# Environmental Challenges, Livelihood and Migration: A Study in Sagar Island, Indian Sundarban Delta

Thesis submitted by

Kishore Roy
(Index No. D-7/ISLM/107/19)

Doctor of Philosophy (Arts)

School of Oceanographic Studies
Faculty of Interdisciplinary Studies, Law & Management
Jadavpur University
Kolkata-700032
INDIA

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**Dedicated to**

**The Inhabitants of Sagar Island**

## DETAILS OF THESIS

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| **4. Email ID of the supervisor** | tuhin.ghosh@jadavpuruniversity.in |

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# STATEMENT OF ORIGINALITY

I, Kishore Roy, registered on 07 November 2019, do hereby declare that this thesis entitled "Environmental Challenges, Livelihood and Migration: A Study in Sagar Island, Indian Sundarban Delta" contains reviews of literature and original research work carried out by the undersigned candidate for the partial fulfilment of the doctoral research.

All information existing 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 provided reference to 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 within 10%.

Signature: Kishore Roy

Date: 27.02.2025

Certified by Supervisor: 27/02/2025

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## CERTIFICATE FROM THE SUPERVISOR

This is to certify that the thesis entitled "**Environmental Challenges, Livelihood and Migration: A Study in Sagar Island, Indian Sundarban Delta**" submitted by **Kishore Roy** who got his name registered on **07 November 2019 (Index No. D-7/ISLM/107/19)** for the award of **Ph.D. (Arts)** degree of **Jadavpur University**, is absolutely based upon his own work under the supervision of **Prof. Tuhin Ghosh** and that neither this thesis nor any part of it has been submitted for either any other degree/diploma or any other academic award anywhere.

Signature of the Supervisor: 27/02/2025

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# Table of Content

# Acknowledgements

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# Executive Summary

The global climate is undergoing rapid changes with significant implications for ecosystems worldwide. The Sundarban, one of the most prominent victims of climate change, face mounting challenges due to a combination of natural factors and anthropogenic activities. Traditional livelihoods in the region are under threat from climate change, environmental degradation, and human-induced issues. Most inhabitants, who rely on natural resource-based economic activities, are experiencing losses and uncertainty. In this context, out-migration has emerged as a significant adaptation strategy to cope with livelihood challenges. This micro-level study assesses the environmental challenges, their impact on livelihoods, and migration patterns in Sagar Island, located in the Indian Sundarban Delta.

**Chapter 1** begins with a succinct overview of the pressing issue of climate change and the various environmental challenges affecting the Indian Sundarban Delta. It then briefly discusses how these environmental challenges have impacted livelihoods in the region. Additionally, the chapter highlights migration as a potential adaptive strategy to address and mitigate livelihood challenges in the region.

**Chapter 2** provides a comprehensive review of existing literature on environmental challenges, livelihood, and migration, with a particular focus on the Indian Sundarban Delta. It begins by examining the current environmental conditions and the multifaceted challenges faced by the region. Subsequently, it steps into the livelihood issues prevalent in the area, drawing on various scholarly sources. Finally, the chapter explores the migration scenario observed in the region, as documented in the literature.

**Chapter 3** discusses the methodology of the present research. This chapter begins with a concise introduction to the study area, explaining the selection of Sagar Island in the Indian Sundarban Delta for this research. It then outlines the primary objectives and the data sources utilized. Following this, the chapter details the reference period of the study and describes the survey methodology and primary data collection process. Finally, it presents the analysis techniques and the conceptual framework employed in the study.

**Chapter 4** offers a comprehensive overview of Sagar Island, beginning with a brief introduction and the island's settlement history. It then delves into the island's physical geographic settings, including geology and soil, land use and land cover, elevation, slope, drainage, and climatic conditions. Following this, the chapter provides an outline of the island's

infrastructural setup. The socio-economic profile of the island is also discussed, covering aspects such as population, sex ratio, literacy rate, social group composition, main economic activities, livelihoods, and occupations of the islanders.

**Chapter 5** discusses the environmental challenges faced by Sagar Island. It begins by illustrating the global impact of climate change on ecosystems, with a particular focus on the Sundarban. The chapter then provides a comprehensive overview of the various environmental challenges affecting the island, including climate change, geomorphological challenges, recent natural hazards, and their consequent impacts.

**Chapter 6** explores the multifaceted threats to traditional livelihoods on the island, stemming from climate change, environmental degradation, and anthropogenic factors. Agriculture has become unpredictable, with crops like watermelon disappearing and chili production shrinking. Betel leaf and paddy cultivation face crises from environmental hazards and floods, pushing many farmers to other jobs or crop diversification. Fish catch has decreased due to overfishing and harmful practices like bottom trawling. Shrimp fry collection has also dropped, failing to provide a minimum wage. Coastal flooding threatens freshwater aquaculture, while brackish water aquaculture struggles with regulatory issues and diseases. Cyclone Yaas caused significant losses in both types of aquacultures, leading many to abandon these livelihoods. Overall, these shifts reflect broader socio-economic changes as islanders adapt to a changing environment, with out-migration becoming a strategy to find income sources.

**Chapter 7** investigates the phenomenon of migration as the primary adaptive strategy employed by the inhabitants of Sagar Island to address the pervasive issues of unemployment and livelihood insecurity. The analysis begins by identifying the various push factors that compel individuals to migrate from the island. These factors include environmental degradation, frequent natural disasters, and limited economic opportunities, which collectively exacerbate the vulnerability of the local population. The study proceeds to map the destination regions of the migrants, highlighting the pull factors that attract them to these areas. These pull factors encompass better employment prospects, higher wages, and improved living conditions. The chapter provides a detailed account of the economic activities that migrants engage in upon reaching their destinations, ranging from agricultural labour to urban informal sector jobs. The chapter also examines the role of remittances in the socio-economic fabric of Sagar Island. Remittances are identified as a crucial source of income for many households, contributing to improved living standards and enabling investments in education and health.

Finally, the chapter explores the future trajectories of migration from Sagar Island. It considers the potential for increased migration in response to ongoing environmental and economic pressures and discusses the implications for both the island and the destination regions.

**Chapter 8** serves as the general conclusion of this thesis, encapsulating the core findings and offering pertinent recommendations. The study underscores the need for comprehensive policy interventions to manage migration effectively and support the livelihoods of both migrants and those who remain on the island.

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# List of Abbreviations

| | |
|---|---|
| AC | Air Conditioning |
| ACI | Agricultural Census of India |
| ASTER | Advanced Spaceborne Thermal Emission |
| BLC | Boat Licence Certificates |
| BLC | Boat Licence Certificate |
| CAA | Coastal Aquaculture Authority |
| CEEW | Council on Energy, Environment and Water |
| COVID | Coronavirus Disease |
| CRZ | Coastal Regulation Zone |
| CTH | Critical Tiger Habitat |
| DISHA | District Development Coordination and Monitoring Committee |
| DSAS | Digital Shoreline Analysis System |
| EPR | End Point Rate |
| FAO | Food and Agriculture Organization |
| FGD | Focus Group Discussions |
| GDEM | Global Digital Elevation Model |
| GDP | Gross Domestic Product |
| GPS | Global Positioning System |
| GSM | Gangasagar Mela |
| HH | Household Head |
| ICDS | Integrated Child Development Services |
| ICIMOD | International Centre for Integrated Mountain Development. |
| INR | Indian Rupee |
| IOM | International Organization for Migration |
| IPCC | Intergovernmental Panel on Climate Change |
| ISD | Indian Sundarban Delta |
| LRR | Linear Regression Rate |
| MAB | Man and Biosphere |
| MNREGA | Mahatma Gandhi National Rural Employment Guarantee Act |

| | |
|---|---|
| MPCS | Multi-Purpose Cyclone Shelters |
| MPEDA | Marine Products Export Development Authority |
| NGO | Non-governmental organization |
| NOAA | National Oceanic and Atmospheric Administration |
| NP | National Park |
| OBC | Other Backward Classes |
| OLI | Operational Land Imager |
| PF | Protected Forest |
| RF | Reserve Forest |
| SBR | Sundarban Biosphere Reserve |
| SC | Scheduled Castes |
| SLR | Sea Level Rise |
| SMPB | State Medicinal Plants Board |
| SRF | Sundarban Reserve Forest |
| SSF | Small-scale fisheries |
| ST | Scheduled Tribes |
| STR | Sundarban Tiger Reserve |
| SUV | Sports Utility Vehicle |
| TIRS | Thermal Infrared Sensor |
| UN | United Nations |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNICEF | United Nations International Children's Emergency Fund |
| USA | United States of America |
| WB | West Bengal |
| WBSAPCC | West Bengal State Action Plan on Climate Change |
| WMO | World Meteorological Organization |

## Abstract

The study explores the intricate relationship between environmental changes, livelihood patterns, and migration on Sagar Island. The major objectives include identifying environmental changes, understanding their impact on the livelihood of the inhabitants, and examining the role of migration as an adaptive strategy. The research draws from a combination of primary and secondary data. The primary data is collected through field surveys utilising various types of questionnaires, including structured, semi-structured, and unstructured formats. Secondary data from sources, such as the Census of India, Agricultural Census of India, and satellite imagery from Landsat 8 – 9 OLI/TIRS, as well as images from Google Earth are used. Findings reveal that climate change has had profound effects on the island's ecosystem. Natural hazards like tropical cyclones, coastal floods, and erosion have caused significant damage to infrastructure, agricultural assets, and aquaculture, thereby undermining livelihood opportunities and prompting socio-economic transformations. Traditional occupations like agriculture and fishing have declined, giving way to alternative means of income such as small-scale trade, labour work and migration. Migration has emerged as a vital adaptive strategy for the inhabitants, with at least one member from 34.79% of households having migrated within a year. Interstate migration, particularly to states like Kerala, Tamil Nadu, Telangana, and Andhra Pradesh, is predominant, driven by better job opportunities, higher wages, and reliable payment processes. The study underscores the urgent need for comprehensive disaster management strategies and sustainable development practices to mitigate the adverse impacts of environmental changes on Sagar Island's ecosystem and its inhabitants. It also highlights the importance of migration in providing alternative sources of income and facilitating adaptation to the changing environmental conditions.

# CHAPTER 1: INTRODUCTION

The global climate is undergoing rapid changes (WMO, 2024; Pörtner et. al., 2019; Church and White, 2011), with significant implications for ecosystems worldwide (IPCC, 2018). Recent decades have seen substantial reductions in polar ice cover, including the loss of ice sheets and glaciers, decreased snow cover, and the thinning of Arctic Sea ice (Pörtner et. al., 2019). Additionally, the increasing ocean heat content, driven by global warming, is a critical factor contributing to rising sea levels through thermal expansion (Church and White, 2011). The pervasive impacts of climate change are evident across all regions of the Earth, manifesting in numerous extreme weather events and temperature variations (WMO, 2024). In India, the frequency of extreme events has markedly increased, from 250 incidents between 1970 and 2005 to 310 events in a shorter span of 2005 to 2019 (Mohanty, 2020).

Environmental sustainability is a great concern for the Sundarban. According to IPCC (2007), the Ganges-Brahmaputra delta in Bangladesh and West Bengal are most vulnerable due to climate change, the increasing number of coastal storms, and the rise of sea levels. The sensitive ecosystem along with underdevelopment has made the region more vulnerable.

Sundarban is one of the most noticeable victims of climate change in India. The temperature in the Sundarban region has been increasing at a rate of 0.019°C per year, affecting both land and sea (Hazra et. al., 2010). Between 1901 and 2003, the Indian Sundarban saw a monsoon rainfall increase of 91 mm and a post-monsoon rise of 25 mm. Conversely, winter and pre-monsoon rainfall decreased by 14.5 mm and 6.7 mm, respectively (WBSAPCC, 2012). The monsoon onset has also been delayed by 5-10 days over the past few decades (WBSAPCC, 2012). Since 1980, the Bay of Bengal's Sea surface temperature has risen by 0.5°C per decade, much higher than the global average of 0.06°C (Ghosh, 2012). This warming leads to thermal expansion, increased evaporation, and stronger tropical cyclones (Gary et. al., 1979; Mohanty, 2020).

The Sundarban region faces mounting challenges due to a combination of natural factors and anthropogenic activities. The landscape is in constant flux (Hazra et. al., 2010; Hajra and Ghosh, 2016), shaped by tidal movements and shifting river paths. The Ganges River's eastward shift has increased freshwater flow into Bangladesh while decreasing it into the Indian Sundarban Delta (ISD). Human interventions, such as upstream dam construction, tidal defence embankments, urban and industrial pollution, and mangrove conversion for agriculture and aquaculture, have significantly altered the region's water regime, sediment patterns, landforms, and hydrological processes (Dasgupta et. al., 2020). Both natural processes and human activities have led to various environmental challenges in the Sundarban.

Sundarban is facing frequent flood events with rising sea levels. Low-lying coastal areas are becoming more vulnerable because of salt-water intrusion into the land and underground aquifers. The intrusion of saltwater into the land and underground aquifers contaminates the drinking water. Agricultural lands become less productive, plants are damaged, and freshwater stocks in ponds for irrigation are salinised due to saltwater intrusion. Freshwater aquaculture and to some extent brackish water aquaculture are also impacted by salinity intrusion. Changes in water density and transparency impact fish production in the region. Along with that, the growing population is creating pressure on the ecosystem of the area by over-extracting resources, and unmindful practices.

The environmental challenges have appeared to be problematic for natural resource-based activities like agriculture and fishing; resulting in the major livelihood practices of the delta region becoming vulnerable. Agricultural production is highly volatile due to reliance on rainfall, cyclones, storm surges, and salinisation. Over time, productivity has declined (Mistry and Das, 2013) due to natural hazards, lack of irrigation, poor-quality seeds, land disputes, small landholdings, insufficient technical and financial support, and increasing population pressure. The main reasons for productivity losses are salinisation, inundation, and erosion, which resulted in poverty in the region (Hajra et. al., 2017). Fishing in the Indian Sundarban Delta (ISD) faces challenges due to the declining number and variety of fish in both oceanic and riverine environments. Furthermore, there are regulatory issues that include limitations on Boat Licence Certificates (BLC), seasonal permits, and ambiguities in pass issuance. Additionally, there are restrictions on specific species and a reduction in the fishing area (Mistri and Das, 2017).

Traditional natural resource-based activities have declined in the region. There is also a lack of proper alternative means of livelihood in the region. The tourism sector in the Indian Sundarban Delta (ISD) faces stagnation due to several factors, including limited income incentives for residents, lack of coordination, and low participation from the local community. To safeguard the environment, heavy industries are prohibited within the ISD, with only natural resource-based industries permitted. Livestock farming, such as animal husbandry, poultry, and dairy farming, exists but remains on a small scale. The lack of alternative livelihood options has pushed people to migrate out for employment opportunities.

Migration is a complex phenomenon, directed by many factors rather than a single controlling factor. Migration is being used as an important strategy to reduce vulnerability to environmental, economic, social, and political pressures through diversification of livelihood

(Myers, 2002; ICIMOD, 2011). Apart from push factors, pull factors also play an important role in attracting migrants. The destination area may have higher employment opportunities, wage rates, better amenities, better education, more peaceful and less vulnerable environment.

