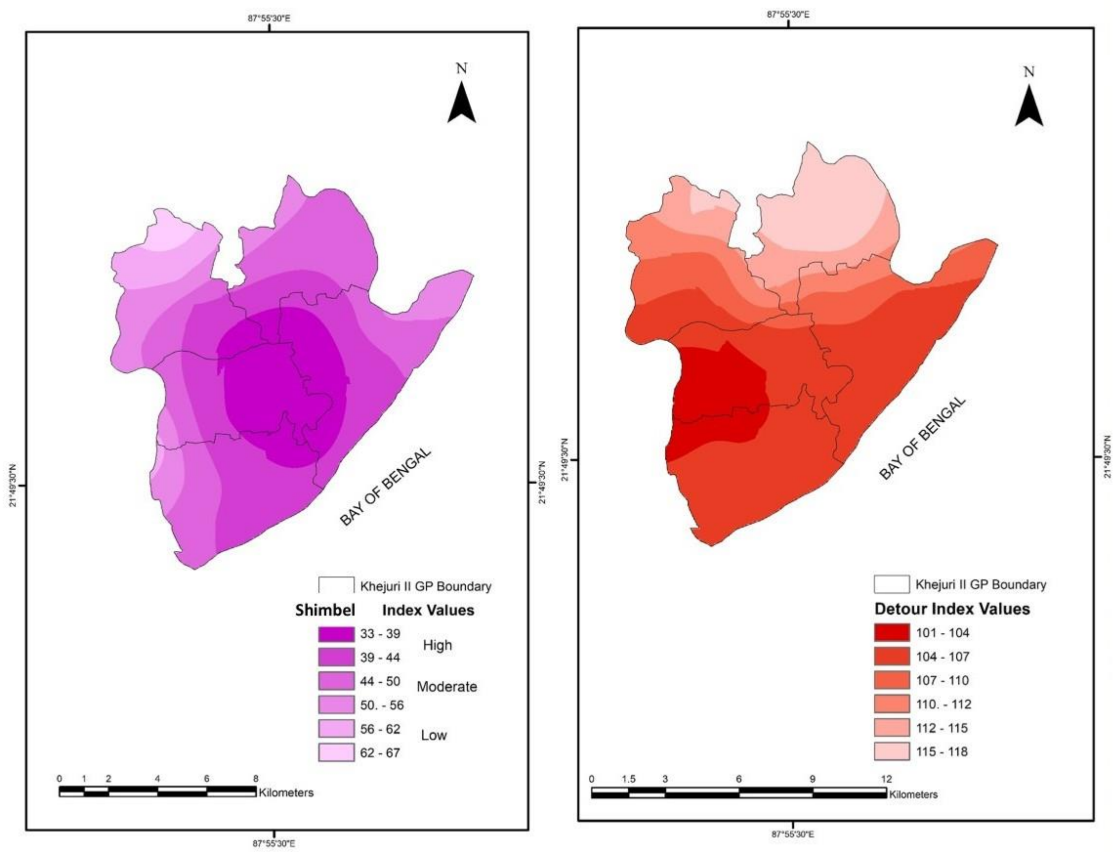

Figure 19: Shimbel and Detour Index of Khejuri II

5.5. Conclusion:

Road network analysis play and important role in identifying the areas with high and low connectivity as well as the level of accessibility. This is extremely important in times of disaster mitigation as well as preparedness. As the roads are the only means of evacuation and through which emergency aid can be brought to the vulnerable. The results will help the policy makers in understanding which areas may need special attention during the disaster preparedness strategy planning and execution. New routes may be proposed in areas having low connectivity so that maximum people can be rescued and brought to safer shelter and proper amenities be delivered to them to alleviate their vulnerability.

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CHAPTER SIX

UTILIZATION OF MULTIPURPOSE CYCLONE SHELTERS

CHAPTER SIX

UTILIZATION OF MULTIPURPOSE CYCLONE SHELTERS

6.0. Foreground:

Cyclones are frequent natural calamity faced by the people living in the coastal areas of India. Tropical cyclones often lead to reshaping sand dunes, near coastal areas causing extensive coastal erosion (Datta, 2015). Cyclonic situations set up in the Bay of Bengal almost every year during the months of April-May and September-December (Department, 2009). The high velocity cyclonic winds are accompanied by tidal waves, storm surges and torrential rainfall. People who reside within a distance of 10 km from the sea coast are generally the worst affected by inundation that vary between 2.5 to 5 meters approximately and last for about 5-6 days (Department, 2009). Recent studies show an intensification of tropical cyclones in terms of wind speed and cyclone size over the Bay of Bengal in the past few decades (Murty, et al., 2016). Climate Change and subsequent Sea Level Rise (SLR) has increased the vulnerability of the coastal population significantly (NDMA, 2009).

Multipurpose Cyclone Shelters (MPCS) are one of the most important structural measures taken by the government to deal with the devastating cyclones and subsequent storm surges in reducing the loss of lives (Orissa State Disaster Management Authority, 2009) . Construction of cyclone shelters has been a well proven measure of preparedness throughout the world. The need of 'Multi-Purpose Cyclone Shelter' surfaced in India after a severe cyclone in Andhra Pradesh in 1977 (Mishra & Prakash, 1982). The construction and maintenance of the cyclone shelters act as motivation for the local people, in a step towards the better preparedness to cyclones. A cyclone shelter is a community building; should be built on an elevated land to ensure safety of the local people from the cyclones and associated storm surge inundation (Rahman & Islam). Cyclone shelters serve as immediate and temporary refuge to the local people and their livestock during any natural calamity (Haider & Ahmed, 2014).

West Bengal has been identified as Category I among 13 cyclone prone States and Union Territories (UTs) in India, based on the frequency of occurrence of cyclones, its vulnerability and size of vulnerable population (The Industry Institute Partnership Cell (IIPC) Jadavpur University, 2019). Under the Prime Minister's National Relief Fund (PMNRF) scheme and National Cyclone Risk Mitigation Project- II (NCRMP-II) (NCRMP-II) and the Integrated Coastal Zone Management (ICZM) Project assisted by the World Bank (Government of West Bengal, 2017) (Environment, 2018), several Multipurpose Cyclone Shelters (MPCS) have been constructed in Purba Medinipur district, while few are still under construction. The MPCSs in Purba Medinipur have distinct designs based on its construction under the respective schemes and projects. Each scheme/project has their own specification for the construction of the cyclone shelters; however, they follow the major design and structural recommendations provided by the GOI-UNDP Disaster Risk Mitigation programme (GoI, 2006). (Figure 20)

Figure 20: View of the MPCS constructed under PMNRF and NCRMP-II respectively, photographs taken by the author, May 2019. Graphical image Source: (GoI, 2006) and (Government of West Bengal, 2017)

6.1. Methodology:

MPCS are an immediate and short-term refuge to the local inhabitants during cyclones, as well as few days after the calamity in some cases. The use and maintenance of cyclone shelters during rest of the year or fair-weather periods is equally important as huge investments are involved in erecting these shelters (NDMA, 2009). The main focus of this study is to enumerate the sustainable utilization during fair-weather periods and evaluate their present condition. The population bearing capacity of each MPCS during a cyclone has been calculated and suitable recommendations attempted.

The MPCS of the five blocks of Purba Medinipur District have been visited physically, and the locations have been collected through a handheld GPS receiver.

The shelters have been categorised based on several criteria with the help of weighted scoring model of multi-criteria decision analysis using Analytical Hierarchy Processing (AHP). The factors for AHP have been assigned a numerical rating based on its relevance to the functioning of the MPCS as obtained from the inputs of the surveyed respondents belonging to the vulnerable population. The inputs were used to generate the weights of the factors using AHP and validated.

Table 8: Factors for rating of MPCS and their numerical rating after discussion with local respondents (Faruk, Ashraf, & Ferdaus, 2017)

	Site selecti	Access ibility	PwD friendl	Ventil ation	Sanita tion	Inner design	Indoor constru	Fire safety	Emerge ncy	Signag e	Mainte nance
Site selection	**1.00**	0.67	0.83	1.67	0.67	0.83	1.67	1.67	1.67	1.43	2.00
Accessibility	1.50	**1.00**	1.25	2.50	1.00	1.25	2.50	2.50	2.50	2.14	3.00
PwD friendly	1.20	0.80	**1.00**	2.00	0.80	1.00	2.00	2.00	2.00	1.71	2.40
Ventilation	0.60	0.40	0.50	**1.00**	0.40	0.50	1.00	1.00	1.00	0.86	1.20
Sanitation	1.50	1.00	1.25	2.50	**1.00**	1.25	2.50	2.50	2.50	2.14	3.00
Inner design	1.20	0.80	1.00	2.00	0.80	**1.00**	2.00	2.00	2.00	1.71	2.40
Indoor construction	0.60	0.40	0.50	1.00	0.40	0.50	**1.00**	1.00	1.00	0.86	1.20
Fire safety	0.60	0.40	0.50	1.00	0.40	0.50	1.00	**1.00**	1.00	0.86	1.20
Emergency power	0.60	0.40	0.50	1.00	0.40	0.50	1.00	1.00	**1.00**	0.86	1.20
Signage	0.70	0.47	0.58	1.17	0.47	0.58	1.17	1.17	1.17	**1.00**	1.40
Maintenance	0.50	0.33	0.42	0.83	0.33	0.42	0.83	0.83	0.83	0.71	**1.00**

The factors were scored on pertinent criteria into 3 classes:
0 unsatisfactory; 1- average; 2- highly satisfactory. A score of 1 or average was marked when the individual factor fulfilled at least one of the criteria but not all.

Table 9: Weighted scores for rating of each MPCS

Key factors	Detailed criteria for scoring	Assigned weights
Site selection	• *Elevated land* • *Nearness to coast*	10
Accessibility	• *Road network connectivity* • *Metalled road connectivity*	15
PwD friendly	• *Ramp for movement of wheelchair* • *Special toilets*	12
Ventilation	• *High ceiling for good air circulation*	6
Sanitation	• *Separate toilets for males and females* • *Area for hand washing*	15
Inner design	• *Shelves for storing belongings of the MPCS users* • *Usable kitchen area* • *Operational fans and lights*	12
Indoor construction	• *Proper Doors and Windows as per the government guidelines* • *Area for shelter of domestic animals* • *staircase*	6
Fire detection	• *Fire safety measures*	6
Emergency power	• *Availability of emergency power generators*	6
Signage	• *Sign boards* • *Knowledge of the existing nearby cyclone shelter among locals*	7
Maintenance of Infrastructure	• *Present condition* • *Sustainable use* • *Maintenance of the building*	5

(Queensland Government, 2006), (CBM International, 2012), (Faruk, Ashraf, & Ferdaus, 2018), (India, 2019), (Government of Bangladesh, 2012), (Government of India, 2010).

Weighted score of each factor was attained by multiplying the individual score of the factor (as obtained above) with the assigned weight. The weighted score of each MPCS was achieved by summation of the weighted scores of each factor thus achieved. (Table 9) The achieved weighted scores of MPCS were then arranged in ascending order and classified into quartile classes: Good, above average, Scope for improvement and Unsatisfactory.

Both primary and secondary data have been used in the study. Primary data has been collected through household survey, detailed questionnaire survey and focused group discussions with different stakeholders. Simple random sampling method has been used for the selection of the respondents of the questionnaire survey.

341 respondents belonging to 118 households were surveyed at doorstep through direct interview. Inputs from the local administrative offices were also taken into consideration. For even representation of household surveys, the study area of 5 blocks was divided into grids of 4 sq km each. At least one household was surveyed randomly from each grid.

Locational suitability of the MPCS with spatial distribution of population has been analysed by mean centre of population. Information about the problems faced by the local people during their stay at the MPCS has also emerged through these surveys. The location of a particular point can be defined by means of two coordinates $(\bar{x}, \bar{y})$ and the mean centre of a point is defined as a point with 2 coordinates (x, y). To find the mean centre, rectangular coordinates (x_i, y_i) of each point (location of MPCS in this study) need to be noted. To provide greater importance to some points than others, they are usually weighed by different relevant variables like shop locations may be weighed by amount of sale, factories by production, wells by number of people using them and, in our study, the location of the MPCS may be weighed with the population of the community development block

Government reports and plans, published journals and the census of India are the major secondary sources of data. The local administrative offices have provided data about the different constructional specification of the cyclone shelters. The road networks to understand the connectivity and accessibility of the cyclone shelters have also been collected from the official website of Institutional Strengthening of Gram Panchayats (ISGP) Programme-II, Panchayats and Rural Development, Government of West Bengal.

6.2. Results and Discussion:

6.2.1. Location and Number of the Cyclone Shelters: A total of 41 existing MPCS have been surveyed in 5 blocks in the district of Purba Medinipur. The MPCS were constructed using government funding under 2 schemes- PMNRF and NCRMP-II. Figure 21 depicts their locations and Table 10 shows their names in the five community blocks of Purba Medinipur district.

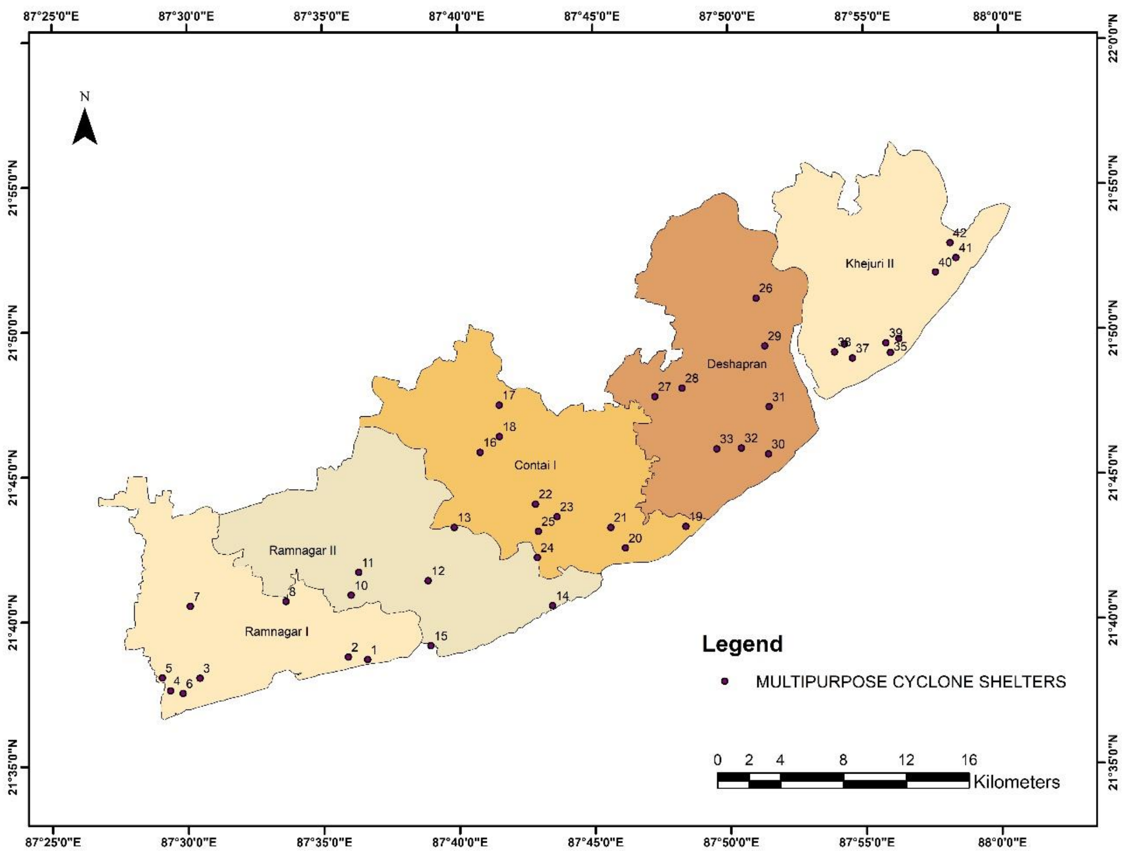

Figure 21: Location of cyclone shelters

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Table 10: Block wise Names of the Multipurpose Cyclone Shelters

Name of The Block	Scheme *	Gram Panchayat	Index Number	Name Of MPCS
RAMNAGAR –I	A	Talgachari - II	8	Talgachari - I MPCS
		Haldia - II	7	Dihibirkul MPCS
		Padima - I	6	Ratanpur Madhyamik Shiksha Kendra
	B	Padima - I	5	Mandala Harijan Primary School
			4	Padima Ramprasad Primary School Ground
			3	Digha D. J. Sikshya Sadan Ground
		Talgachari - II	2	Chandpur Kamdeb Upper Primary School Ground
			1	Jaldha Harijan Primary School
RAMNAGAR – II	A	Balisai	10	Balisai Kanya Vidalaya
			11	Purba Karanji MPCS
		Satilapur	12	Kandarpapur MPCS
			13	Uttar Shitala MPCS
	B	Kalindi	14	Dakshin Purusottampur Bholanath SSK
			15	Mandarmoni MPCS
CONTAI – I	A	Dulalpur	16	Dulalpur MPCS
		Haipur	17	Haipur MPCS
		Raipur Paschimbar	18	Raipur MPCS
	B	Nayaput	19	Biramput Primary School Gournd
			20	Baguran Jalpai
			21	Chinnchuraput Primary School Ground
		Sabajput	22	Sabajput G. P. Ground
			23	Badalpur Primary School Ground
			24	Samudrapur Primary School Ground
			25	Daudpur Pry. School
DESHAPRAN	A	Amtalia	26	Amtalia MPCS
		Sarda	27	Mahisamundra MPCS
		Basantia	28	Basantia MPCS

	B	Basantia	29	Shyamchak Primary School
		Dariapur	30	Bankiput High School Ground
			31	Dariapur Primary School Ground
			33	Uttar Haraschak Sorojani Shiksha Niketan Ground
		Bamunia	32	Jhawa Panchanan Primary
KHEJURI – II	**A**	Nijkasba	34	Panchuria MPCS
			35	Owasilchawk,Near Amrit Bharti High School
	B	Nijkasba	36	Shillyaberia R. H. C.
			37	Hijli Gopichak High School
			38	Battalya Primary School
			39	Kalaychak
		Khejuri	40	Ram Krishna Saraswati Jr. Basic Pry. School
			41	Khejuri Irrigation Bunglow
			42	Sathkhanda Saheb Nagar Jr. Basic Primary School
*__Scheme A represents PMNRF__, and **Scheme B represents NCRMP-II**				

The analysis of the central tendency in a spatial distribution of point patterns yields an idea of the centre involving the average of a given data set. Mean centre of distribution is the simplest measure of central tendency which allows locating the mean centre of a spatial distribution. Cyclone shelters are more required in areas having higher population in the concerned Community Development Block. So, the locations of the centroid of the

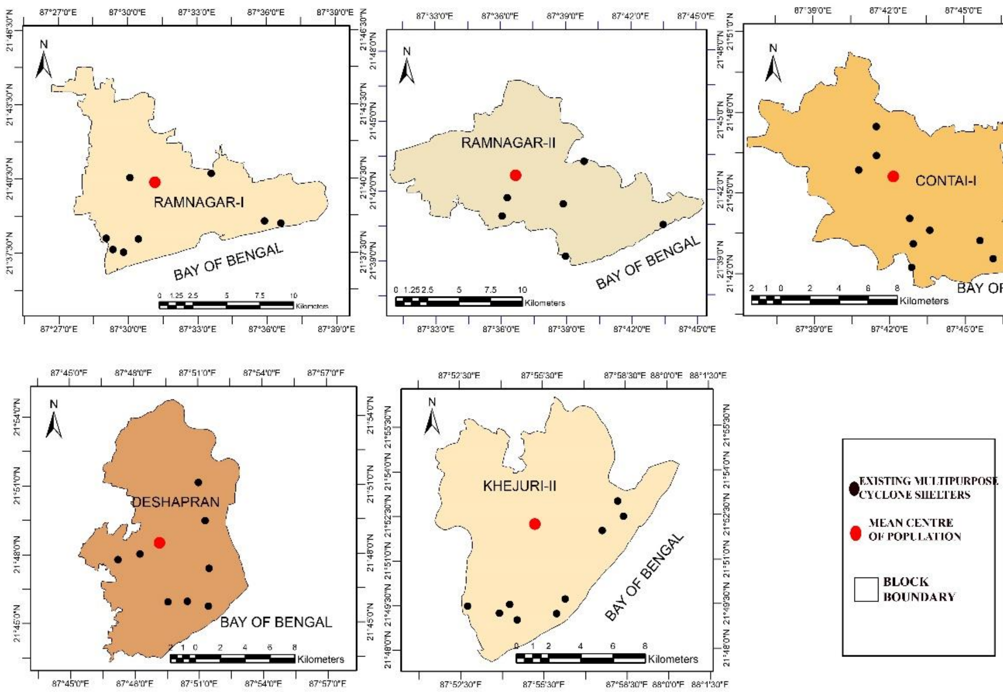

Figure 22: Mean Centre of Population and Location of Existing MPCS

administrative unit have been weighted by population. Figure 22 depicts the weighted mean centre of population in correspondence to the locations of the existing MPCS.

$$\bar{x}_w = \frac{\sum(x_i w_i)}{\sum w_i}$$

$$\bar{Y}_w = \frac{\sum(y_i w_i)}{\sum w_i}$$

Where, $(\bar{x}_w \bar{y}_w)$= the coordinates of the weighted mean centre; W_i= the weight (i.e., population) (Burt, Barber, David, Robeson, & Horner, 2009).

The cyclone shelters in Ramnagar-I are located near the coast, about 6 kilometres from the mean centre of population. The shelter nearest to the mean centre is at a distance of about 2 kilometres. There is unavailability of shelters towards the northern parts of the block. People residing in the northern parts of the block face difficulty in finding concrete structures during cyclones. Most of the shelters are concentrated in the south western part of the block.

In Ramnagar-II block, the shelter nearest to the mean centre of population is 1.8 kilometres away while the farthest is 12 kilometres away. All the MPCS in this block are within 10 kilometres of the coast.

Maximum number of MPCS is located in Contai-I block. However, there is scope for construction in the northern parts and around the mean centre of population for providing shelter to more vulnerable population.

In Deshapran block, the farthest MPCS from the mean centre of population is 7 kilometres away. The MPCS are dispersed almost throughout the block. However, there is need for more in the northern part of the block as well as the western section.

All the MPCS are away from the mean centre of population in Khejuri-II block. They are concentrated near the coast line, almost 7 kilometres away.

According to the UNDP guidelines, coastal states are advised to carry out a survey within 10 km from the coast (GoI, 2006). The cyclone shelters are to be located on the available elevated lands. In absence of available elevated area, the structure may be elevated through construction of a mound or shelter be built on stilt (NDMA, 2009). Studies have shown that unless a cyclone shelter is within 1.5 km of the house, it may be too distant to reach the shelters at the crisis moment. The local people, afraid of theft sometimes defer their withdrawal to the shelter (Rahman & Islam). At times, conveyance is provided by the local authorities to relocate the vulnerable people to the shelters, but in most cases the villagers have to walk along with their belongings to the nearest cyclone shelters. Hence the physical condition of the roads leading to the MPCS need to be taken into consideration. The shelters are a community asset for sustainable and regular utilization of the structure and it is best to be constructed inside or near villages (GoI, 2006).

6.2.2. Physical Facilities available in the MPCS: The shelters are equipped with 2 toilets each for male and female occupants in addition to 6 urinals dedicated for men. The toilets are 9 sq. ft. to 12 sq. ft. in size. Septic tanks are available. Figure 23 shows a complete view of a MPCS. There are community kitchens (c) in each MPCS; people take refuge in the shelters for about 2 to 3 days or until the water has receded. In such cases cooking meals for the people is very important. No kitchen utensils or provisions for cooking gas have been noticed in any of the cyclone shelters. There are storage areas available in the shelters for keeping supply like emergency kits, medication, grocery etc. Some villagers own livestock like cows, goats, pigs, hens, chicken and other domesticated animals that are also under threat during severe cyclones and sea water inundation. The shelters have specific areas to provide protection to these animals (e). Ramp with a slope of 1:8 for easy access of physically disabled, aged and children and animals are provided in the MPCS

Fishermen and small-scale farmers residing in small mud huts near the coast are at highest risk from the cyclones. These huts in most cases are unable to withstand the high velocity winds. Cyclones are also associated with storm surges that inundate few kilometres of land. These local people often take refuge in the Multipurpose Cyclone shelters during the disaster periods. The cyclone shelters are concrete structures that are able to withstand more than 65 km/h of wind speed. Under guidelines provided by the government, the buildings are two storeyed with or without stilt depending on the level of storm surge. Depending on the local top soil conditions and soil strata, pile foundations are done (GoI, 2006). The plinth height of 1.5 m is used for stilt with the height varying from 2.5 m to 4.5 m in areas with the storm surge level of more than 1.5 m and less than 4.5 m. According to the guidelines, the floor levels of the shelters in the coastal areas are constructed at least 0.5 m above the possible maximum surge level (NDMA, 2009).

Figure 23: (a) view of the MPCS, (b) hall for people to take shelter, (c) kitchen, (d) toilet for specially abled person, (e) space for cattle, (f) ramp for easy entry into the MPCS. Photographs taken by author

The MPCS were categorised into quartile classes. Relevant factors were considered and they were assigned weights. The MPCS was scored in each of these factors as 0, 1 and 2. (Table 9). The weighted score of each MPCS is calculated and the ascending order of their arrangement is depicted in the form of a box and whisker diagram with quartile classes.

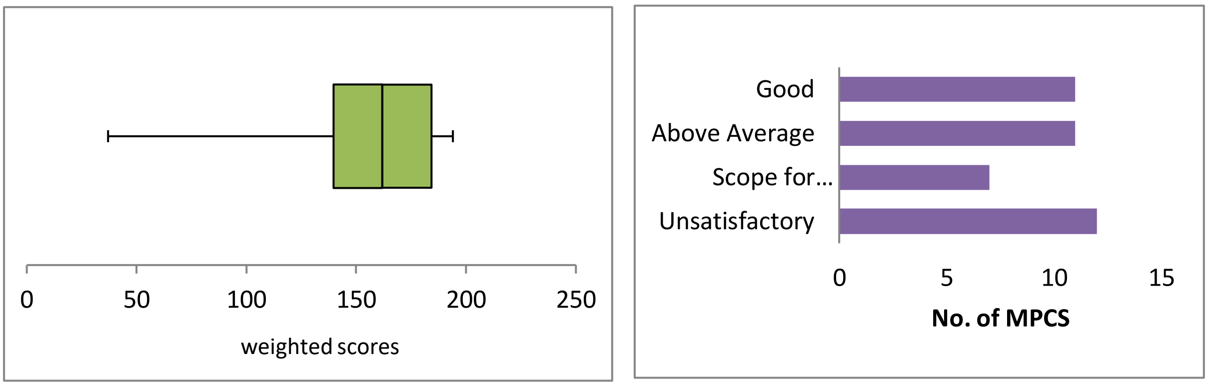

Figure 24: a) Box and whisker diagram of the MPCS as per their assigned weighted score
b)Classification of MPCS according to their weighted score

The study finds that 29.2% (n=12) of the 41 MPCS in the 5 blocks to be unsatisfactory in terms of maintenance and available amenities, while 26.8% (n=11) fared good in the selected criteria.

Observations of some of the surveyed villagers obtained through questionnaire studies and focused group discussion are depicted in Table 11.

Table 11: Selected observations of some of the locals from the vulnerable population about MPCS

Response	**Respondent**
1.Rooms are inadequate in size and gets too crowded during emergency	Housewife, age 48
2.There should be more shelters and separate room for females	Housewife, age 40
3. There should be clear directional sign or arrow in the main rood to the flood shelter.	Student, age 21
4.There is need to employ security guards	Government official, Ramnagar II
5.There should be some provision of solid cooked foods	Housewife, age 21, mother of 2.
6.The toilet have no water supply and gets very dirty during the stay at crisis periods	Runs a shack, age 38,

7.Have to sit throughout the stay no provision of lying down	Housewife, age 52
8.We use the cyclone shelter for our school's annual programme	Student, age 13
9.The shelters are beautiful and pride of our village	Fisherman, age 58

Source: Primary survey by author.

6.2.3. Sustainable use of the MPCS: The use of this shelter during non-disaster periods leads to its better maintenance and can be used more effectively during emergencies. Regular use also provides economic justification for the investment. The primary use of the cyclone shelter is to provide refuge to the local population in times of the natural calamities such as flood, cyclone, tsunami and other disasters. The Cyclone shelters are often used as training camps, election booths, health camps, community gatherings and meetings, but use as schools or offices are not recommended as the shelters are to be evacuated immediately in case of cyclone warning. In Ramnagar I block one of the cyclone shelters is being used to assemble and store bicycles (Figure 25) for a local government scheme which is violating the basic norms as relocating huge amount of goods and parts of a bicycle is not a very easy task considering disaster situations. Another MPCS in Contai 1 is being used as a computer training centre. Some are even used as local primary schools.

a b c

Figure 25: a) Computer Training Centre; b) Cycle Assembling/ Storing; c) Primary school

6.3. Conclusion:

There are 41 existing Multipurpose Cyclone Shelters spread across 5 blocks of Purba Medinipur district of West Bengal. It is observed that the MPCS are not suitably located with respect to the mean centre of population in most of the blocks under study. The mean centre of population denotes the area where the availability of MPCS would be of maximum benefit to the vulnerable population.

Through extensive survey of different stakeholders, the study further concludes that the villagers are reluctant to move to the MPCS in a cyclone warning. The main reasons elucidated are lack of conveyance, lack of knowledge about the nearest shelter as well as lack of trust in the local administration.