Due to serious stresses created by a sizeable number of environmental challenges the Indian Sundarban Delta is currently in a vulnerable situation in terms of sustainability of the local ecosystem. The natural resource-based traditional activities have been declining and the scope for livelihood opportunities is also limited in the ecosystem. Migration is one of the major adaptive strategies to overcome unemployment and livelihood issues.

Thus, it is important to understand the interrelation between environmental challenges, livelihood conditions, and migration scenarios in the Indian Sundarban Delta. Sagar Island has been selected for the study due to its location at the extreme of ISD which makes it more vulnerable to environmental challenges compared to the rest of the Indian Sundarban. The region also lacks forest cover compared to the other regions of the ISD. In addition, alarming population growth has created pressure on the livelihood and employment of the region. Therefore, a detailed study to understand the interrelation between environmental challenges, livelihood conditions, and migration scenarios on the island would add value to the academic domain.

# CHAPTER 2: REVIEW OF LITERATURE

## 2.1 Background of the Study

Climate change denotes prolonged changes in temperatures and atmospheric conditions (UN, 2024). Climate change is a multifaceted phenomenon that affects the environment and human society in many ways. There are noticeable differences in temperature changes between high and low latitudes, as well as between land and water (IPCC, 2007). Precipitation is likely to decrease in most tropical and subtropical land areas, whereas it is expected to increase in high latitudes (IPCC, 2007). The planet is pushed into climatic conditions that have never occurred in the history of human beings (Consortium et. al., 2023; Ripple et. al., 2024). A lot of climatic records have been broken in recent years (Ripple et. al., 2023). Numerous studies have examined the notable spatial diversity of its effects. The hottest extratropical summer was experienced in the Northern Hemisphere in two millennia (Esper et. al., 2024). The global average sea level has reached an all-time high, primarily due to the overall warming (Lee, 2024). The melting of continental ice is responsible for about half of this rise in sea level (Horwath et. al., 2021). Emissions of fossil fuel have surged to an unprecedented level, with the three hottest days on record occurring in July 2024 (Guterres, 2024). There has been a recent surge in carbon dioxide levels (NOAA, 2024). Additionally, the acceleration in the growth rate of methane emissions is deeply concerning (Shindell et. al., 2024). In the year 2023, unprecedented sea surface temperatures were experienced (Cheng et. al., 2024). In 2021 and 2023 the heat waves led to mass mortality events among marine animals (White et al. 2023; Goreau and Hayes, 2024). There are reductions in the diversity of macroinvertebrates and the availability of fish in the ocean (O'Donnell et. al., 2024). Climate change also poses a significant threat to coral reefs (Hoegh-Guldberg et. al., 2017; Thiem, 2024). Climate change is affecting food security, health, employment, housing, and safety.

Additionally, we can expect increasingly extreme weather events in the future (Masson-Delmotte et. al., 2021). While emissions have global consequences, their impact is especially harsh in the Global South (Ngcamu, 2023). Climate change vulnerability is influenced by a complicated web of economic, social and political elements, disproportionately affecting the marginalised populations (Levy and Patz, 2015). Vulnerable populations, such as those living in developing countries and small islands, are more at risk from rising sea levels, storms, floods, and saltwater intrusion (UN, 2024).

The Sundarban and the existence of its local communities who depend on the forest for their livelihoods are being significantly impacted by the changing climate (Dasgupta et. al., 2020;

Agrawala et. al., 2003; Ghosh et. al., 2022). The range of climate-related issues that they encounter includes rising sea levels, rising atmospheric $CO_2$ concentrations, rising air and ocean temperatures, and an increase in the frequency and intensity of rainfall and cyclonic storms (Hazra et. al., 2010; Dasgupta et. al., 2020).

Along with climate change, the Sundarban region faces mounting challenges due to, a combination of natural factors and anthropogenic activities. The landscape is in a constant state of change (Hazra et. al., 2010; Hajra and Ghosh, 2016; Ghosh and Sengupta, 1997), shaped by tidal movements, while the rivers within it carve new paths. The Ganges River's gradual eastward shift has a profound impact on sediment distribution and freshwater inflow; the flow of freshwater into Bangladesh has increased while the flow into the Indian Sundarban Delta (ISD) has decreased. Human interventions in recent years, such as the construction of dams upstream, the building of embankments for tidal defense, and pollution from urban and industrial sources, along with the conversion of mangrove areas for agricultural and aquaculture purposes, have significantly altered the region's water regime, sediment patterns, landforms, and overall hydrological processes (Dasgupta et. al., 2020). Both natural processes and human activities have led to various changes in the environment of Sundarban.

### 2.2 Indian Sundarban Delta

World's largest delta Sundarban is developed by the confluence of the Ganga, Brahmaputra, and Meghna rivers in the southernmost part of Bangladesh and West Bengal. It is home to the single largest halophytic mangrove forest. An intricate web of channels, distributaries, and tidal creeks fragments the region into several islands fabricated with silt and silty clay. The name Sundarban is derived from 'Sundari' (Heritiera Fomes) and 'Bani' (Avicennia Officinalis) mangrove trees that are abundant in the region. Some say 'Sudur ban' meaning vast forest is the original term of Sundarban. There are other views as well in terms of the origination of the name Sundarban. Another opinion is that the name derives from the two words 'Sundar' meaning beautiful and 'Ban' meaning a forest.

#### 2.2.1 Areal extension and geographical setup

The total area of Sundarban is around 25,000 sq. km. within which 9630 sq. km. is in India and the rest is in Bangladesh (Hazra et. al., 2002). The Indian Sundarban Delta (ISD) consists of 4264 sq. km of reserve forest and 5366 sq. km. of human-inhabited area. The region is a large archipelago consisting of 102 islands, among which 54 islands are human-inhabited and 48 are

filled with mangrove forests (Danda, 2007). Sundarban mangroves comprise more than sixty percent of the total mangrove forest cover of India (DISHA, 2009).

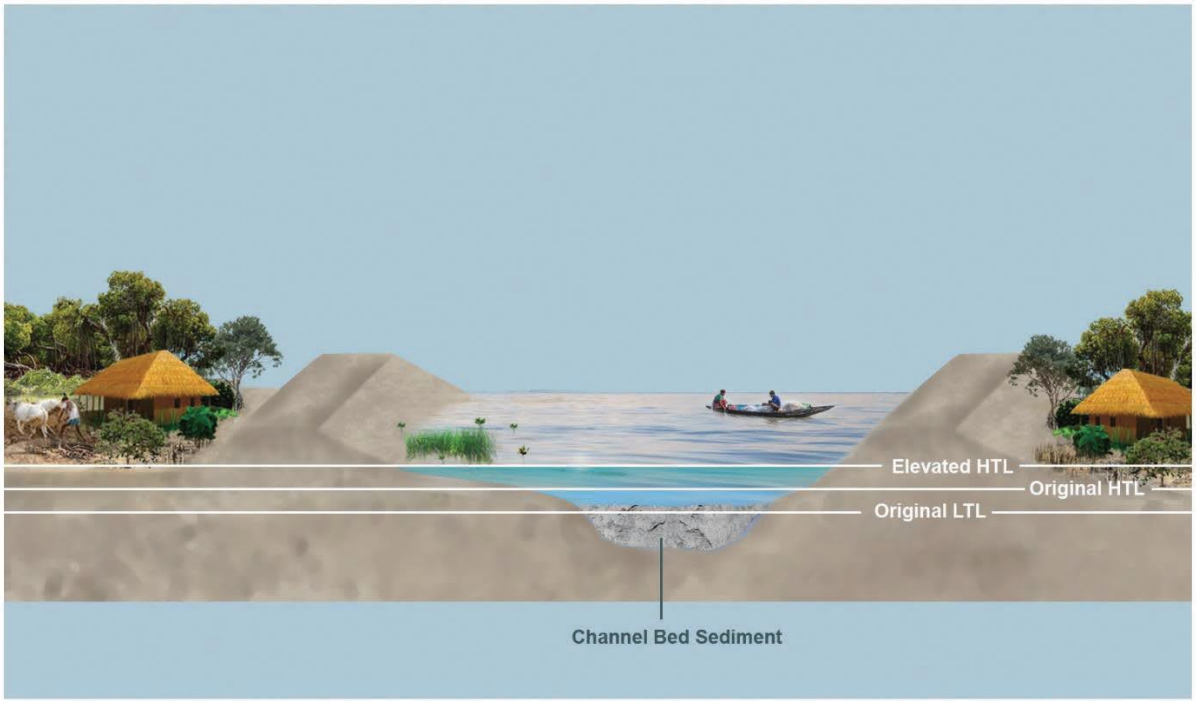


Figure 2.1: Deposition of sediment on river bed due to the barrier of embankments and consequent elevated high tide level

*Image source: Environment Department, Govt. of West Bengal, 2021*

Most of the human-inhabited islands are still juvenile in terms of geomorphological formation. People settled down before the completion of the natural process of siltation. The settled islands are protected by embankments mostly built of mud. A more than 3500 km embankment is supposed to stand as a defence system for islanders from the destruction of water bodies. These islands are low-lying. People settled here before the lands were formed maturely. The average height of the island varies from 0.9 meters to 2.11 meters from the mean sea level. The embankments were made to act as a barrier from entering saline water at the time of high tide into the island. There are negative sides to these barriers as well, they stopped the natural process of silt submission on the islands which would have helped to increase the height of the islands. River flow velocity is another factor of silt deposition along the river bed. Also, due to the barrier of high embankments rainwater does not pass freely to the rivers as runoff, it is removed at the time of low tide by the sewage gate. If the embankments were not built saline water would have poured canals, tanks, and low-lying areas a long way into the island. For the

significant role of mud-built embankments, it can be called the lifeline of the people of Sundarban.

### 2.2.2 Establishment of settlement

The human settlement in Coastal areas of the Ganga-Bhamhaputra-Meghna Delta has been inhabited for a long back by humans due to their plentiful resources and livelihood opportunities. The history of Sundarban inhabitation can be tracked down back to time 200–300 AD. Archaeological shreds of evidence from the Baghmara forest suggest a city built by Chand Sadagar who was a powerful and rich sea and river merchant claimed by both Bengali and Assamese communities (Directorate of Forests Govt. of West Bengal, 2017). From the 8$^{th}$ century to before the 18$^{th}$ century, the deltaic islands of Indian Sundarban were very scattered and settled (Eaton, 1990).

A process of forest clearance along with embankment construction made sizeable human inhabitation feasible in the Sundarban which mainly began in the late 19$^{th}$ century and extended through the 20$^{th}$ century. In the British period, the Sundarban started to lease out divided plots to prospective landlords for agriculture, timber extraction, and other economic activities to collect revenues. The colonised rule transformed the unstable land into a source of economic gain by collecting agricultural taxes. During that period vast number of mangroves were erased for agriculture and settlement.

### 2.2.3 Biodiversity

The region consists of a spectacular biodiversity of flora and fauna. Having 1586 animal and 81 plant species Sundarban is the largest mangal diversity in the world. More than 165 species of fish, 163 species of birds, 56 species of reptiles, 40 species of mammals, 23 species of molluscs, 67 species of crabs, and 15 species of prawns have been reported in ISD so far. Besides, the region is well known for the habitat of the Royal Bengal Tigers. (UNESCO, n.d.) 90% of mangrove species in India are found in the Indian Sundarban Delta, which accounts for more than 60% of the nation's total mangrove cover.

### 2.2.4 The legal status and designations of Sundarban

The designation of Sundarban has been evolving since 1878 (Table 2.1). The total area of these different designations varies or sometimes coincides with each other. At first, the area was announced as a Protected Forest (PF). In 1928 It was designated as a “Reserve Forest” (RF). Then in 1973, a part of the area was declared as “Sundarban Tiger Reserve” (STR) in the

program ‘Project Tiger’ launched by the Government of India. It is one of the earliest nine Tiger Reserves authorized at that time. A part of the Tiger Reserve Forest was declared as “Sajnekhali Wildlife Sanctuary” in 1976. After that in 1984, the core of STR was notified as Sundarban National Park. Later in 1987, UNESCO declared the national park as a “Natural World Heritage Site”. In 1989 Government of India declared the STR along with adjoining forest and human habitat area as the “Sundarban Biosphere Reserve” (SBR) having 9630 sq km. In 2001 under the Man and Biosphere (MAB) programme, UNESCO acknowledged SBR as a Global Biosphere Reserve. In 2007 the core area of tiger reserve was increased from 1330.10 sq. km. to 1699.62 sq. km. and named as Core or Critical Tiger Habitat.

The Sundarban Tiger Reserve, Sundarban National Park (NP), and Sajnekhali Wildlife Sanctuary are all under the watch of the Conservator of Forests and Field Director of the STR, operating within the Directorate of Forests, Government of West Bengal. This team also oversees and regulates human activities within the reserve forest. Human interference is completely prohibited within the Core/NP area. The SRF area is forbidden for human settlement.

A total of 54 islands constitute the human settlement area or Transition Zone. Within the Transition Zone of SBR, the human settlements are confined. The transition zone comprises some parts of both North 24 Parganas and South 24 Parganas. Four subdivisions from South 24 Parganas named Kakdwip, Diamond Harbour, Baruipur, and Canning in under the transition zone along with one subdivision of North 24 Parganas named Basirhat is under transition zone (Table 2.2). These five subdivisions include a total of 19 blocks. Out of 19 blocks 13 blocks namely Sagar, Namkhana, Kakdwip, Patharpratima, Mathurapur-I, Mathurapur-II, Kultali, Joynagar-I, Joyganar-II, Canning-I, Canning-II, Basanti and Gosaba in under South 24 Pargana district. And the rest 6 blocks namely Hingalganj, Hasnabad, Sandeshkhali-I, Sandeshkhali-II, Haroa, and Minakhan are in North 24 Pargana. Except for Jaynagar-I rest of the areas are rural areas. A total of 17 police stations are therein the transition zone; 12 in South 24 Parganas and 5 in North 24 Parganas. A total of 190 Gram Panchayats and 1062 villages are there (Census of India, 2011).

Table 2.1: Designations and demarcated areas of Indian Sundarban through time

| Year | Legal designations | Demarcated area |
|---|---|---|
| 1878 | The area was declared a Protected Forest (PF) | entire Sundarban in the 24 Parganas district (consisting at that time of the Basirhat and Namkhana ranges) |
| 1928 | It was declared as a Reserve Forest (RF) | 4263 sq. km. |
| 1973 | One of the first nine Sundarban Tiger Reserves (STR) declared under the Project Tiger Scheme | 2584.89 sq. km covering a land area of 1600 sq. km and a water body of 985 sq. km |
| 1976 | A part of the Sundarban Tiger Reserve (STR) was notified as to the Sajnekhali Wildlife Sanctuary | 362.42 sq. km |
| 1984 | The core area of the tiger reserve was declared as the Sundarban National Park (NP) | NP is 1330.12 sq. km of which 124.40 sq. km is preserved as a primitive zone to act as a gene pool. |
| 1987 | The National Park was inscribed as a Natural World Heritage Site by UNESCO | 1330.10 sq. km |
| 1989 | The STR along with the adjoining forest area and human habitat was declared as Sundarban Biosphere Reserve (SBR) by the Government of India | 9630 sq. km (4263 sq. km forest area + 5367 sq. km inhabited area) |
| 2001 | The SBR was enlisted on the UNESCO World Network of Biosphere Reserves (WNBR) under the Man and Biosphere (MAB) program | 9630 sq. km |
| 2007 | The freshly designated core of the STR or Critical Tiger Habitat (CTH) | 1699.62 sq. km |
| 2009 | Buffer zone notification | 885.27 sq. km including 362.42 sq. km Sajnekhali Wildlife Sanctuary |
| 2019 | Ramsar site | 4230 sq. km |

*Data source: UNESCO (n.d.); RSIS (n.d.); Mistry and Das, 2020*

Table 2.2: Administrative unit of Indian Sundarban

| District | Sub-Division | Police Stations | Blocks / Panchayat Samitee | Gram Panchayats | villages | Mouzas | Census Town |
|---|---|---|---|---|---|---|---|
| North 24-Parganas | Bashirhat | Hingalganj, Hasnabad, Sandeshkhali, Haroa, Minakhan | Hingalganj, Hasnabad, Sandeshkhali-I, Sandeshkhali-II, Haroa, Minakhan. | 61 | 361 | 336 | 0 |
| South 24-Parganas | Kakdwip | Sagar, Namkhana, Kakdwip, Patharpratima | Sagar, Namkhana, Kakdwip, Patharpratima | 129 | 701 | 751 | Joynagar - I |
| | Diamond Harbour | Mathurapur, Roydighi | Mathurapur-I, Mathurapur-II | | | | |
| | Baruipur | Kultali, Joynagar | Kultali, Joynagar-I, Joynagar-II | | | | |
| | Canning | Canning, Basanti, Gosaba, Sundarban Costal | Canning-I, Canning-II, Basanti, Gosaba | | | | |
| Total | 5 | 17 | 19 | 190 | 1062 | 1087 | 1 |

*Data source: Census of India 2011*

## 2.3 Environmental Changes and Related Risks in Sundarban

The deltaic ecosystem of Sundarban is encountering various challenges due to environmental changes. Both natural and anthropogenic factors, such as sea-level rise, coastal erosion, land subsidence, population pressure, and developmental activities during the Anthropocene pose threats to the delta's sustainability. Erosion, flooding, salinisation, cyclones, storm surges, waterlogging, etc. are the most common phenomena in this region. The impacts of these events are increasing day by day due to increasing population pressure and climate-related variability and changes.

Table 2.3: Environmental issues in the Indian Sundarban

| Natural issues | Anthropogenic issues |
|---|---|
| **Climatic**<br>1. Sea-level change<br>2. Extreme weather conditions (cyclonic storms, flooding, etc)<br>3. Uncertainty of rain<br>**Geographical and geological**<br>4. Coastal erosion<br>5. Geographical remoteness & isolation<br>6. Deficit of fresh groundwater<br>7. Saltwater intrusion<br>**Ecological**<br>8. Dependence on forest, river, marine-based living<br>9. Ecological depletion & Biodiversity loss<br>10. Human-animal conflict | **Demographic risks**<br>1. Increasing population pressure<br>2. Water pollution and Pesticide calamity<br>**Socio-economic risks**<br>3. Decreasing agricultural land and production<br>4. Very few alternate livelihood options<br>5. Poverty<br>6. Lack of educational facilities<br>7. Lack of Infrastructure |

*Source: Hajra and Ghosh, 2016; Chakraborty, 2015; Hazra et. al., 2010; Bandyopadhyay and Basu, 2017; Mistri and Das, 2020*

### 2.3.1 Sea level rise

Eustatic Sea level rise is one of the significant effects of global warming. Melting of continental and polar ice sheets and thermal expansion by direct warming of ocean water is resulting in sea

level rise (Ericson et. al., 2006). Eustatic changes can also occur due to seafloor shape changes due to geotectonic reasons. Along with Eustatic SLR, relative SLR is going to make the matter worse for Sundarban (Sánchez-Triana et. al., 2020). Sea level rise, as well as complex hydrodynamic conditions, are playing a role in many changes in the deltaic systems of Sundarban (Hajra and Ghosh, 2016).

### 2.3.2 Cyclone and storm surges

The Sundarban region has been a field of cyclonic storms for a long history of time. The Bay of Bengal is one of the major producers of tropical cyclones. More than 35 cyclones are listed by Chakraborty (2015) between 1909 and 2009 that took place in the Indian Sundarban. One of the major events occurred on $25^{th\text{-}26th}$ May 2009, the severe cyclone Aila created havoc in the Indian Sundarban along with spring high tide, which devastated the region on a massive scale (Pal and Ghosh, 2018). Heavy rainfall with a wind speed of 120-140 km/hour, flooding, and major landslides were recorded. The devastating event destroyed 900,000 houses and 500 km of embankments in ISD (Chakraborty, 2015). The tidal surge inundated the region with an enormous amount of salty water, which stayed stagnant for a long period and resulted in increased soil salinity. Due to high soil salinity, the agricultural system was disrupted. A thin layer of salt was observed in many places of agricultural fields. The average production of rice per bigha before the cyclone was 640-800 kg which reduced to 320-400 kg per bigha after the cyclone (Debnath, 2013). The water bodies were contaminated by high salinity led to a crisis of fresh drinking water. The economy of the region was hampered at a significant level.

Danda (2007) recorded 1.5 km of the destruction of embankments in the western part of Mousuni Island due to cyclonic storm surges in 2005. The embankment system of the Sundarban is not well enough which was made to protect the region from inundation, and many portions of embankments are vulnerable to overtopping and breaches due to storm surges (Sánchez-Triana et. al., 2020). Embankment overtopping due to storm surges creates repeated challenges for those living near the embankments. Destructive surges mainly happen when spring tide occurs coinciding with the high speedy wind. A study by Danda (2010) on Baliara a village in Mousuni Island recorded that around 13% of inhabitants are affected on an annual basis by storm surges. The overtopped water is difficult to drain from the relatively lower land behind embankments. This leads to increased soil salinity and agricultural losses. Kay et. al. (2015) predicted based on extensive modeling studies that storm surge flooding during high tides will create more risk in the future.

Table 2.4: List of cyclones in the Bay of Bengal during 1999-2018

| Name | Date of occurrence | Category |
|---|---|---|
| ---- | 28th October 1999 | Super Cyclonic Storm |
| ---- | 28th October 2000 | Cyclonic Storm |
| ---- | 19th May 2003 | Severe Cyclonic storm |
| ---- | 17th May 2004 | Severe Cyclonic storm |
| ---- | 2nd October 2005 | Cyclonic Storm |
| Mala | 24th April 2006 | Super Cyclonic Storm |
| ---- | 13th May 2007 | Severe Cyclonic storm |
| Sidr | 15th November 2007 | Super Cyclonic Storm |
| ---- | 28th June 2007 | Super Cyclonic Storm |
| Rashmi | 26th October 2008 | Cyclonic Storm |
| Nargis | 27th April 2008 | Very Severe Cyclonic Storm |
| Bijli | 16th April 2009 | Severe Cyclonic storm |
| Aila | 24th May 2009 | Severe Cyclonic storm |
| Giri | 19th October 2010 | Very Severe Cyclonic Storm |
| Phailin | 4th October 2013 | Very Severe Cyclonic Storm |
| Komen | 31st July 2015 | Cyclonic Storm |
| Titli | 11th October 2018 | Very Severe Cyclonic Storm |

*Data source: Hazra et. al. (2010) and India Meteorological Department*

Table 2.5: Recent cyclones that impacted the Sundarban (2019-2024)

| Name | Date of occurrence | Category |
|---|---|---|
| Fani | 23rd April 2019 | Extremely Severe Cyclonic Storm |
| Bulbul | 9th November 2019 | Super Cyclonic Storm |
| Amphan | 20th May 2020 | Super Cyclonic Storm |
| Yaas | 26th May 2021 | Very Severe Cyclonic Storm |
| Sitrang | 22nd October 2022 | Cyclonic Storm |
| Remal | 24th May 2024 | Severe Cyclonic Storm |

*Data source: India Meteorological Department*

In recent years, the Indian Sundarban delta has been affected by several cyclones, including Bulbul, Amphan, Yaas, and Remal. Among these, Amphan and Yaas caused significant

damage to various locations within the delta. In contrast, Cyclone Fani had a minimal impact. While Cyclone 'Sitrang' primarily affected Bangladesh did not directly impact the Indian Sundarban delta.

### 2.3.3 Erosion and submergence

Generally, the coastal regions are a dynamic and fragile type of landscape. Both the natural and anthropogenic processes can make changes in this landscape easily. The Sundarban have faced drastic coastal erosion in the recent past. Many Islands have been completely submerged; many inhabitants lost their habitat. A study by Hazra et. al. (2010) has shown that the amount of erosion in the southern islands of ISD is much greater than in the rest of the area. The amount of erosion is quite high in the southern islands like Sagar, Jambudwip, Ghoramara, Moushuni, Namkhana, Lothian, Dakshin Surendranagar, Dhanchi, Bulcher, Dalhousie and Bhangaduni (Hazra et. al., 2010). In the year 2001, the total area of Indian Sundarban was 6402.09 sq. km. which has been reduced to 6358.048 sq. km. in the year 2009 (Hazra et. al., 2010). Within this period 64.162 sq. km. of land has been eroded and 20.120 sq. km of land has been accredited which means net loss during this period was 44.042 sq. km (Hazra et. al., 2010).

Bedford, Lohachara, and Suparibhanga islands are completely Submerged resulting in a huge number of populations becoming environmental migrants (Ghosh et. al., 2014; Hajra and Ghosh, 2016). The changes observed in Ghoramara Island are quite significant which produced a large number of outmigrants due to land losses. From 1967-68 to 1995 net land loss from this Island is 3.19 sq km (Ghosh and Sengupta, 1997). There is a significant amount of deposition on the eastern side and immense erosion on the western side of the island. The impact of the erosional activity is larger than the depositional activity. Baisnabpara and Khasimara had been completely eroded from the western part of Ghoramara Island (Ghosh and Sengupta, 1997). Another study by Ghosh et. al. (2007) has shown gradual losses of land from Ghoramara Island by using satellite images of the different years. The study found in 1975 the total land of Ghoramara Island was 8.51 sq km which was reduced to 4.43 sq km in 2012. The total loss of land is 4.8 sq km from this Island within 32 years (Ghosh et. al., 2007).

### 2.3.4 Scarcity of freshwater

Another serious concern is the rising salinity in the estuaries of the Indian Sundarban Delta. The Ganges Delta region is enriched with an enormous amount of surface and groundwater. However, the soil salinity, seawater intrusion, geo-hydrology, and high content of soil clay have created serious issues in the region. Freshwater scarcity is linked to many socio-economic

problems like loss of agricultural productivity, high morbidity due to various water-borne diseases, lack of large-scale industry, and Poverty (Bandyopadhyay and Basu, 2017).

The volume of saltwater is increasing gradually due to rising sea levels and the amount of sweet water is reducing in the river Hooghly and its tributaries consequently the soil salinity is rising. (Bandyopadhyay and Basu, 2017). Due to high siltation, connection to fresh meltwater has been restricted in the Bidyadhari channel which resulted in high salinity in the central part of ISD (Banerjee, 2013).

In South 24 Parganas district there are two aquifers the upper one is brackish, situated at 70-160 m below ground level and the lower one is fresh water in nature situated at more than 160 m below ground level (Bandyopadhyay and Basu, 2017). The problem with groundwater aquifers is that the brackish water is not desirable for use and the freshwater is too costly to use for drinking and irrigation.

### 2.3.5 Anthropogenic risks

The Indian Sundarban Delta remains a backward isolated and remote region of the state of West Bengal. The combined effect of all the demographic, economic, social and political factors, such as high growth of population, lack of industries and service sector opportunities, lack of electricity, organized transport system, lack of irrigation facilities, rain-dependent mono-crop agriculture, low level of income, limited financial assets make the life and livelihood of the inhabitants of Sundarban dependent on the natural resources of the ecosystem.

### 2.3.6 Population pressure on the ecosystem of Sundarban

Since the early history of human settlement, deltas have been changing by human activities (Tompkins et. al., 2020). Modifications in the Ganges-Brahmaputra-Meghna Delta by humans have been recorded back to 3000 years ago approximately (Fergusson, 1863). The ecological balance is disrupted gradually in the Indian Sundarban due to increasing population pressure (Chakraborty, 2015). Due to significant birth rates and an influx of migrants, population density remains high and continues to increase in the ISD (Sánchez-Triana et al., 2014).

Forest clearance along with embankment construction made sizeable human inhabitation feasible in the Sundarban. The process began mainly in the late 19$^{th}$ century and extended through the 20$^{th}$ century on a large scale. The mangrove cover was extended to the city of Kolkata at the end of the 18$^{th}$ century (Ghosh et. al., 2015); by 1947 at the time of independence, the forest cover reduced to 50% of the pre-colonial period (Giri et. al., 2007). Division of

Bengal at the time of India and Pakistan's independence from Britishers the entire Sundarban has seen a rapid inflow of migration. The post-independent period has continued a large pool of in-migration on several occasions such as the independence of Bangladesh in 1971. The increasing population pressure both due to the influx of population from Bangladesh and other parts of West Bengal and the high natural birth rate demanded more land for agriculture and construction activity. The gradual demand for land led to extensive forest cleansing. The population of Indian Sundarban in 1951 was 11,59,559 by 1991 increased to 32,05,552 and in the 2011 census it became more than 40 lakhs. Additional Influx of population has led to more competition for livelihood, resource crisis, and pressure on ecosystem services.

### 2.3.7 Ecological changes

In recent times the net forest area has not changed much but the vegetation pattern has been significantly changed. From 1970 to 2000 net decrease in forest area was 1.2% in Sundarban both including India and Bangladesh (Giri et. al., 2007). The cleansing of the forest has not been significant due to protection and management status. Due to aggradation, erosion, afforestation, deforestation, and degradation, the vegetation cover is going through regular changes (Giri et. al., 2007). Some species of mangroves from the Sundarban are on the verge of extinction (Mistri and Das 2020).

Increasing pollution from the upstream of Hooghly and its tributaries is another challenge for the ecosystem of the region. Rivers of ISD are polluted by industrial, agricultural, and domestic wastes. A study by Samanta et al. (2005) recorded enough high levels of Cd, Cu, and Pb in the Hooghly River near Haldia which may affect the aquatic ecosystem. A study by Guzzella et. al. (2005) has also recorded high levels of toxic pollutants like polychlorinated biphenyls across the lower stretch of the Hooghly River.

Human-animal conflict is another issue in Sundarban. The increasing population pressure and need for livelihood opportunities have increased the competition for resources with the wild animals which inevitably result in violent conflict between humans and wild animals leading to losses on both sides.