Most of the shelters in the surveyed blocks of Purba Medinipur district are reasonably maintained and offer acceptable number of basic amenities. However, some deviations from the guidelines set forth by the government and different global organisations are observed. Lack of maintenance of the structures, lack of sanitation and hygiene and basic amenities like electricity and potable water were also observed in a fairly large number of the MPCS that need addressal to ensure their smooth functioning at times of need.

The study intends to classify the standards of the surveyed 41 MPCS according to set parameters in a weighted scoring model. It is found that majority of the MPCS in the 5 blocks to be unsatisfactory in terms of maintenance and available amenities.

Few of the MPCS are being sustainably used. Some even have regular revenue generation that in turn assists in funding the maintenance of the structures. Semi-permanent structures and furniture within the MPCS building that was observed in some may be difficult to evacuate on a cyclone warning.

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CHAPTER SEVEN

LOCATIONAL SUITABILITY OF MULTIPURPOSE CYCLONE SHELTERS

CHAPTER SEVEN

LOCATIONAL SUITABILITY OF THE MPCSs

7.0. Foreground:

Hazards have varied impacts on affluent and impoverished countries of the world (Rentschler, Salhab, & Jafino, 2022). Coastal cities of south-eastern part of Asia face the ill effects of anthropogenic activities brought on by population growth and climate vulnerability (Andal, 2022). The poor population of a hazard prone area have limited choices, where they can live or take shelter during a crisis (United Nations, 2015) . Coastal resilience is the ability of the community to deal with the effects of the disasters a coastal area is subjected to (Masselink & Lazarus, 2019). It involves development and deployment of measures that help to reduce the effects of a disaster as well as speedy recovery after a disaster (Almutairi, Mourshed, & Ameen, 2020). Assessing the community resilience is the first step towards reducing the actual disaster risk (Burton, 2014). Infrastructural development is an important step towards reducing the risk of the hazard (Dasgupta, et al., 2010). Formulating natural disaster policies is a paramount responsibility for governments and policymakers to safeguard the lives and property of their citizens (Yum, 2024).

Availability of infrastructural support plays an important role in deciding whether a hazard will turn into a disaster. Infrastructure refers to the systems required for the functioning of a community (Scawthorn, 2009). Infrastructural facilities increase the communities' resilience and reduces the vulnerability (Mallick, Rahaman, & Vogt, 2011). According to OECD, infrastructural developments help to reduce direct losses so new infrastructure need to be built and the existing to be retrofitted (OECD, 2018). Some of the important physical infrastructural development in a coastal area includes construction of embankments, accessible roads, construction of high velocity wind resistant community buildings, availability of hospitals and health centres and safe drinking water availability. Embankment along the coast can prevent salt water inundation and reduce the amount of loss and damage (Mallick , et al., 2005). Good roads are essential for better accessibility and movement. During cyclones, people are advised to stay in high velocity wind resistant concrete structures. Multipurpose cyclone shelters (MPCS) are considered more effective disaster risk reduction, measured in comparison to cyclone track and storm surge predictions (Seo, 2017) .

Fishermen and small-scale farmers often reside in mud huts with thatched roofs within 200m of the high tide line. They lack the means to construct any disaster resilient house. Providing a cyclone resistant community building is extremely important to reduce fatalities. In unavailability of a MPCS, school buildings are also used to provide safe shelter to the otherwise poor population. It has been mentioned by (Cooper & Boyko, 2010) that it is ideal for coastal infrastructure to be situated at sufficient distance from the shore to maximise the protection from coastal hazards.

This study seeks to understand the status of existing public infrastructural facilities in the cyclone prone coastal belt of West Bengal, India. The uniformity of distribution of infrastructure and its proportional demand are two important aspects of evaluating infrastructural vulnerability. Mean centre of population is the estimation of spatial distribution of population geographically, similar to the arithmetic mean and standard deviation. In order to identify the kind of distribution—random, clustered, or uniform—Nearest Neighbour Analysis calculates the linear distance between two or more designated neighbouring places. Findings from this study and knowledge of the above-mentioned geographic parameters may assist legislators in more equitable distribution of resources, our case study being an example. This will eventually enhance coastal resilience, reducing loss to lives, livelihood and economy.

7.1. Methodology:

7.1.1 Data source and study approach: The study takes into consideration the existing infrastructural facilities, mainly focusing on multipurpose cyclone shelters, high schools, healthcare centres, road infrastructure and administrative institutions that are available in the study area. Primary data has been collected through household survey, detailed questionnaire survey and focused group discussions with different stakeholders. Cluster sampling method has been used for the selection of the respondents of the questionnaire survey.

Sample size has been calculated as per formula (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

For even representation of household surveys, the study area of 5 blocks is divided into grids of 4 sq. km each as depicted in Fig 24. At least one *kaccha* household (non-concrete structure) is surveyed randomly from each grid. 341 respondents belonging to 118 households are surveyed at doorstep through direct interview.

The considered infrastructural facilities have been visited physically and the locations have been recorded through a handheld GPS receiver. Geographic Information system (GIS) software like Arc GIS 10.3.1 and QGIS 3.14 have been used to compute the buffer areas of each infrastructure. The road network has been extracted and from the official website of Institutional Strengthening of Gram Panchayats (ISGP) Programme-II, Panchayat and Rural Development, Government of West Bengal (Government of West Bengal, 2019) as well as from Google Earth Pro.

7.1.2 Methods of analysis: In this study equality of distribution of the available infrastructure has been evaluated after Clarks and Evans (Clark & Evans, 1954) by using Nearest Neighbour scale. Nearest Neighbour Analysis (NNA) evaluates the spread or distribution of something over a geographical area and its calculation is depicted as follows (Royal Geographical Society, 2023). It calculates a numerical value that denotes whether a set of points are clustered or uniformly dispersed in a geographical space.

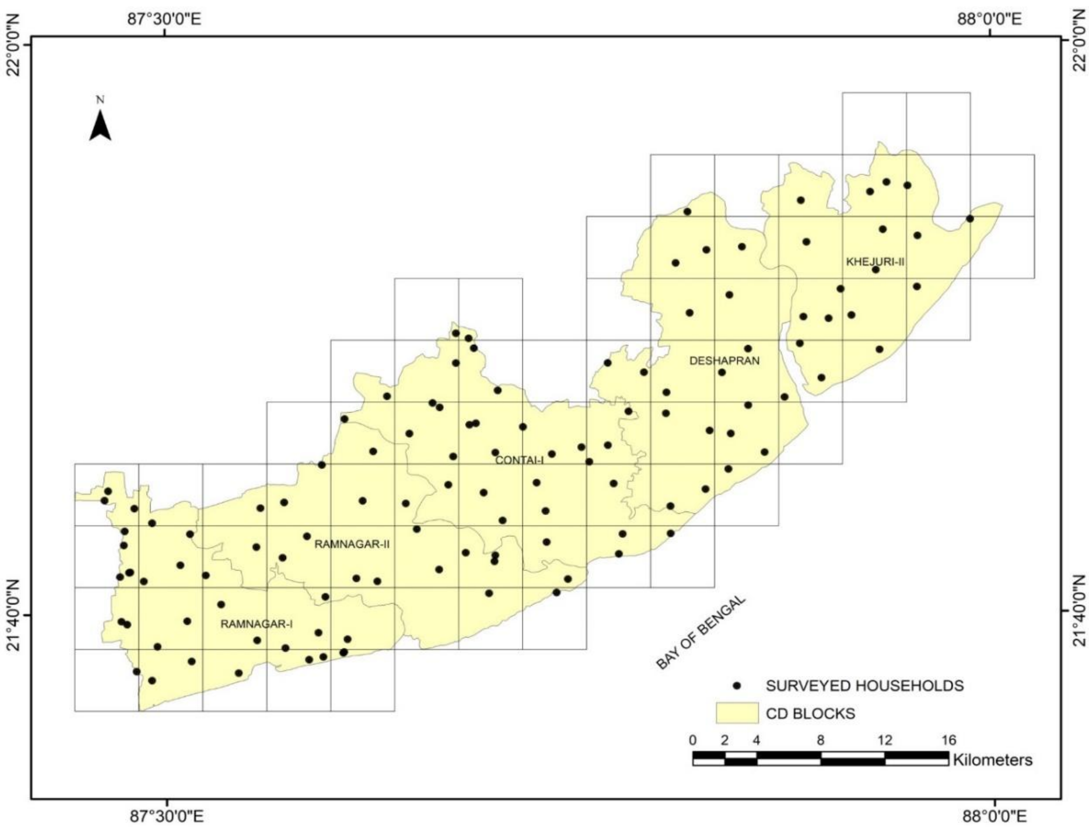


Figure 26: Grid map of study area

$R_n = \frac{\bar{D}o}{\bar{D}E}$

$\bar{D}_O$=*observed* mean of the nearest neighbour distance

$\bar{D}_E$= expected mean of the nearest neighbour distance

$\bar{D}_O = \frac{\Sigma d}{n}$ $\bar{D}_E = \frac{1}{2\sqrt{p}}$

n= Total number of MPCS in a region

R_n= Nearest Neighbour Index

a= Area of the respective CD blocks under study

p = density of points in an area $^{n}/_{a}$ [22]

The study postulates that:

H_0= Point distribution is random

H_1= Point distribution tends towards clustering/ dispersion

z score is calculated by the formula: $z = \frac{\bar{D}O - \bar{D}E}{SE}$

Standard Error is calculated by: $SE = \frac{SD}{\sqrt{n}}$ (SD= Standard Deviation)

According to the theory of normal distribution, z score has critical values of + 1.96 and – 1.96 at α=0.05. If $z < -1.96$, the null hypothesis H_0 is rejected and alternate hypothesis (H_1) of clustering is accepted. On the other hand, if $z > 1.96$, the null hypothesis H_0 is rejected and alternate hypothesis of dispersion is accepted. When $-1.96 < z < +1.96$, H_0 must be accepted to state that the pattern is random.

The distribution pattern can be interpreted by following a scale of nearest neighbour index. If *Rn* value is < 1, the distribution pattern is considered to be clustered, if *Rn* is around 1, it is said to be geometrically regular and uniform and if *Rn* value > 1, it indicates that the distribution is randomly dispersed. The degree of dispersion increases with increasing value of *Rn*.

A cyclone shelter is a community building; built to ensure safety of the local people from the cyclones and associated storm surge inundation (Rahman & Islam , 2015). Cyclone shelters serve as immediate and temporary refuge to the local people and their livestock during any natural calamity (Haider & Ahmed, 2014). They are considered a well proven measure of preparedness throughout the world. Several studies have shown that people are unwilling to move to the cyclone shelters if they are more than 1.5 km from their house (Rahman & Islam , 2015) . From primary survey it is seen that the local residents are not willing to walk more than 30 minutes to reach a nearby MPCS. In times of emergency most people are able to walk a distance of 1km in 30 minutes (Hossain & Rahman, 2018). So MPCS within 1km of the respondent's house has been considered to be used. High schools are permanent public structures that can be used for emergency evacuation centres in times of natural hazards like cyclones, tsunamis and tornadoes (National Center for Education Statistics, 1999), (Department of Defense, 1962). Again, a distance of 1 km of a high school has been considered, where people can take shelter in case of an emergency or unavailability of a MPCS. There are a limited number of health care facilities in the study area. A Health centre 2 km from a respondent's household is considered. Administrative buildings such as Block development office and gram panchayat office are concrete structures that can also be used to take refuge in case of a cyclone hazard. This study only considers public infrastructures and not private ones. Road network links all the facilities available; availability of a metalled road for easy movement. Road accessibility is an important criterion for utilization of all the other infrastructural facilities. The local residents opined that if a metalled road is available within 500 m of their residence, they will be able to relocate to the nearest shelter more easily along with their cattle and belongings. This mood of the surveyed population is reflected in Table 12 as feasible distance of the surveyed household from the selected infrastructure.

Table 12: Distance of surveyed households from selected infrastructure

Infrastructure	Surveyed Households within a radius of
Multipurpose Cyclone Shelters	1 Km
High Schools	1 Km
Healthcare Facility	2 Km
Administrative offices	2 Km
Metalled Roads	0.5 Km

To calculate the "uniformity of distribution" of the different infrastructural facilities the following formula has been used (Mallick, Rahaman, & Vogt, 2011).

$$Rx = \frac{SHx}{SH}$$

"Demand index" and the corresponding "Degree of Demand" (Mallick, Rahaman, & Vogt, 2011) has been calculated to evaluate the functionality of the selected public infrastructures. The formulae used are:

$$Dx = \frac{Ex * SH}{SHx}$$

$$DDx = \frac{Dx - Ex}{Dx}$$

R_x	Uniformity of distribution value of the x-th infrastructure
SH_x	Total number of surveyed households possessing the chance of accessing the x-th infrastructure
SH	Total number of surveyed households
D_x	Total demand of the x-th infrastructure
E_x	Total number of x-th infrastructure presently existing in the study area
DD_x	Degree of demand of the x-th infrastructure

Uniformity of distribution R_x denotes a value ranging between '0 and 1'. If $R_x = 1$, the x-th infrastructure caters to 100% of the total population; similarly, if Rx=0, then x infrastructure in unable to sustain the population.

DDx also lies between '0 and 1'. So, if the value of DDx=0, then the selected infrastructure is capable of supporting the population whereas if the $DDx = 1$, it is incapable of supporting the population. *Rx* and *DDx* values are contrary to each other.

7.2. Results and Discussion:

Based on the Nearest Neighbour Analysis or R_n values, the MPCSs in all five selected community development blocks of Purba Medinipur have been assessed and depicted in Table 13. The MPCS of Ramnagar I is geometrically regular and uniform, as evidenced by R_n value of 1.01 (z score = 0.03 at α=0.05). In Contai-I and Deshapran, the pattern of distribution of MPCS fares somewhat inferiorly to Ramnagar I with R_n value of 0.89 and 0.90 and z score of -0.91 and -0.94 respectively at α=0.05, that indicates comparatively lesser geometrical uniformity.

The MPCS of Ramnagar II is randomly dispersed with R_n value of 1.43 and z score of 1.35 (α=0.05). This poses problems to the vulnerable population in relocating effectively during the disaster periods. Khejuri II portrays a clustered pattern of the distribution of the MPCS (R_n value of 0.45 and z score of -10.65 at α=0.05). The MPCS are clustered in 2 pockets in the southern part of the block, near the coast line.

Table 13: Nearest Neighbour Analysis

	Ramnagar I	Ramnagar II	Contai I	Deshapran	Khejuri II
Total Distance in km (ΣD)	16.50	22.30	18.32	16.90	7.78
Total No. of MPCS (Σn)	8.00	6.00	10.00	8.00	9.00
Area in sq km (a)	133.00	162.00	168.00	175.00	134.00
D_O	2.06	3.72	1.83	2.11	0.86
D_E	2.04	2.60	2.05	2.34	1.93
R_n	**1.01**	**1.43**	**0.89**	**0.90**	**0.45**
SE	0.59	0.83	0.24	0.24	0.10
Z score	**0.03**	**1.35**	**-0.91**	**-0.94**	**-10.65**

The nearest infrastructure from the surveyed households can be measured with the uniformity of distribution (Rx) of the selected infrastructure of the study area. The highest Rx value is

0.83 whereas the lowest *Rx* value is 0.21, this denotes that 21% of surveyed population have access to the respective public infrastructure and there is a scope for development of more infrastructure for the remaining 79% of the population which is the *DDx* value of the respective infrastructure. This indicates the degree of demand of the infrastructure is inverse to the uniformity of distribution.

Remarkably, MPCS have been found to cater to only 21 % of the vulnerable population. . The absence of metalled road infrastructure is found in the surveyed 5 blocks of Purba Medinipur with only 31% of the vulnerable population having access to this valuable infrastructure at times of need. High schools are concrete public buildings that can act as shelters in times of need or in absence of a MPCS, which is again remarkably low, and accessible to only 31% of the surveyed population. There is a more equitable distribution of health care facilities and administrative offices. There is a provision of improvement to cater to the rest 17% people, i.e., DDx for the same infrastructure is 0.17. It has to be noted that hospitals cannot used as mass scale refuge centres and only the people in serious need are to be relocated here.

Table 14: Uniformity of distribution and degree of demand

Infrastructure	*Ex*	*SHx*	*Rx*	*Dx*	*DDx*	% of Household possessing access to the infrastructure
Multipurpose Cyclone Shelters	41	25	0.21	193.52	0.79	21
High Schools	60	31	0.26	228.39	0.74	26
Healthcare Facilities	108	98	0.83	130.04	0.17	83
Administrative offices	41	65	0.55	74.43	0.45	55
Metalled Roads	64	36	0.31	209.73	0.69	31

Figures 27 to 31 denote the location of the respective infrastructures in the community development blocks along with the radius of a pre-fixed catchment area and the corresponding location of the surveyed households.

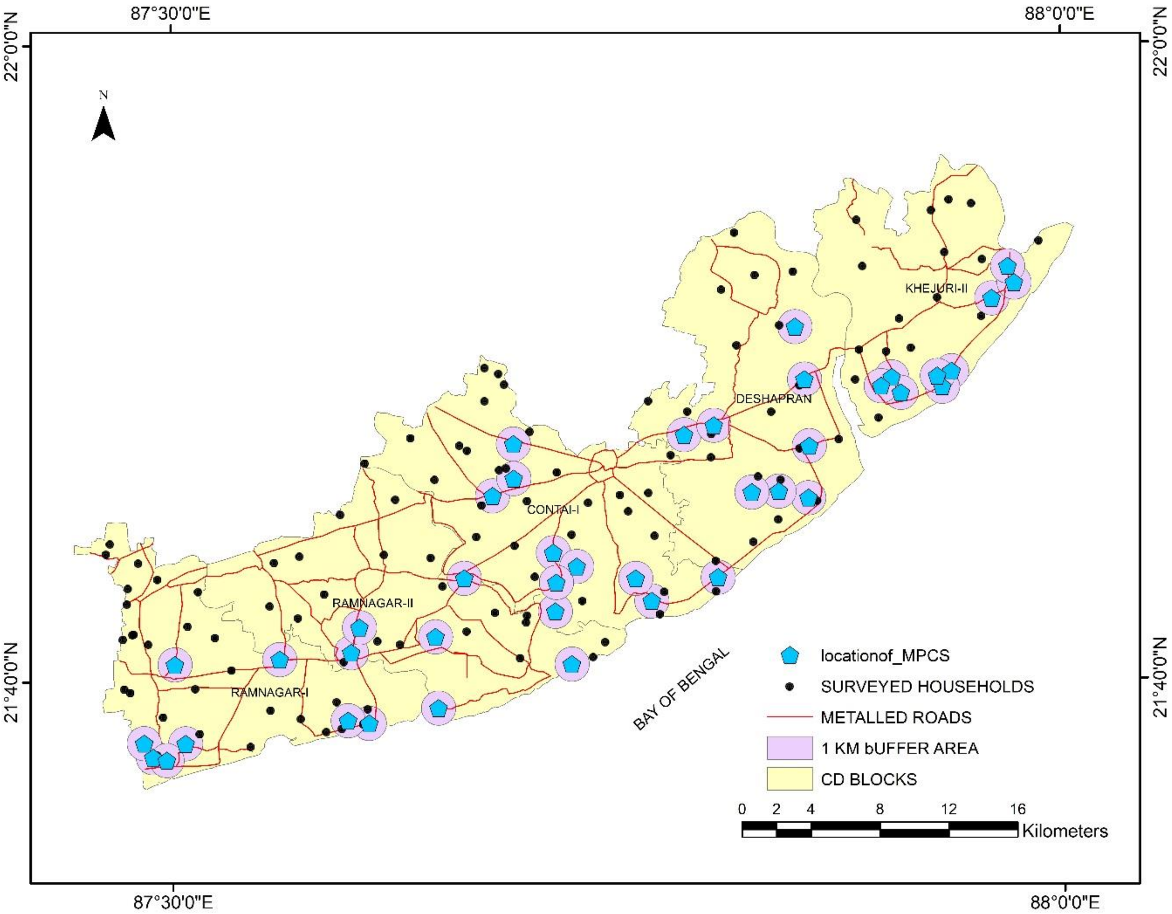
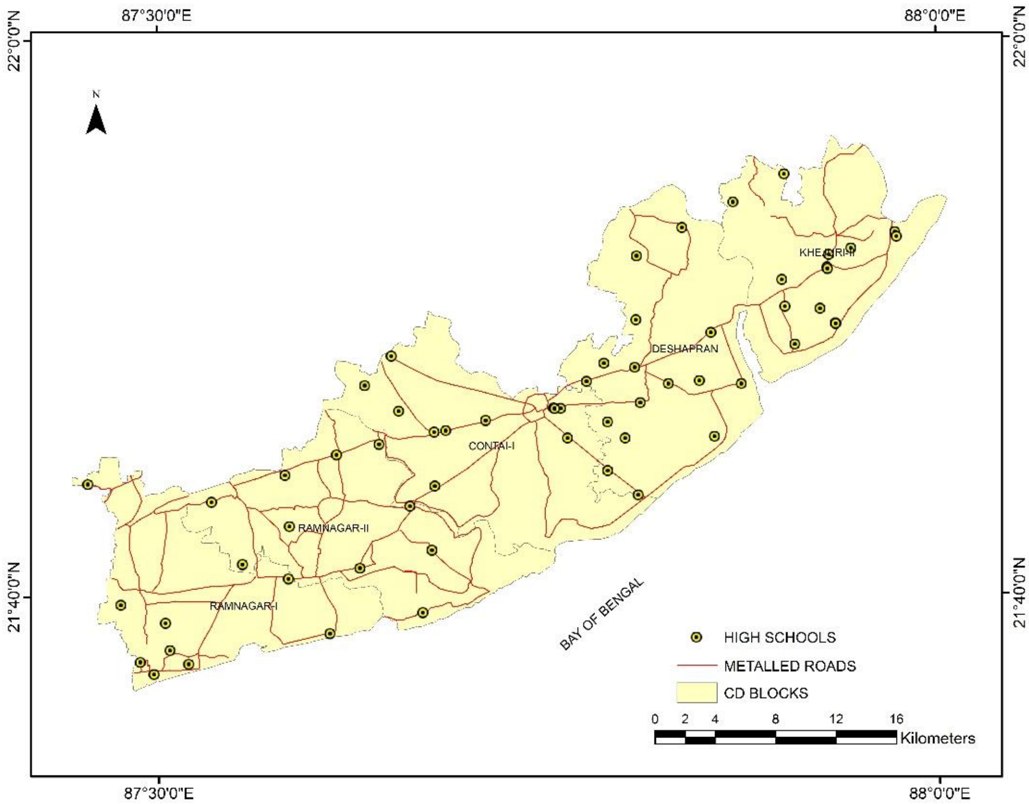


Figure 27: Surveyed households within 1 km radius of the MPCS



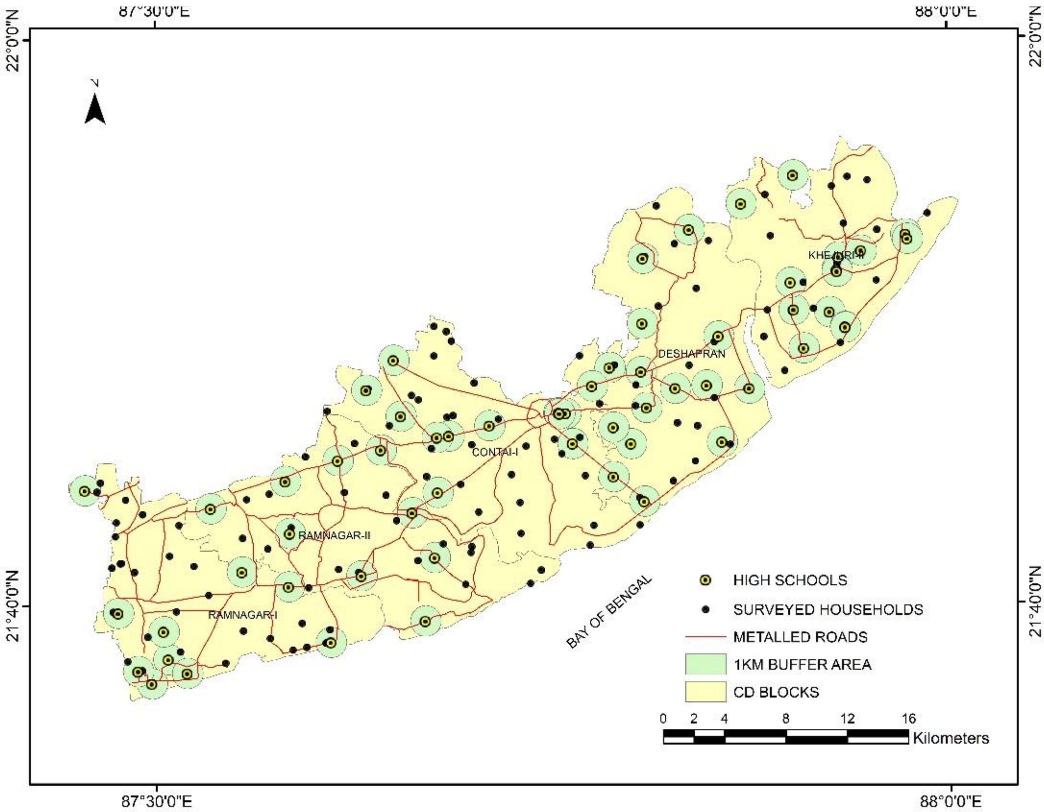


Figure 28: (i) Location of high schools in the 5 surveyed blocks of Purba Medinipur
(ii) Surveyed households within 1 km radius of the high schools

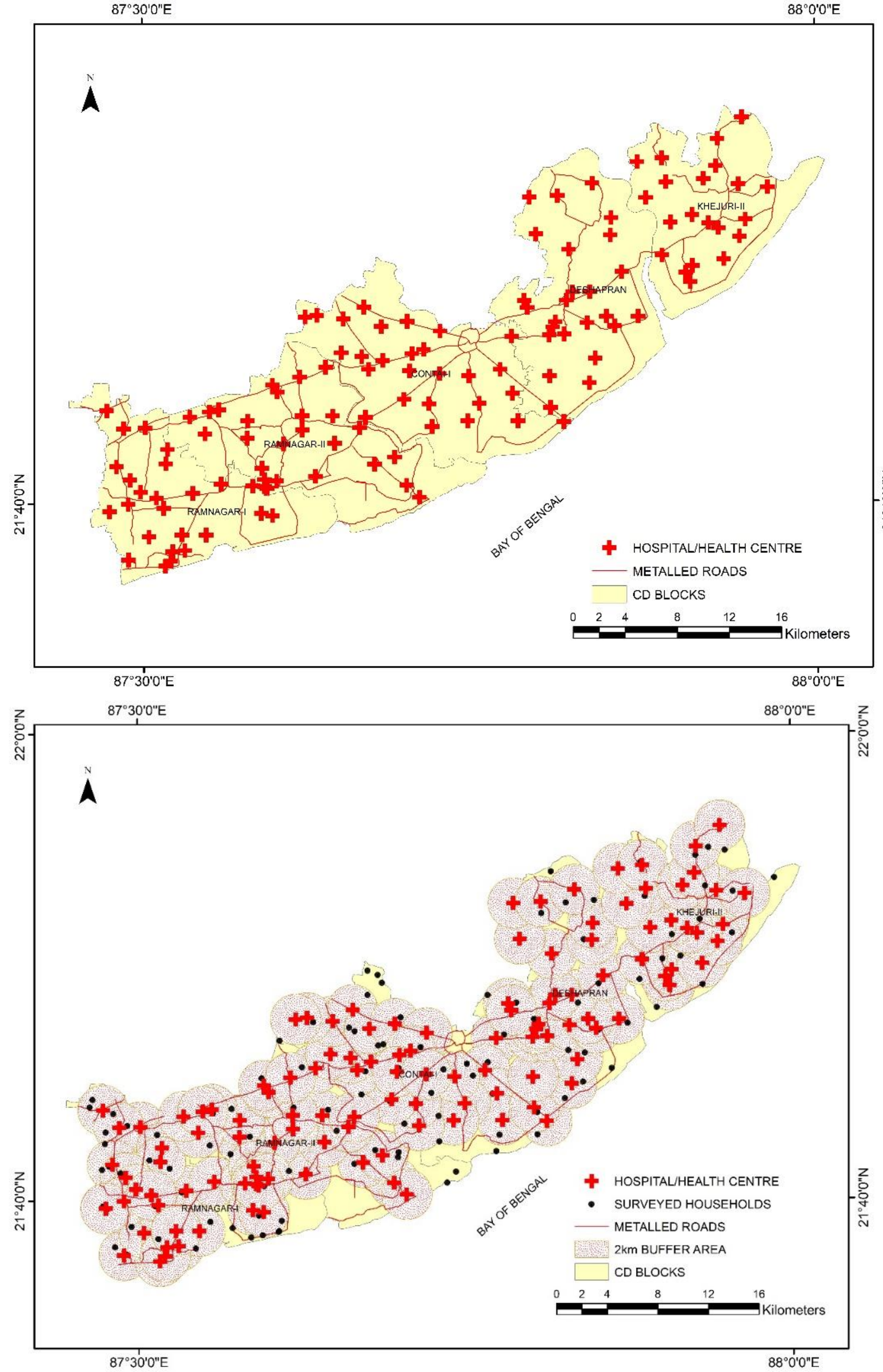
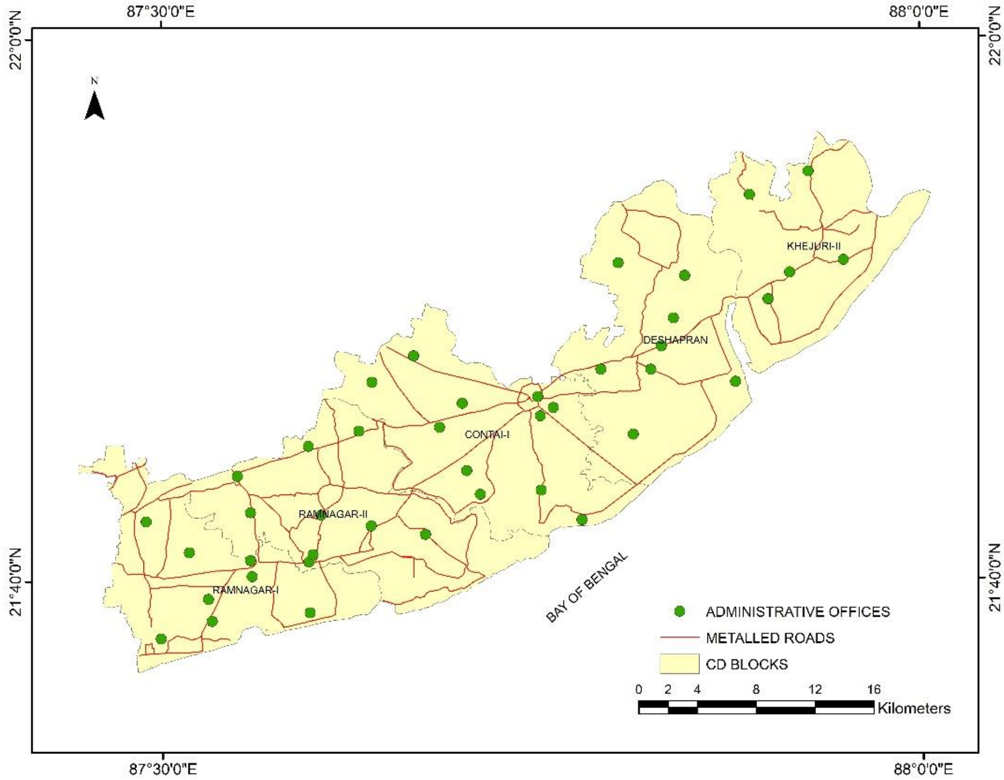