Mainly due to encroachment and habitat loss of tigers, human-tiger conflict is a constant problem in the region. A survey conducted by Das (2014) reported 237 cases of tiger intrusion into villages near the forest area during 1995-2010. There were 7 cases of human death while the villagers killed 12 tigers during those tiger intrusion events. The majority of incidents are about attacks on livestock.

## 2.4 Livelihood, Employment, and Job in Indian Sundarban

Farming is the main occupation of the Indian Sundarban. Riverine and marine fishing along with aquaculture are also important economic activities in the region. A lot of the population is also dependent on the collection of forest products such as honey and wood. Household industry, tourism, and small businesses also contribute to the economy of Indian Sundarban.

### 2.4.1 Agricultural issues

The majority of the inhabitants of this region are primarily dependent on agricultural activity. The farming process is traditional and monsoon-dependent. The farmers do not generate high revenues from agriculture. Mainly subsistence type of farming is practiced here. Monocropping is practiced here by most of the farmers due to water scarcity, for the rest of the year they look for other opportunities for employment both within and outside of their village boundary. The production of rice the principal crop of ISD, along with other crops especially potato and khesari (grass pea) has become volatile (Mistri and Das, 2013). Agricultural production is volatile due to rain dependence, the risk of cyclones, storm surges, salinisation, etc. Agricultural production has also declined over time (Mistry and Das, 2013). Along with natural hazards and disasters Lack of irrigation facilities, low-quality seed usage, land dispute, marginal landholdings, inadequate technical and financial assistance, and growing population pressure are responsible for declining productivity.

The main reasons for productivity losses are erosion, salinization, and inundation which resulted in poverty (Hajra et. al., 2017). The serious barriers to agricultural production in Sundarban are the unavailability of freshwater irrigation, high soil salinity, and high salinity of river water, which restricts agricultural production. After the cyclone Aila (2009), agricultural productivity fell to a significant amount (Debnath, 2013). Due to agricultural losses and below-average crop production food security becomes another serious issue in the Sundarban (Guha and Roy, 2016). Agriculture being the prominent income source of the region, major productivity losses result in poverty (Hazra et. al., 2002).

Table 2.6: Restrictions imposed in Indian Sundarban

| Instruments of Restriction | Areas of Restriction |
|---|---|
| The Wildlife (Protection) Act 1972 | Protection of scheduled flora and fauna. Example: Prohibition of hunting of dolphins, turtles etc. Prohibition of picking, uprooting, etc of specified plants. The declaration of restrictions and consequent imposition of restrictions on entry and activities in sanctuaries, national parks and closed areas. |
| Forest (Conservation) Act 1980 & Rules | Prohibition on use/clearing of forestland for non-forest purposes. |
| Timber harvesting ban, 1989 | Timber harvesting ban in the Indian Sundarban was implemented by the central govt. aimed to protect the delicate mangrove ecosystem and its unique biodiversity. |
| The Biological Diversity Act, 2002 & Rules | Restriction on access to biological resources or knowledge associated with research or for commercial utilization or bio-survey and bio-utilization. |
| Coastal Regulation Zone Notification (1991 & 2011) | CRZ-I applies to the whole of Sundarban because it is an ecologically sensitive and mangrove forest area. The restrictions are: 1. No new construction shall be permitted within 500 meters of the High Tide Line. 2. No construction activity (except as listed under 2 (xii) of the notification) will be permitted between the Low Tide Line and the High Tide Line. No construction activity (except those specified under sec.3 of the notification) will be permitted within 50 meters or the width of the river/creek whichever is less. |
| Coastal Aquaculture Authority Act & Rules (2005) | Compulsory registration of aquaculture farms. Restrictions on methods of farming, discharge of pollutants, etc. |
| Marine Fishing Act, WB (1993) | Restrictions on trawl and large mechanized fishing within 15 km. of the coast. Prohibition of the use of mosquito (fishing) nets. Promulgation of the no-fishing period of 61 days (April 15 to 14 June). |

*Source: DISHA, 2006*

### 2.4.2 Fishing-related issues

A significant share of the population is engaged in fishing. Riverine and marine fishing and prawn seed collection along aquaculture are observed in the region. Fishing in ISD is hindered due to several reasons for high restrictions in Sundarban Reserve Forest (Table 2.6) like restrictions in Boat Licence Certificate (BLC), seasonal permits and pass ambiguities, restrictions on specific species, and shrinking the area under fishing (Mistri and Das, 2017). The decreasing number of fish and fish varieties in the ocean and rivers are the issue with this occupation.

### 2.4.3 Issues in the tourism sector

The tourism sector is stagnated due to several reasons such as fewer income incentives for the residents, lack of coordination, low participation of inhabitants, etc. To protect the environment heavy industries are not allowed inside ISD, only some natural resource-based industries are allowed. Live-stock firming like animal husbandry, poultry bird, and dairy farming, are there but on a small scale.

The issues related to the existing livelihood and income options are one of the major reasons that drive the inhabitants to migrate out from Sundarban.

## 2.5 Migration

Human migration is a complex phenomenon that includes a variety of movements of people and situations involving them. Migration has impacts on both the origin and destination region. The definition of a migrant by the UN Migration Agency (IOM) says any person who is moving or has moved across an international border or within a State away from his/her habitual place of residence, regardless of (1) the person's legal status; (2) whether the movement is voluntary or involuntary; (3) what the causes for the movement are; or (4) what the length of the stay is." According to the 'World Migration Report 2018' in recent years, an increase in migration has been observed due to environmental change and degradation and lack of opportunity and security. A wide range of displacement induced by weather and climate-related hazards was observed in many regions of the globe in 2018 and 2019; countries like India, China, Mozambique, Philippines, USA, etc affected the most (McAuliffe and Khadria, 2020).

### 2.5.1 Migration in the world context

The whole world is going to be affected by climate change but the intensity will be different for different areas (Newland, 2011). The major consequences of climate change on human life

and livelihood can be divided into two categories, resource crisis and the increasing number of natural hazards and disasters, which will lead to economic instability, political instability, and migration (Das, 2013).

The biggest environmental threat faced by South Asia is Climate change (Rajan, 2008). In countries like Bangladesh, India, and Pakistan around 130 million people live in the Low Elevation Coastal Zone which is less than 10m above sea level are could be displaced by the effect of climate change (Rajan, 2008).

By the end of the 20$^{th}$ century, around 75 million from Bangladesh and 50 million from India, in total 125 million inhabitants from the densely populated coastal area and other vulnerable parts could be displaced (Rajan, 2008).

Ericson et. al. (2006) estimated that by 2050 around one million inhabitants would be directly harmed in the Ganges– Brahmaputra–Meghna delta in Bangladesh and West Bengal by sea-level rise alone. The other mega deltas like the Mekong Delta in Vietnam and the Nile Delta in Egypt also face similar problems (Ericson et. al., 2006).

### 2.5.2 Migration in the Indian context

In countries like India and Bangladesh, the migration induced by climate change is likely to be internal or across adjacent borders (Newland, 2011). In India, an estimated 42.50 million people were at risk of storm surges, powerful cyclones, and associated incidents (Mohanty, 2020). In India, large coastal cities like Kolkata, Mumbai, and Chennai at 2-10 m are elevated from sea level. In a few decades, major migration streams will flow from these coastal cities to mainland cities like Delhi, Hyderabad, Bangalore, Pune, and Ahmedabad which are already burdened and will have serious resource constraints (Rajan, 2008). By the end of the 20$^{th}$ century, 8 million people could migrate from rural areas to urban areas as they are more likely to be affected by both climate change and globalisation (Rajan, 2008).

### 2.5.3 Migration scenario of the Indian Sundarban Delta

The submergence of Bedford, Lohachara, and Suparibhanga and the severe erosion of Ghoramara Island have forced a large number of people to become environmental migrants. There were 374 residents in 1991, who became migrants after the submergence of Lohachara Island (Ghosh et. al., 2007). Another study by Guha and Roy (2016) also noted a total number of 6,000 environmental migrants after becoming homeless due to the cases of submergence of

the islands namely Bedfort, Lohachara, Suparibhanga, and Kabasgadi in ISD. The inhabitants of Lohachara and Bedford Island mostly settled in Ghoramara and Sagar Islands. The erosion of five villages namely Khasimara, Baishnabpara, Khasimara Char, Lakshmi Narayanpur, and Bagpara of Ghoramara Island has also created population pressure on Sagar Island and the rest of the part of Ghoramara Island (Ghosh et. al., 2007).

Migration has historically been a human strategy for adapting to natural hazards and environmental challenges (Black, 2001). Migration is a noticeable strategy to get livelihood or employment opportunities in the Indian Sundarban Delta (Mistri, 2019). A household survey study on Satjelia Island by Mistri (2013) found that in three-fourths of the households, at least one member migrates out from ISD for employment. Climate change and erosion have impacted the economy of the Indian Sundarban Delta which is associated with outmigration (Hajra and Ghosh, 2016). Poverty serves as an additional 'push' factor associated with the environmental problems that displace people (Myers, 2002).

### 2.6 Interrelationship between Environmental Change, Livelihood, and Migration

There is an interrelation between environmental change, livelihood, and migration in the Indian Sundarban. The ecosystem of Sundarban is particularly vulnerable to the effects of climate change and other environmental changes, such as increasing water salinity, rising sea levels, frequent cyclones, coastal erosion, land salinisation, etc. The conventional agricultural and fishing-based livelihoods of the local populations are directly threatened by these environmental pressures. The residents are forced to decide to either adapt or migrate out for income generation as natural resource-based livelihoods become insufficient to live a decent or even a bare minimum life (Mistry and Das 2020).

# CHAPTER 3: METHODOLOGY

### 3.1 Study Area

Sundarban, one of the vast mangrove forests in the world is shared between two countries India and Bangladesh along the northern boundary of the Bay of Bengal. The total area of Sundarban is around 25,000 sq. km. among which 9630 sq. km. is in India and the rest is in Bangladesh. (Hazra et. al., 2002). The Indian Sundarban Delta (ISD) consists of 4264 sq. km. of reserve forest and 5366 sq km of human-inhabited area. The ISD possesses 102 islands, among which 54 islands are human-inhabited and the rest are filled with mangrove forests. The latitudinal extension of ISD is from 21˚30' N to 22˚40'48" N and the longitudinal extension is from 88˚01'48" E to 89˚04'48" E. The Dampier-Hodges line demarcates the area in the north and the south Sundarban is facing the Bay of Bengal. The eastern boundary of Sundarban is delineated by the river Hooghly and the western side is bounded by the Haribhanga-Raimangal-Ichamati rivers.

The Sundarban is ecologically sensitive and fragile because of frequent flooding, coastal erosion, embankment failures, submergence, cyclones, and storm surges. Furthermore, growing population pressure in the environmentally sensitive ecosystem has created serious concern among the research community (Ghosh, 2012).

The location of Sagar Island makes it more vulnerable to natural disasters and hazards compared to the rest of the Indian Sundarban. The region also has fewer ecosystem services compared to the rest of the Indian Sundarban Delta (ISD). The region lacks forest cover compared to the other regions of the ISD. In addition, alarming population growth has created pressure on the livelihood and employment of the region. Migration has emerged as an adaptive strategy to overcome the stress on employment and income opportunities (Hajra and Ghosh, 2017) in this area.

Sagar Island is relatively more exposed to storm surges, coastal flooding, cyclones, and coastal erosion due to its location at the extreme southwest of ISD. A study by Hazra et. al. (2016) has shown that the amount of erosion in the southern islands is much greater than the rest of the area. The amount of erosion is quite high in the southern islands like Sagar, Jambudwip, Ghoramara, Moushuni, Namkhana, Lothian, Dakshin Surendranagar, Dhanchi, Bulcher, Dalhousie and Bhangaduni (Hazra et. al., 2010). Situated at the meeting junction of the Bay of Bengal and the river Hooghly, Sagar Island is constantly facing geomorphic land-use changes due to the strong influence of Sea level rise, human interference, and neo-tectonic effects (Ghosh et. al., 2001). Bakshi et. al. (2001) estimated the rise of the local sea level at 2.36 mm

per year. Due to the neo-tectonic eastward tilt, the course of river Ganga has shifted eastward (Blasco, 1997). Since then, the freshwater inflow into the Hooghly estuary has drastically reduced and the Island is facing a hydrodynamic imbalance (Ghosh et. al., 2001).

Along with the natural hazards, the high population density of the Sagar block makes it more vulnerable. Over-exploitation of resources is a common phenomenon in the region (Hajra and Ghosh, 2017). The increasing demand for land due to population pressure is the prominent factor in the growing settlement area, non-mangrove plantations, ponds, etc. (Ghosh et. al., 2001). The annual population growth of Sagar Block is 2.1%, which is very high compared to the stable islands of Sundarban (Ghosh et. al., 2014; Hajra and Ghosh, 2016). Due to the submergence of Lohachara, Bedford, Suparibhanga and parts of Ghoramara Islands the displaced population has been shifted to Sagar Island, which has also played a major role in increasing the population pressure on Sagar Island (Ghosh et. al., 2007; Ghosh et. al., 2014;).

Several cases of reported vulnerability and agricultural loss have been reported in the region. Decreasing agricultural productivity is causing a significant amount of out-migration in the region. A study by Hajra and Ghosh (2017) has found that the relationship between a decrease in agricultural productivity and out-migration is positively correlated.

### 3.1.1 Location of Sagar Island

Located on the mouth of river Hugli, Sagar Island is the extreme southwestern island of the ISD. The longitudinal extension of the area is 21˚37'21" N to 21˚52'28" N and the latitudinal extension is 88˚2'17" E to 88˚10'25" E. The area falls under the Kakdwip subdivision of the South 24 Parganas District of West Bengal. The land area covered by Sagar Island is 251.58 sq. km. The maximum length of the north-south direction of the island is about 30 km and the maximum width along the east-west direction is around 12 km (Hajra and Ghosh, 2014).

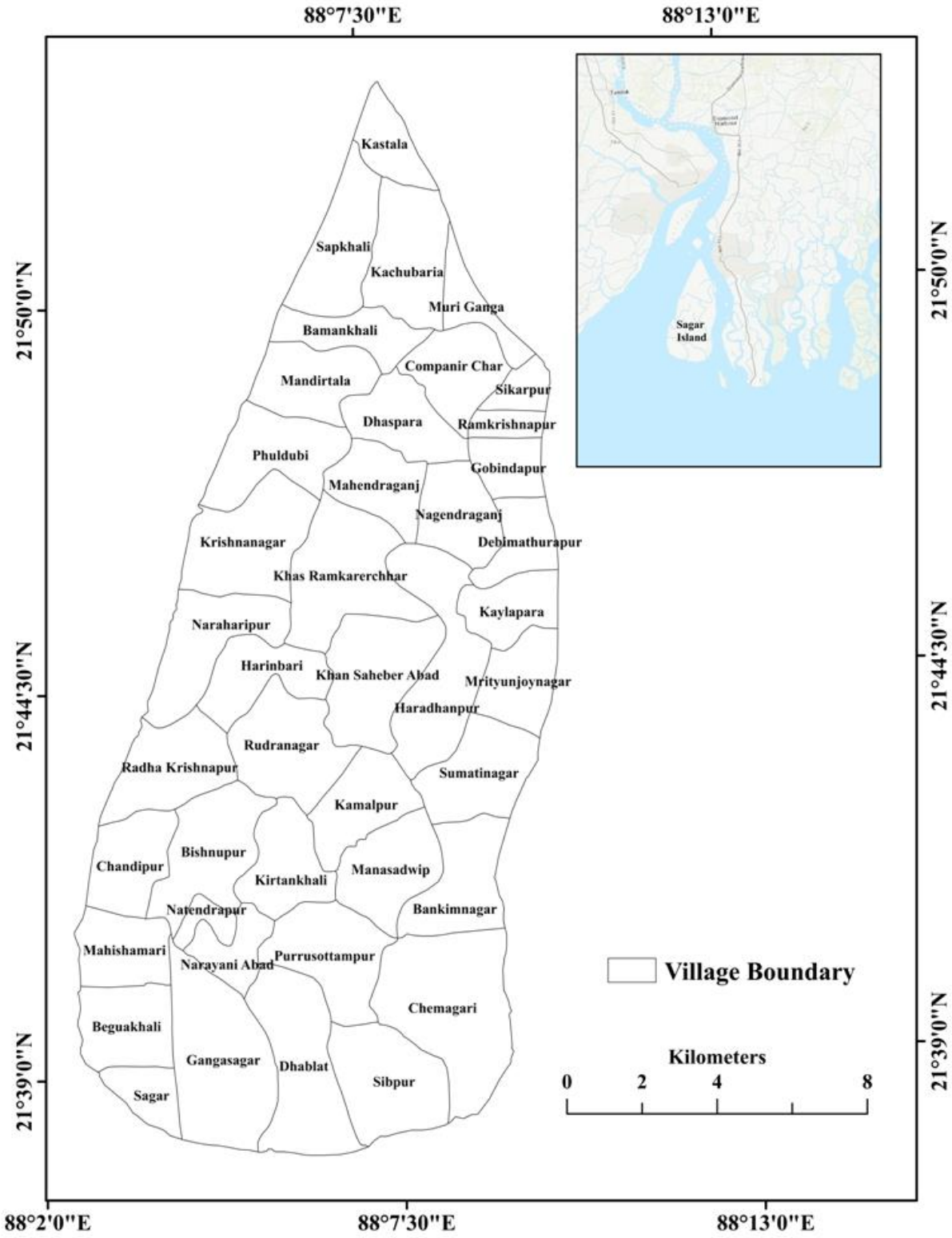


Figure 3.1: Location of Sagar Island

### 3.2 Objectives

The major objectives of the study are

1. To identify the environmental changes in Sagar Island.
2. To understand the impact of environmental changes on the livelihood of the inhabitants.
3. To understand the role of migration as a strategy to adapt to the livelihood issues.

### 3.3 Data Sources

Both the primary and secondary data have been used in the present study. It is mainly based on primary data. Secondary data has also played a notable role throughout the study.

#### 3.3.1 Secondary data sources

Main secondary data used in the study are sourced from the Census of India, Agricultural Census of India, Landsat 8 – 9 OLI/TIRS images, Handbook on fisheries statistics, Ministry of Fisheries, Animal Husbandry & Dairying, Govt. of India, Google Earth Images.

Table 3.1: Major secondary data sources

| Data source | Time |
|---|---|
| Census of India | 1951, 1961, 1971, 1981, 1991, 2001, 2011 |
| Landsat 8 – 9 OLI/TIRS images | 2013, 2018, 2023 |
| Handbook on fisheries statistics, Ministry of Fisheries, Animal Husbandry & Dairying, Govt. of India | 2020, 2022 |
| Agricultural Census of India | 2015-16 |
| Google Earth Images | Various images between 2013 to 2023 |

#### 3.3.2 Primary field survey

##### 3.3.2.1 Reference period

Through field investigation, primary data is collected. The reference period of the present study is from 7$^{th}$ November 2019 to 6$^{th}$ November 2024. The survey period of the study is November 2022 to June 2023.

### 3.3.2.2 Methods of survey

The primary field surveys were conducted on Sagar Island in two phases. At first, a pilot survey was conducted in November 2022. Then from 1st March to 13th June 2023, the major part of the survey was conducted. Primary data is majorly acquired through surveys with structured, semi-structured, and unstructured questionnaires are used.

Table 3.2: Snapshot of primary field survey

| Primary field survey | Total number |
|---|---|
| Key Informant Interviews | 56 |
| Focused Group Discussions (FGD) | 18 |
| Household Survey | 480 |

Key informant interviews and focus group discussions (FGD) were conducted with the help of structured, semi-structured, and unstructured questionnaires. Field observations also played an important role in collecting information.

Table 3.3: Selected mouzas for the household survey

| Geographical location | Mouza/census village |
|---|---|
| North-east | Kachuberia, Muriganga |
| North-west | Bamankhali, Mandirtala |
| Centre | Rudranagar, Harinbari |
| South-east | Sumatinagar, Bankimnagar |
| South-west | Mahishamari, Beguakhali |
| South | Sibpur, Dhablat |

A total number of 480 households was surveyed with the help of a structured questionnaire. A stratified sampling method is used to select the mouzas/census villages for household surveys. The island is divided into 5 strata namely north-east, northwest, centre, south-east, south-west and south based on its geographical location. From each stratum 2 mouzas were selected for household survey. Out of 42 inhabited mouzas, total 12 mouzas are selected (Table 3.3). 30 households are randomly selected for the household survey from each mouza. Any adult member of a household is considered to be a respondent among those who were available at the time of the survey. A person having the highest income in the household is considered as

household head (HH). Detailed information about the occupation/livelihood of the HH is collected during the survey.

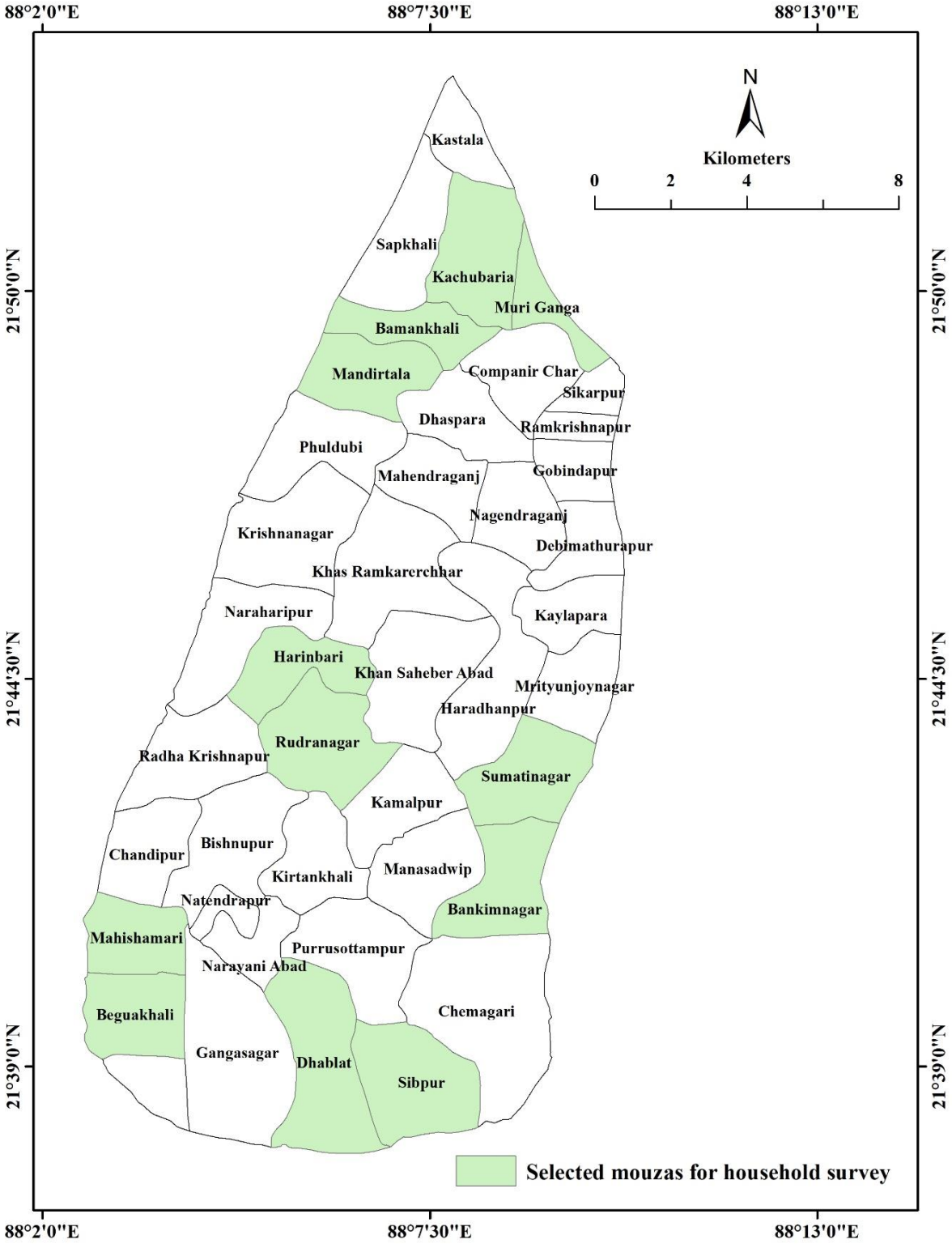


Figure 3.2: Selected mouzas for the household survey

### 3.3 Methods of Analysis

Mainly qualitative methods (Content analysis, Narrative analysis, and Thematic analysis) were adopted in the study. Along with that Quantitative techniques are also used. These are Cross tabulations, Different kinds of Descriptive statistics, cartographic methods, shoreline change analysis, erosion-accretion rate measurement, and mapping of various physical elements of the Island with the help of GPS and satellite images.

### 3.4 Operational Definitions

To represent various types of migration various operational definitions are adopted. These definitions are mentioned below.

On the date of the survey, any member of a household who left the household to stay outside the village boundary as per census for three weeks or more is viewed as an ‘out-migrant’ and the household is noted as a ‘migrant household.’ Information on the migrant members of a household is collected from the present adult member of the household.

Various types and patterns of migration are observed in the study area: Permanent and temporal, short-term and long-term migration, seasonal migration, cyclic migration, environmental migration, displacement, and return migration, etc. Three major patterns selected for the study are permanent, temporal, and return migration.

On the date of survey If any migrant member of a household has stayed out of the village boundary and the person is likely to stay there and has no plan to return to the place of source area are noted as ‘permanent migrant.’ If the migrant has a plan to return to the source area is defined as a ‘temporary migrant.’

On the flip side, if a former migrant member of the household is staying in the source area at the time of enumeration is viewed as a ‘return migrant.’

If there are cases of the whole household out-migration that household is out of the sampling process as there is no household member to address.

As many people on the island engage in various economic activities demarking a person's main occupation or livelihood is also necessary. Based on the contribution of economic activities a person's main occupation or livelihood is marked. For example, a person is identified as a cultivator if his/her maximum income comes from cultivation.

### 3.5 Conceptual Framework of the Study

Environmental changes are creating much stress on the life and livelihood assets of the inhabitants of Sundarban. The basic concept of the study is migration as a strategy to cope with environmental stressors both natural and anthropogenic.

The natural stressors in the Sundarban include climatic events (Cyclones, floods), climatic processes (sea level rise), and geomorphological processes (marine and riverine processes). On the other hand, anthropogenic stressors include demographic, socio-economic, and political changes like overpopulation, extortion of natural resources, etc. The stressors negatively impact the life and livelihood assets of the inhabitants. People use different sorts of measures or strategies such as migration, job diversification, job transformation, adoption of new technologies, sustainable use of resources, etc to adapt to these adverse conditions of livelihood. In Sundarban, migration is one of the most important strategies among them (Hajra and Ghosh, 2014; Hajra and Ghosh, 2017; Mistri and Das, 2020).

The present study concentrates on the interrelation between environmental challenges, livelihood, and out-migration from Sagar Island. Firstly, the study identifies the main environmental challenges present on the island. Then it focuses on the major livelihoods obtained by the inhabitants and how these livelihoods are impacted by the environmental challenges. The study also explores the strategies adopted by the inhabitants especially the out-migration process for livelihood and income generation.

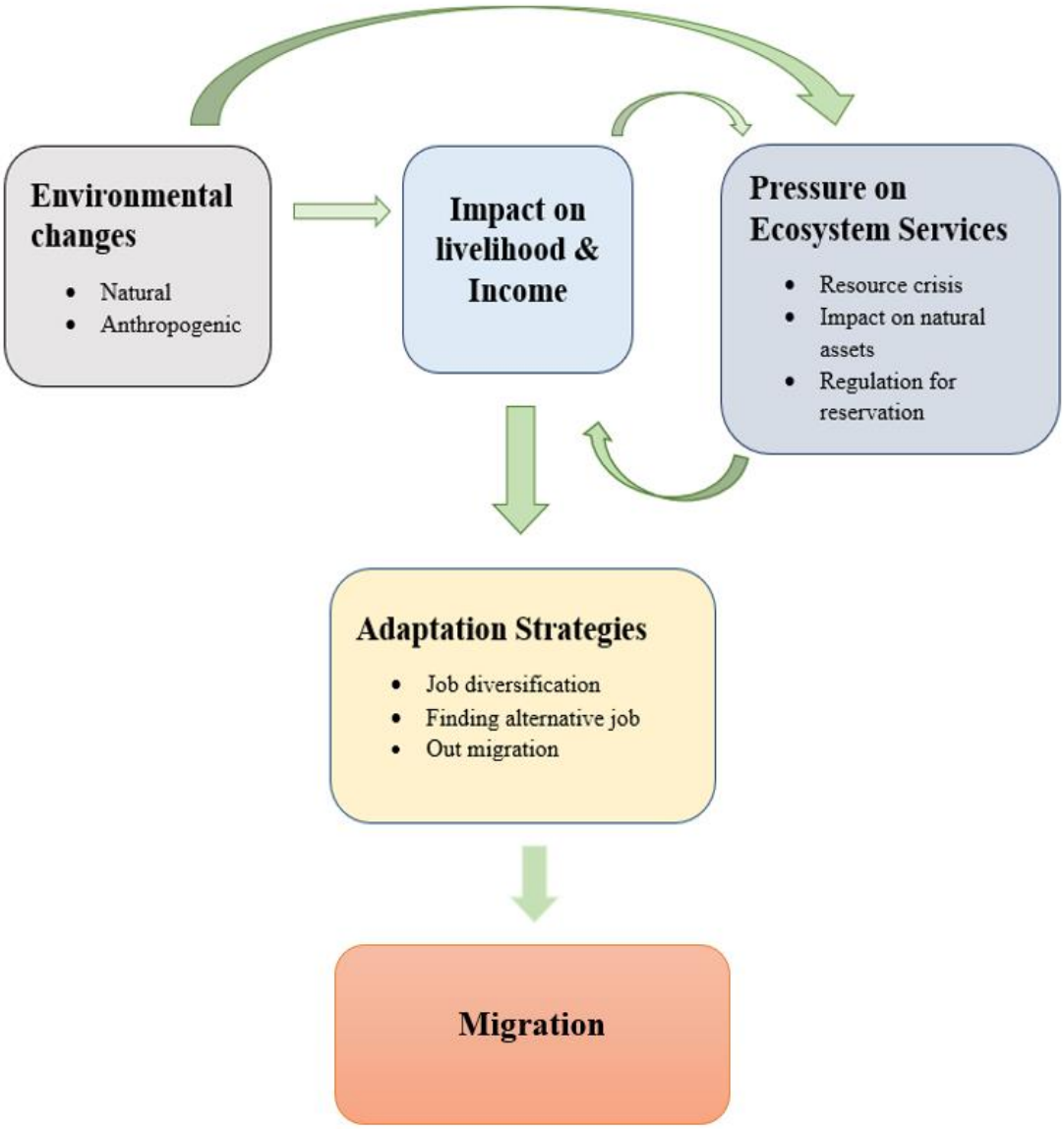


Figure 3.3: Conceptual framework of the study

The study tries to understand the push factors that are driving migration from the island. The study identifies the destination region of migrants, the pull factors of these regions, and the economic activities migrants are involved. The role of remittances will also be discussed in the present study. Further, the study will try to find out the future possibilities of migration.