Figure 29: (i) Location of hospitals and health care centres in the surveyed blocks of Purba Medinipur (ii) Surveyed households within 2 km radius of the hospitals and health care centres



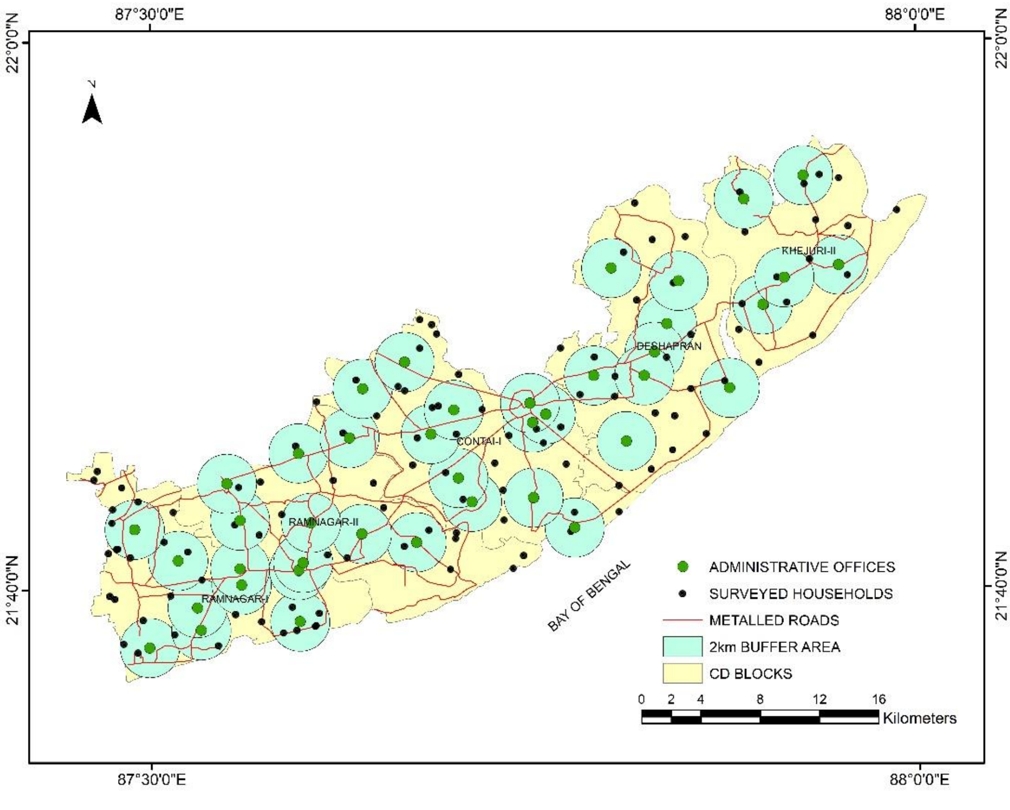
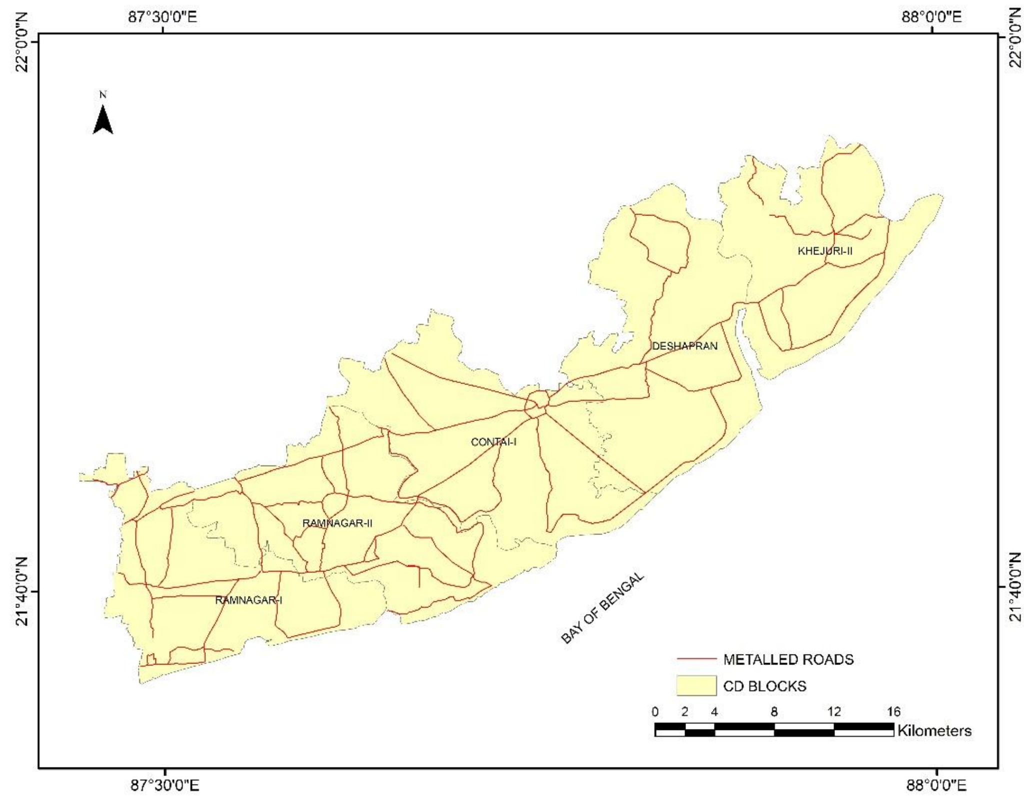


Figure 30: (i) Location of administrative offices in the 5 surveyed blocks of Purba Medinipur
(ii) Surveyed households within 2 km radius of the administrative offices



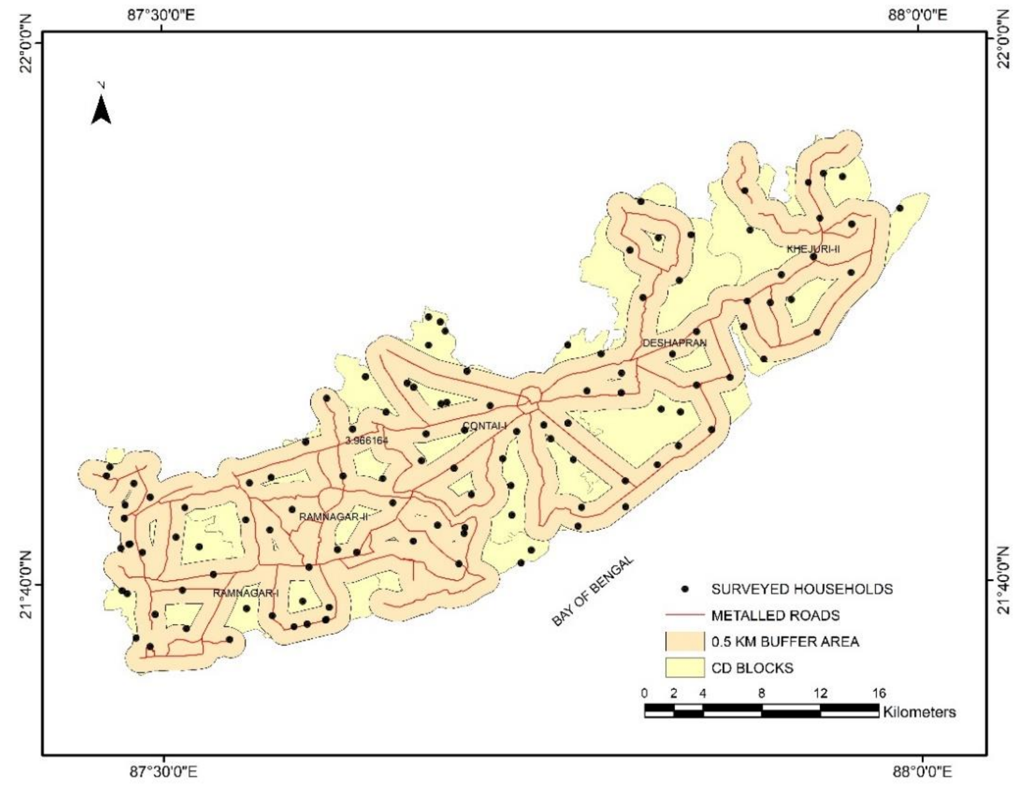


Figure 31: (i) Location of metalled roads s in the 5 surveyed blocks of Purba Medinipur
(ii) Surveyed households within 0 .5 km buffer of the metalled roads

Cyclone preparedness of a community is judged according to the number of households within a fixed radius of selected existing infrastructures. This study showcases the problems faced by the common population due to the limited number of community buildings. The UNDP guidelines advise the coastal states to thoroughly survey areas within 10 km from the coast as they are considered to be most vulnerable (Government of India, 2006).

The areas with maximum population require shelters as lives of huge population is at stake. Rahman A and Islam R opined that unless a cyclone shelter is within 1.5 km of the house, it may be too distant for the villagers to reach the shelters by foot in the time of crisis (Rahman & Islam , 2015). The local people, afraid of theft sometimes defer their withdrawal to the shelter. Unless a shelter is within walking of the household old people are very reluctant to relocate to the shelters. While selecting the location of the shelters, the population needs to be considered (Rana, Al Azad, & Islam, 2018).

For example, during the cyclone warning of "Cyclone Amphan" in May 2020 (Indian Meteorological Department, 2020), people living in small huts with thatched roofs were forced to relocate urgently. The shelters were over-crowded and the helpless vulnerable people were left with almost no suitable relocation options. Some took refuge in Pucca (Concrete) houses in the neighbourhood while few unfortunate others had to stay back in their houses with their livestock. This cyclone also coincided with the peak of the Covid-19 pandemic that made relocation and rescue efforts even more challenging, as there was a dilemma as to relocate maximum people or follow Covid protocols of social distancing (Sarkar , Chakraborti, & Dutta , 2021), (Office of the Registrar General & Census Commissioner, 2011).

Public awareness is another pillar of disaster management and capacity building (Mondal, Haldar, Biswas, Mandal, & Paul, 2021). From primary survey it has been seen that most of villagers are unaware of the location of the nearest cyclone shelter. At times they have no knowledge about the existing community structures that they can access in times of calamity. Political supremacy is noticed and alleged corruption in distribution of financial aid for reconstruction of the dilapidated households is quite rampant. Motivating or counselling these people during fair weather times need to be promoted. Pregnant women are rehabilitated at the nearest hospitals during the calamity period to avoid any unfortunate event, but women, in general are often apprehensive to leave their family members behind and move to the hospitals all by themselves.

Road accessibility is another aspect to be considered for capacity building and disaster preparedness. The roads are the lifeline of any area and connect to different infrastructure. On a cyclone warning all arrangements of food, drinking water are supplied to the shelters (Government of India, 2010). After the cyclone, if the connecting roads become inundated and inaccessible then the local inhabitants taking shelter are literally stuck in a deserted island without any connection with the outside world. The electricity supply of the area is often disrupted; so, having emergency backup power supply is important.

This study finds the MPCS of Khejuri to be both clustered and away from the mean centre of population of that community development block. The strategic locations of the MPCS of Ramnagar-I, Contai-I and Deshapran community development blocks are comparatively acceptable while that of Ramnagar-II are too widely dispersed to cater to the larger mass during times of need.

Moreover, if we take a holistic view of the entire study area, MPCS, high schools, healthcare facilities, administrative buildings and metalled roads are the important permanent infrastructures that deserve attention and provide much needed relocation, food and healthcare relief to the vulnerable population during the disaster periods. Natural disasters are seen to have less catastrophic impact when the local governmental bodies utilize public funding more effectively and provide better infrastructure (De Oliveira, de França, & Martins, 2024). The study finds an unequitable distribution of MPCS, high schools and metalled roads with only 21%, 26% and 31% of the surveyed households having reliable access to these infrastructures respectively. Healthcare facilities and administrative blocks are more uniformly distributed with only 17% and 45% of the surveyed households having inaccessibility to these respectively.

7.3. Conclusion:

This study was conducted in the 5-cyclone prone community development blocks in Purba Medinipur district of West Bengal, India. Primary data was obtained by surveying of 118 households selected by stratified random sampling and Secondary data was obtained from government registries and census of India.

The study finds a wide variability in locational distribution of the MPCS in the 5 CD blocks. The MPCS in the blocks of Ramnagar I, Contai I and Deshapran are uniformly distributed with Contai I and Deshapran showing a tendency towards lesser uniformity compared to Ramnagar I. Contrarily, the MPCS in Ramnagar II is widely dispersed and of Khejuri II is very clustered, posing problems to the vulnerable population.

An infrastructure is utilised utmost if it is located in the vicinity of the mean centre of population. Spatial analysis of the 5 CD blocks reveals the poor alignment of the location of MPCS in correspondence to the mean centre of population. Khejuri II is a stark example of poor planning of locational selection with none of the MPCS being close to the mean centre of population.

This study finds that 21 % of the vulnerable population have reasonable access to MPCS during the disaster periods, thus creating a huge unmet degree of demand. Quite satisfactorily, 83 % of the vulnerable population have access to healthcare facility during these difficult times.

Thus, while the administrative efforts are laudable, the absence of judicious planning is evident in many aspects of building a disaster resilient infrastructure. This study deciphers the lacunae of the existing infrastructure in disaster risk reduction. Addressing these to ensure a more equitable distribution of infrastructure may lead to a more holistic disaster preparedness planning of the community.

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CHAPTER EIGHT

ASSESSMENT OF HEALTH VULNERABILITY

CHAPTER EIGHT

ASSESSMENT OF HEALTH VULNERABILITY

8.0. Foreground:

The Indian subcontinent has recently seen an increasingly high incidence of natural disasters (Yadav & Barve, 2017), (Chakraborty & Joshi, 2016). Cyclones are the most common natural hazard experienced in the coastal areas of India (Ghosh & Mistri, 2023). Loss of lives and property and damage to crops are common phenomenon. Climate change is predicted to increase the frequency and intensity of disasters in the years to come (Field & Barros, 2014). The damage caused by these cyclones do not solely depend on the intensity and frequency of the cyclones alone, but also on the coping capacity of the people exposed to these cyclones (Dube, Mazumder, & Das, 2006).

Risk is defined by the negative effects of interactions between exposure, hazards, and vulnerable situations (UNISDR, 2009), (Brooks, 2003). Hazard refers to hazardous phenomena that could have a detrimental impact on one's health (Blaikie, et al., 2014), (Sterlacchini, et al., 2013) .Exposure relates to those who are present in hazard zones and may suffer potential health losses. Vulnerability describes the traits and conditions of a community which make it susceptible to the negative consequences of a hazard or in other words it is lack of competence to handle the possible undesirable outcomes (Shoaf & Rotiman, 2000). Hazard, exposure, and vulnerability can all be thought of as components of disaster risk (Kron, 2005), (Kelman, 2018).

The majority of the existing vulnerability measures and indices emphasize on social and economic vulnerability and often exclude the detailed aspects of health vulnerability while computing a holistic vulnerability assessment index (Khan, Chatterjee, & Bisai , 2013), (Chan, et al,. 2019). (Brooks, Adger, & Kelly , 2005). Health is often linked with the socio-economic condition and lifestyle of the community (Cutter, et al., 2003). Majority of health vulnerability indices were computed after 2010 and focused on how vulnerable the people were to climate change and climate-related events like heat wave, flooding and dengue fever (Chan, et al., 2019). Majority of increase in health problems are observed in the first 4 weeks following a cyclone (Wang & Geng, 2019), (GOI, 2021), (Saulnier, Ribacke, & Schreeb, 2017). The health problems of notable mention in the aftermath of a cyclone include diarrhea – including viral and bacterial etiology (cholera, etc.), pneumonia, outbreaks of measles, tuberculosis, typhoid due to overcrowding and lack of proper sanitation, etc (Huang, et al., 2023). The health infrastructural preparedness, vaccination status, comorbid status among others are important predictors for the extent of acute health crises after the natural hazards.

West Bengal is enlisted under the 12 cyclone prone states of India (Chatterjee & Kundu, 2021). The research area comprises five community development blocks in the Purba Medinipur district of West Bengal, India: Ramnagar-I, Ramnagar-II, Contai-I, Deshapran, and Khejuri-II. In parts of Purba Medinipur District of West Bengal, India, people living in close proximity to the sea are socio-economically backward and extremely vulnerable to the destruction caused by natural hazards. Risks do not pose only from high velocity winds but also from associated storm surge and inundation, causing several health problems. This requires the urgent need of understanding the level of health vulnerability of the local inhabitants and plan for their mitigation accordingly.

The study aims to compute a Health Vulnerability Index (HVI) that will help the identifying areas that need development in terms of health aspects, so as to reduce the spread of infectious diseases as well as lower mortality due to hazards.

8.1. Methodology:

A three-phase methodology was used to develop the final disaster risk model. (Figure 32).

Phase 1 of the approach encompasses extensive literature review and identification of the relevant indicators to construct a health vulnerability index. Phase 2 involves a two-stage dimension reduction statistical method to identify the weighing of the indicators that were included in Phase 1. Phase 3 intends to create the final disaster risk by combining the three relevant variables (exposure, hazard, vulnerability index) by the formula:

Risk = Exposure X Hazard X Vulnerability.

Phase 1: Thorough literature review was conducted to identify the relevant indicators of health vulnerability of a community (Noji, 2001), (Shin & Ji, 2021), (Zahran, Peek,, Snodgrass, Weiler, & Hempel, 2011). Based on the work by various authors, the health indicators of interest were noted to be population below 15 and above 65 years, under-five mortality rate, maternal mortality ratio, prevalence of tuberculosis, age-standardized elevated blood pressure, physician-to-bed ratio, hospital bed ratio, and vaccination coverage for the first-dose measles-containing vaccine (MCV1), diphtheria tetanus toxoid and pertussis vaccines (DTP) (Chan, Huang, Lam, Wong, & Zou, 2019). With this literature review and considering the lower socio-economic distribution of the affected population as well as the tuberculosis endemic status of India, the modified final list of relevant health indicators was formulated (Table 17). The data was collected from field survey and census of India.

Phase 2: Existing literature doesn't make any obvious assumption on the weightage of indicators for the particular index towards their contribution to an HVI; hence a robust statistical method was needed to weigh the indicators and creation of the indices. Two stage dimension reduction method was used. This method also allows for monitoring changes over time. In stage one, factor analysis (FA) was used as the primary statistical procedure for dimension reduction. The observed and correlated indicators were assumed to be adequately explained by a lower number of unobserved and uncorrelated factors. Stage two modelling was based on the result of FA; the selected health indicators were used to produce a more compact representation of the factors.

Stage I: Selected indicators (Table 17) are normalized and included in the FA analysis. The number of factors extracted were such that they should contribute cumulatively to the explanation of the overall variance by more than 60% and have Eigen value greater than 1 (Table 16), (Figure 33). The matrix of factor loadings was estimated via the principal component analysis method. KMO and Barlett's test of sphericity and Chi-square test were conducted for the authenticity of the reproduced data and interpreted at $P < 0.05$ (Table 15).

Stage II: Each latent factor has factor loading on every health indicator, measuring the correlation between the health factor and the health indicator. The construction of the weights of the selected health indicators is from the rotated matrix of factor loadings (Table 17).

(1) the proportion on each latent factor of the total unit variance was extracted (Table 2); (2) the intermediate weights of the health indicators were calculated from the rotated component matrix (Table 5); (3) the proportion on each latent factor (1) is multiplied by the intermediate weights of the health indicators (2) to generate the final weights for the selected health indicators.

Finally, the weights were multiplied by the corresponding standardized health indicator parameter, and were added together for the block's Health Vulnerability Index (HVI) and standardized using min-max normalization. A higher value indicates a more vulnerable block. The HVI value of each block was categorized into five HVI clusters using the equal interval method for data presentation in the form of a vulnerability map.

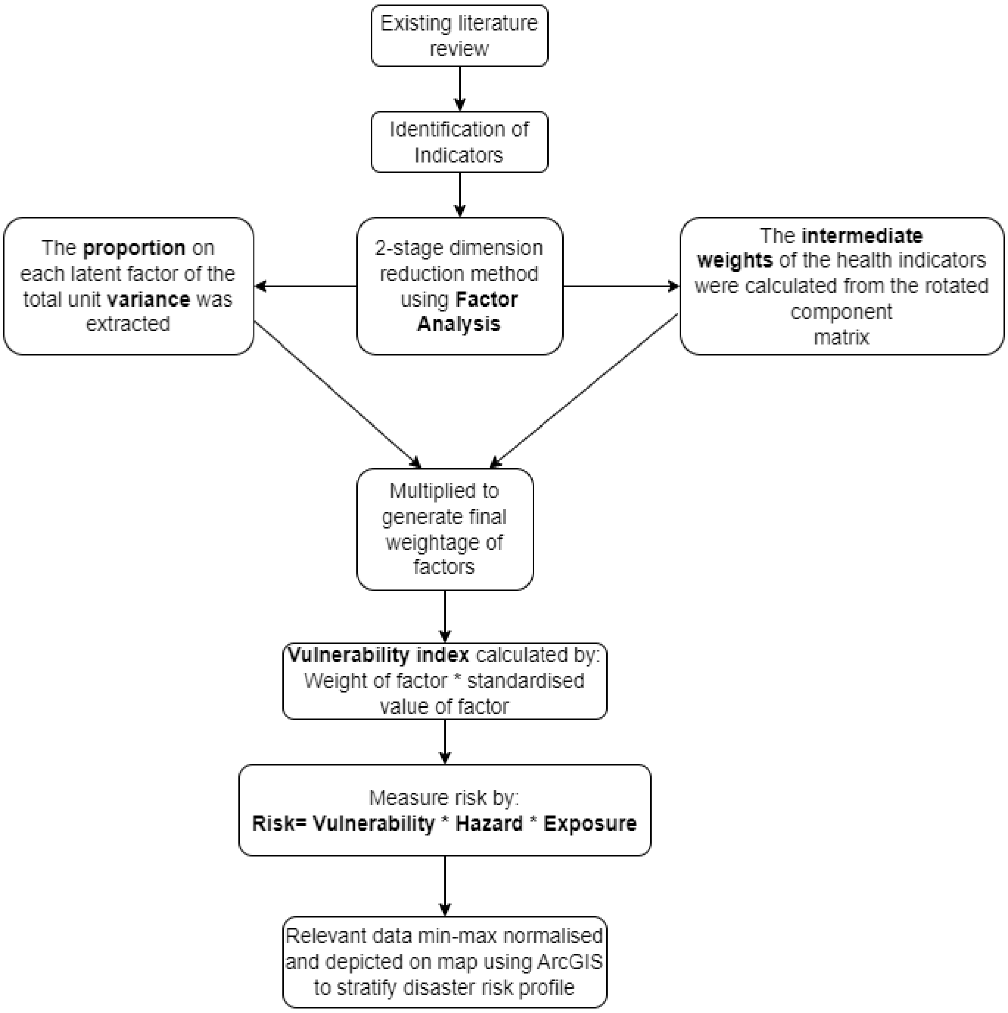

Figure 32: Flow chart showing Methodology to calculate Health Vulnerability Index

Phase 3: Exposure was ascertained to be the number of major cyclones in the last 20 years and hazard was estimated as the distance between the sea and the mean centre of population of the block. Risk is calculated as:

Risk = Exposure X Hazard X Vulnerability

8.2. Results:

8.2.1. Key indicators of vulnerability: Nine health indicators were chosen and incorporated into the final index formulation based on the evaluation criteria. The main health indicators are included in the following (Table 16). The Health Vulnerability Index was calculated for the five cyclone-prone community development blocks of Purba Medinipur district of West Bengal, India. The indicators are chosen in a way that it is thought that indicators one and two are reflective of the vulnerable population load in the community, three and seven are indicative of health status of the community, four and five are measures of coping capacity of the physical and manpower infrastructure, six, eight and nine are measures of socio-economic strata and attitude and practice towards vaccination measures. The correlations between the health indicators are shown in Table18, ($p<0.05$)

8.2.2. Factor analysis of Health Vulnerability: The result of dimension reduction model by principal component analysis reveals that 76% of the variance of the dataset can be explained confidently by 4 unrelated principal components (factors). Also, the Eigen values greater than 1 are plotted in the Scree plot which reinstates that 4 components can explain majority variance of the total data set (Figure 33). KMO and Bartlett's Test was conducted to ascertain the suitability of the factor analysis and adequacy of sampling. A KMO value greater than 0.6 and a significance level lesser than 0.05 is desirable (Table 15). The four factors are named household health status, health unfavourability, unmet facilities and age factor (Table 19). The respective factor loadings after varimax rotation are shown.

Table 15: KMO and Bartlett's Test of Sphericity and sampling Adequacy Showing statistical Significance.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.785
Bartlett's Test of Sphericity	Approx. Chi-Square	51.477
	df	36
	Sig.	0.046

Table 16: 76% of Total Variance of the dataset can be explained by 4 unrelated components.

Total Variance Explained

Component	Initial Eigenvalues	
	Total	Cumulative %
1	2.707	30.074
2	1.795	50.014
3	1.257	63.975
4	1.139	76.626
5	0.732	84.758
6	0.728	92.851
7	0.347	96.702
8	0.228	99.240
9	0.068	100.000

Extraction Method: Principal Component Analysis.

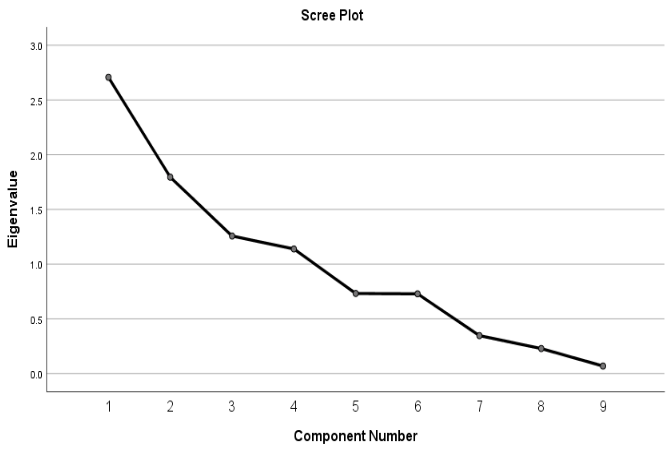

Figure 33: Scree plot showing 4 extracted components to have Eigen values >1.