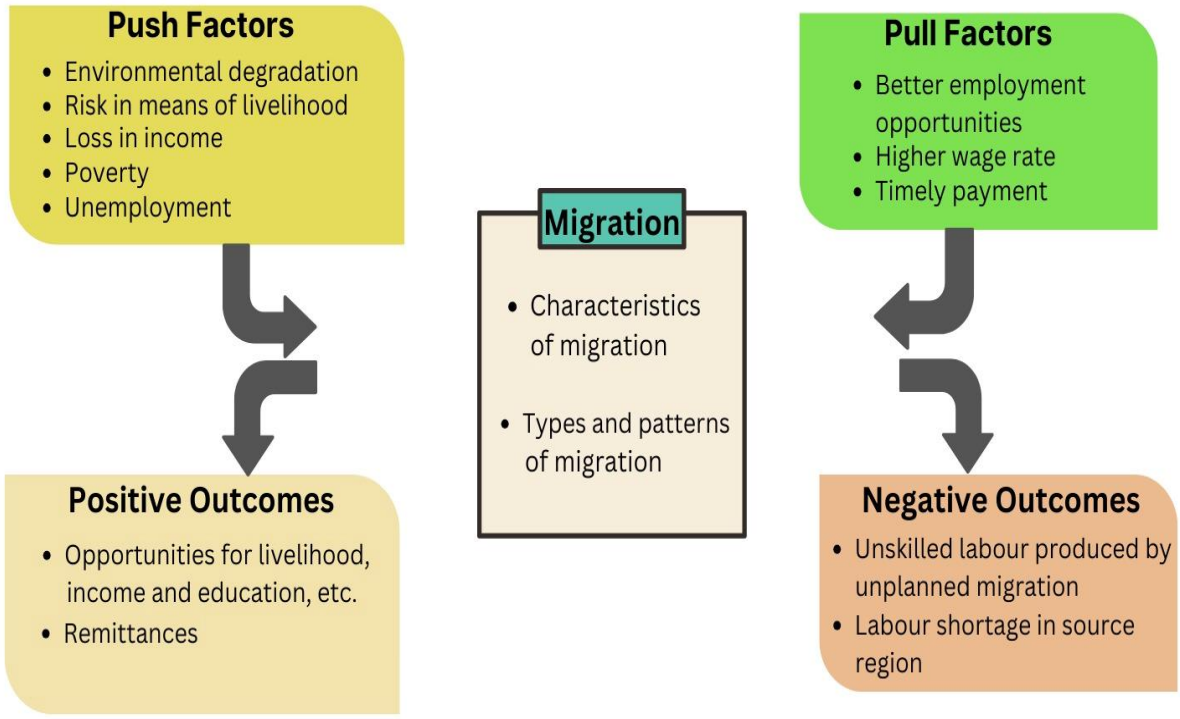


Figure 3.4: Conceptual framework of the migration process

Finally, it presents a general conclusion and offers comprehensive recommendations aimed at enhancing environmental conditions, improving the well-being of migrants, and boosting livelihood opportunities by identifying and leveraging the island's potential.

# CHAPTER 4: PROFILE OF SAGAR ISLAND

The unique ecosystem of Sagar Island is characterized by resource combination at the interface of land and sea offering beaches, scenic beauty, rich terrestrial and marine biodiversity, diversified cultural and historic heritage, etc. (Hajra and Ghosh, 2014). Gangasagar a village located in the southern part of the Island, is a significant site for pilgrims and travelers due to its religious and spiritual identity. Gangasagar holds mythological ties with the ashram of the saint Kapil Muni and tells of the legend of King Sagar. The Kapil Muni Temple at Gangasagar has been the place for rituals and prayers, further amplifying the island's captivation for the seekers of spirituality. These rich mythological stories appeal to pilgrims and travelers. Especially on Makar Sankranti, a great number of Hindus gather here and take holy dips at the confluence of the river Hugli and the Bay of Bengal.

### 4.1 Settlement History

Like other locations in the Sundarban, Sagar Island also underwent a comparable process of land reclamation and development of the embankment system. Multiple research investigations have found proof of human settlement ruins before the interference of the British government (Hunter, 1875; Mookherji, 1958). However, the area was unsettled and covered with forest in the year 1811 when the process of land reclamation on Sagar Island began (Pargiter, 1934). To stop floods, saline intrusion, and soil erosion, earthen embankments were built along the tidal channels and coastal areas on Sagar Island (Bandyopadhyay, 1997b). The settlement process started slowly but finally picked up substantial momentum in the second half of the nineteenth century. According to the latest census of 2011 total population of the island has reached 2,06,844 having a density of 830 persons per square kilometer.

### 4.2 Physical Geographic Profile

#### 4.2.1 Geology and soil

The island is a segment of the Bengal basin (Das et al., 2013). The Island system is precisely located on the transition between continental and oceanic crust at the elevated zone where the Stable shelf and the Central deep basin converge (Das et.al. 2013). The deposits from estuaries created the island. According to Bandyopadhyay (2003), the soil has been formed by two different processes. The River Hugli carried and deposited alluvium straight onto the Island. Tidal forces, indirectly deposited silt, and clay. Bandyopadhyay (2003) also classified the soil type into two groups based on the location and hydrodynamics (a) the soils on the eastern side of the island, which border the Muri Ganga River, are denser in composition due to high salinity

in the river and (b) The soils on the western side, which face the Gabtala river, are subject to greater freshwater flow, resulting in a lighter texture.

### 4.2.2 Land-use & land-cover

Most of the area of the island is used for agricultural purposes. Settlements are mainly built along the road networks. Although some dispersed settlements are also observed in several parts of the island. Along the coastal areas of Gangasagar and Sagar mouza, there are a few temporary colonies also present for fish drying activity. The island does not have much forest cover; few patches of jungles are observed along the coastlines.

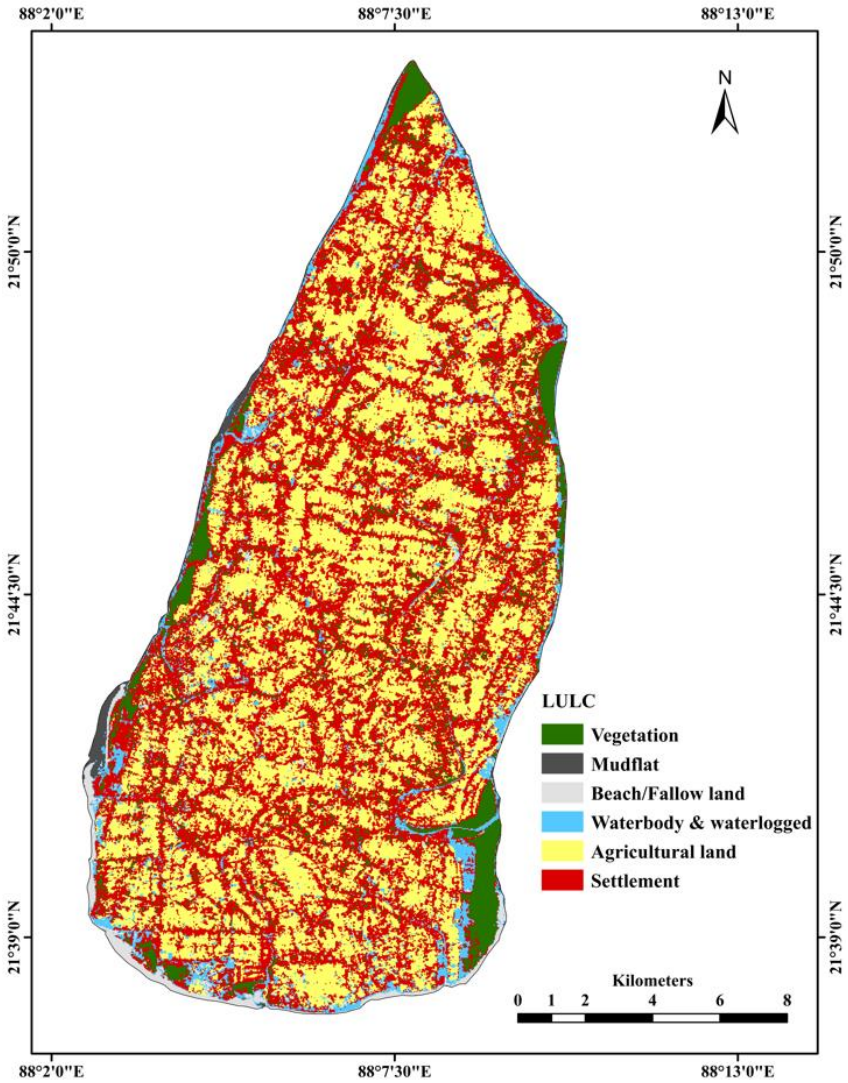


Figure 4.1: LULC map of Sagar Island, 2023

*Data source: ASTER GDEM spatial resolution of 30m X30m*

### 4.2.3 Elevation and slope

Topographically, Sagar Island features a low-lying, flat terrain with a gentle slope. To visually present the elevation and slope of the area elevation map (Figure 4.2: a) and slope map (Figure 4.2: b) were produced using ASTER GDEM data, which offers a 30-meter spatial resolution. The elevation map shows that the elevation in the western and northwestern parts ranges from 6 to 9 meters above sea level, while the eastern and southern parts vary from -6 to +6 meters. Most of the island's area is between 3-6 m high from the mean sea level. Situated within the largest macro tidal and flood-dominated estuary, the coastal portions of this island consist of low mudflats, sandy shores, and patches of mangrove covers. Some portions of land outside of marginal embankments regularly go underwater during high tide. A significant area of land even inside the marginal embankments frequently faces coastal flooding and becomes saline due to tidal surges and storm surges.

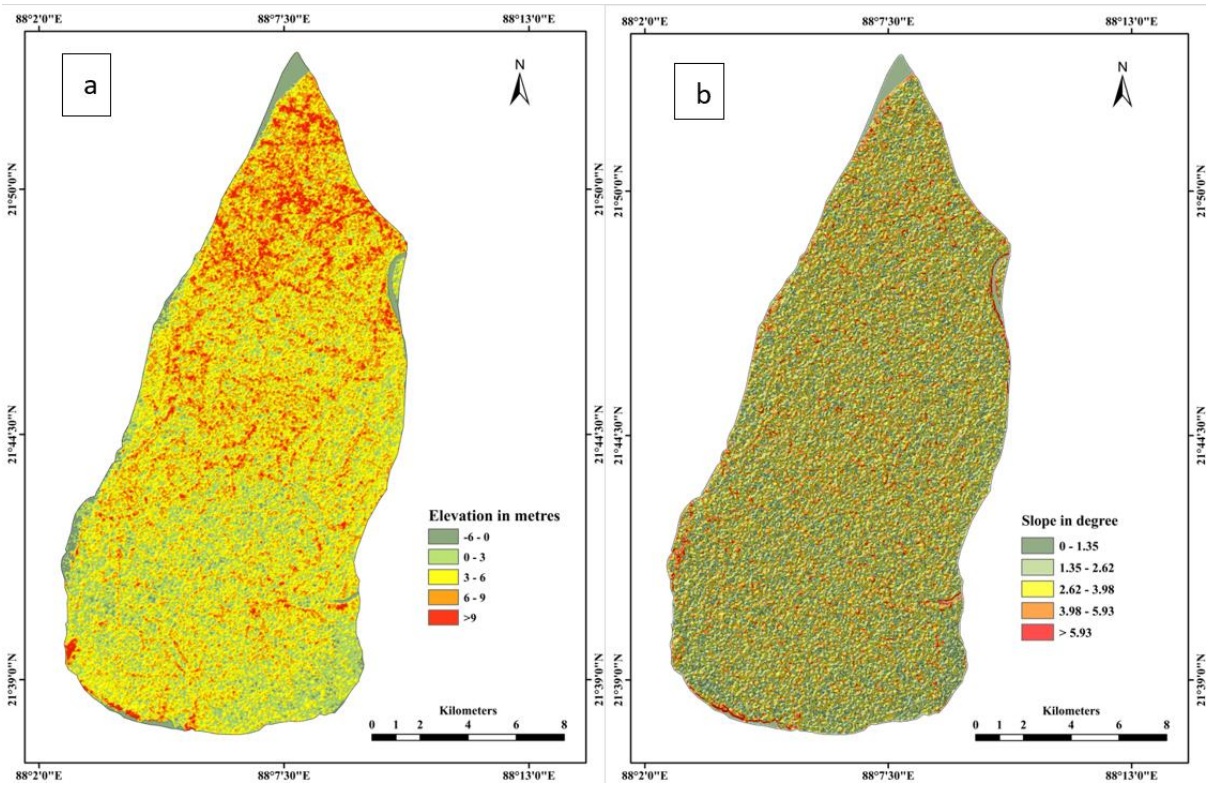


Figure 4.2: (a) Elevation map and (b) slope map of Sagar Island, 2023

*Data source: ASTER GDEM spatial resolution of 30m X30m*

The overall gradient descends from the elevated northwest to the comparatively lower southeast, accompanied by a subtle, wavy landscape of sand dunes and flats in the southern

region. On a micro-scale, the slope across the region was measured in degrees, showing a range from 0° to 6°, with most of the area having a slope of less than 1.35°.

### 4.2.4. Drainage

The island has an intricate network of creeks and canals. The water flows of these canals are mainly driven by tidal actions. The drainages are embanked by earthen structures to prevent saline water intrusion. Breaches and overtopping of embankments typically occur during strong storm surges, especially in the case of cyclonic surges. Several canals are often regulated to harvest rainwater for agriculture.