Table 17: Table Showing Dimensions of Health Vulnerability and the health indicators along with their relationship to vulnerability

Dimension of Health Vulnerability	Indicator	Description	Conceptual relevance to health vulnerability	Relation with vulnerability
Vulnerable Population	Vulnerable Age	Population aged 0 to 14 years and more than 65 years	Children and the elderly in particular are considered to be more susceptible to health risks and are less likely to be resilient in the event of a disaster. They are more prone to develop health issues and may require special care after a disaster.	Positive
	Disability	Disabled population / 10000	Individuals with any type of disability require special attention during and after a disaster which make them less resilient in comparison to any person with special needs.	Positive
Premature mortality	Under-5-mortality	probability of dying by age five per 1000 live births.	One of the leading indicators of health according to WHO as well as the SDG 3 is premature mortality.	Positive
Coping capacity	Hospital beds	Hospital beds (per 10,000 population)	Resources within health systems show the degree of access to and quality of care received, which are strongly connected with the ability to save lives and overall health.	Negative
	Physicians' density	Doctor's density per 1000 population		Negative
Socio-economic status	Poor household	Monthly family Income < Rs 5000	People belonging to the low socio economic strata are more vulnerable to disasters due to limited resources making them less resilient.	Positive
Infectious Diseases	Incidence of Tuberculosis	Incidence of tuberculosis (per 100,000 population per year)	Tuberculosis is a communicable disease that is transmitted by droplets, specially in poor living conditions and in overcrowding scenarios, as is expected during the disaster times. The incidence of tuberculosis gives an indication of the burden of TB in the community.	Positive
Vaccination Gap	DTP vaccination gap	Diphtheria tetanus toxoid and pertussis (DTP3) immunization coverage gap among 1-year-olds (%)	These vaccinations form a part of the Universal Immunisation Program for common preventable childhood communicable diseases. Measles outbreaks are dreaded among children during periods of close contact, especially as may be expected during these disaster periods. Tetanus infection may happen due to exposure of any wound to the pathogenic bacteria. Moreover, these measures are useful indicators to assess the performance of the health system.	Positive
	Measles vaccination gap	Measles-containing-vaccine first-dose (MCV1) immunization coverage gap among one-year-olds (%)		Positive

Table 18: Correlation matrix of the health indicators p<0.05

	% Vulnerable	% Disabled	Under 5 mortality	Bed Per 10,000	Doctors Per 100,000	Poor Household	TB per 100,000 pop	DTP gap	Measles gap
% Vulnerable	**1.000**	-0.067	0.084	-0.278	0.033	-0.279	0.082	-0.042	-0.019
% Disabled	-0.067	**1.000**	0.455	0.173	0.074	0.463	0.487	-0.052	-0.093
Under 5 mortality	0.084	0.455	**1.000**	0.212	0.400	0.197	0.172	0.011	-0.018
Bed Per 10,000	-0.278	0.173	0.212	**1.000**	0.381	0.269	0.229	-0.172	-0.369
Doctors Per 100,000	0.033	0.074	0.400	0.381	**1.000**	0.440	0.046	-0.140	-0.199
Poor Household	-0.279	0.463	0.197	0.269	0.440	**1.000**	0.342	-0.094	-0.152
TB per 100,000 population	0.082	0.487	0.172	0.229	0.046	0.342	**1.000**	-0.038	-0.129
DTP gap	-0.042	-0.052	0.011	-0.172	-0.140	-0.094	-0.038	**1.000**	0.786
Measles gap	-0.019	-0.093	-0.018	-0.369	-0.199	-0.152	-0.129	0.786	**1.000**

Table 19: The individual 9 indicators are clubbed according to their factor loadings into 4 unrelated principal components. Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

	Component			
	1 Household health status	2 Health unfavourability	3 Unmet Facilities	4 Age Factor
Perc Vuln	-.084	.030	-.130	**.904**
Perc Disability	.005	**.856**	-.171	-.073
Under 5 mortality	**.764**	.353	-.722	.177
Bed Per Ten Thousand	.310	-.121	**.826**	.522
Doctors Per One Lac	.143	.060	**.884**	.141
Poor Household	**.802**	.494	-.362	-.501
TB per 1000 pop	-.094	**.831**	.018	.009
DTP gap	**.958**	-.018	.015	-.027
Measles gap	**.971**	-.077	.088	.063

8.2.3. Formulation of Health Vulnerability Index and Disaster Risk Mapping

The weights of the 9 indicators were calculated as per methodology. The weights are 0.11, 0.04, 0.08, 0.18, 0.17, 0.05, 0.06, 0.16 and 0.15 for vulnerability, disability, under 5 mortality rate, unmet bed demand, unmet doctor demand, poor households, TB per 100,000 population, DTP vaccination gap and Measles vaccination gap respectively. The scores of the 4 unrelated factors, namely household health status, health unfavourability, unmet facilities and age factor were calculated for the study area of 5 blocks by multiplying weightage with the respective parameter (Table 20). The development of the Health Vulnerability Index by adding the above values was based on the Factor Analysis model explained above. To calculate risk as per the given formula, proximity from the spatial geocentre to the coastline (in km) is taken as exposure and no. of major cyclones in the study area in the last 20 years has been measured as the hazard.

Table 20: Table showing health Vulnerability Index and Health Risk of the Five cyclone prone Community developments blocks of Purba Medinipur, West Bengal

Block	Unmet Facilities	Household health status	Age factor	Health unfavourability	Health Vulnerability Index	Standardised HVI	Proximity to coast (in km) [Exposure]	Hazard	Total risk = H * E * I
Ramnagar 1	-0.51	-0.24	0.05	-0.03	-0.73	0.00	5.57	10.00	0.00
Ramnagar 2	-0.03	-0.09	0.04	0.19	0.11	0.63	10.02	10.00	62.91
Contai 1	0.24	-0.10	0.04	-0.06	0.13	0.64	9.61	10.00	61.15
Deshapran	0.27	-0.16	-0.22	-0.02	-0.12	0.45	7.49	10.00	33.75
Khejuri 2	0.02	0.58	0.09	-0.07	0.61	1.00	5.24	10.00	52.40

The Health Vulnerability Index and Disaster Risk thus calculated are categorized into five levels and are depicted in maps of the study area of the five cyclone-prone community development blocks of Purba Medinipur district of West Bengal. (Figure 33,34)

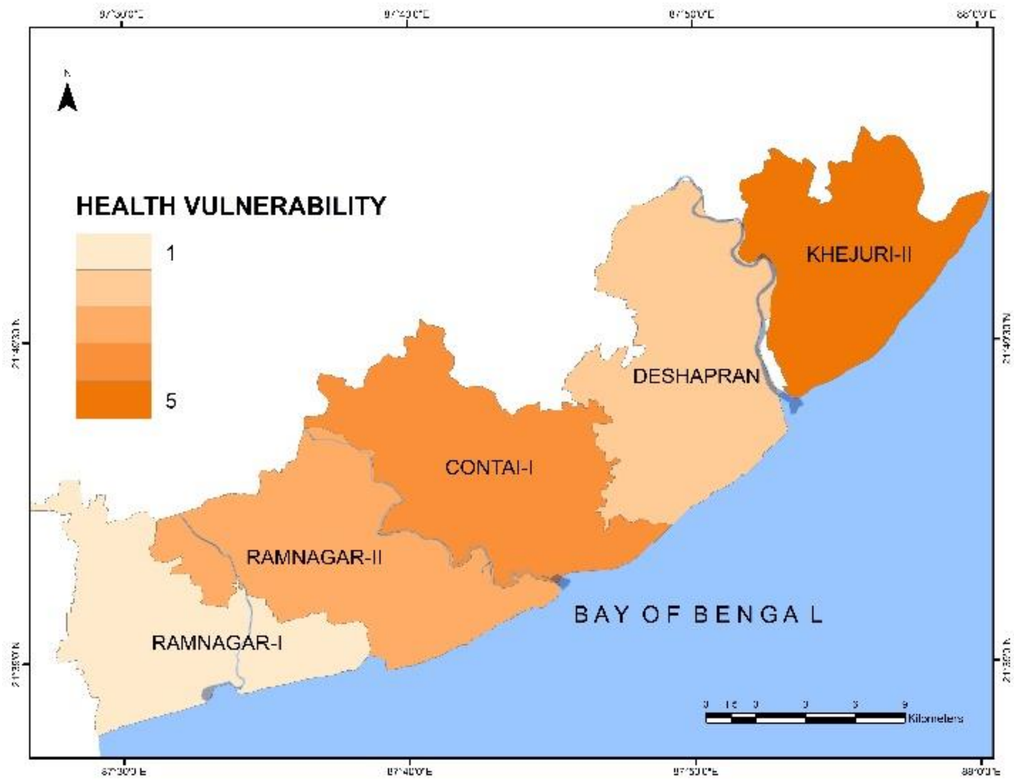

Figure 34: Map of the study area showing standardised health vulnerability index of the five blocks of Purba Medinipur

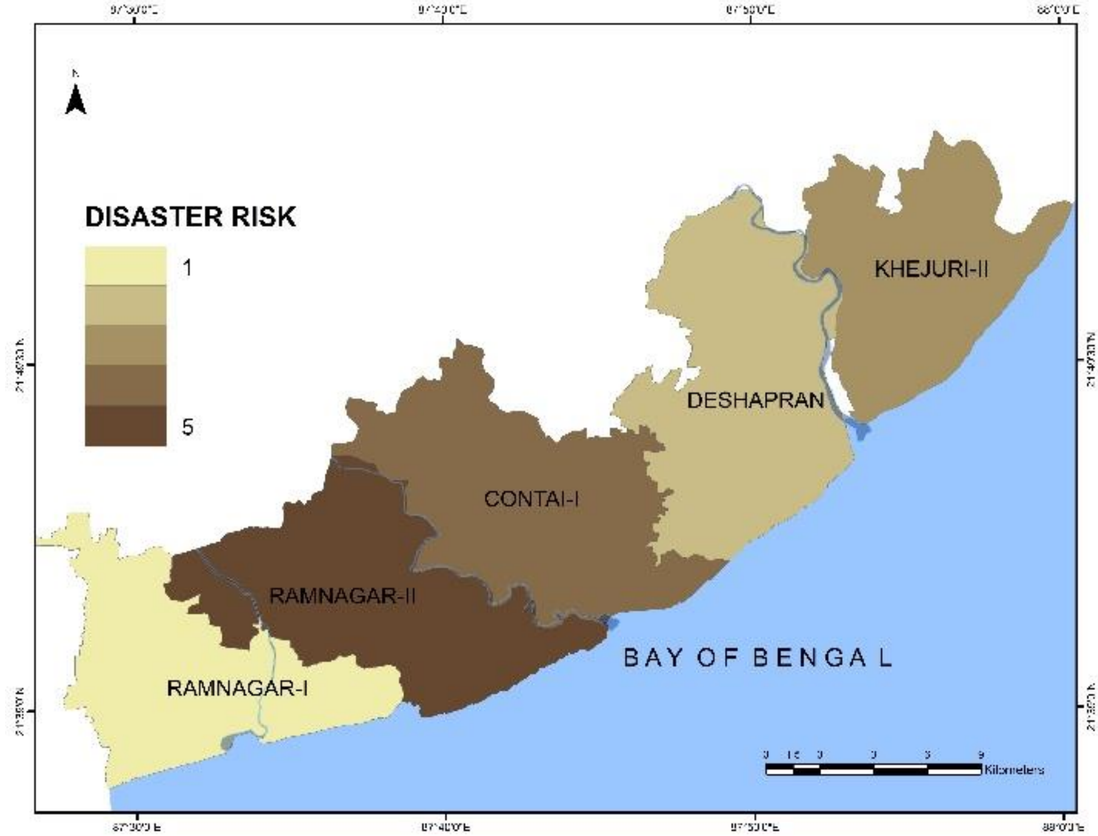

Figure 35: Map showing the Disaster Risk of the five CD Blocks of Purba Medinipur district.

8.3. Discussion:

The study intends to compute a Health Vulnerability Index of the five coast-adjacent, cyclone prone blocks of Purba Medinipur district of West Bengal. Assessment of vulnerability of the at-risk blocks will help in formulation of better localized policies and dedication of infrastructure to mitigate the cyclone hazards resulting in improved resilience and better survival rates (Lee, Chang, & Liao, 2023). Most of the existing literature has focused on social and physical vulnerability indices while a holistic approach in detecting health vulnerability is yet unreached. In this study, the different health indicators have been identified and assigned relevant weights for further calculation of the Health Vulnerability Index.

Identification of these indicators is an indication of the general health status and disease burden of the community, the infrastructural readiness of the healthcare facility. These are thought to be reliable indicators to ascertain the acute health impact in the aftermath of a natural disaster. Vulnerable population indicates the people belonging to the age groups of above 65, children below 14 years and people with special needs. In times of disaster, this population may require extra care and are more susceptible to different diseases making them the less resilient community to tackle the adverse event. The health status of an area can be understood with the rate of under 5 mortalities. It is considered as a health indicator world-wide according to the WHO and is also mentioned in the Sustainable Development Goal 3 by the United Nations (Hák, Janoušková, & Moldan, 2016). The coping capacity of a community is dependent on available infrastructure and man power. Availability of bed in hospitals and doctors in fair-weather times and especially during disaster scenarios is of utmost importance. The socio-economic background of individual also influences his capability to adapt to adverse situations. Poor households are more likely to be vulnerable due to possession of limited resources. During cyclone disasters, people are often relocated to community buildings like Multi Purpose Cyclone Shelters (MPCS) (Dash & Walia, 2020), (Almutairi, Mourshed, & Ameen, 2020). During these times of crowding and close contact, the chances of droplet-borne infections are alarmingly high. Being a country with a high tubercular endemicity, the incidence of active TB in the community is an effective indicator of the adaptability and well-being of the population during times of crowding and unhygienic living standards (Mao , et al., 2020). These scenarios are also notorious for causing measles outbreak in the paediatric population (Misin, et al., 2020). Hence, the vaccination coverage with measles and allied vaccines are also a reliable measure to predict the resilience of the vulnerable population. Overall, the health performance of the existing institutes and attitude of a community can be judged from the vaccination coverage, thus providing an important factor to reliably predict the adaptive capacity of a population (Charnley, Kelman, Gaythorpe, & Kris A. Murray, 2021). From the different statistical analyses, we find that infrastructural readiness, namely hospital beds per ten thousand population, doctors per one lac population, DTP and measles vaccination gap carry the most weightage towards calculating an HVI. This is similar to a study by Chan EY, et al where greater weightage for calculating HVI along the Belt and Road Initiative (BRI) region were assigned to physician density and vaccination gap (Chan, Huang, Lam, Wong, & Zou, 2019).

Among the five cyclone-prone coastal blocks, Khejuri II has the highest index of health vulnerability with a high corresponding risk. It also has the lowest number of cyclones shelters as well as hospitals where people can take refuge in times of need. This block portrays lowest infrastructural development and low socioeconomic status of the residents in comparison the other blocks of the study area, thus compounding the aggravated risk. Contrarily, Ramnagar I poses the lowest Health Vulnerability Index and subsequently the lowest risk. This block has many sprawling beaches that dot the coastline of Bay of Bengal and its associated tourism and water sports, which leads to revenue generation, thus resulting in infrastructural development of the area and overall socio-economic upliftment of its residents.

8.4. Conclusion:

This paper presents a health vulnerability index aiming to improve disaster risk assessment for better risk reduction. Along with the existing social and physical vulnerability assessments, emphasis needs to be given on the chronic health parameters as it affects the resilience of the local community. The proposed health vulnerability index includes nine indicators: vulnerable age groups, disability, under-5-mortality, no. of hospital beds, physicians' density, households with low income, incidence of tuberculosis, DTP vaccination gap and measles vaccination gap. A statistical analysis shows the health vulnerability status and corresponding risk of the five coast adjacent blocks of Purba Medinipur district which addresses the need for proper streamlining and equitable distribution of resources for improved disaster risk mitigation.

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CHAPTER NINE

ASSESSMENT OF SOCIAL VULNERABILITY

CHAPTER NINE

ASSESSMENT OF SOCIAL VULNERABILITY

9.0. Foreground:

The concept of Vulnerability is relevant in many different fields. Risk and vulnerability are intricately linked to hazards. The interaction between social systems and geophysical conditions has increasing importance and social systems are recognised as one of the determinants of vulnerability along with the geophysical aspects that denote the level of risk (Liverman, 1990) , (Dow, 1992) (Montz & Tobin , 2003) . Disaster management from the very starting has primarily focused on infrastructure and technology. After the 1970s, researchers introduced the concept of social vulnerability, recognising the importance of socio economic factor and their impact on community resilience building (Juntunen, 2005), (Flanagan, et al., 2011). Some communities are more vulnerable to different hazards and thus face greater damage and loss. Social Vulnerability investigates the social distribution of risk and the reasons behind higher risk that is associated with certain communities to any given hazard (Gayen, Villalta, & Haque, 2020). According to the (ISDR, 2004) Social Vulnerability is associated with the level of wellbeing of individuals as well as the community and society as a whole.

Few definitions of social vulnerability that are found are, (Adger, 2006) defined social vulnerability as a group or individual's exposure to stress as a result of social and environmental changes where stress is unanticipated damage to livelihoods. Social Vulnerability arises from social inequalities. It is the vulnerability of social groups and communities to the effects of hazard and the capacity to effectively recuperate from them (Cutter & Emrich, 2006). Social Vulnerability is the societal framework that helps mitigate risk of hazards. It is a consequence of inequalities (Veen, et al., 2009).

After a hazard, distinct patterns among populations are exposed. This elucidates why specific groups within the community, such as children, the elderly, women, or marginalized individuals, experience hazards more acutely than others despite having comparable exposure (Cutteret al., 2003). Vulnerability is associated with the ownership of different assets and rights. Consequently communities with fewer assets may be more susceptible to more hazards than ones with more resources (Moser, 1998).

It is a well-established fact that elevated social status correlates with increased access to resources, thereby enhancing the group's resilience to hazards or events. It also enhances the ability to recover more swiftly from the event's impact. Gender is another element within the. Women are more likely to be vulnerable than their male counterparts due to additional responsibilities related to family and children. High dependency ratio that is the ratio between earning and dependent members of a family contributes highly to its social vulnerability.

The economic factors plays an important role in social vulnerability. Communities or households with enhanced economic resources have greater resilience. In India households below the poverty line (BPL) exhibit higher social vulnerability. The occupational structure also need to be comprehended when evaluating the social vulnerability, as occupations dependent of natural resources like agriculture, fishing are more susceptible to natural hazards.

Demographic factors also significantly influences the social vulnerability. Higher populations indicate more sharing of resources so higher population density render to community susceptible to resources sharing and in turn potentially diminishing quality. Similarly in a family set up, elderly and young population are also vulnerable as they are at most times emotionally, monetarily and physically dependent on others. Physically disable people also have certain disadvantages of being dependent on others with make them highly vulnerable in times of need.

Infrastructure serve as an indicator of development of a community thus helps in mitigation to vulnerability risks, by providing opportunities for growth and self-actualization in a society

9.1. Assessment of Social Vulnerability Index:

(Gornitz , Daniels , White , & Birdwell, 1994) Initially developed the Coastal Vulnerability Index (CVI) for the south-eastern United States. Their work did not incorporate socio economic data in the Coastal Vulnerability Index formulation, yet it remains one of the most widely accepted methods for assessing the physical vulnerability of coasts worldwide (Cutter, Boruff, & Shirley , 2012), (Boruff , Emrich , & Cutter, 2005) (Kumar, et al., 2010), (Murali , et al., 2013). The significance of socioeconomic factors in hazard studies gained prominence in the mid-1990s (Pelling , 1997), (Klein , et al., 1998) (Cutter, et al.,2003). (Boruff , Emrich , & Cutter, 2005) integrated the Social Vulnerability Index (SoVI) and (Cutter, et al., 2003) with the Coastal Vulnerability Index (CVI) to comprehend the Coastal Social Vulnerability Index (CSoVI). Boruff's methodology has been extensively employed for analysis of coastal hazard vulnerability throughout the globe (Mazumdar & Paul, 2016).

9.2. Methodology:

A three-phase methodology was used to develop the final social vulnerability index model similar to the health vulnerability disaster risk model.

Phase 1 of the approach encompasses extensive literature review and identification of the relevant indicators to construct a social vulnerability index and infrastructural adaptivity vulnerability index.

Phase 2 involves a two-stage dimension reduction statistical method to identify the weighing of the indicators that were included in Phase 1.

Phase 3 intends to create the final disaster risk, namely infrastructural adaptivity risk and demographic and economic sensitivity risk by combining the three relevant variables (exposure, hazard, vulnerability index) by:

Risk = Exposure X Hazard X Vulnerability.

Phase 1: Based on thorough literature review, the indicators of interest were drawn (Table 21). The data was collected from field survey and census of India.

Phase 2: The dimension reduction procedure was applied in two stages. This approach also makes it possible to track changes over time. The main statistical method for dimension reduction in stage one was factor analysis (FA). A smaller number of unseen and uncorrelated factors were thought to be sufficient to explain the observed and correlated indicators. The results of FA served as the basis for stage two modelling, which created a more compact depiction of the factors using the chosen health indicators.

Stage I: Selected indicators are normalized and included in the FA analysis. The number of factors extracted were such that they should contribute cumulatively to the explanation of the overall variance by more than 60% and have Eigen value greater than 1. The matrix of factor loadings was estimated via the principal component analysis method. KMO and Barlett’s test of sphericity and Chi-square test were conducted for the authenticity of the reproduced data and interpreted at $P < 0.05$.

Stage II: Weight of each latent factor of social vulnerability index was calculated from the rotated matrix of factor loadings and standardized, similar to that of health vulnerability index as earlier.

Table 21: Table Showing Dimensions Economic & demographic Sensitivity, Adaptive capacity and hazards and exposure indicators along with their relationship to vulnerability

	Dimension of Vulnerability	Indicator	Description	Relation with vulnerability
Economic & demographic Sensitivity	Demographic	Population density	Area with higher density of people is more vulnerable	Positive
		Population share	The proportion of population in single gram panchayet compared to the total population of the block.	Positive
		Female population	Females are considered more vulnerable, mainly due to low economic stability, family responsibilities and emotions	Positive
		Under 5 population	Children under 5 are more vulnerable as they lack in knowledge	Positive
		Above 65 population	Geriatric population is considered vulnerable due to decreased mobility and dependency due to low employment	Positive
		Minority population	Minority population of a society is often the most neglected and outcasted, making them vulnerable	Positive
		Disabled population	People with physical disability often low-income stability	Positive
		Dependent household	Households with no earning member within the age group of 16-59	Positive
	Economic capacity	No Cultivators		Positive
		Landless households	household that does not own any land, have to work as labourers decreasing their economic upliftment and in turn causing vulnerability	Positive
		Per household income	lower the income more the people are vulnerable.	Negative
		Unemployed households	households who do not have a permanent source of income	Positive

	Dimension of Vulnerability	Indicator	Description	Relation with vulnerability
Adaptive capacity	Infrastructure	Banking facilities	households that have access to banking facilities often have savings or are eligible for loans	Negative
		Availability of Safe Drinking water	safe drinking water ensures better health and less diseases	Negative
		Availability of Safe sanitation	Safe sanitation ensures less diseases	Negative
		Pucca households	Household that are able to withstand high velocity winds are less vulnerable	Negative
		High Schools	More high schools ensure education as well as a place pf refuge in case of a cyclone hazard	Negative
		MPCS	Multipurpose cyclone shelters are community buildings used for the upliftment of the society	Negative
		Hospitals		Negative
		Administrative buildings		Negative
		Road Network		Negative
Hazards and exposure		cyclones in the past 20 years		
		distance from the sea in km		

Phase 3: Exposure was ascertained to be the number of major cyclones in the last 20 years; hazard as the distance between the sea and the mean centre of population of the block.

Risk is calculated as: **Risk = Exposure X Hazard X Vulnerability**

Table 22: The individual 12 indicators are clubbed according to their factor loadings into 4 unrelated principal components
Table 1

Rotated Component Matrix[a]				
Factor Loadings	Component			
	1	2	3	4
Population density	-0.303	**0.441**	-0.467	-0.305
Population share	**0.898**	0.026	0.095	0.068
Female population	**0.848**	-0.101	0.024	0.116
Under 5 population	**0.782**	0.268	0.212	-0.076
Above 65 population	**0.562**	-0.060	-0.520	-0.095
Minority population	**0.860**	-0.129	0.038	0.009
Disabled population	-0.136	-0.189	0.152	**0.804**
Dependent household	0.145	-0.008	**0.583**	-0.229
No Cultivators	-0.119	**0.733**	0.047	0.186
Landless households	0.093	**0.792**	0.332	0.103
Per household income	0.049	0.225	**0.876**	0.108
Unemployed households	0.114	0.175	-0.188	**0.727**

[a] *Extraction Method: Principal Component Analysis.*
Rotation Method: Varimax with Kaiser Normalization.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.777
Bartlett's Test of Sphericity	Approx. Chi-Square	147.082
	df	66
	Sig.	0.000

Table 24: KMO and Bartlett's Test of Sphericity and sampling adequacy showing statistical significance

Table 23: 68% of Total Variance of the dataset can be explained by 4 unrelated components

Component	Total Variance Explained	
	% of Variance	Cumulative %
1	**23.092**	**23.092**
2	**19.366**	**42.458**
3	**14.837**	**57.295**
4	**10.832**	**68.127**
5	8.024	76.151
6	6.168	82.319
7	5.340	87.659
8	4.125	91.784
9	3.095	94.880
10	1.971	96.851
11	1.810	98.661
12	1.339	100.000

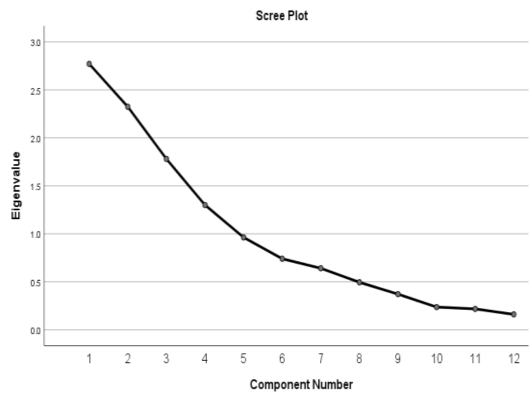

Figure 36: Scree plot showing 4 extracted components to have Eigen values >1

Table 25: 68% of Total Variance of the dataset can be explained by 4 unrelated components

Component	Total Variance Explained		
	% of Variance	Cumulative %	
1	**26.528**	**26.528**	
2	**16.992**	**43.520**	
3	**13.700**	**57.221**	
4	**12.000**	**69.221**	
5	10.512	79.733	
6	8.585	88.318	
7	4.828	93.146	
8	4.328	97.473	
9	2.527	100.000	

Table 26: The individual 9 indicators are clubbed according to their factor loadings into 4 unrelated principal

Rotated Component Matrix[a]

Factor Loadings	Component			
	1	2	3	4
% of households with banking	**0.704**	0.242	-0.002	-0.017
% of households with safe drinking water	**0.726**	-0.174	-0.007	-0.291
% of households with safe sanitation	0.398	-0.416	0.112	**0.531**
pucca household	**0.878**	0.022	0.036	0.029
High Schools	0.029	**0.886**	-0.129	0.106
MPCS	-0.007	**0.652**	0.576	-0.062
Hospital	0.018	0.127	-0.024	**0.775**
Administrative buildings	0.005	-0.095	**0.914**	0.046
Road network	**0.615**	0.060	-0.088	-0.451

[a] *Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.*

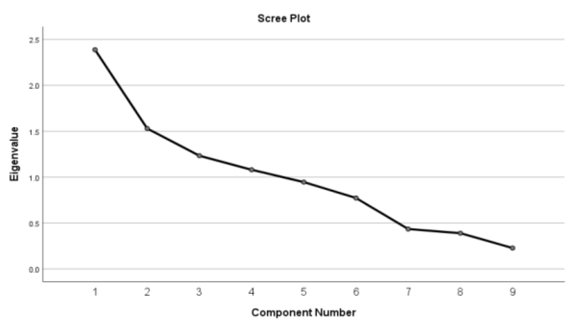

Figure 37: Scree plot showing 4 extracted components to have Eigen values >1

Table 27: KMO and Bartlett's Test of Sphericity and sampling adequacy showing statistical significance

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.770
Bartlett's Test of Sphericity	Approx. Chi-Square	65.978
	df	36
	Sig.	0.002

9.4. Results and Discussion:

Table 28: Correlation matrix of the indicators $p<0.05$

	Populati on density	**Populati on share**	**Female populati on**	**Under 5 populati on**	**Above 65 populati**	**Minorit y populati**	**Disabled populati on**	**Depende nt househo**	**Cultivat ors**	**Landles s househo**
Populatio n density	**1.000**	-0.247	0.264	-0.111	-0.038	-0.275	-0.243	-0.158	-0.220	0.128
Populatio n share	-0.247	**1.000**	-0.019	0.700	0.379	0.724	-0.022	0.116	-0.015	0.162
Female population	0.264	-0.019	**1.000**	0.149	-0.076	-0.224	-0.031	-0.072	-0.435	0.637
Under 5 population	-0.111	0.700	0.149	**1.000**	0.188	0.582	-0.157	0.178	-0.256	0.228
Above 65 population	-0.038	0.379	-0.076	0.188	**1.000**	0.328	-0.206	0.029	0.029	-0.029
Minority population	-0.275	0.724	-0.224	0.582	0.328	**1.000**	-0.042	0.032	-0.091	-0.031
Disabled population	-0.243	-0.022	-0.031	-0.157	-0.206	-0.042	**1.000**	-0.084	0.290	0.005
Dependent household	-0.158	0.116	-0.072	0.178	0.029	0.032	-0.084	**1.000**	0.021	0.243
Cultivator s	-0.220	-0.015	-0.435	-0.256	0.029	-0.091	0.290	0.021	**1.000**	-0.440
Landless household s	0.128	0.162	0.637	0.228	-0.029	-0.031	0.005	0.243	-0.440	**1.000**
Per household income	-0.320	0.130	0.193	0.271	-0.447	0.079	0.097	0.332	-0.098	0.436
Unemploy ed household s	-0.061	0.056	0.081	0.043	0.083	0.025	0.269	-0.034	-0.055	0.099

Per household	Unemployed househo
-0.320	-0.061
0.130	0.056
0.193	0.081
0.271	0.043
-0.447	0.083
0.079	0.025
0.097	0.269
0.332	-0.034
-0.098	-0.055
0.436	0.099
1.000	-0.010
-0.010	**1.000**

9.4.1 Key indicators of vulnerability: Twelve indicators were chosen and incorporated into the final index formulation based on the evaluation criteria for calculation of demographic and economic sensitivity risk. Similarly, nine indicators were chosen after thorough literature review for derivation of infrastructural adaptivity risk for each of the Gram Panchayats of the five cyclone-prone community development blocks of Purba Medinipur district of West Bengal, India. The correlation between the indicators is shown in Table 28.