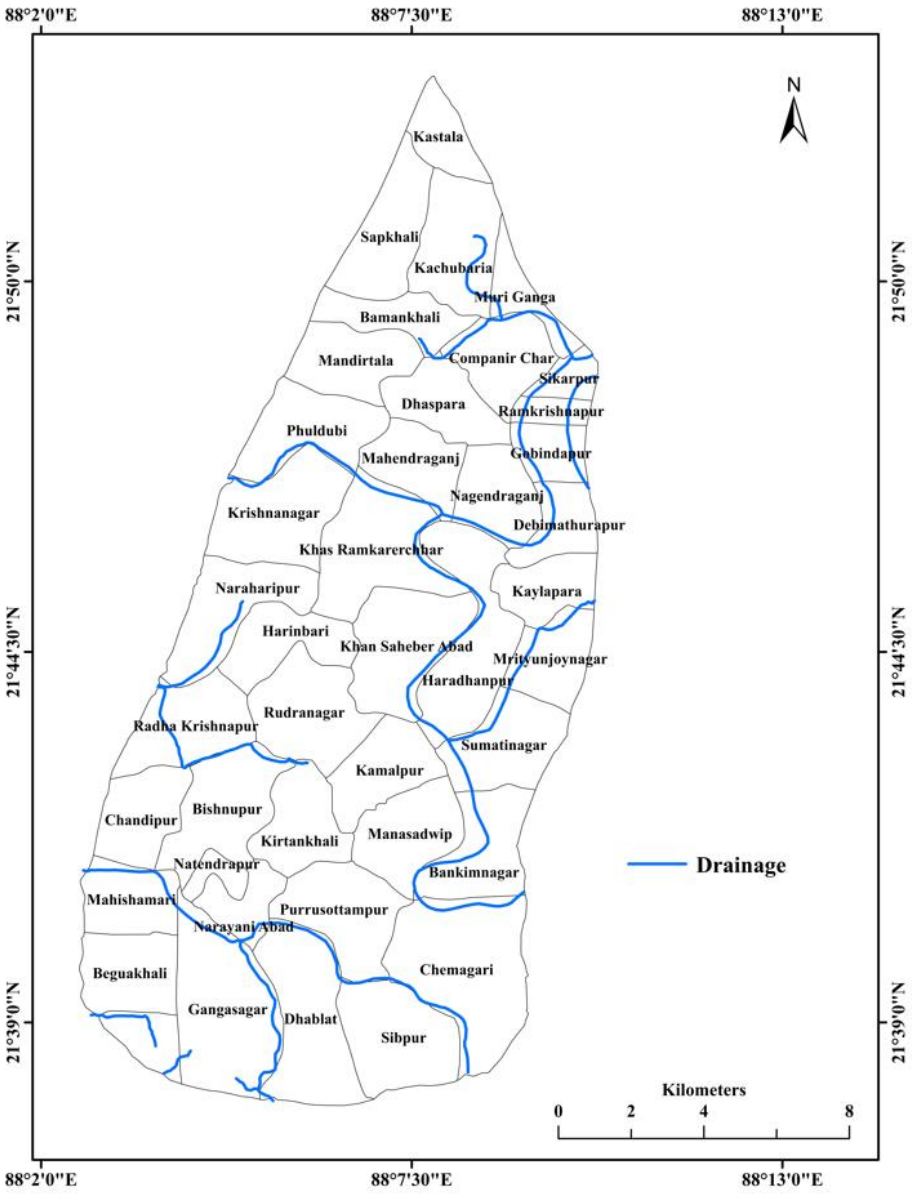


Figure 4.3: Major creeks and canals of Sagar Island, 2023

*Data source: ASTER GDEM spatial resolution of 30m X30m*

### 4.2.5 Climate

Sagar Island is positioned in one of India's six climate zones—the Tropical wet and dry climate zone—according to Koppen's categorization scheme. This climate is marked by extreme variations in rainfall and temperature over the year. A hot, dry summer precedes the monsoon season (Mid-June to September), which brings southwest monsoon rains. Following the monsoon's retreat, the weather becomes more pleasant, leading to a brief winter from December to February.

## 4.3 Infrastructure

Pivoting around the Kapil Muni Temple at Gangasagar the island has a good infrastructural facility to hold thousands of tourists which helped the Island to emerge as a significant tourist spot. Sagar Island also has a good no of educational and health-related institutes to serve its local people. According to the Census of India 2011, the total no of Govt Pre-Primary Schools, Govt Primary Schools, Govt Middle Schools, Govt Secondary Schools, Govt Senior Secondary Schools are 153, 153, 39, 30 and 20 in successive order. The total no of Govt Arts and Science Degree College and Govt Engineering College are sequentially 4 and 2. There are 2 medical colleges on the island. The no of Community Health Centres, Primary Health Centres, Primary Health sub-centres, and Hospitals are consecutively 2, 3, 5, 34 and 3. Among them, Sagar Gramin Hospital located at Rudranagar is the best medical institute located on the Island. As environmental threats like cyclones, coastal floods and erosion have posed a great challenge for the island, so discussing the infrastructural facilities like transportation facilities, cyclone shelters and the availability of embankment facilities related to tackling these hazards is also essential.

### 4.3.1 Connectivity

Sagar Island has no road, railway, or airway connection with the mainland. Waterways are the only transportation system currently available to connect to the mainland. The nearest Railway stations used by the inhabitants of this island are mainly Kakdwip, Namkhana and Kashinagar Halt.

There is no national or state highway on the island but there is a 32 km long major district road extended from the north to the extreme south of the island. This road Starts from Kachuberia Ferry Ghat and ends near Gangasagar Bus-stand. The island has an intricate network of

concrete, brick and earthen roads which makes the inland connectivity better than the other parts of the Sundarban.

The main Ferry ghat of the island is the Kachuberia Vessel ghat which mainly connects with Lot- 8, Kakdwip. The transportation capacity and frequency at Kachuberia in comparison to other ferry connectivity available on this island. Kachuberia is also connected to Haldia. Benuban situated at the extreme northeast of Chemaguri village and Mayagoalini situated at the northern coast of Radhakrisnapur village are also important ferry ghat of Sagar Island. Except for these Kakdwip via Gangasagar to Talpati and Kakdwip via Gangasagar to Katakhali ferry services are also there to connect the island with the mainlands.

Table 4.1: Major waterway connectivity of Sagar Island

| Ferry ghats of Sagar Island | Connected ferry ghats |
|---|---|
| Kachuberia | Lot-8, Kakdwip |
| | Haldia |
| Benuban | Namkhana |
| | Bagdanga |
| Mayagoyalini | Rasulpur |
| Sumatinagar via Mityunjaynagar | Narayanpur |

*Data source: Field survey*

### 4.3.2 Embankments

The presence of earthen and concrete layered embankments in Sagar Islands has been marked by recent field observations between 2022 to 2023. Only the embankments along the coastlines are mapped (Figure 4.4) as this plays the most important role in hazard management in the case of Sagar Island. But it should be mentioned that inside the coastline there are many layers of internal embankment in the form of earthen roads, concrete roads etc. In the map, we can see that there are different types of embankments currently present on Sagar Island almost covering the entire circumference of the Island. The embankments of Sagar Island are broadly divided into two categories: (i). Earthen (earthen and old brick-paved) and (ii) concrete (Aila Bandhs and new concrete layered). Embankments constructed after the disaster of Cyclone Aila (2009) are considered new in this study. The concrete layered embankments are an upgraded version of brick-paved embankments (locally called block pitching embankments) having a top layer of concrete above the blocks of bricks. The older brick-paved embankments cover very less

stretches now. The older brick-paved embankments of the eastern coasts were breached or eroded completely and on the retreated shoreline, either new concrete embankments or earthen embankments were built. On the western coast, the older brick-paved embankments are barely recognizable in most places due to reconstruction and repair by mud in the broken and older places. In some places, these small stretches are covered with soil and plant layers. So, in the map (Figure 4.4) both the earthen and old brick-paved embankments are classified as earthen embankments on the western coast. The total length of embankments at the periphery of the island is 85.47 km. Among which 69.07 km is Earthen and 16.40 km is Concrete.

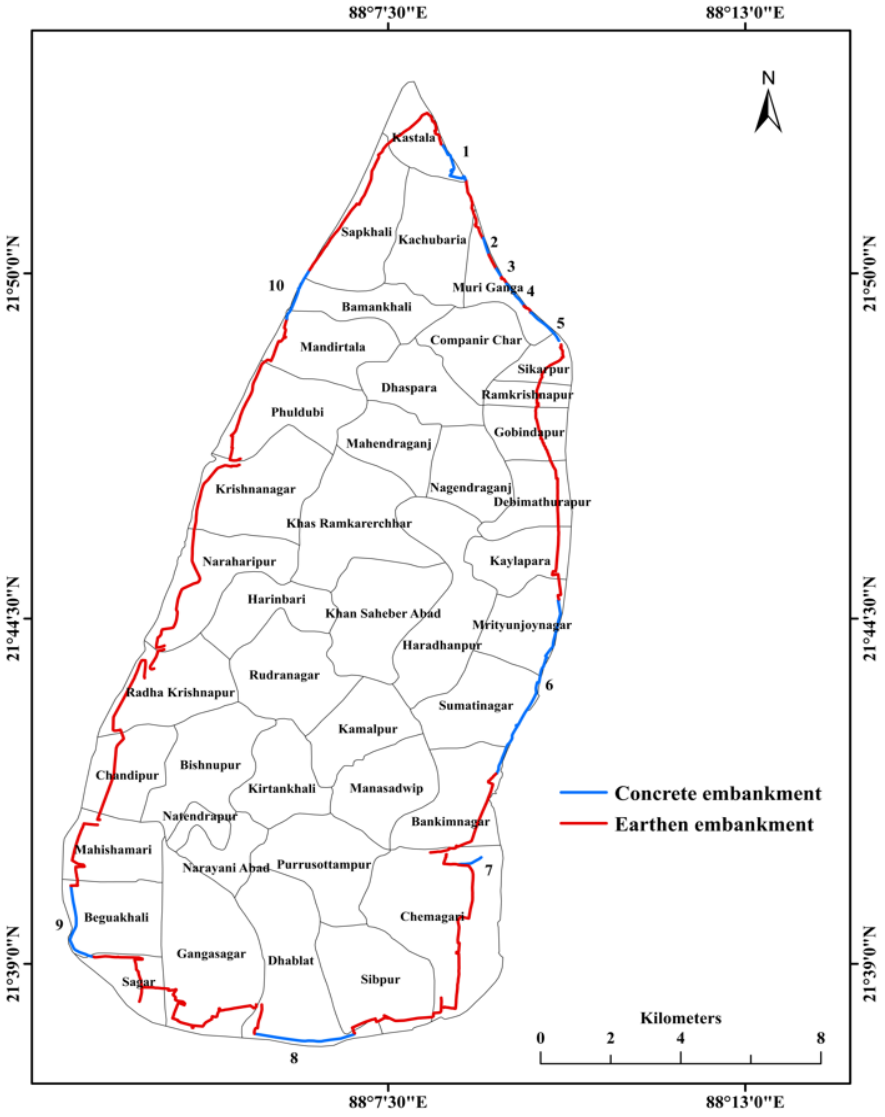


Figure 4.4: Types of embankments of Sagar Island, May 2023. *Sl. No. given in the map is described in Table 4.2.*

*Data source: Field survey and Google Earth images*

There are many individual stripes of Earthen and Concrete embankments. Earthen embankments vary in terms of their height, slope, width, and construction materials. The specifications of most of the earthen embankments of the island are 2.5 to 3.5 meters for the crest width and 2 to 3 meters above present ground level. In the case of Sibpur the sea-facing earthen embankment is larger in height and bigger in width having a higher slope value in comparison to the other earthen embankments of the island. In terms of construction materials bamboo or wooden structures are being used in front of the earthen dykes. In many cases, these dykes are also covered by layers of brick, textile sheets or other materials.


Plate 4.1: (a) Earthen embankment of Sibpur mouza with wood log piling and covered with textile sheets and (b) concrete embankment (Aila Badh) of Beguakhali mouza

There are a total of 10 stripes of concrete embankments spread over the Island's periphery. Out of these 10, one stripe located at the south of the eastern coastline of Kastala village is mainly a concrete road having block pitching embankments along its eastern side. Another stipe located near Benuban ferry ghat at the northern boundary of Chemaguri village is also a concrete road serving as an embankment. The rest of the stripes of concrete embankments have almost similar characteristics. The concrete embankments (Aila Bandhs) of Dhablat and Beguakhali are bigger in width with a gentle slope having steps and stronger than the other concrete embankments of the Island. Moving northward the concrete embankments become less wide.

Table 4.2. Details of concrete embankments

| Sl. No. given in Figure 4.4 | Concrete Embankment Stripe | Length (meter) | Year of completion | Properties |
|---|---|---|---|---|
| 1 | South-eastern coastline of Kastala | 1676 | 2018 | Mainly a road |
| 2 | Muriganga northern coastline | 322 | 2021 | Concrete layered |
| 3 | Muriganga Upper middle coastline | 271 | 2020 | Concrete layered |
| 4 | Muriganga Lower Middle Coastline | 811 | 2019 | Concrete layered |
| 5 | Muriganga Southern coastline | 1118 | 2019 | Concrete layered |
| 6 | Mrityunjaynagar-Sumatinagar Coastline | 6847 | 2022 | Concrete layered |
| 7 | Benuban Ferry Ghat Road | 679 | - | Mainly a road |
| 8 | Dhablat Coastline | 2728 | 2018 | Aila Bandh |
| 9 | Beguakhali Coastline | 2512 | 2018 | Aila Bandh |
| 10 | Bamankhali Coastline | 1585 | 2020 | Concrete layered |

*Data Source: Field survey and Google Earth images*

### 4.3.3 Cyclone shelters

Multi-Purpose Cyclone Shelters (MPCS) were constructed as part of the Integrated Coastal Zone Management Project and the Prime Minister National Relief Fund. A total of 10 MPCS (shown in Table 4.3) were identified within Sagar Island during the field survey (2022-2023). The details are listed in the table.

It should be mentioned, nevertheless, that the capacity of these shelters is inadequate concerning the large population size of the island and the shelters also lack the adequate water supply and sanitary amenities.

Government institutes (like schools, health centers, ICDS, Anganwadi centers, etc.), private institutes, Hotels and lodges are used as cyclone shelters at times of emergency. The collected

field data reveals that people residing in vulnerable houses far from the above-mentioned facilities take shelter in comparatively better houses of neighbors or relatives.