9.4.2 Factor analysis: The result of dimension reduction model by principal component analysis reveals that 68% and 69% of the variance of the dataset of demographic and economic sensitivity risk and infrastructural adaptivity risk respectively can be explained confidently by 4 unrelated principal components (factors). Also, the Eigen values greater than 1 are plotted in the Scree plot which reinstates that 4 components can explain majority variance of the total data set. KMO and Bartlett's Test was conducted to ascertain the suitability of the factor analysis and adequacy of sampling. A KMO value greater than 0.6 and a significance level lesser than 0.05 is desirable.

The risks of the GPs are as below and are also depicted in maps of the study area.

Table 29: Table showing health Vulnerability Index and Health Risk of the five cyclone prone Community developments blocks of Purba Medinipur, West Bengal

Block	Panchayat	Infrastructural Adaptivity Risk	Demographic & Economic Sensitivity Risk	Standardised Social Vulnerability Index
Ramnagar 1	Badhia	37.40	71.90	0.54
	Basantapur	16.16	20.71	0.37
	Gobra	20.98	11.41	0.32
	Haldia 1	14.35	11.84	0.10
	Haldia 2	9.53	15.66	0.09
	Padima 1	11.20	2.36	0.32
	Padima 2	4.69	0.00	0.04
	Talgachari 1	35.70	11.45	0.58
	Talgachari 2	8.89	2.26	0.36
Ramnagar 2	Badalpur	28.53	22.78	0.32
	Balisai	30.98	13.02	0.40
	Depal	35.63	49.90	0.47
	Kadua	9.11	39.57	0.14
	Kalindi	8.91	17.68	0.54
	Maithana	11.75	59.49	0.28
	Paldhui	21.95	17.48	0.13
	Satilapur	0.00	32.61	0.23

The study intends to compute a Social Vulnerability Index and the corresponding Economic and Demographic Risk and Infrastructural Adaptivity Risk of each of the Gram Panchayats of the five coast-adjacent, cyclone prone blocks of Purba Medinipur district of West Bengal. Assessment of the vulnerability will pave the way for a more equitable distribution of resources for the better adaptivity during disaster periods. Demographic

Table 29: Table showing health Vulnerability Index and Health Risk of the five cyclone prone Community developments blocks of Purba Medinipur, West Bengal

Block	Panchayat	Infrastructural Adaptivity Risk	Demographic & Economic Sensitivity Risk	Standardised Social Vulnerability Index
Conati 1	Badalpur	21.22	10.50	0.00
	Dulalpur	71.35	51.83	0.61
	Hoipur	31.23	53.04	0.25
	Mahishagote	41.32	19.97	0.36
	Majilapur	1.96	18.22	0.27
	Nayaput	15.00	15.84	0.46
	Rajpur Paschimbar	51.17	65.87	0.63
	Sabajput	24.15	10.32	0.25
Deshapran	Amtalia	155.00	96.26	1.00
	Aurai	74.50	61.93	0.72
	Bamunia	14.87	10.37	0.60
	Basantia	52.84	41.09	0.97
	Chalti	13.44	37.92	0.51
	Dariyapur	19.92	20.62	0.89
	Dhobaberia	26.39	23.16	0.60
	Sarada	27.11	76.60	0.68
Khejuri 2	Baratala	9.08	66.10	0.70
	Haludbari	15.34	83.01	0.54
	Janka	19.86	49.74	0.78
	Khejuri	9.17	18.48	0.63
	Nijkasba	13.27	22.29	0.98

variables like vulnerable population (less than 5 yrs old or more than 65 yrs old), disabled population, female and minority population are generally deemed to be more susceptible during disaster periods and need special attention, thus justifying their inclusion in the creation of appropriate index and the resultant demographic and economic risk stratification of the cyclone prone gram panchayats of the study area. Similarly, landless households, low income and unemployed households pose significant vulnerability during disaster periods, thus warranting a more equitable distribution of available resources for adequate disaster preparedness.

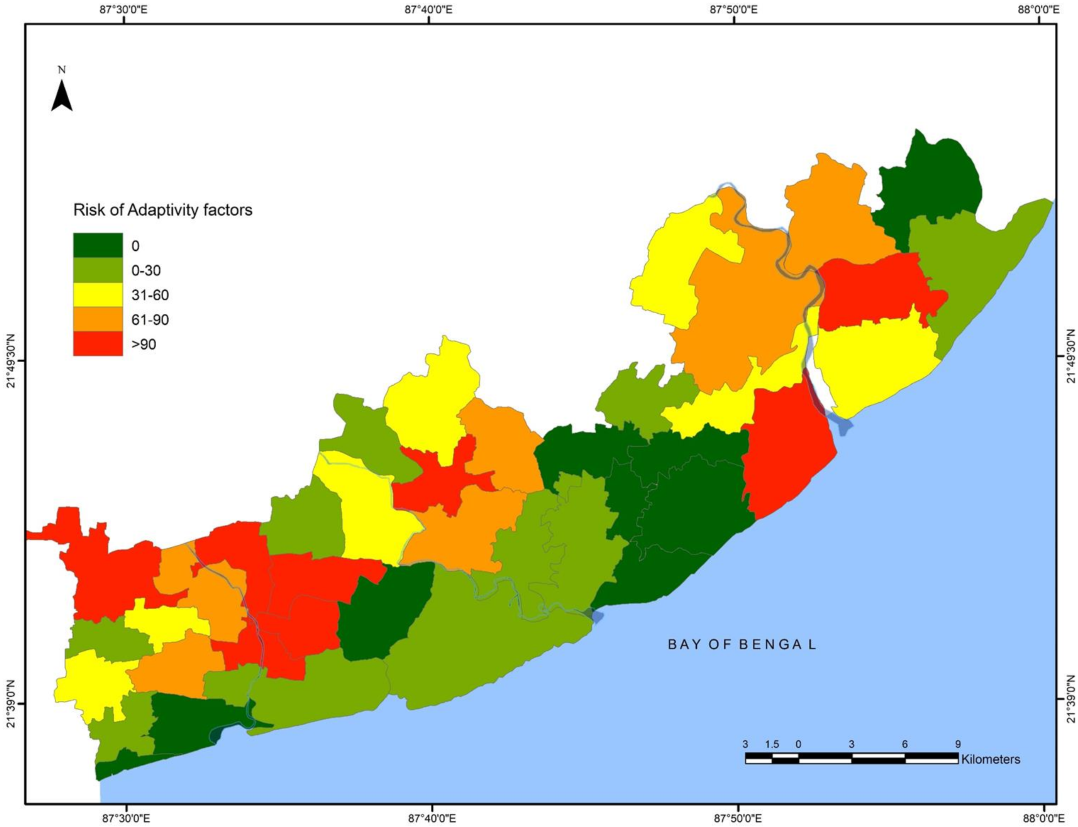

Figure 38:Map of the study area showing the Infrastructural Adaptability Risk

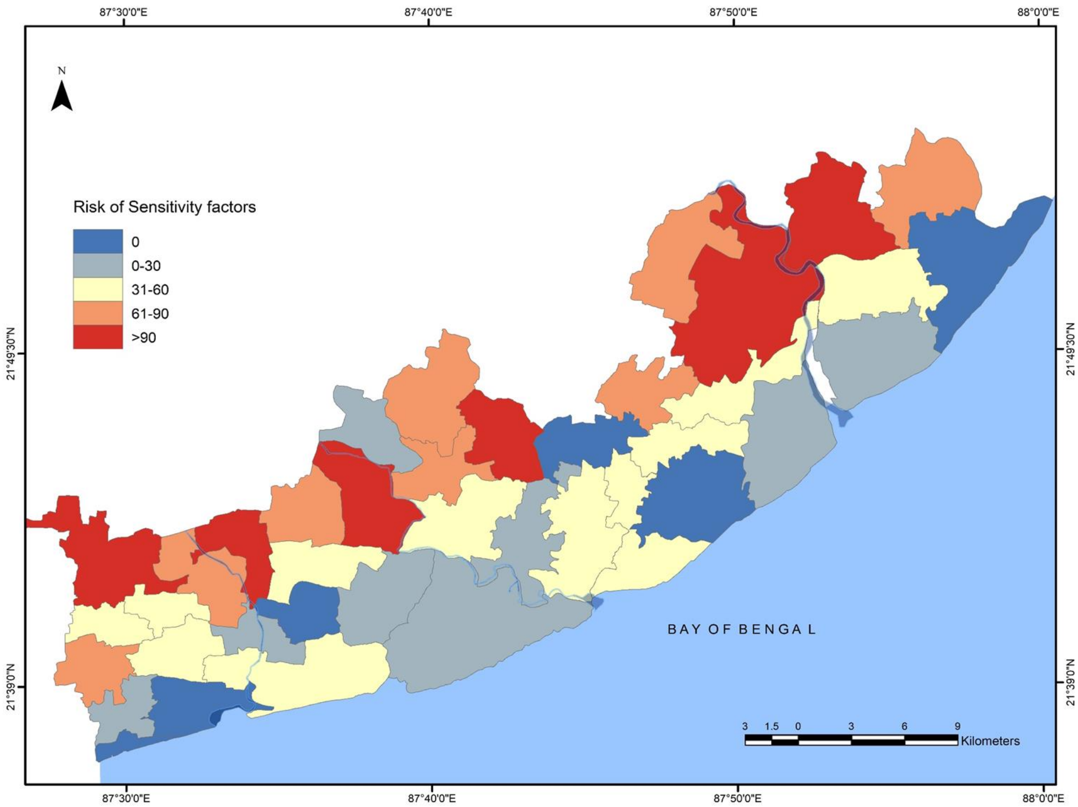

Figure 39: Map of the study area showing the Economic and Demographic Sensitivity Risk

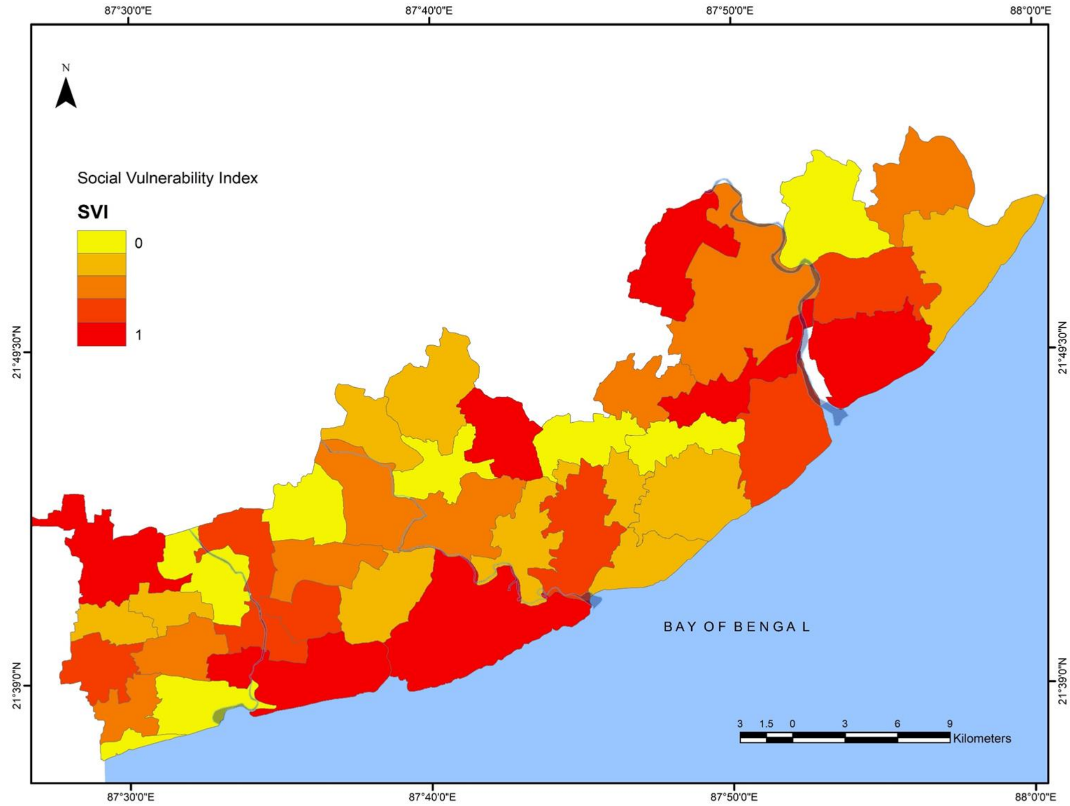

Figure 40: Map of the study area showing the Social Vulnerability Index

The social vulnerability status of an individual with respect to his/her demographic and economic risk stratification poses important vulnerability aspects during disaster times, as does the infrastructural readiness of the community to cope with the displaced population. Safe sanitation and hygiene measures like availability of safe drinking water and toilet facilities, facilities for relocation like MPCS, schools, hospitals, administrative offices and effective road networks are proper infrastructural readiness yardsticks for disaster preparedness.

The GPs possessing significant demographic and economic risk to cyclone disasters in our study area include Amtalia (Deshapran CD Block), Haludbari (Khejuri 2 CD block), Sarada (Deshapran CD Block), Baratala (Khejuri 2 CD block) and Badhia (Ramnagar 1). GPs possessing significant infrastructural adaptivity risk to cyclone disasters in our study area include Amtalia (Deshapran CD Block), Aurai (Deshapran CD Block), Dulalpur (Contai 1 CD Block), Basantia (Deshapran CD Block) and Rajpur Paschimbar (Contai 1). Focused distribution of resources will lead to better disaster preparedness strategies.

9.5. Conclusion: The study presents a social vulnerability index and corresponding demographic and economic sensitivity risk and infrastructural adaptivity risk, thus aiming to gauge disaster risk assessment and improve preparedness. Along with the chronic health and physical vulnerability assessments, emphasis needs to be given to the demographic, economic and infrastructural parameters as it affects the resilience of the local community.

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CHAPTER TEN

RECOMMENDATIONS

CHAPTER TEN

RECOMMENDATIONS

10.0. Foreground:

A Multipurpose cyclone shelter is a concrete structure and is a community building, built on an elevated land and is able to withstand high velocity winds for safe refuge of local people from the cyclones and associated storm surge inundation (Rahman & Islam). On an average, about 50-60% of total population of vulnerable locations use the cyclone shelters during emergencies (GoI, 2006). Cyclone shelters provide shelter to both the villagers and their livestock. It caters to the basic needs of the people by providing electricity, drinking water and sanitation during cyclones and storm surge.

10.1. Population bearing Capacity of MPCS: According to the UNDP guidelines, the recommended floor space in the MPCS per person is 2 sq. feet (UNDP 2006). However, even in times of emergency and considering the duration of stay in the MPCS to be not too brief due to the flood situation, dignity of the vulnerable population should be respected. It will be too optimistic to expect that people will stand or squat throughout the difficult times, because the allocated 2 sq. feet of floor area may be too little for any other postural change. . The 41 studied MPCS erected under the government schemes are constructed in lines with a uniform design where there are two halls in two floors that cater to the shelter of the vulnerable population- “the small hall” in the first floor having a dimension of 24.8 ft X 24.6 ft and “the large hall” in the second floor having dimension of 38.5 ft X 24.6 ft. The total floor area of the two living halls is 1557 sq. ft.

As per this guideline, the MPCS will be able to bear 778 persons from the vulnerable population (1557 sq. feet total floor area of the two halls / 2 sq. feet per person allocated floor area). However, such a distribution will be catastrophic given the number of communicable diseases it may spring up in the aftermath of the pandemic due to lack of proper living conditions, not to mention the abysmally poor hygienic situations and the huge toll on mental health of the occupants.

The average Indian man measures 5’8” in height and weighs 65 kg. The average Indian woman measures 5’3” in height and weighs 55 kg (ICMR-NIN, 2020). With a gender distribution of 950 females to 1000 males in the affected population (Government of India, 2010) (Sarkar , Chakraborti, & Dutta , 2021), . The author advocates 8.25 sq. feet of area per person (5.5 ft X 1.5 ft) to each individual and hence vertical bunk beds each measuring 6’ X 3’, each bed having 3 storeys that can carry 2 persons in each tier with reasonable living conditions are recommended (Table 30, Figure 42).

10.2. Discussion:

10.2.1. Capacity Calculation of MPCS: In the present scheme of arrangement in the MPCS, the height of the halls is not being utilised resulting in under-utilisation of the total available volume and hence, reduced floor area per person that in many a situation may lead to unfavourable living conditions, even considering the emergency situation. Since the postulated design intends to use triple storey bunk beds, the effective usable area is enhanced by 3 times the actual floor area as the height of the halls is being utilised. Hence, with the same architectural infrastructure of the MPCS, interior modifications lead to optimal utilisation of space resulting in ability to accommodate more from the vulnerable population. This design also intends to provide better and more hygienic living conditions for the relocated population, thus preventing or minimising food and water borne diseases that are rampant in the aftermath of a cyclone disaster, generally further aggravated by overcrowding.

This design apart from utilising the height of the rooms and accommodating sizable number of affected persons in reasonable living conditions, also provides for sufficiently wide corridors and empty spaces in front of doors and windows in the rooms. This provides for movement of the people with reasonable ease and assures smooth evacuation if any emergency arises. It also ensures adequate sunlight in the room maintaining the hygienic conditions and catering to the mental health of the occupants of the MPCS even in the difficult times

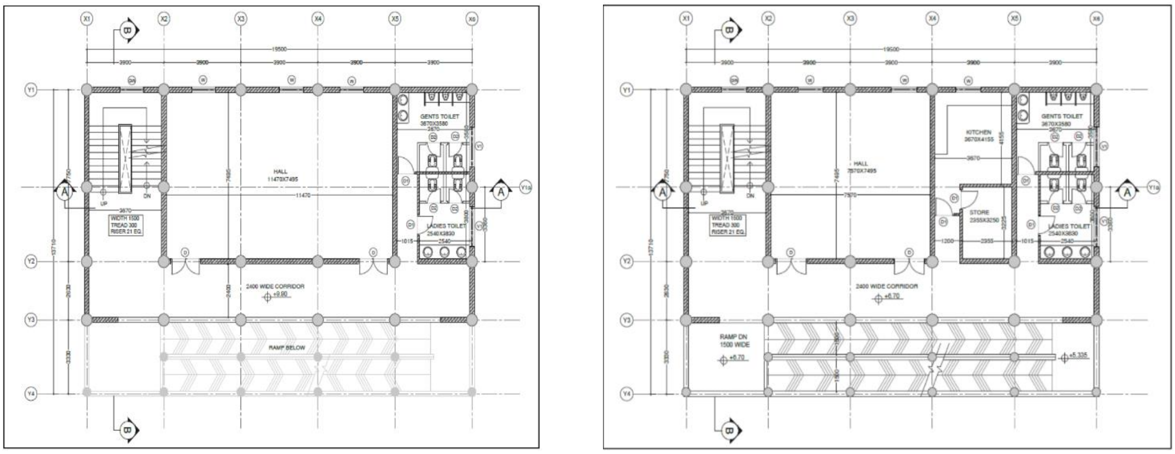

Figure 41: Blueprint of the design of the first and second floor of a standard MPCS

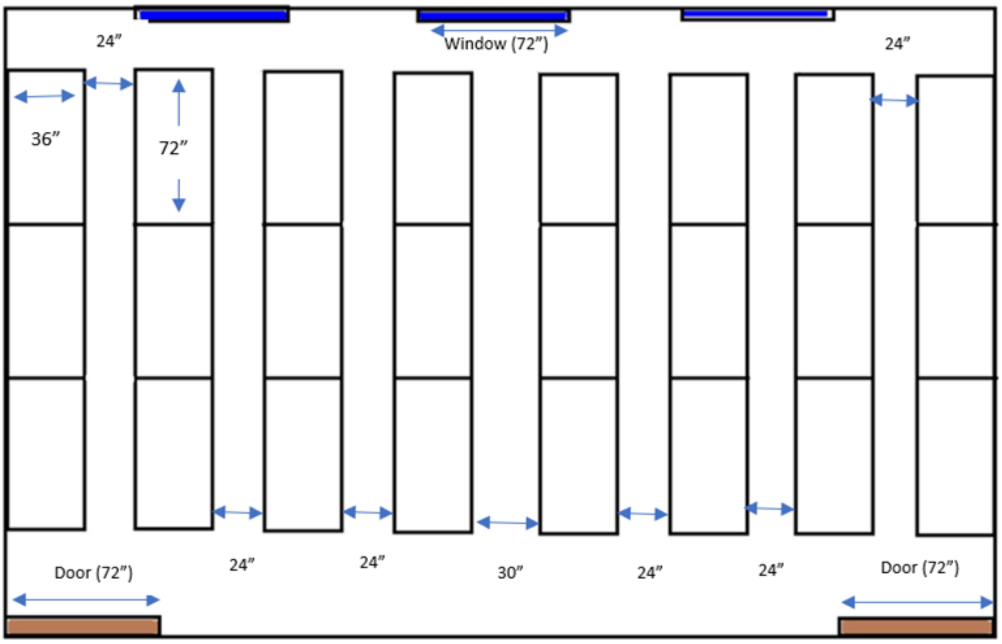

Figure 42: Line diagram of the arrangement of the multi-layered vertical bunk beds in the large hall of the second floor of a standard MPCS of the study area

Table 30: Capacity Calculation of each MPCS

Item	Small Hall	Large Hall
Location	First Floor	Second Floor
Floor dimensions	24.8 ft X 24.6 ft	38.5 ft X 24.6 ft
Total floor area (a_1,a_2)	610 sq ft	947 sq ft
No of columns of series of vertical bunk beds (b)	5	8
No of vertical bunk beds in each series (c)	3	3
Total no of bunk beds (d) [d=b*c]	15	24
Total no. of sleeping surface (each bunk bed has 3 storeys) (e) [e=d*3]	15 X 3= 45	24 X 3= 72
Accommodation strength (f_1,f_2) [f=e*2]	90	144
Cumulative floor area (g) [$g=a_1+a_2$]	1557 sq ft	
Total persons accommodated in the two halls ($f= f_{1+}f_2$)	234	
Effective floor area per person (g/f)	6.65 sq ft	

10.2.2. Emergency Storage Kit: Field surveys have revealed that during the disaster periods, a large portion of the population are unsure of what belongings they should carry with them to the cyclone shelters. This has resulted in carrying of some bizarre stuff like utensils, bed sheets, etc and also results in delays in evacuation process. Discussion with the stakeholders reveal that it would be highly beneficial if an emergency storage kit is devised and distributed for the storage of all necessary paper works like educational certificates, house deeds, medications and any other belongings that they deem to be valuable for shifting to the MPCS.

Moreover, the respondents also need to be counselled about the use of the kit and not to repurpose the same for other purposes which will then defy the whole purpose.

Table 31 shows details about the emergency storage kit and Figure 43 provides a pencil sketch of the various views of the emergency storage kit.

Table 31: Details about the emergency storage kit

Size	35 cm (L) X 25 cm (W) X 10 cm (D)
Colour	Yellow base colour with fluorescent orange/ red strips
Material	Acrylonitrile butadiene styrene (ABS) with washer to prevent water entry
Choice of material	• Impact resistance, toughness and rigidity; usable between -20 to 80 ºC. • Easy addition of pigments to get desired colour. • Resistant to common acids, water, electricity. • Recyclable. • Used in manufacturing automobile parts, helmets, the iconic Lego toys and Lamy fountain pen, thus known reputation in crash resistance and safety • Cost-effective and durable
Utility	• Official documents like Adhaar card, PAN card, Ration Card, EPIC Card, Passport, Caste certificate, marriage certificate, house deed, educational certificates and marksheets, etc. • Any other belonging of significant importance according to the owner, specially which are difficult to obtain in duplicate

(Rutkowski & Levin, 1986)**,** (Sharon , etal., 2016)**,** (Peters, 2002)

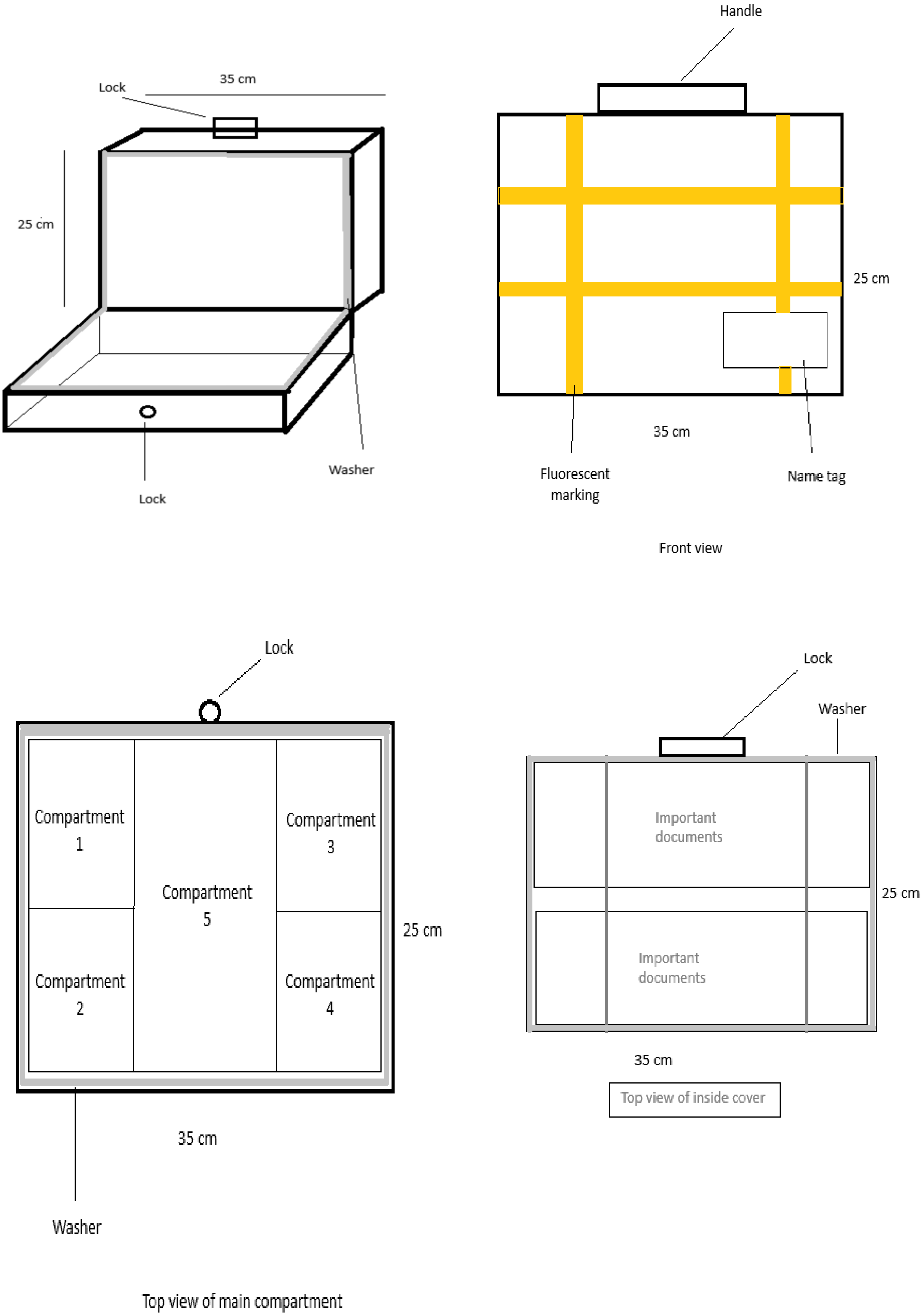

Figure 43:(clockwise) a) Design of the box. b) Front view of the box. c) Top view of inside cover. d) Top view of main compartment

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CHAPTER ELEVEN

CONCLUSION

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CONCLUSION

11.0. Foreground:

Tropical Cyclones are atmospheric disturbances formed over warm ocean water. They are rapidly spinning storms that acquire their energy from the warm tropical ocean's waters beneath. The Bay of Bengal has experienced an increase in the intensity of tropical cyclones in terms of wind speed and cyclone size in recent decades. Over the past five years, tropical cyclones FANI (May 2019), BULBUL (November 2019), AMPHAN (May 2020), YAAS (May 2021), REMAL (May 2024) and DANA (October 2024) have severely disrupted the social and economic structure of West Bengal's coastal areas. The people living near the coast are especially vulnerable as they are poor and lack in resources. They mainly depend on land and water for agriculture and fishing respectively. The government is taking initiatives for better preparedness and mitigation of cyclone disasters. This study aims in understanding the level of vulnerability of the coastal community in few aspects such as health, socioeconomic and infrastructure as well as evaluates the existing infrastructures facilities like road network and MPCSs as preparedness strategies.

11.1. Summary of major findings from the research objectives: This section summarises the significant findings in relation to the aim of the research.

11.1.1. Fulfilling Research Objective 1: Evaluate the existing Structural Preparedness Strategies.

Research questions:

- 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

All the CD blocks are found to have moderately connected, moderately efficient complex road networks of varying spatial distribution and development. The road network analysis reveals a variable pattern of distribution with certain areas having road networks that are efficient and accessible as analysed by Shimbel and detour index. However, a consistent pattern is that the Gram Panchayats nearer to the coastline fare poorly with respect to the

Shimbel and Detour index, thus providing a valuable area for equitable allocation of funds for proper disaster mitigation.

Research questions:

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

Approach: Uniformity and equitability of distribution of MPCS

The pattern of distribution of MPCS is random and clustered in Contai-I and Deshapran while it was random and uniform in Ramnagar I, random and dispersed in Ramnagar II and clustered in Khejuri II.

The study finds an unequitable distribution of MPCS, high schools and metalled roads with only 21%, 26% and 31% of the surveyed households having reliable access to these infrastructures respectively. Healthcare facilities and administrative blocks are more uniformly distributed with only 17% and 45% of the surveyed households having inaccessibility to these respectively.

Research questions:

- Are the existing MPCS sustainable?
- Are the conditions at MPCS humane to carry the vulnerable population?

Approach: Evaluation of existing MPCS

The study finds that 29.2% (n=12) of the 41 MPCS in the 5 blocks to be unsatisfactory in terms of maintenance and available amenities, while 26.8% (n=11) fared good in the selected criteria.

The use of this shelter during non-disaster periods leads to its better maintenance and can be used more effectively during emergencies. Regular use also provides economic justification for the investment. The Cyclone shelters are often used as training camps, election booths, health camps, community gatherings and meetings, but use as schools or offices are not recommended as the shelters are to be evacuated immediately in case of cyclone warning.

11.1.2. Fulfilling Research Objective 2: To comprehend the level of Vulnerability of the coastal community to tropical cyclones.

Research questions:

- How does chronic disease burden affect the vulnerability?

- Which CD blocks need special attention?
- Which health dimension needs special intervention?

Approach: Health Vulnerability Index

The proposed health vulnerability index includes nine indicators: vulnerable age groups, disability, under-5-mortality, no. of hospital beds, physicians' density, households with low income, incidence of tuberculosis, DTP vaccination gap and measles vaccination gap. A two-stage dimension reduction model using Principal Component Analysis was used to compute the index and corresponding risk of the five cyclone-prone coastal blocks of Purba Medinipur district of West Bengal, India. Khejuri II has the highest index of health vulnerability with a high corresponding risk. It also has the lowest number of cyclones shelters as well as hospitals where people can take refuge in times of need. Contrarily, Ramnagar I poses the lowest Health Vulnerability Index and subsequently the lowest risk. This block has many sprawling beaches that dot the coastline of Bay of Bengal and its associated tourism and water sports, which leads to revenue generation, thus resulting in infrastructural development of the area and overall socio-economic upliftment of its residents.

Research questions:

- 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

Indicators of relevance for the computation of social vulnerability index and the corresponding demographic and economic sensitivity risk and infrastructural adaptivity risk were finalised after thorough literature review and like the formulation of health vulnerability index, a two-stage dimension reduction model using Principal Component Analysis was used. Summarily, the GPs possessing significant demographic and economic risk to cyclone disasters in our study area include Amtalia (Deshapran CD Block), Haludbari (Khejuri 2 CD block), Sarada (Deshapran CD Block), Baratala (Khejuri 2 CD block) and Badhia (Ramnagar 1). GPs possessing significant infrastructural adaptivity risk to cyclone disasters in our study area include Amtalia (Deshapran CD Block), Aurai (Deshapran CD Block), Dulalpur (Contai 1 CD Block), Basantia (Deshapran CD Block) and Rajpur Paschimbar (Contai 1). Focused distribution of resources will lead to better disaster preparedness strategies.

11.2. Major recommendations:

11.2.1. Capacity enhancement of MPCS:

A vertical multi-level bunk bed system is proposed for the MPCS. This plan, apart from utilising the height of the rooms and accommodating sizable number of affected persons in reasonable living conditions, also provides for sufficiently wide corridors and empty spaces in front of doors and windows in the rooms. This provides for movement of the people with reasonable ease and assures smooth evacuation if any emergency arises. It also ensures adequate sunlight in the room maintaining the hygienic conditions and catering to the mental health of the occupants of the MPCS even in the difficult times

11.2.2. Formulation of emergency storage kit:

Field surveys have revealed that during the disaster periods, a large portion of the population are unsure of what belongings they should carry with them to the cyclone shelters resulting in unnecessary delays in the evacuation process as well as loss of important documents and belongings, causing further hardships. After discussion with the local stakeholders, a shatterproof emergency storage kit, built of impact resistant, tough, rigid and temperature proof Acrylonitrile Butadiene Styrene (ABS), measuring 35 cm (L) X 25 cm (W) X 10 cm (D) is proposed for the safe storage and carry of necessary documents and belongings during disaster periods.

11.3. Contribution of the research: The contributions of this research study are in manifolds.

11.3.1. Contribution to knowledge: The study provides a comprehensive insight into the disaster preparedness of the five cyclone prone coastal blocks of Purba Medinipur district of West Bengal. The aspects of road network analysis, degree of demand of MPCS and other existing permanent infrastructure, upkeeping and status of the MPCS have been dealt with in detail. The concept of health vulnerability index based on certain selected chronic health indicators have been introduced and risk stratified block-wise. Each Gram Panchayat of the study area has been risk stratified based on its economic and demographic sensitivity and infrastructural adaptivity. The data thus obtained may pave the way for more equitable distribution of resources by the authority for a more comprehensive and holistic disaster preparedness strategy.

11.3.2. Contribution to methodology: The vulnerability indices and risk stratification of the GPs and blocks with respect to health, economic and demographic sensitivity and infrastructural adaptivity have been calculated using a two-stage dimension reduction model using Principal Component Analysis. The methodology is robust enough to accommodate any change in variables or data in the future. Moreover, the methodology may be extrapolated to other disaster-prone area with minimal customisation. Scoring of the MPCS using multi criteria decision making model using Analytical Hierarchy Process (AHP) is comprehensive to accommodate any future changes and may also be extrapolated to other disaster-prone area with minimal customisation**.**

11.4. Limitations of the study:

- Unbiased survey regarding MPCS was not possible at times due to some external factors beyond our control
- Some Chronic disease burden like diabetes and hypertension data are not robust enough to be included into the Health Vulnerability assessment. However, the Vulnerability Index model created is competent enough to include any new variable.
- Up to date data from the secondary data source was not available for the calculation of SVI in all the study blocks
- Some disaster management variables have been calculated at the level of Gram Panchayat while some have been calculated at the level of CD blocks due to non-availability of ground level data below that, resulting in a non-uniformity of results like indices and risk stratification.

11.5. Future scope:

The study sets the tone and may be used as a pilot to introduce the concept of health vulnerability based on chronic health parameters. Moreover, as the chronic disease registry gets populated and updated with the government’s increasing efforts on non-communicable diseases, more variables may be introduced to create a more holistic health vulnerability index. The methodology used is robust enough to accommodate any new changes from time to time. Similarly, as the census gets updated from time to time, the social vulnerability index, demographic and economic risk and infrastructural adaptivity risk may be continuously updated to reflect the changing scenario. The recommendations of emergency storage kit and vertical bunk beds may be tried as a pilot project in the study area with some authorised funding and resource building to ascertain if any scope for improvisation arises. Thus, co-operated and co-ordinated efforts and improved governmental oversight and funding with inputs from verified inputs may pave the way for comprehensive disaster resistance and risk reduction models in the vulnerable population.

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ANNEXURE

Field photographs

Photograph 1: Small Makeshift Bridge over a tidal creek in Contai 1. May 2019

Photograph 2: During Social Survey, May 2019

Photograph 3: Cyclone Shelter near tidal creek, November 2019

Photograph 4: Figure 1: Households Surveyed, June 2022

Photograph 5: Local villagers during surey, November 2019

Photograph 6: Signage indicating towards the MPCS, April ,2022

Photograph 7: MPCS within a school ground in Khejuri 2

Photograph 8: Primary school in the MPCS April 2022

Photograph 9: Fishermen's huts within 200m of the sea, Tajpur, 2019

Photograph 10: Gram Panchayat Office of Basantapur mouza, Contai 2

Photograph 11: Group discussions with villagers in Badhia, April 2022

FiPhotograph 12: Cultivation field in Ramnagar 1

Photograph 13: Beach of Dakshin Purushottampur, ramnagar2

Photograph 14: Sand accumulation in front of hotel in Mandarmani

Photograph 15: Concrete road in study area. May 2022

QUESTIONNAIRE

GPS ID: Waypoint ID: Photograph ID:

Demographic Vulnerability Status:

1. Name: ……………………………………………(Caste: ……………. Age: …..….)

2. Language Spoken…………………………………………………………..

3. Demographic structure:

A. No. of Family Members: …………… M [ ] F [ ].

B. Age Group: 0-5 [ ] 5-13 [ ] 14-17 [ ] 18-35 [ ] 35-59 [ ] 60+ [ ].

C. Educational qualification:

Primary		Secondary		Higher Secondary		Graduate Level		Post Graduate Level		Diploma/Doctoral/Others	
M	F	M	F	M	F	M	F	M	F	M	F

4. Occupation Type: ……………………………………………

5. Monthly Income: ………………………………………………

6. MONTHLY EXPENDITURE:

FOOD	CLOTHING	EDUCATION	HEALTHCARE	MISCELLANEOUS

7. House Condition:

Criteria	Score	Remarks
Roof's condition (leakage)		
Sanitation facilities		
Ventilation (doors & windows)		
Electrical features' condition (safety purpose)		
Floor Type		
Dampness and humidity in house		

0 unsatisfactory; 1- average; 2- highly satisfactory.

8. Source of Water: Piped [ ] Well [ ] Pond [ ] Pit [ ] Tube-well [ ] Other………… Distance: ………..

9. Change in the drinking water source and quality (if any please specify). …..…………………………..

10. Availability and Accessibility of Sanitation facility during day and night:

A)

Available	Available during day only	Not Available

b) Exclusive for the household [ ]   shared with 2 households [ ]   community toilets [ ]

11. Types and number of livestock owned by the family

Goat	Hen	Duck	Cow	Pig	others

12. Types and number of vehicles owned by the family

Car	Cycle	Bike/scooter	Motor Van	Van Rikshaw	Toto/Auto	Tractor	others

Perception on Cyclones and MPCS:
1. Last Cyclone witnessed:
2. Year: …………………………… Loss of property (in rupees):
…………………………………………………………………
3. House fully destroyed / partially destroyed / was intact   approx. Loss………………………………..
4. Livestock lost/ remained safe   approx. loss
………………………………………….
5. Loss of crops, type: …………………………………..   Approx. loss
……………………………………………………….
6. Area inundated: distance up to: ……………………………………duration:
…………………………………………………
7. Area remained: accessible / inaccessible   [how long………………..]
8. Damage to   kuccha roads only/ metaled roads also / no damage to roads
9. Major failures:
……………………………………………………………………………………………………..
10 Location of Nearest MPCS……………………………………………………………

11. Nearest High School………………………………………………………………….

12. Nearest Hospital/ Health care centre………………………………………….

13. Rating of hazards (0: least threatening; 4: most threatening)

	Hazard						Change during time			duration
A.	Cyclonic wind	0	1	2	3	4	⇧	⇩	⇔	
B.	Storm Surge	0	1	2	3	4	⇧	⇩	⇔	
C.	Coastal flooding (fresh weather)	0	1	2	3	4	⇧	⇩	⇔	
D.	Flood (non-stormy/ due to rain)	0	1	2	3	4	⇧	⇩	⇔	
E.	Saline water intrusion (ground)	0	1	2	3	4	⇧	⇩	⇔	
F.	Salt water intrusion (surface)	0	1	2	3	4	⇧	⇩	⇔	

14. Disaster Management: Before Cyclones

A. Information disseminated through: Miking by local police or panchayats / radio/ newspaper/ SMS / social media
B. Evacuation done: By local police and panchayats/ by self / NGOs / NDRF Teams / No evacuation done
C. Evacuated to: Cyclone Shelters/ Local Schools / Private House or Hotels/ Others please specify
D. Hours of stay: …………………………… Way of Staying: Standing / Sitting / Laying
E. People per room: ………………………... any Govt. Official's presence: Y / N
F. Food Provided: Yes / No. if yes, types and quality:
G. Livestock evacuated? Y / N provided shelter?

15. Disaster Management: Post Cyclones

A. Any type of vector disease outbreak: ……………………………………….
B. Medical facilities / Aid for house repairing / Food supply / restoration of electricity / restoration of embankments and roads / Aid for loss of crops and livestock
C. Remarks:

16. Rating of some facilities (0: fully unsatisfactory; 4 fully satisfactory):

							Change in 10 years		
A.	Disaster information dissemination	0	1	2	3	4	⇧	⇩	⇔
B.	Evacuation procedure	0	1	2	3	4	⇧	⇩	⇔
C.	Condition of Shelters	0	1	2	3	4	⇧	⇩	⇔
D.	Food provided	0	1	2	3	4	⇧	⇩	⇔
E.	Post cyclone management	0	1	2	3	4	⇧	⇩	⇔
F.	Aid (Monetary) Provided	0	1	2	3	4	⇧	⇩	⇔

17. Coping Strategies

Through Food: ……………………………………………………………………

a) Limit food intake per meal [ ]

b) Limit the number of meals per day [ ]

c) Skipping one major meal

d) Buying less expensive food []

f) Purchase food on credit [ ]

Borrowing Money ……………………………………………………………….

g) Taking Loan from Bank/ NGOs/ money lenders [ ]

h) Borrow from relatives/friends and neighbours [ ]

i) Sell cattle /livestock/ land and other assets [ ]

j) Spend money from savings [ ]

Through Extra Work: ……………………………………………………………..

k) Work as unskilled labour [ ]

l) Work extra shifts [ ]

M) Migrate to city or other area for work [ ]

Perception on Health Vulnerability Status:

1. Common illness: ……………………………

2. Person contacted when sick: Asha worker/ Doctor/Nurse/ Religious person/ others

3. Treatment availed at: Govt Hospital [ ], Private Hospital [ ], Private Clinics [ ]

4. Up-to-date Vaccination of children: Y/N

5. Cases of Tuberculosis in the household:

6: Cases of Measles and Chicken pox in the family

7. Any Special care for pregnant women during cyclone warning?

Remarks…………………………………………………………………………………….................

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....

....

Name of Surveyor and Date:

Table 1: Data for Detour Index (Ramnagar-I)

NODE PAIR	ACTUAL DISTANCE(KM)	RAMNAGAR-I STRAIGHT LINE DISTANCE(KM)	DI	DI%
1,2	1.941268	1.760882	1.102441	110.2441
2,5	1.520116	1.499205	1.013948	101.3948
3,5	0.365209	0.365209	1	100
4,5	0.734762	0.71578	1.026519	102.6519
5,6	3.415645	2.940901	1.161428	116.1428
6,7	0.783556	0.7822673	1.001647	100.1647
6,8	0.355553	1.861097	0.191045	19.10449
8,9	1.865256	1.861097	1.002235	100.2235
9,10	2.519576	2.488644	1.012429	101.2429
9,12	2.51444	0.765184	3.286059	328.6059
12,13	5.424871	5.264501	1.030463	103.0463
13,14	0.953023	0.909503	1.04785	104.785
14,15	2.186038	1.914931	1.141575	114.1575
8,14	4.346051	4.259823	1.020242	102.0242
14,16	1.076172	1.07173	1.004145	100.4145
13,18	5.509142	5.421149	1.016231	101.6231
17,18	1.446771	1.442157	1.003199	100.3199
17,23	3.669114	3.648611	1.005619	100.5619
16,17	5.011707	4.988239	1.004705	100.4705
16,20	2.733734	2.610216	1.047321	104.7321
26,28	0.432235	0.432235	1	100
26,27	2.03438	0.598568	3.398745	339.8745
24,27	0.807702	0.805692	1.002495	100.2495
24,25	2.461509	2.456079	1.002211	100.2211
21,25	0.870196	0.853839	1.019157	101.9157
21,23	0.194638	0.195779	0.994172	99.4172
21,22	2.012814	1.946226	1.034214	103.4214
18,19	1.609173	1.538607	1.045864	104.5864
29,30	11.875187	2.994143	3.966139	396.6139
19,29	1.367822	2.683313	0.509751	50.97512
24,23	3.317586	2.683313	1.236377	123.6377

Table 2: Data for Detour Index (Ramnagar-II)

NODE PAIR	ACTUAL DISTANCE(KM)	RAMNAGAR-II STRAIGHT LINE DISTANCE(KM)	DI	DI%
4,5	3.559932	3.307975	1.076167	107.6167
2,4	0.756709	0.738496	1.024662	102.4662
2,3	0.387847	0.378155	1.02563	102.563
1,2	3.063121	3.055478	1.002501	100.2501
2,9	5.968171	5.954393	1.002314	100.2314
9,24	1.337343	1.337139	1.000153	100.0153
24,25	3.356214	3.063196	1.095658	109.5658
24,26	3.427711	3.006484	1.140106	114.0106
26,27	0.428136	0.397258	1.077728	107.7728
26,28	0.59162	0.515919	1.14673	114.673
23,24	3.13043	3.067856	1.020397	102.0397
10,23	0.901223	0.888151	1.014718	101.4718
9,10	2.749127	2.593926	1.059832	105.9832
10,11	1.109114	0.983702	1.12749	112.749
8,11	4.294231	3.888432	1.104361	110.4361
7,8	0.921821	0.907236	1.016076	101.6076
4,7	1.013953	0.998346	1.015633	101.5633
6,7	3.707873	3.658584	1.013472	101.3472
8,14	3.127471	3.001178	1.042081	104.2081
13,14	2.896221	2.369835	1.222119	122.2119
12,13	0.786471	0.710742	1.106549	110.6549
11,12	1.324996	1.257359	1.053793	105.3793
12,23	2.136136	2.012156	1.061616	106.1616
23,29	4.70714	4.618188	1.019261	101.9261
22,29	1.831606	1.814043	1.009682	100.9682
21,22	1.931686	1.92548	1.003223	100.3223
21,20	2.528574	1.762461	1.434684	143.4684
19,20	1.373649	1.372423	1.000893	100.0893
17,19	1.440076	1.427886	1.008537	100.8537
17,18	0.439311	0.43505	1.009794	100.9794
16,17	0.239607	0.238607	1.004191	100.4191
13,16	3.158362	2.864467	1.1026	110.26
15,16	2.540445	0.830902	3.057454	305.7454
14,15	6.237432	2.300585	2.711237	271.1237
22,30	4.625581	5.896194	0.784503	78.45029
33,30	1.29914	3.658677	0.355085	35.50846
32,33	5.55061	1.299132	4.272553	427.2553
19,33	9.322995	1.299084	7.176591	717.6591
30,31	9.217803	5.032236	1.831751	183.1751
29,30	1.299132	6.140674	0.211562	21.15618

Table 3: Data for Detour Index (Contai-I)

		CONTAI-I		
NODE PAIR	ACTUAL DISTANCE(KM)	STRAIGHT LINE DISTANCE(KM)	DI	DI%
1,2	5.915021	5.844274	1.012105	101.2105
3,4	9.660219	9.605904	1.005654	100.5654
2,6	3.056038	2.973071	1.027906	102.7906
2,5	6.236579	6.201288	1.005691	100.5691
8,9	2.716507	2.69649	1.007423	100.7423
6,7	7.524474	4.645864	1.619607	161.9607
7,8	11.006987	6.536373	1.683959	168.3959
10,11	0.658119	0.658119	1	100
9,10	0.384877	0.364385	1.056237	105.6237
5,9	0.796796	0.757508	1.051865	105.1865
4,5	0.569742	0.627215	0.908368	90.83679
4,14	2.132906	1.491053	1.43047	143.047
5,15	0.929277	0.877975	1.058432	105.8432
4,15	0.764269	0.689855	1.107869	110.7869
15,17	0.758919	0.575778	1.318076	131.8076
13,14	0.459725	0.43123	1.066078	106.6078
12,13	0.205448	0.147058	1.397054	139.7054
13,17	3.924329	3.822302	1.026693	102.6693
14,18	1.351181	1.364057	0.990561	99.05605
11,12	0.468398	0.464841	1.007652	100.7652
11,16	8.53222	8.530973	1.000146	100.0146
10,16	16.283951	8.80771	1.848829	184.8829

Table 4: Data for Detour Index (Deshapran)

NODE PAIR	ACTUAL DISTANCE(KM)	DESHAPRAN STRAIGHT LINE DISTANCE(KM)	DI	DI%
1,2	4.985362	4.905479	1.016284	101.6284
2,3	7.33913	6.585714	1.114402	111.4402
3,4	5.473376	4.501117	1.216004	121.6004
4,5	0.521175	0.521175	1	100
2,6	0.522172	0.5174	1.009223	100.9223
6,9	0.484457	0.479083	1.011217	101.1217
9,10	5.247083	3.615977	1.451083	145.1083
8,10	4.857875	4.637221	1.047583	104.7583
6,7	5.706775	5.589666	1.020951	102.0951
7,11	2.638436	2.146843	1.228984	122.8984
7,8	6.00456	4.366063	1.37528	137.528
8,12	10.016828	8.334615	1.201835	120.1835
12,13	7.749214	3.879285	1.997588	199.7588

Table 5: Data for Detour Index (Khejuri-II)

NODE PAIR	ACTUAL DISTANCE(KM)	KHEJURI-II STRAIGHT LINE DISTANCE(KM)	DI	DI%
1,2	0.798514	0.790783	1.009776	100.9776
2,3	1.759842	1.86835	0.941923	94.19231
3,4	3.479954	3.400321	1.023419	102.3419
4,5	2.216119	2.077576	1.066685	106.6685
5,6	0.28532	0.28532	1	100
6,7	5.485358	4.385947	1.250667	125.0667
6,8	7.772562	5.998943	1.295655	129.5655
5,9	3.736256	3.502456	1.066753	106.6753
5,10	2.801762	2.466722	1.135824	113.5824
11,12	2.228511	2.221428	1.003188	100.3188
12,15	9.628601	9.070161	1.061569	106.1569
2,13	4.27147	3.820824	1.117945	111.7945
14,15	3.856815	3.074777	1.25434	125.434
3,13	4.259862	4.131965	1.030953	103.0953
4,12	4.214585	4.002185	1.053071	105.3071
7,6	0.969532	1.024592	0.946262	94.62615

Table 6: Data for calculation of road network indices of the study area

alpha	nodes	edges			
ramnagar1	561	652	92	1117	0.082363
ramnagar2	292	335	44	579	0.075993
contai1	747	817	71	1489	0.047683
deshapran	387	428	42	769	0.054616
khejuri2	370	423	54	735	0.073469

beta	nodes	edges	
ramnagar1	561	652	1.16221
ramnagar2	292	335	1.14726
contai1	747	817	1.093708
deshapran	387	428	1.105943
khejuri2	370	423	1.143243

gama	nodes	edges		
ramnagar1	561	652	1677	0.38879
ramnagar2	292	335	870	0.385057
contai1	747	817	2235	0.365548
deshapran	387	428	1155	0.370563
khejuri2	370	423	1104	0.383152

eta	total length	edges	
ramnagar1	325.614901	652	0.499409
ramnagar2	300.715356	335	0.897658
contai1	514.954562	817	0.630299
deshapran	329.98343	428	0.770989
khejuri2	303.03237	423	0.716389

theta	total length	nodes	
ramnagar1	325.614901	561	0.580419
ramnagar2	300.715356	292	1.029847
contai1	514.954562	747	0.689364
deshapran	329.98343	387	0.85267
khejuri2	303.03237	370	0.819006

Table 7: Data for calculation of mean centre of population (Ramnagar-I)

CD BLOCKS	TOTAL POP	LATITUDE	LONGITUDE	XP	YP
Bherichauli	446	21.658413	87.605928	9659.652198	39072.2439
Dublabari	612	21.668142	87.603462	13260.9029	53613.3187
Alampur	29	21.670179	87.614844	628.435191	2540.83048
Jaldha	2,177	21.654178	87.612717	47141.14551	190732.885
Bera Khana		21.645774	87.620644	0	0
Tajpur	920	21.656132	87.630812	19923.64144	80620.347
Junbani		21.6682	87.633122	0	0
Nardanda	530	21.652023	87.464314	11475.57219	46356.0864
Medinipur	2,083	21.649468	87.508606	45095.84184	182280.426
Paya	458	21.652133	87.500971	9916.676914	40075.4447
Kashipur	661	21.645987	87.500027	14307.99741	57837.5178
Bansbani	597	21.642868	87.490879	12920.7922	52232.0548
Mandala	1,220	21.635931	87.482393	26395.83582	106728.519
Mrijapur	1,037	21.637417	87.487511	22438.00143	90724.5489
Saripur	290	21.637262	87.49575	6274.80598	25373.7675
Padima	1,458	21.627615	87.489415	31533.06267	127559.567
Bhagibaharampur	970	21.625845	87.510248	20977.06965	84884.9406
Chanpabani	1,026	21.628854	87.505038	22191.2042	89780.169
Ratanpur	926	21.623978	87.49313	20023.80363	81018.6384
Jatimati	2,133	21.63188	87.499534	46140.80004	186636.506
Dakshinshimulia	1,543	21.639274	87.504902	33389.39978	135020.064
Bilamria	1,516	21.635116	87.512008	32798.83586	132668.204
Jagadishpur	718	21.639245	87.523812	15536.97791	62842.097
Ghersai	901	21.638836	87.531564	19496.59124	78865.9392
Gobindabasan	1,007	21.629161	87.529398	21780.56513	88142.1038
Somaibasan	269	21.63185	87.535818	5818.96765	23547.135
Gangadharpur	359	21.627261	87.536294	7764.186699	31425.5295
Atili	42	21.629989	87.543185	908.459538	3676.81377
Jagai Basan	102	21.633549	87.54098	2206.621998	8929.17996
Maitrapur	1,204	21.64001	87.541797	26054.57204	105400.324
Mirjapur	362	21.643372	87.545043	7834.900664	31691.3056
Haropur	1,070	21.648746	87.539397	23164.15822	93667.1548
Alankarpur	1,481	21.650331	87.529074	32064.14021	129630.559
Daha Daya	1,720	21.648944	87.519558	37236.18368	150533.64
Purba Mukundapur	2,766	21.6448	87.553958	59869.5168	242174.248
Begundiha		21.632267	87.547729	0	0
Digha		21.638474	87.565507	0	0
Raypur		21.639918	87.568248	0	0
Jhaoa		21.63844	87.578158	0	0
Khadalgobra (CT)	5,344	21.632357	87.519538	115603.3158	467704.411
Kanda Gram	988	21.741882	87.468222	21480.97942	86418.6033
Kachua	227	21.738385	87.45837	4934.613395	19853.05
Barbatia	552	21.735541	87.450827	11998.01863	48272.8565
Bakharpur	516	21.732868	87.466061	11214.15989	45132.4875
Udampur		21.72534	87.465299	0	0

Badhia	5,979	21.726484	87.479228	129902.6478	523038.304
Bag Brajakishor	927	21.712301	87.474604	20127.30303	81088.9579
Santeshwarpur	2,857	21.705435	87.479212	62012.4278	249928.109
Shakhamudi	351	21.699793	87.479806	7616.627343	30705.4119
Shyamsundarpur	39	21.69521	87.476868	846.11319	3411.59785
Purushottampur	2,715	21.699766	87.490526	58914.86469	237536.778
Damadarpur	4,236	21.70412	87.511885	91938.65232	370700.345
Chandanpur Patna	979	21.71172	87.495222	21255.77388	85657.8223
Minabag	406	21.713435	87.488279	8815.65461	35520.2413
Padubar	1,671	21.720989	87.491611	36295.77262	146198.482
Juki	2,410	21.72493	87.506028	52357.0813	210889.527
Chandanpur	1,766	21.714782	87.501258	38348.30501	154527.222
Bidyadharpur	806	21.714701	87.50864	17502.04901	70531.9638
Uttar Mukundapur	1,176	21.71268	87.51385	25534.11168	102916.288
Baliharpur	138	21.724304	87.516709	2997.953952	12077.3058
Haldia	3,370	21.690478	87.529013	73096.91086	294972.774
Khairanda	1,767	21.694198	87.520555	38333.64787	154648.821
Rania	837	21.688018	87.517082	18152.87107	73251.7976
Nilkantapur	1,125	21.686771	87.511459	24397.61738	98450.3914
Jharpadima	524	21.694884	87.512856	11368.11922	45856.7365
Sadi	2,152	21.695819	87.506715	46689.40249	188314.451
Arjjuni	601	21.683865	87.506512	13032.00287	52591.4137
Akhuya Dangri	982	21.684908	87.499717	21294.57966	85924.7221
Kholaberya	841	21.693465	87.501106	18244.20407	73588.4301
Kainara	2,875	21.690155	87.491326	62359.19563	251537.562
Dedanri	1,812	21.683064	87.491072	39289.71197	158533.822
Ashwatthapur	1,920	21.678098	87.483602	41621.94816	167968.516
Ranisai	3,976	21.687313	87.477223	86228.75649	347809.439
Nonaari	1,124	21.677958	87.471884	24366.02479	98318.3976
Mukundapur	5,054	21.669228	87.481626	109516.2783	442132.138
Kiyakuli	892	21.669579	87.470694	19329.26447	78023.859
Jashateghari	1,176	21.661942	87.470358	25474.44379	102865.141
Hinari	362	21.655509	87.463818	7839.294258	31661.9021
Santra	2,612	21.656001	87.475603	56565.47461	228486.275
Shonpur	1,508	21.656893	87.486902	32658.59464	131930.248
Durgapur	2,194	21.659827	87.497281	47521.66044	191969.035
Deuli	1,584	21.667654	87.494413	34321.56394	138591.15
Rautrapur	653	21.67024	87.489749	14150.66672	57130.8061
Dihibir Kul	2,430	21.675945	87.497989	52672.54635	212620.113
Madhupur	776	21.677461	87.509191	16821.70974	67907.1322
Tangabani	258	21.677132	87.513695	5592.700056	22578.5333
Shukra Shani	562	21.6783	87.517464	12183.2046	49184.8148
Hajipur	228	21.682366	87.516397	4943.579448	19953.7385
Bandhmuri	750	21.683263	87.520748	16262.44725	65640.561
Kulbudhi	1,259	21.678015	87.526005	27292.62089	110195.24
Uttar Shimulia	943	21.681332	87.533918	20445.49608	82544.4847
Shanbalishai	785	21.681755	87.541097	17020.17768	68719.7611
Hirapur	1,514	21.672566	87.537572	32812.26492	132531.884

Bagmari	1,271	21.672059	87.528804	27545.18699	111249.11
Mangalpur	1,117	21.673534	87.518104	24209.33748	97757.7222
Kantabani	1,896	21.669746	87.511516	41085.83842	165921.834
Gangpura	1,344	21.669536	87.502248	29123.85638	117603.021
Gobra	2,661	21.661919	87.50885	57642.36646	232861.05
Basantapur	1,364	21.648316	87.494496	29528.30302	119342.493
Ullaspur	909	21.646198	87.484598	19676.39398	79523.4996
Paschimbar	949	21.64695	87.477708	20542.95555	83016.3449
Mahajan	1,136	21.66145	87.517079	24607.4072	99419.4017
Akna	674	21.660776	87.523862	14599.36302	58991.083
Ghanta Shala	688	21.668417	87.522296	14907.8709	60215.3396
Dakshin Kaya	515	21.667573	87.529571	11158.8001	45077.7291
Birampur	975	21.66094	87.531242	21119.4165	85342.961
Fatepur	1,012	21.659309	87.538188	21919.22071	88588.6463
Pariharpur	334	21.6599	87.544624	7234.4066	29239.9044
Kabra	1,658	21.673155	87.543477	35934.09099	145147.085
Tikra	904	21.670694	87.549279	19590.30738	79144.5482
Talga Chhari	3,421	21.674143	87.557559	74147.2432	299534.409
Ghritapura	359	21.67947	87.549798	7782.92973	31430.3775
Diksal	1,117	21.688957	87.541009	24226.56497	97783.3071
Potapara	239	21.695921	87.537069	5185.325119	20921.3595
Uttar Basulipat	558	21.692515	87.566008	12104.42337	48861.8325
Bagpura	3,270	21.683985	87.573033	70906.63095	286363.818
Dakshin Basulipat	909	21.683468	87.563755	19710.27241	79595.4533
Saiyadpur	1,383	21.679809	87.566788	29983.17585	121104.868
Ramnagar	1,914	21.673005	87.568409	41482.13157	167605.935
Talaria		21.661095	87.563135	0	0
Jhaugerya	746	21.652197	87.559605	16152.53896	65319.4653
Deulbatta	461	21.661718	87.556968	9986.051998	40363.7622
Bahadurpur	405	21.657999	87.552145	8771.489595	35458.6187
Dakshin Gopalpur	650	21.65897	87.54839	14078.3305	56906.4535
Chhota Balarampur	1	21.64014	87.5783	21.64014	87.5783
Kiagoria		21.636113	87.574546	0	0
Jamra Shyampur	702	21.640819	87.587693	15191.85494	61486.5605
Lachhimpur	842	21.644946	87.584854	18225.04453	73746.4471
Dalbaladya	177	21.647686	87.580971	3831.640422	15501.8319
Panch Daria	337	21.643961	87.575868	7294.014857	29513.0675
Dakshin Balarampur	130	21.642493	87.572954	2813.52409	11384.484
Shankarpur	545	21.64896	87.573392	11798.6832	47727.4986
Purba Birampur		21.655182	87.567011	0	0
Katan Diha		21.661415	87.56798	0	0
Kuliyata	143	21.663541	87.570853	3097.886363	12522.632
Jashipur	470	21.656754	87.577676	10178.67438	41161.5077
Kaluya Sanda	224	21.667221	87.579254	4853.457504	19617.7529
Bara Solemanpur	2,321	21.67485	87.57673	50307.32685	203265.59
Narina	1,580	21.677817	87.583121	34250.95086	138381.331
Nandi Chak	208	21.674163	87.583506	4508.225904	18217.3692
Biswanathpur	941	21.667138	87.590133	20388.77686	82422.3152

Bodhora	1,775	21.656552	87.586328	38440.3798	155465.732
Tengramari	1,460	21.654793	87.59454	31615.99778	127888.028
Kaema	248	21.645895	87.591335	5368.18196	21722.6511
Chandapur	1,944	21.644255	87.6003	42076.43172	170294.983
Kshirpal	671	21.656901	87.601291	14531.78057	58780.4663

Table 8: Data for calculation of mean centre of population (Ramnagar-II)

CD BLOCKS	TOTAL POP	LATITUDE X	LONGITUDE Y	XP	YP
Kasafaltalya	731	21.72	87.52278	15876.4	63979.2
Gobindapur	958	21.72	87.52437	20811.5	83848.3
Hamirpur	1,203	21.73	87.53355	26136.4	105302.9
Baranga	2,212	21.73	87.54298	48062.1	193645.1
Chakghuli	628	21.72	87.54070	13640.0	54975.6
Bheri Baranga	2,496	21.71	87.52641	54193.9	218465.9
Jagadishpur	1,026	21.70	87.53390	22267.3	89809.8
Mandar	3,583	21.69	87.55449	77710.1	313707.7
Paldhui	3,813	21.70	87.54517	82757.4	333809.7
Raghunathpur	836	21.70	87.55602	18138.4	73196.8
Kanpur	4,523	21.71	87.57302	98178.9	396092.8
Talkanpur	919	21.70	87.56685	19945.2	80473.9
Sabitrapur	3,367	21.70	87.55962	73079.8	294813.2
Madhabpur	3,191	21.72	87.55110	69294.8	279375.6
Nashirpur	246	21.72	87.55095	5343.8	21537.5
Gaurangabar	156	21.72	87.55625	3388.8	13658.8
Shikarbar	340	21.72	87.56033	7385.1	29770.5
Dayanidhibar	440	21.72	87.56639	9556.8	38529.2
Akulbar	365	21.72	87.57594	7927.7	31965.2
Jagadish Paschimbar	1,015	21.73	87.56996	22051.6	88883.5
Depar Shasanbar	1,805	21.73	87.55360	39219.3	158034.2
Ranichak	459	21.73	87.55333	9975.2	40187.0
Depal	3,359	21.74	87.55905	73009.8	294110.8
Kanjia	1,074	21.73	87.57024	23342.3	94050.4
Arya Padyapur	1,358	21.74	87.57542	29521.0	118927.4
Naya Shyampur	123	21.74	87.58339	2674.1	10772.8
Kadua	3,615	21.73	87.59132	78562.9	316642.6
Dharash	1,337	21.74	87.59626	29070.8	117116.2
Manikbasan	1,261	21.74	87.58217	27414.3	110441.1
Malancha	1,024	21.75	87.58356	22271.0	89685.6
Kalapunja	3,637	21.75	87.60208	79119.2	318608.8
Chata Padmapur	961	21.77	87.61528	20919.9	84198.3
Sonakania	879	21.76	87.62066	19125.2	77018.6
Dumana Paikbar	326	21.76	87.62631	7092.7	28566.2
Dumaria	1,168	21.76	87.62685	25416.8	102348.2
Paikbar	42	21.77	87.62607	914.2	3680.3

Katmundi	856	21.76	87.63676	18630.1	75017.1
Maithna Paikbar	154	21.76	87.64432	3351.7	13497.2
Mandarpur	1,682	21.76	87.64523	36592.2	147419.3
Khojabar	314	21.76	87.64206	6832.5	27519.6
Mahammadpur	295	21.76	87.63647	6419.5	25852.8
Bali Pukhuria	564	21.76	87.63274	12272.6	49424.9
Nij Maithuna	1,937	21.75	87.62513	42133.8	169729.9
Senapatibar	198	21.75	87.63370	4306.7	17351.5
Baksispur	1,475	21.75	87.63678	32081.0	129264.2
Uttar Maithuna	613	21.74	87.62537	13328.6	53714.4
Danda Belbani	2,705	21.74	87.61174	58808.6	236989.7
Lalpur	367	21.73	87.60612	7975.7	32151.4
Shonamui	736	21.73	87.61531	15992.6	64484.9
Dakshin Maithuna	866	21.74	87.62671	18823.1	75884.7
Haripur	191	21.74	87.63579	4151.6	16738.4
Sikharpur	58	21.74	87.63673	1261.0	5082.9
Dakshin Tentultala	1,603	21.74	87.64497	34846.3	140494.9
Uttar Tentultala	1,289	21.75	87.64581	28033.3	112975.4
Uttar kalyanpur Betulya		21.74	87.65430	0.0	0.0
Kalyanpur	150	21.74	87.65663	3261.0	13148.5
Raipur	168	21.74	87.66040	3652.1	14726.9
Dakshin Kalayanpur	711	21.73	87.65235	15452.4	62320.8
Balarampur	255	21.71	87.60518	5535.5	22339.3
Shahapur	538	21.73	87.64370	11690.4	47152.3
Khidirpur	1,023	21.73	87.63503	22227.9	89650.6
Ahammadpur	398	21.72	87.64385	8645.8	34882.3
Jinandipur	1,474	21.72	87.63334	32012.3	129171.5
Tatkapur	811	21.72	87.61926	17615.1	71059.2
Sherpur	730	21.71	87.62253	15851.6	63964.4
Khoyapur	431	21.71	87.62166	9356.7	37764.9
Dhanubar	313	21.71	87.61678	6795.8	27424.1
Uttar Gopalpur	1,564	21.72	87.61008	33966.0	137022.2
Purbba Raghunathpur	300	21.73	87.60713	6517.9	26282.1
Tajpur Purbbabar	1,594	21.72	87.59888	34621.9	139632.6
Gopal Chak	361	21.72	87.58945	7842.1	31619.8
Amritbar	346	21.72	87.58313	7516.4	30303.8
Nachhimpur	1,093	21.72	87.58359	23735.8	95728.9
Shyampur	847	21.71	87.58752	18387.0	74186.6
Kismathiar	918	21.70	87.58127	19923.5	80399.6
Thiar	2,180	21.70	87.58656	47305.4	190938.7
Uttar Kachua	577	21.71	87.59764	12524.4	50543.8
Tajpur Dakshinbar	1,196	21.71	87.59528	25968.6	104764.0
Radhapur	339	21.71	87.59977	7358.9	29696.3
Bar Badalpur	55	21.71	87.61273	1194.0	4818.7
Badalpur	1,096	21.70	87.61363	23788.2	96024.5
Chhota Kashinathpur	147	21.70	87.62563	3190.3	12881.0
Bara Kashinathpur	116	21.70	87.63220	2517.3	10165.3
Chahaka	623	21.69	87.62958	13515.9	54593.2

Satilapur	4,570	21.69	87.62184	99101.7	400431.8
Karonji	4,329	21.70	87.60269	93920.7	379232.0
Narandia	2,404	21.68	87.60937	52120.6	210612.9
Talkatalia	2,211	21.68	87.60185	47945.2	193687.7
Bara Bankuya	6,169	21.68	87.59221	133744.8	540356.4
Narkuli	2,597	21.69	87.57962	56330.3	227444.3
Mandarmani	507	21.65	87.65575	10977.0	44441.5
Silampur	963	21.66	87.65983	20859.1	84416.4
Deuli	2,357	21.68	87.63472	51108.0	206555.0
Phulbari	738	21.68	87.63650	16000.1	64675.7
Kalikapur	675	21.68	87.64102	14636.4	59157.7
Kandarpapur	1,862	21.69	87.64866	40385.0	163201.8
Nalguna	67	21.69	87.64137	1453.5	5872.0
Kanchibar	231	21.70	87.64110	5012.5	20245.1
Chak Pratappur	44	21.70	87.64826	954.7	3856.5
Islampur	2,847	21.71	87.64099	61796.5	249513.9
Satbatia	496	21.71	87.65106	10766.9	43474.9
Ghol	1,844	21.71	87.65018	40038.4	161626.9
Banbar	401	21.72	87.65076	8708.3	35148.0
Uttar Shitala	1,204	21.72	87.66418	26147.6	105547.7
Dakshin Shitala	1,605	21.71	87.66153	34843.2	140696.8
Keishnapur	214	21.70	87.65918	4643.5	18759.1
Chhota Chaulkhola	88	21.69	87.65675	1909.1	7713.8
Keshabpur	539	21.69	87.65533	11691.4	47246.2
Kalindi	4,893	21.69	87.66751	106122.5	428957.1
Suberia	1,431	21.70	87.66856	31057.2	125453.7
Purbba Bar	1,065	21.70	87.67812	23112.1	93377.2
Purbba Gadhadharpur	349	21.71	87.67224	7577.3	30597.6
Ramchandra Nagar	716	21.72	87.67506	15548.5	62775.3
Purbba Ramchandrapur	126	21.71	87.68380	2736.0	11048.2
Lachhandrapur	793	21.71	87.68390	17214.2	69533.3
Bishnupur	310	21.70	87.68819	6727.9	27183.3
Haurburi	265	21.70	87.68768	5749.8	23237.2
Kismat Haurburi	354	21.70	87.69348	7680.4	31043.5
Teghari	1,283	21.70	87.70045	27838.7	112519.7
Purbba Purushottampur	1,045	21.70	87.70799	22680.0	91654.9
Daudpur	141	21.69	87.68972	3057.9	12364.2
Dhunia Baraj	291	21.69	87.68248	6312.2	25515.6
Dera	3,628	21.68	87.68191	78653.5	318110.0
Sona Muhi	712	21.66	87.68527	15423.5	62431.9
Rania	2,313	21.68	87.69517	50136.8	202838.9
Dadanpatra	1,391	21.67	87.70665	30142.9	121999.9
Mania	6	21.68	87.71023	130.1	526.3
Dakshin Purushottampur	2,394	21.69	87.72748	51917.4	210019.6

Table 9: Data for calculation of mean centre of population (Contai-I)

CD BLOCKS	TOTAL POP	X	Y	XP	YP
Bishwanathpur	2,853	21.78064	87.616488	62140.16592	249969.8403
Paschim Chandanpur	1,804	21.785342	87.625635	39300.75697	158076.6455
Paschim Manikpur	2,308	21.800354	87.621564	50315.21703	202230.5697
Jangipur	187	21.794246	87.628286	4075.524002	16386.48948
Badalpur 1St Part	3,980	21.789427	87.636499	86721.91946	348793.266
Baramushapur	367	21.797777	87.636137	7999.784159	32162.46228
Saheb Khankeranibar	745	21.808715	87.645326	16247.49268	65295.76787
Brajamal	472	21.799532	87.64451	10289.3791	41368.20872
Kholanashwari	1,082	21.801779	87.651307	23589.52488	94838.71417
Ugrasenbar	991	21.795855	87.65485	21599.69231	86865.95635
Haipur	1,823	21.786093	87.65314	39716.04754	159791.6742
Junbani	1,637	21.782832	87.645962	35658.49598	143476.4398
Band Gobindapur	1,311	21.77881	87.635751	28552.01991	114890.4696
Alalpur	1,196	21.77087	87.640437	26037.96052	104817.9627
Kudbheri	2,088	21.768674	87.653636	45452.99131	183020.792
Laskar Pada	672	21.776809	87.654987	14634.01565	58904.15126
Gopal Pur 2Nd Part	557	21.773834	87.662624	12128.02554	48828.08157
Kashi Bhuianbar	72	21.781481	87.662281	1568.266632	6311.684232
Kanurautbar	8	21.785967	87.661294	174.287736	701.290352
Akandi	1,068	21.785855	87.668228	23267.29314	93629.6675
Ektarpur		21.725413	87.735038	0	0
Madanmohanbar	483	21.794088	87.66059	10526.5445	42340.06497
Dhaneshwari	512	21.79466	87.664889	11158.86592	44884.42317
Analberya	453	21.792719	87.671373	9872.101707	39715.13197
Kulbaria	1,194	21.801868	87.669681	26031.43039	104677.5991
Dakshin Khasda	133	21.809739	87.674655	2900.695287	11660.72912
Harichak	201	21.811748	87.668451	4384.161348	17621.35865
Kanchra Gerya	1,073	21.806093	87.664306	23397.93779	94063.80034
Akgerya	289	21.812908	87.663001	6303.930412	25334.60729
Dakshin Charai Khia	1,738	21.809341	87.65452	37904.63466	152343.5558
Uttar Charai Khia	553	21.815545	87.655918	12063.99639	48473.72265
Palta Beria	901	21.818535	87.669104	19658.50004	78989.8627
Paschim Teghari	114	21.825414	87.667004	2488.097196	9994.038456
Tedubi	3,083	21.825802	87.678976	67288.94757	270314.283
Uttarkhasda	1,315	21.815627	87.683739	28687.54951	115304.1168
Ulu Bere	294	21.811248	87.686175	6412.506912	25779.73545
Naraharichak		21.807561	87.678578	0	0
Dhangan	402	21.802759	87.677455	8764.709118	35246.33691
Paschim Jagannathchak	674	21.804049	87.684215	14695.92903	59099.16091
Natdighi	1,286	21.798448	87.691695	28032.80413	112771.5198
Nandaberya	91	21.79541	87.684096	1983.38231	7979.252736
Nunia	188	21.79412	87.678773	4097.29456	16483.60932
Rautara	822	21.798279	87.67548	17918.18534	72069.24456
Maisali	1,002	21.788517	87.679808	21832.09403	87855.16762
Surundia	746	21.783019	87.67712	16250.13217	65407.13152

Marra	490	21.774931	87.675182	10669.71619	42960.83918
Irda	903	21.779059	87.668831	19666.49028	79164.95439
Sitalpur	700	21.770869	87.668943	15239.6083	61368.2601
Hamirmahal	661	21.768539	87.66674	14389.00428	57947.71514
Betbani	277	21.765354	87.664569	6029.003058	24283.08561
Payradwip	543	21.762941	87.660444	11817.27696	47599.62109
Eryafatepur	912	21.761536	87.668687	19846.52083	79953.84254
Betgerya	1,055	21.754221	87.667067	22950.70316	92488.75569
Khalisabhanga	655	21.75651	87.665289	14250.51405	57420.7643
Sujulpur	180	21.757304	87.659747	3916.31472	15778.75446
Silampur	2,032	21.754195	87.652898	44204.52424	178110.6887
Gopalpur	414	21.745501	87.660907	9002.637414	36291.6155
Shribachhipur	364	21.748163	87.669021	7916.331332	31911.52364
Dulalpur	1,191	21.751986	87.67929	25906.61533	104426.0344
Mukundapur	1,726	21.754042	87.674144	37547.47649	151325.5725
Beltalya	1,257	21.741283	87.670724	27328.79273	110202.1001
Badalpur 2Nd Part	470	21.728247	87.655564	10212.27609	41198.11508
Ratanpur	583	21.724752	87.65901	12665.53042	51105.20283
Paschim Rasulpur	1,063	21.731198	87.663963	23100.26347	93186.79267
Nimdasbar	790	21.725098	87.666992	17162.82742	69256.92368
Surghani	314	21.732609	87.670415	6824.039226	27528.51031
Adambar	414	21.72739	87.672083	8995.13946	36296.24236
Kanchanpur	141	21.726113	87.677948	3063.381933	12362.59067
Sahajadapur	1,291	21.723398	87.684474	28044.90682	113200.6559
Subarnadihi	732	21.734122	87.678645	15909.3773	64180.76814
Bahulia	1,018	21.740743	87.683663	22132.07637	89261.96893
Kapasda	1,784	21.753385	87.68759	38808.03884	156434.6606
Tajpur	1,616	21.762285	87.68667	35167.85256	141701.6587
Rani Basan	1,167	21.760643	87.678633	25394.67038	102320.9647
Majna	4,653	21.766747	87.679256	101280.6738	407971.5782
Pania	1,497	21.769597	87.688034	32589.08671	131268.9869
Kantai	2,045	21.778709	87.685129	44537.45991	179316.0888
Jamgudi		21.789697	87.688222	0	0
Barbarya	1,352	21.785352	21.785352	29453.7959	29453.7959
Raipur Paschimbar	685	21.790965	87.696745	14926.81103	60072.27033
Raipur	1,608	21.795859	87.705594	35047.74127	141030.5952
Saria	447	21.788634	87.705164	9739.519398	39204.20831
Chanddia Dundibar	954	21.783483	87.700414	20781.44278	83666.19496
Chandia Haibatbar	114	21.78481	87.704156	2483.46834	9998.273784
Kanchuri	324	21.784741	87.711931	7058.256084	28418.66564
Sasania	955	21.792069	87.71514	20811.4259	83767.9587
Krishnachak	1,158	21.782587	87.722842	25224.23575	101583.051
Gimagere	956	21.774713	87.720889	20816.62563	83861.16988
Badhie	1,742	21.779361	87.716745	37939.64686	152802.5698
Tentulmuri	1,491	21.776455	87.710901	32468.69441	130776.9534
Jugi Bar	355	21.773262	87.70668	7729.50801	31135.8714
Tengunia	1,669	21.77551	87.700235	36343.32619	146371.6922
Rania	1,707	21.774023	87.692671	37168.25726	149691.3894

Alipur	195	21.768119	87.696648	4244.783205	17100.84636
Bhupatinagar	637	21.765879	87.696231	13864.86492	55862.49915
Siria	410	21.764804	87.701401	8923.56964	35957.57441
Nandierya	485	21.767303	87.705203	10557.14196	42537.02346
Namal	476	21.769937	87.709039	10362.49001	41749.50256
Raktia	286	21.769381	87.71527	6226.042966	25086.56722
Tagaria Gopalpur	397	21.761048	87.703505	8639.136056	34818.29149
Kachua	799	21.76098	87.696714	17387.02302	70069.67449
Tagria	556	21.753821	87.695151	12095.12448	48758.50396
Dakshin Ramchak	474	21.745985	87.693749	10307.59689	41566.83703
Uttar Bahulia	232	21.734051	87.693228	5042.299832	20344.8289
Sarishaberya	361	21.740639	87.696133	7848.370679	31658.30401
Mahishgot	1,033	21.73426	87.699732	22451.49058	90593.82316
Potapukhuria	384	21.727459	87.702756	8343.344256	33677.8583
Murabania	284	21.726585	87.69571	6170.35014	24905.58164
Dakshin Potapukhuria		21.713893	87.722286	0	0
Haripur	624	21.719559	87.696914	13553.00482	54722.87434
Krishna Khayartibar	1,521	21.712897	87.694895	33025.31634	133383.9353
Enayet Chak	161	21.709863	87.698752	3495.287943	14119.49907
Takia Haripurkhal	113	21.706106	87.697651	2452.789978	9909.834563
Daudpur	1,242	21.71845	87.70976	26974.3149	108935.5219
Sekh kochbar	510	21.723012	87.714275	11078.73612	44734.28025
Sabajpur	610	21.728418	87.710615	13254.33498	53503.47515
Shikarpur	214	21.73346	87.713807	4650.96044	18770.7547
Gamartalia	1,050	21.73549	87.708581	22822.2645	92094.01005
Bagdian	575	21.741673	87.716869	12501.46198	50437.19968
Sankarkundi	411	21.742861	87.711118	8936.315871	36049.2695
Kaitalia	821	21.740708	87.703839	17849.12127	72004.85182
Hatiberya	224	21.745467	87.70246	4870.984608	19645.35104
Ghatua	1,904	21.752539	87.707783	41416.83426	166995.6188
Erya Gobindapur	405	21.761284	87.708168	8813.32002	35521.80804
Dandapur	387	21.766836	87.709109	8423.765532	33943.42518
Laudanda	543	21.766683	87.711576	11819.30887	47627.38577
Chhatradhara	260	21.759148	87.719779	5657.37848	22807.14254
Srirampur	3,274	21.766037	87.721889	71262.00514	287201.4646
Banamali Pur	618	21.7647	87.739308	13450.5846	54222.89234
Jagannathpur 2Nd Part	716	21.795147	87.647295	15605.32525	62755.46322
Janubasan	445	21.757634	87.744277	9682.14713	39046.20327
Bankaberya	851	21.758261	87.738357	18516.28011	74665.34181
Kandarpapur	651	21.75194	87.737391	14160.51294	57117.04154
Kulaipadima	230	21.756713	87.730066	5004.04399	20177.91518
Keoranala	614	21.751952	87.730298	13355.69853	53866.40297
Ramchandrapur	622	21.751753	87.723361	13529.59037	54563.93054
Baidyaharana	247	21.74923	87.718611	5372.05981	21666.49692
Payrachali	382	21.746372	87.722795	8307.114104	33510.10769
Satberia	152	21.742446	87.723991	3304.851792	13334.04663
Gobindapur	287	21.737003	87.721037	6238.519861	25175.93762
Pailachhanpur	923	21.734792	87.727353	20061.21302	80972.34682

Kulalpada	729	21.730602	87.71961	15841.60886	63947.59569
Jamalpur	398	21.723609	87.718487	8645.996382	34911.95783
Matalpur	81	21.72558	87.721591	1759.77198	7105.448871
Badalpur	281	21.723208	87.729073	6104.221448	24651.86951
Lachhanpur	620	21.72004	87.727317	13466.4248	54390.93654
Samudrapur	1,653	21.704846	87.718954	35878.11044	144999.431
Samudrapur Jalpai	3	21.695293	87.722619	65.085879	263.167857
Machnendatur Jalpai		21.699571	87.731759	0	0
Machhalandapur	403	21.706662	87.728912	8747.784786	35354.75154
Damudarpur Jalpai	21	21.69982	87.739448	455.69622	1842.528408
Serpurjalpai	37	21.697474	87.748308	802.806538	3246.687396
Dakshin Sherpur	316	21.703774	87.748194	6858.392584	27728.4293
Damodarpur	426	21.705842	87.739488	9246.688692	37377.02189
Padmaput chhakubanarbar	311	21.712472	87.73689	6752.578792	27286.17279
Pateshwarpur	228	21.709547	87.74352	4949.776716	20005.52256
Purushottampur		21.712832	87.75521	0	0
Puridasbar	767	21.710144	87.758196	16651.68045	67310.53633
Jharkoshbar	233	21.703893	87.754048	5057.007069	20446.69318
Purushottampuri	111	21.710318	87.751091	2409.845298	9740.371101
Madhabpur	576	21.717656	87.753299	12509.36986	50545.90022
Amadpur	341	21.715676	87.748906	7405.045516	29922.37695
Batipur	461	21.717364	87.742873	10011.7048	40449.46445
Bara Rammaiti Bar	421	21.718462	87.735968	9143.472502	36936.84253
Bhandu Basan	1,014	21.731913	87.735018	22036.15978	88963.30825
Nayaput	2,372	21.729628	87.746335	51542.67762	208134.3066
Panipia	666	21.723324	87.756002	14467.73378	58445.49733
Paschim Chechura Put	662	21.722333	87.760367	14380.18445	58097.36295
Baksispur	2,788	21.734991	87.757148	60597.15491	244666.9286
Damudarpur	901	21.744113	87.7609	19591.44581	79072.5709
Baliarpur	606	21.747057	87.753073	13178.71654	53178.36224
Fatepur	520	21.744366	87.745556	11307.07032	45627.68912
Amartalya	595	21.740199	87.738531	12935.41841	52204.42595
Balbhadrapur	732	21.743474	87.731977	15916.22297	64219.80716
Narasingapur	605	21.749468	87.741747	13158.42814	53083.75694
Durgapur	1,127	21.753833	87.748442	24516.56979	98892.49413
Chandanpur	422	21.753985	87.759073	9180.18167	37034.32881
Jamna Madhusudan Bar	454	21.754471	87.753364	9876.529834	39840.02726
Baghmari	502	21.764119	87.750996	10925.58774	44050.99999
Gahira Bar	229	21.758727	87.785368	4982.748483	20102.84927
Chuaphali	737	21.760563	87.777573	16037.53493	64692.0713
Dakshin Darua	209	21.767883	87.770402	4549.487547	18344.01402
Dakshin Rampur	685	21.760732	87.758559	14906.10142	60114.61292
Dakshin Gopinathpur	751	21.760954	87.764694	16342.47645	65911.28519
Barachun Fali	704	21.763395	87.768631	15321.43008	61789.11622
Khikina	344	21.75857	87.771576	7484.94808	30193.42214
Benipur	277	21.756447	87.76714	6026.535819	24311.49778
Kandarapur Sanniyasibar	290	21.752209	87.765187	6308.14061	25451.90423
Hamirpur	287	21.747287	87.761726	6241.471369	25187.61536

Hugli	407	21.748307	87.769723	8851.560949	35722.27726
Subdi	574	21.753474	87.773095	12486.49408	50381.75653
Pather Ghata	430	21.750378	87.777012	9352.66254	37744.11516
Dakshin Dauki	735	21.750106	87.781634	15986.32791	64519.50099
Puan Bali Bar	758	21.741671	87.776514	16480.18662	66534.59761
Majila Pur	2,937	21.738289	87.771592	63845.35479	257785.1657
Karanji	1,141	21.727538	87.766839	24791.12086	100141.9633
Dakshin Gobinda Pur	15	21.717575	87.764635	325.763625	1316.469525
Sujanbhunia Bar	41	21.712587	87.764236	890.216067	3598.333676
Raghu Sardar Bar	238	21.71614	87.759952	5168.44132	20886.86858
Purba Ram Chandra Pur	668	21.704293	87.760566	14498.46772	58624.05809
Shilampur	166	21.726003	87.775271	3606.516498	14570.69499
Shilampur	548	21.728129	87.778379	11907.01469	48102.55169
Bachhipur Bar	271	21.717549	87.779469	5885.455779	23788.2361
Maharampur	17	21.70956	87.772879	369.06252	1492.138943
Baguran Jalpai	1,573	21.703397	87.773799	34139.44348	138068.1858
Baguran	281	21.715806	87.773465	6102.141486	24664.34367
Rasulpur	230	21.711251	87.776412	4993.58773	20188.57476
Bhuianpada	657	21.709015	87.780193	14262.82286	57671.5868
Sharad Pur	205	21.705962	87.788042	4449.72221	17996.54861
Hari Pur	1,050	21.712527	87.790184	22798.15335	92179.6932
Mankarai Put	250	21.707541	87.795237	5426.88525	21948.80925
Shyam Rai Bar Jalpai	501	21.711984	87.801625	10877.70398	43988.61413
Kamarput	303	21.718451	87.80247	6580.690653	26604.14841
Syamrai Bar	1,074	21.719856	87.794742	23327.12534	94291.55291
Deshdatta Bar	885	21.723102	87.786838	19224.94527	77691.35163
Rangamalput	865	21.724485	87.803273	18791.67953	75949.83115
Biramput	2,370	21.721013	87.811628	51478.80081	208113.5584
Chhota Ektarpur	152	21.728069	87.726522	3302.666488	13334.43134

Table 10; Data for calculation of mean centre of population (Deshapran)

CD BLOCKS	TOTAL POP	X	Y
Sarda	3,099	21.799608	87.765423
Durmut	4,617	21.800523	87.781534
Kajla	1,810	21.811276	87.775678
Hinchi	1,782	21.808709	87.768602
Parulia	1,490	21.817682	87.773582
Jhaubani	1,034	21.888921	87.793967
Kulanjara	1,043	21.894857	87.81028
Umapati Bar	904	21.902508	87.821234
Shunia	908	21.903365	87.832074
Baharchandberya	1,364	21.893685	87.82703
Ghoraghata	925	21.886786	87.841693
Kasafalia	1,609	21.881534	87.854781

Phulbari	1,375	21.872048	87.845077
Chandberya	2,082	21.881945	87.828876
Kaliagachhia	505	21.887976	87.816397
Harranamaldina	3,662	21.870149	87.817061
Basudebberya	4,229	21.878485	87.797098
Anurai Belya Chatta	2,212	21.860446	87.799012
Karpura	1,344	21.859318	87.785558
Abasberya	414	21.860023	87.778494
Anurai	3,349	21.849903	87.802938
Mundapara	1,588	21.849588	87.818069
Durgapur	1,757	21.863591	87.824644
Chandibhetibar	508	21.856688	87.826805
Barchandibhetty	1,529	21.854379	87.832422
Uttar Amtalia	1,183	21.861171	87.84439
Uttar Dihimukundapur	2,956	21.860439	87.865479
Daksin Dihimukundapur	500	21.850329	87.862391
Purba Amtalia	1,878	21.842653	87.860599
Purba Rasulpur	603	21.8408	87.872477
Dakshinaria	473	21.825554	87.868223
Benichak	432	21.823667	87.861522
Shyamchak	592		
Uttar Deulpota	1,513	21.827711	87.853943
Dakshin Amtalia	1,214	21.835493	87.845088
Amtalia	2,657	21.846668	87.842937
Chandibhetti	1,972	21.841778	87.818259
Dhobaberya	1,123	21.828981	87.825198
Dhobaberya	528	21.838621	87.826538
Banamaliberya	541		
Balabhadrapur	466	21.82994	87.813525
Jagannathchak	1,375	21.821748	87.819642
Kumarberya	807	21.820582	87.810728
Chattabheri	1,437	21.831057	87.804176
Gotshauri	1,049	21.815073	87.785157
Maheshpur	26	21.81554	87.79003
Kurkraul (P)	1,005		
Panchgechhya	775	21.810839	87.800351
Manikpur	394	21.802319	87.803122
Fuleshawar	2,086	21.805409	87.794162
Gopinathpur	1,182	21.794227	87.798147
Satikeshwar	1,327	21.791153	87.792529
Maishamura	1,792	21.789778	87.784116
Khagrabani	3,589	21.775226	87.780471
Kalikapur	1,196	21.773319	87.789679
Raghurampur	1,664	21.776051	87.791452
Brahman Sasan	690	21.785244	87.791624
paschim Purushottampur	1,682	21.780311	87.797099
Balu Bar	725	21.785729	87.796592
Gobindaberabar	1,754		

Chak Gobindaberia	312		
Chaudhuri Bar	1,659	21.799827	87.811359
Purba Mukundapur	2,258	21.797259	87.803606
Mahammadpur	977	21.808983	87.808727
Tilakberya	120	21.807925	87.80622
Chhota Kukraaul		21.815007	87.804832
Dharadharpur	385	21.815763	87.81514
Khashafaua	1,018	21.81075	87.817053
Kendua	99	21.811618	87.823703
Chak Hajratpur	246	21.807175	87.822573
Baijapur	936	21.806746	87.829204
Safiabad	3,322	21.823933	87.832738
Dholmari	1,948	21.820964	87.839138
Gokulnagar Deulpota	331	21.805201	87.834173
Prakash Kultalia 1st Part	1,815	21.812571	87.843298
Chaitanyapur	584	21.804811	87.847438
Bara Subarnanagar	1,871	21.802236	87.856032
Rupnagar	1,020	21.813679	87.856509
Krishnalal Chak	498	21.81333	87.861879
Sikdar Chak	739	21.815376	87.86648
Daha Shonamui	1,621	21.808003	87.87019
Pratappur	485	21.796621	87.877953
Haripur	985	21.78854	87.876309
Ramchak Gopalchak	1,061	21.797146	87.871182
Bamunia Nankar	784	21.791898	87.867571
Purba Bamunia	627	21.739139	87.812923
Dariapur	1,375	21.79003	87.862728
Daulatpur	1,142	21.781984	87.856411
Kazichak	541		
Chhota Subarnanagar	285	21.789264	87.850475
Nankar Gopinathpur	758	21.794738	87.854668
Purba Bhagabanpur	551	21.7964	87.846102
Purba Mahammadpur	1,190		
Ghoshpur	921	21.798129	87.832159
Mirzapur	788	21.791192	87.830703
Dakshin Deulpota	718	21.792042	87.824324
Purba Kushbani	362		
Paschim Kusbani	1,224	21.801162	87.821817
Kalikakumary	707	21.794202	87.819023
Saraswatipur	1,309	21.786405	87.818785
Hirakala	206		
Durgapur	825	21.783878	87.849371
Phulbani	825	21.780856	87.807599
Uttar Adaberya	1,406	21.774558	87.801915
Dhoba Berya	67	21.766937	87.798471
Dakshin Ada Berya	559	21.764345	87.80033
Sarsa	759	21.756229	87.790033
Baghaghol	670	21.765693	87.786615

Purba Teghari	294	21.765347	87.780471
Uttar Dauki	685	21.745014	87.784965
Dakshin Paikbar	1,869	21.734727	87.784076
Faridpur	1,122	21.745369	87.791882
Biswanathpur	299		
Damudar Dattabar	308	21.738527	87.803524
Aladarput	1,355	21.737034	87.797955
Hosenaput	65	21.73425	87.792584
Kalaminaput	415	21.729533	87.796222
Dakshin Murabanya	722	21.730757	87.804904
Bichina	1,139	21.729252	87.811148
Purba Chechuraput	411	21.727269	87.817662
Dakshin Kadua	1,131	21.733588	87.825282
Purba Sikarpur	366		
Bamunia	2,002	21.799537	87.86457
Tithaipada	822	21.747618	87.802897
Chhota Bantalia	1,103	21.753876	87.79801
Bara Bantalia	1,180	21.758595	87.806254
Barjubar	38	21.749109	87.809689
Champainagar	773	21.753653	87.814323
Mahishagot	1,278	21.762118	87.819649
Purushottompur	372	21.777789	87.81083
Basanta Shyamraybar		21.771737	87.811619
Purushottampur	222		
Chalti	2,261	21.77843	87.816586
Murabania	9	21.76836	87.81604
Ujhalpur	94	21.767718	87.820443
Danguapur	122	21.770868	87.825295
Baikunthapur	382	21.779532	87.823958
Purba Gobindapur	1,270	21.782598	87.830596
Tengarberya	386	21.788037	87.830607
Kajibasan	1,527	21.778013	87.834587
Bhetapukhuria	295	21.777291	87.84344
Bhabanipur	258		
Durgapur Part-IV	307		
Payrakola	85	21.77747	87.850402
Bargolia	133	21.772364	87.8543
Hajrakola	622	21.770094	87.850585
Gopalchak	1,690	21.769004	87.839964
Jhawamanu Rautbar	446	21.767272	87.832444
Jhawa	1,813	21.757139	87.82884
Masjidpur	324	21.747307	87.819384
Uttar Kadua	625	21.745072	87.828779
Paschim Kadua	175	21.741746	87.82235
Kadua Mukundapur	1,116	21.744936	87.836182
Gopalpur 5Th Part	697	21.747112	87.847294
Baghapur	699	21.760959	87.845759
Dakshin Harsha Chak	360	21.758073	87.839427

Uttar Harshachak	292	21.765142	87.848068
Jagannathpur 3Rd Part	1,473	21.754446	87.847296
Bhogpur	221	21.75144	87.855789
Perijpur	194	21.75946	87.86283
Kalichar	144	21.761233	87.854635
Kalidas Bar	111	21.765706	87.859077
Bhupati Chak	348	21.764835	87.864315
Bankipur	841	21.766996	87.856332
Tiakola	199	21.755397	87.859539
Kaluraybar	44	21.758822	87.868198
Kanai Chatta	458	21.775935	87.873348
Purba Gopinathpur	1,732	21.787435	87.84243
Basantia (CT)	5,455	21.790164	87.809508

Table 11: Data for calculation of mean centre of population (Khejuri-II)

CD BLOCK	TOTAL POP	X	Y	XP	YP
Keshab Chak	1,420	21.920666	87.879993	31127.34572	124789.5901
Dekhali	9,619	21.89245	87.872233	210583.4766	845243.0092
Halud Bari	2,849	21.914435	87.889055	62434.22532	250395.9177
Jagannath Chak	1,066	21.908414	87.898802	23354.36932	93700.12293
Narsulya Chak	999	21.918993	87.90091	21897.07401	87813.00909
Maldaha	3,885	21.912616	87.920525	85130.51316	341571.2396
Serkhan Chak	7,347	21.926685	87.944328	161095.3547	646126.9778
Pankhai	4,269	21.9078	87.958727	93524.3982	375495.8056
Baratala	3,682	21.910368	87.93959	80673.97498	323793.5704
Ram Chak	3,006	21.899144	87.925514	65828.82686	264304.0951
Garang	1,332	21.898348	87.904579	29168.59954	117088.8992
Chauddha Chuli	3,903	21.892705	87.891771	85447.22762	343041.5822
Mundamari	2,907	21.879374	87.892788	63603.34022	255504.3347
Kartik Khali	2,772	21.883499	87.910881	60661.05923	243688.9621
Mada Khali	2,323	21.889476	87.919958	50849.25275	204238.0624
Kastala	1,768	21.887838	87.93345	38697.69758	155466.3396
Pirijpur	577	21.897363	87.941779	12634.77845	50742.40648
Kunjapur	1,352	21.883679	87.943151	29586.73401	118899.1402
Hemanta Chak	438	21.889441	87.950961	9587.575158	38522.52092
Satkumari	750	21.893247	87.948799	16419.93525	65961.59925
Talpati	128	21.89435	87.955396	2802.4768	11258.29069
Mansinghabar	1,486	21.894765	87.958873	32535.62079	130706.8853
Chatur Bhuj Chak	382	21.886696	87.952078	8360.717872	33597.6938
Pakhuria	768	21.881966	87.954147	16805.34989	67548.7849
Barka Saria	1,685	21.875995	87.959216	36861.05158	148211.279
Sat Khanda Saheb Nagar	1,637	21.887655	87.963772	35830.09124	143996.6948
Saheb Nagar	1,159	21.884414	87.97311	25364.03583	101960.8345
Khajuri	7,471	21.865266	87.95889	163355.4023	657140.8672
Dhobaghata Baman chak	330	21.864786	87.975653	7215.37938	29031.96549
Alichak	550	21.862078	87.96897	12024.1429	48382.9335

Baman Chak	27	21.856035	87.966084	590.112945	2375.084268
Safar Chata	202	21.855705	87.971129	4414.85241	17770.16806
Radha Nagar	709	21.849772	87.961656	15491.48835	62364.8141
Satsimali	1,131	21.848133	87.950977	24710.23842	99472.55499
Chak Arak Bari	463	21.846069	87.945525	10114.72995	40718.77808
Purbba Bhangan Mari	1,560	21.853364	87.942813	34091.24784	137190.7883
Paschim Bhangan Mari	1,843	21.851566	87.935924	40272.43614	162065.9079
Kasaria	2,062	21.871714	87.942499	45099.47427	181337.4329
Tengra Mari	759	21.867106	87.933514	16597.13345	66741.53713
Monohar Chak	325	21.86361	87.93102	7105.67325	28577.5815
Chalta Talya	613	21.863668	87.925187	13402.42848	53898.13963
Sahapur	638	21.869056	87.927835	13952.45773	56097.95873
Kadirpur	1,792	21.871947	87.923081	39194.52902	157558.1612
Phulbari	794	21.868567	87.920821	17363.6422	69809.13187
Bhupati Chak	808	21.860756	87.919199	17663.49085	71038.71279
Purbba Panikhya	610	21.860696	87.913085	13335.02456	53626.98185
Paschim Panikhya	1,975	21.868888	87.910616	43191.0538	173623.4666
Shyampur Jalpai	846	21.867449	87.898862	18499.86185	74362.43725
Gorahar Jalpai	1,583	21.869705	87.887832	34619.74302	139126.4381
Gorahar	848	21.861994	87.886749	18538.97091	74527.96315
Gorahar Gonsai Chak	699	21.858178	87.887827	15278.86642	61433.59107
Katkadebi Chak	1,647	21.85078	87.887105	35988.23466	144750.0619
Murali Chak	1,090	21.857308	87.900643	23824.46572	95811.70087
Shyampur	2,198	21.847536	87.897433	48020.88413	193198.5577
Shyampur Katka	980	21.841165	87.885404	21404.3417	86127.69592
Boga	2,824	21.832997	87.887913	61656.38353	248195.4663
Koyal Chak	608	21.82446	87.879521	13269.27168	53430.74877
Alipur	1,780	21.824521	87.887	38847.64738	156438.86
Sundarpur	1,943	21.814701	87.890535	42385.96404	170771.3095
Khari Pukhuria	673	21.833665	87.896641	14694.05655	59154.43939
Shilla Berya	1,183	21.831079	87.903403	25826.16646	103989.7257
Raypur	501	21.841111	87.905181	10942.39661	44040.49568
Janka	2,804	21.851354	87.908901	61271.19662	246496.5584
Damodar Chak	577	21.855265	87.921472	12610.48791	50730.68934
Ajan Bari	2,474	21.856894	87.930089	54073.95576	217539.0402
Ser Chak	534	21.849142	87.925037	11667.44183	46951.96976
Jafar Chak	504	21.849118	87.919833	11011.95547	44311.59583
Bara Kasha Phalia	418	21.846296	87.91348	9131.751728	36747.83464
Abdulla Chak	231	21.842101	87.917711	5045.525331	20308.99124
Chhota Kasha Phalia	401	21.839901	87.911684	8757.800301	35252.58528
Bara Garania	1,446	21.830853	87.911171	31567.41344	127119.5533
Chhota Garania	874	21.833721	87.91836	19082.67215	76840.64664
Lakshan Chak	1,657	21.835298	87.925103	36181.08879	145691.8957
Matilal Chak	1,980	21.840767	87.931206	43244.71866	174103.7879
Jhati Hari	711	21.826274	87.929458	15518.48081	62517.84464
Thana Berya	1,675	21.832989	87.938499	36570.25658	147296.9858
Arak Bari	1,389	21.839159	87.948512	30334.59185	122160.4832
Ban Basarya	212	21.828665	87.945619	4627.67698	18644.47123

Oashil Chak	870	21.823754	87.936969	18986.66598	76505.16303
Nankar Gobindapur	13	21.819487	87.937921	283.653331	1143.192973
Gobindapur		21.816001	87.936262	0	0
Joshua	17	21.814765	87.931296	370.851005	1494.832032
Pacharya	1,753	21.822262	87.925326	38254.42529	154133.0965
Kalagachhia	940	21.816042	87.920874	20507.07948	82645.62156
Karmi Chak	41	21.824921	87.916378	894.821761	3604.571498
Chhota Garania	394	21.8205	87.911497	8597.277	34637.12982
Gopi Chak	615	21.819894	87.90482	13419.23481	54061.4643
Adampur	340	21.81751	87.908648	7417.9534	29888.94032
Battalya	794	21.822034	87.899014	17326.695	69791.81712
Andiram Chak	214	21.815541	87.900931	4668.525774	18810.79923
Oshmanpur	147	21.811562	87.904123	3206.299614	12921.90608
Nona Pata	434	21.809212	87.906965	9465.198008	38151.62281
Meidi Nagar	1,745	21.808275	87.911125	38055.43988	153404.9131
Padar Bheri	382	21.808673	87.900022	8330.913086	33577.8084
Dakshin Ali Chak	1,217	21.805801	87.89088	26537.65982	106963.201
Nijkashba	2,435	21.798948	87.895422	53080.43838	214025.3526
Kadirabad Char	1,482	21.8875	87.989159	32437.275	130399.9336

Table 12: Raw data for calculation of health vulnerability

Block	% vulnerable	% disabled	Under 5 mortality	Bed/ 10000 pop	Doctors/ 1 lac pop	Poor Household	TB/ 1000 pop	DTP gap	Measles gap
Ramnagar 1	32.12	2.60	0.12	7.14	6.86	73.59	0.16	5.40	16.30
Ramnagar 2	31.38	4.48	0.28	1.86	6.19	75.13	0.30	10.00	9.60
Contai 1	31.62	2.81	0.26	3.19	2.90	78.93	0.11	8.60	9.10
Deshapran	14.91	3.41	0.09	0.55	4.44	87.87	0.12	9.20	10.10
Khejuri 2	34.76	2.41	0.14	5.02	3.59	79.73	0.12	44.20	40.40
Khejuri 1	34.14	3.82	0.17	2.75	4.82	82.80	0.17	6.80	2.70
Bhagawanpur 2	32.53	4.01	0.09	8.10	3.60	86.99	0.04	5.30	11.00
Contai 3	32.70	2.89	0.22	2.10	1.60	82.39	0.09	6.70	13.50
Mahishadal	32.20	3.31	0.07	5.90	11.00	79.30	0.34	16.70	19.60
Nandigram 1	36.70	3.40	0.10	2.46	4.42	82.54	0.13	0.00	1.40
Nandigram 2	34.60	3.54	0.17	2.36	3.93	83.55	0.20	0.00	12.30
Sutahata	33.55	2.72	0.22	9.03	4.72	79.94	0.12	1.10	7.70
Haldia	32.94	1.54	0.10	1.99	4.98	79.22	0.06	0.00	0.00
Patashpur 1	31.60	5.14	0.33	2.20	2.76	90.09	1.07	13.70	14.70
Patashpur 2	33.10	4.36	0.32	1.60	2.29	85.09	0.25	0.00	0.00
Bhagawanpur 1	34.33	3.49	0.08	3.07	4.51	84.47	0.97	0.00	0.00
Egra 1	32.01	2.60	0.19	1.17	2.34	84.31	0.41	0.00	0.00
Egra 2	32.71	3.19	0.03	2.53	3.55	75.86	0.41	2.70	3.70

Table 13: Raw data for infrastructural adaptivity index and social vulnerability index calculation

		% of Banking	% of drinking water	% sanitary	kaccha household	High Schools	MPCS	Hospital	Administrative buildings
Ramnagar 1	Badhia	-0.06	0.04	0.04	-0.03	-0.03	-0.06	0.12	-0.01
	Basantapur	0.28	0.25	-0.02	-0.06	-0.16	-0.06	-0.05	-0.22
	Gobra	0.13	0.25	-0.02	-0.21	-0.03	-0.06	0.01	-0.01
	Haldia 1	-0.14	0.19	0.03	-0.12	-0.16	0.00	-0.10	-0.01
	Haldia 2	0.05	0.20	-0.07	-0.24	-0.03	-0.06	-0.05	-0.22
	Padima 1	0.25	0.16	-0.11	-0.25	0.23	0.17	-0.10	-0.01
	Padima 2	0.03	0.23	-0.08	-0.25	-0.03	-0.06	0.17	-0.01
	Talgachari 1	0.18	0.26	-0.10	-0.20	-0.03	0.00	-0.05	0.20
	Talgachari 2	0.21	0.29	-0.01	-0.15	0.10	0.05	-0.05	-0.01
Ramnagar 2	Badalpur	0.13	-0.02	0.06	-0.03	-0.03	-0.06	-0.05	-0.01
	Balisai	0.07	0.07	0.05	-0.09	-0.16	0.05	0.12	0.20
	Depal	0.03	0.05	0.03	-0.06	-0.03	-0.06	0.06	-0.01
	Kadua	-0.10	-0.05	-0.01	-0.10	-0.03	-0.06	-0.05	-0.01
	Kalindi	0.01	-0.03	-0.03	0.01	-0.03	0.05	0.06	-0.01
	Maithana	0.03	-0.11	-0.05	-0.03	-0.03	-0.06	-0.05	-0.01
	Paldhui	0.13	-0.14	0.07	-0.20	0.10	-0.06	-0.05	-0.01
	Satilapur	-0.02	-0.24	-0.05	-0.17	-0.03	0.05	-0.05	-0.01
Conati 1	Badalpur	-0.16	-0.04	0.06	-0.07	-0.03	-0.06	0.01	-0.01
	Dulalpur	0.22	0.15	0.04	-0.14	0.10	0.00	0.06	-0.01
	Hoipur	-0.21	-0.01	0.07	0.01	-0.03	0.00	0.01	-0.01
	Mahishagote	0.22	-0.09	0.06	0.00	0.10	-0.06	-0.05	-0.01
	Majilapur	-0.03	-0.07	0.00	0.17	-0.29	-0.06	-0.05	-0.01
	Nayaput	-0.12	-0.10	0.03	0.14	-0.16	0.11	0.01	0.20
	Rajpur Paschimbar	0.00	0.07	-0.01	0.01	-0.03	0.00	-0.10	0.20
	Sabajput	-0.02	-0.17	0.06	0.22	-0.03	0.17	-0.16	-0.01
Deshapran	Amtalia	0.08	-0.09	0.05	0.35	0.23	0.00	0.17	-0.01
	Aurai	-0.11	-0.22	0.06	0.43	-0.03	-0.06	0.06	-0.01
	Bamunia	0.00	-0.21	-0.01	0.27	0.10	0.00	0.06	-0.01
	Basantia	0.05	0.10	0.01	0.14	-0.03	0.05	0.01	0.20
	Chalti	-0.22	-0.12	-0.05	0.21	-0.03	-0.06	-0.05	-0.22
	Dariyapur	-0.30	0.01	0.03	0.29	0.10	0.11	0.01	-0.01
	Dhobaberia	-0.09	-0.09	0.05	0.27	0.10	-0.06	-0.10	-0.01
	Sarada	-0.07	-0.01	-0.13	0.11	0.10	0.00	-0.10	-0.01

Khejuri 2	Baratala	-0.18	-0.10	0.03	0.03	-0.16	-0.06	0.06	-0.01
	Haludbari	-0.23	-0.05	0.03	-0.06	-0.03	-0.06	0.01	-0.01
	Janka	-0.05	-0.10	-0.01	-0.01	0.10	-0.06	0.12	-0.01
	Khejuri	-0.02	-0.08	-0.04	-0.07	0.10	0.11	0.01	-0.01
	Nijkasba	0.01	-0.16	-0.06	-0.10	0.23	0.29	0.12	-0.01

		Population density	Population share	Female population	Under 5 population	Above 65 population	Minority population	Disabled population	Dependent household	Cultivators	Landless households	Per household income	Unemployed households
Ramnagar 1	Badhia	1201	19.49	47.79	9.00	5.94	8.25	3.59	2.20	17.56	40.43	80.39	1.21
	Basantapur	1576	10.31	48.14	8.18	6.48	6.04	2.79	2.34	22.71	34.69	77.37	1.85
	Gobra	1486	11.36	48.41	8.35	6.49	12.10	3.00	2.27	9.15	29.50	68.63	0.48
	Haldia 1	1693	8.08	47.78	7.90	7.00	6.63	2.38	1.31	13.46	30.80	85.49	0.88
	Haldia 2	1868	10.01	48.03	9.13	6.03	9.94	2.45	1.04	5.56	30.48	66.62	1.85
	Padima 1	1219	10.07	48.04	8.56	5.80	17.90	1.41	1.63	6.73	26.36	67.19	1.29
	Padima 2	987	10.77	48.74	8.30	6.58	1.85	2.19	0.97	5.72	20.74	67.13	0.79
	Talgachari 1	1884	9.90	48.57	8.41	6.10	7.16	1.69	2.00	9.60	40.50	65.99	0.62
	Talgachari 2	533	9.70	47.54	7.55	6.09	23.17	2.93	1.68	21.75	27.73	79.94	0.41
Ramnagar 2	Badalpur	1103	10.80	47.69	7.55	6.87	7.25	5.39	1.57	42.65	20.74	73.42	0.60
	Balisai	1639	10.15	48.83	8.09	6.50	13.47	3.83	1.62	6.12	31.09	69.69	0.81
	Depal	1417	13.01	49.04	8.21	6.90	6.58	2.99	2.48	17.18	31.18	71.81	2.99
	Kadua	901	11.16	48.01	8.39	6.51	8.72	1.84	1.68	20.67	35.80	80.42	1.32
	Kalindi	507	15.80	48.27	8.81	5.65	14.62	6.31	1.72	20.60	40.67	78.93	2.26
	Maithana	932	13.37	48.14	9.31	6.46	15.01	3.01	2.01	13.72	29.84	78.42	2.78
	Paldhui	1275	12.18	48.04	7.60	6.71	9.73	2.41	0.95	15.59	27.32	76.87	1.34
	Satilapur	1059	13.53	48.07	7.98	5.69	27.79	9.47	0.83	14.66	33.36	69.66	3.16
Contai 1	Badalpur	1300	10.20	48.00	6.93	7.25	7.14	1.72	1.83	12.38	21.63	74.45	2.49
	Dulalpur	1668	12.84	50.60	8.37	6.78	2.65	3.20	0.02	8.66	42.15	74.23	1.19
	Hoipur	1062	14.18	47.91	7.94	6.56	15.37	1.91	2.30	10.45	38.73	78.54	1.32
	Mahishagote	941	10.89	48.00	7.35	6.48	12.41	6.21	2.05	14.35	32.05	77.44	0.63
	Majilapur	859	13.09	48.13	8.51	5.78	21.86	2.81	1.82	6.22	45.81	85.00	2.70
	Nayaput	954	12.90	48.81	7.73	6.09	25.90	2.42	2.05	7.88	42.44	81.86	1.44

	Rajpur Paschimbar	1518	15.44	49.97	8.12	6.16	9.47	1.81	2.01	7.40	52.81	80.38	0.66
	Sabajput	913	10.34	48.91	7.67	6.43	11.58	3.10	0.02	8.04	36.30	77.23	1.71
Deshapran	Amtalia	869	13.99	49.35	9.63	5.60	6.50	1.69	2.07	10.56	40.10	93.64	1.05
	Aurai	819	11.52	48.97	9.01	6.03	12.46	2.85	2.80	4.29	43.62	94.07	1.14
	Bamunia	885	12.98	48.78	8.70	6.01	5.34	3.10	2.54	8.99	37.54	83.02	0.98
	Basantia	1502	14.13	49.35	9.07	5.89	15.20	3.94	1.97	6.10	52.87	82.22	1.02
	Chalti	1736	12.56	49.54	8.78	5.66	3.55	2.22	1.83	7.13	53.74	90.34	1.89
	Dariyapur	835	13.31	48.95	8.72	6.00	16.81	7.25	2.51	11.66	43.85	94.36	1.47
	Dhobaberia	996	9.67	48.98	8.65	6.10	16.54	2.24	2.56	10.53	43.25	84.25	1.59
	Sarada	1374	11.85	52.03	8.86	6.55	7.96	3.56	1.70	5.86	55.91	79.87	2.21
Khejuri 2	Baratala	1058	18.37	48.57	10.09	6.00	63.20	4.29	1.90	7.17	37.09	91.45	2.52
	Haludbari	985	20.16	48.58	10.14	6.22	38.59	3.16	1.58	18.16	21.40	85.36	1.13
	Janka	1259	20.77	48.20	9.72	5.30	74.33	1.57	1.77	9.62	39.45	84.85	0.73
	Khejuri	795	19.37	48.04	10.23	5.29	55.93	1.76	1.60	9.66	34.34	79.68	0.51
	Nijkasba	1074	21.33	48.20	9.55	90.31	53.31	1.01	1.90	12.97	35.57	56.10	1.81

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