Table 4.3: List of MPCS in Sagar Island visited during field survey

| Multi-Purpose Cyclone Shelters | Village | Latitude | Longitude |
|---|---|---|---|
| Dakshin Sagar Bani Teertha High School | Beguakhali | 21.6701 | 88.0580 |
| Gobindapur Tarachand High School | Gobindapur | 21.7888 | 88.1562 |
| Harinbari Yudhisthir Sikshayatan | Harinbari | 21.7500 | 88.0929 |
| Muriganga FP School | Muriganga | 21.8262 | 88.1551 |
| Fulbari Sitala high School | Sapkhali | 21.8622 | 88.1288 |
| Prasadpur Atal Vidyabhavan | Sibpur | 21.6456 | 88.1063 |
| Krishnanagar Soudamini Balika Vidyalaya | Krishnanagar | 21.7884 | 88.1032 |
| Radhakrishnapur High School | Radhakrishnapur | 21.7222 | 88.0702 |
| Sikarpur FP School | Sikarpur | 21.8125 | 88.1637 |
| Sundarban Janakalyan Sangha Vidyaniketan | Rudranagar | 21.7201 | 88.1055 |

## 4.4 General Demographic Profile

In this part, a very basic idea of the demographic outline of the island is provided using data from the census of India.

### 4.4.1 Population

Table 4.4: Population change in Sagar Island

| Census year | Total population of Sagar Island |
|---|---|
| 1951 | 48388 |
| 1961 | 69587 |
| 1971 | 86569 |
| 1981 | 110672 |
| 1991 | 149222 |
| 2001 | 180408 |
| 2011 | 206844 |

*Data source: Census of India*

Sagar Island is the largest and most populated island in ISD. Sagar Island is a completely rural area having 42 mouzas among them one mouza called Sagar does not have any human inhabitation (Census of India, 2011). There is no town, city, or urban center on Sagar Island.

As per the census of India 2011, the total population of the area was 2,06,844. There were 42,621 households in the area in 2011. The population density of the island is 830 people per square kilometre.

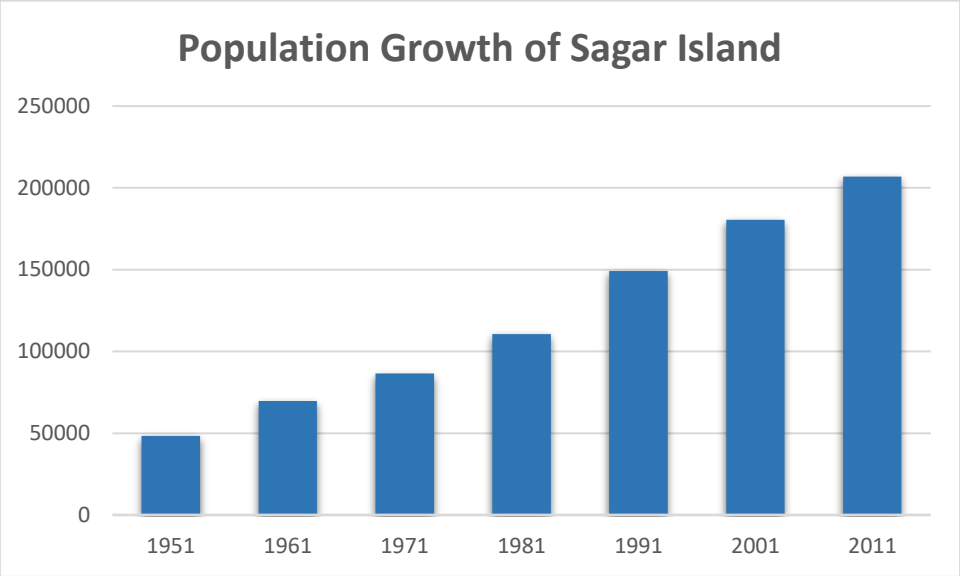


Figure 4.5: Population Growth of Sagar Island.

*Data source: Census of India*

The population of Sagar Island has shown a consistent upward trend from 1951 to 2011 (Figure 4.5). In 1951, the population was 48,388, and by 1961 it had increased by about 44% to 69,587. The growth continued, with the population reaching 86,569 in 1971 (a 24% increase), 110,672 in 1981 (a 28% increase), and 149,222 in 1991 (a 35% increase). From 1991 to 2001, the population grew by approximately 21% to 180,408, and by 2011 it had risen by around 15% to 206,844. This steady growth is attributed to factors such as natural population growth and in-migration from nearby areas. The island has become a refuge for many climate migrants from neighbouring islands (Lohachara, Bedford, and Ghoramara) that have submerged, become uninhabitable, or dealing with serious environmental challenges due to rising sea levels and frequent storms. Additionally, there has been a history of migration from Medinipur to this island, a trend that continues, although in very small numbers. The rising population with limited natural resources on the island has become a concern for the economic and environmental sustainability of the area.

Table 4.5 provides an overview of the village-wise (Census village/Mouza) density of population in Sagar Island. Bankimnagar village has the highest population density of 1263 per sq. km. on the island. The population density of Ramkrishnapur village is 263 per sq. which is the lowest population density village among all.

Table 4.5: Village-wise population density of Sagar Island

| Village | Population density (person/sq. km) | Village | Population density (person/sq. km) |
|---|---|---|---|
| Bankimnagar | 1263 | Beguakhali | 876 |
| Narayani Abad | 1181 | Khan Saheber Abad | 865 |
| Kamalpur | 1154 | Bishnupur | 854 |
| Dhaspara | 1116 | Gangasagar | 844 |
| Sibpur | 1048 | Debimathurapur | 832 |
| Kachubaria | 1045 | Sapkhali | 782 |
| Sagar | 1008 | Sumatinagar | 776 |
| Mahendraganj | 1008 | Chemagari | 771 |
| Harinbari | 991 | Gobindapur | 750 |
| Kaylapara | 976 | Radha Krishnapur | 692 |
| Sikarpur | 955 | Kirtankhali | 686 |
| Nagendraganj | 938 | Mahishamari | 651 |
| Rudranagar | 935 | Mrityunjoynagar | 637 |
| Krishnanagar | 933 | Dhablat | 593 |
| Purrusottampur | 928 | Muri Ganga | 547 |
| Chandipur | 927 | Kastala | 545 |
| Natendrapur | 923 | Manasadwip | 538 |
| Khas Ramkarerchhar | 914 | Naraharipur | 534 |
| Phuldubi | 913 | Ramkrishnapur | 263 |
| Haradhanpur | 912 | Sagar | 0 |
| Mandirtala | 900 | **Sagar Island** | **830** |
| Bamankhali | 895 | | |

*Data source: Census of India, 2011*

### 4.4.2 Sex ratio

The sex ratio of the Island is 936 which is lower than the state (West Bengal) average of 950 and even lower than the national average of 943. Table no 4.6 represents the village-wise (Census village/Mouza) sex ratio of Sagar Island. It stated that Sikarpur village (984) has the highest sex ratio and Gobindapur village (872) has the lowest sex ratio in Sagar Island.

Table 4.6: Village-wise sex ratio of Sagar Island

| Village | Sex ratio | Village | Sex ratio |
|---|---|---|---|
| Gobindapur | 872 | Khas Ramkarerchhar | 935 |
| Debimathurapur | 877 | Manasadwip | 936 |
| Natendrapur | 886 | Narayani Abad | 939 |
| Ramkrishnapur | 896 | Kirtankhali | 939 |
| Sumatinagar | 906 | Dhablat | 939 |
| Naraharipur | 909 | Kamalpur | 943 |
| Purrusottampur | 911 | Mandirtala | 945 |
| Kastala | 912 | Rudranagar | 945 |
| Bankimnagar | 913 | Sibpur | 947 |
| Mrityunjoynagar | 913 | Kachubaria | 948 |
| Harinbari | 916 | Khan Saheber Abad | 951 |
| Bishnupur | 918 | Beguakhali | 952 |
| Radha Krishnapur | 918 | Chemagari | 954 |
| Sapkhali | 919 | Kaylapara | 961 |
| Mahishamari | 923 | Companir Char | 963 |
| Mahendraganj | 924 | Muri Ganga | 965 |
| Bamankhali | 925 | Dhaspara | 967 |
| Krishnanagar | 930 | Chandipur | 973 |
| Phuldubi | 930 | Gangasagar | 978 |
| Haradhanpur | 931 | Sikarpur | 984 |
| Nagendraganj | 934 | **Sagar Island** | **936** |

*Data source: Census of India, 2011*

### 4.4.3 Education

Table 4.7: Village-wise literacy rate of Sagar Island

| Village | Literacy (%) | Village | Literacy (%) |
|---|---|---|---|
| Ramkrishnapur | 66.77 | Chemagari | 84.70 |
| Sikarpur | 72.38 | Manasadwip | 84.87 |
| Nagendraganj | 76.17 | Radha Krishnapur | 84.89 |
| Muri Ganga | 78.01 | Sumatinagar | 84.95 |
| Sapkhali | 79.09 | Dhaspara | 85.02 |
| Beguakhali | 79.79 | Dhablat | 85.36 |
| Kastala | 79.86 | Khas Ramkarerchhar | 85.84 |
| Kachubaria | 80.27 | Bishnupur | 86.27 |
| Gobindapur | 80.60 | Narayani Abad | 86.64 |
| Companir Char | 80.85 | Purrusottampur | 86.75 |
| Debimathurapur | 81.49 | Rudranagar | 87.32 |
| Phuldubi | 81.54 | Harinbari | 87.55 |
| Sibpur | 81.79 | Mrityunjoynagar | 87.72 |
| Mahishamari | 82.84 | Naraharipur | 87.72 |
| Bankimnagar | 83.20 | Krishnanagar | 87.79 |
| Haradhanpur | 83.27 | Khan Saheber Abad | 88.19 |
| Gangasagar | 83.56 | Mahendraganj | 88.36 |
| Chandipur | 83.63 | Natendrapur | 88.52 |
| Kamalpur | 83.64 | Kirtankhali | 88.78 |
| Kaylapara | 83.90 | Bamankhali | 93.90 |
| Mandirtala | 84.58 | **Sagar Island** | **84.26** |

*Data source: Census of India, 2011*

The literacy rate of Sagar Block is 84.2% which is higher than the state average (76.26%) and the national average (74.04%). The gap between male and female literacy is quite high in Sagar Island. Table 4.7 presents the literacy rate of all the villages of Sagar Island. All the villages of Sagar Island have a better scenario of literacy rate compared to the state and district average except Sikarpur (72.38%) and Ramkrishnapur (66.77%). Bamankhali (93.90%) has the highest literacy rate in Sagar Island consequently followed by Kirtankhali (88,78%), Natendrapur

(88.52%), Mahendraganj (88.36%), Khan Saheber Abad (88.79%), Krishnanagar (87.79%) and so on.

### 4.4.4 Religious composition

For the religious composition data, Sagar blocks data has been used as a proxy for Sagar Island. Sagar Block has one more additional island village named Ghoramara in addition to the 42 villages of Sagar Island. The block of Sagar holds a diverse presence of religious communities. Having an 87.88 % share of the total population the dominant religious group of the region is Hindu. The second highest population share (11.73%) belongs to the Muslim community. The population share of Christians, Sikhs, Buddhists, Jains, and others is very small.

Table 4.8: Religious composition of Sagar Block

| Religion | Total population | Percentage | Male | Female | Sex ratio |
|---|---|---|---|---|---|
| Hindu | 186346 | 87.884 | 96431 | 89915 | 932 |
| Muslim | 24879 | 11.733 | 12600 | 12279 | 975 |
| Christian | 117 | 0.055 | 64 | 53 | 828 |
| Sikh | 30 | 0.014 | 20 | 10 | 500 |
| Buddhist | 19 | 0.009 | 12 | 7 | 583 |
| Jain | 16 | 0.008 | 7 | 9 | 1286 |
| Others | 3 | 0.001 | 2 | 1 | 500 |
| Not specified | 627 | 0.296 | 332 | 295 | 889 |

*Data source: Census of India, 2011.*

### 4.4.5 Social groups

Schedule Caste (SCs) population has a share of 26.60% which is slightly higher than West Bengal's SC population share (23.51%) and the Schedule Tribe (STs) population has a share of 0.41% of the total population on the island which is much less in comparison to state's ST population share (5.80%). The rest of the 72.99% are other castes (OBC and General). Table 4.9 shows the population share of marginal social groups like Scheduled Caste and Scheduled Tribe populations on Sagar Island.

To find out whether there is any residential segregation in terms of caste hierarchy, SC and ST populations have been combined as marginalised populations. The percentage of the marginalised population to the total population has been calculated for each village to show the

concentration. Then to visually present (Figure 4.6) the residential pattern of the marginalised population, a choropleth map has been created using ArcGIS 10.8 software.

Table 4.9: Village-wise percentage of social groups of Sagar Island.

| JL No. | Village | SC (%) | ST (%) | JL No. | Village | SC (%) | ST (%) |
|---|---|---|---|---|---|---|---|
| 36 | Beguakhali | 81.26 | 0.14 | 39 | Natendrapur | 21.54 | 0 |
| 17 | Gobindapur | 72.77 | 0.05 | 31 | Harinbari | 20.55 | 0 |
| 10 | Companir Char | 68.55 | 0 | 27 | Khan Saheber Abad | 20.24 | 1.61 |
| 35 | Mahishamari | 64.22 | 0 | 12 | Bamankhali | 20.16 | 0 |
| 11 | Dhaspara | 58.91 | 0.02 | 4 | Kastala | 20.16 | 0 |
| 8 | Sikarpur | 58.05 | 0.15 | 44 | Dhablat | 19.4 | 0.01 |
| 43 | Sibpur | 42.04 | 0.03 | 13 | Mandirtala | 18.55 | 0 |
| 7 | Muri Ganga | 41.61 | 0 | 29 | Krishnanagar | 18.51 | 0.02 |
| 18 | Debimathurapur | 40.62 | 0.04 | 32 | Radha Krishnapur | 17.55 | 1.65 |
| 6 | Kachubaria | 37.17 | 0.01 | 42 | Chemagari | 16.62 | 0.7 |
| 15 | Mahendraganj | 32.59 | 0.11 | 40 | Narayani Abad | 16.49 | 0 |
| 21 | Mrityunjoynagar | 30.16 | 0.22 | 23 | Bankimnagar | 15.7 | 0 |
| 38 | Gangasagar | 30 | 2.12 | 28 | Khas Ramkarerchhar | 14.35 | 2.79 |
| 5 | Sapkhali | 27.52 | 0.01 | 46 | Kirtankhali | 13.36 | 0 |
| 16 | Nagendraganj | 27.06 | 0 | 41 | Purrusottampur | 9.82 | 0.21 |
| 14 | Phuldubi | 26.47 | 0 | 25 | Kamalpur | 7.13 | 0.02 |
| 33 | Chandipur | 24.5 | 0.04 | 26 | Rudranagar | 6.62 | 0.15 |
| 20 | Haradhanpur | 24.45 | 0 | 34 | Bishnupur | 5.75 | 0.02 |
| 22 | Sumatinagar | 22.56 | 0 | 24 | Manasadwip | 4.87 | 2.16 |
| 19 | Kaylapara | 22.45 | 0 | 9 | Ramkrishnapur | 1.09 | 0 |
| 30 | Naraharipur | 21.78 | 0 |  | Sagar Island | 26.6 | 0.41 |

*Data source: Census of India, 2011*

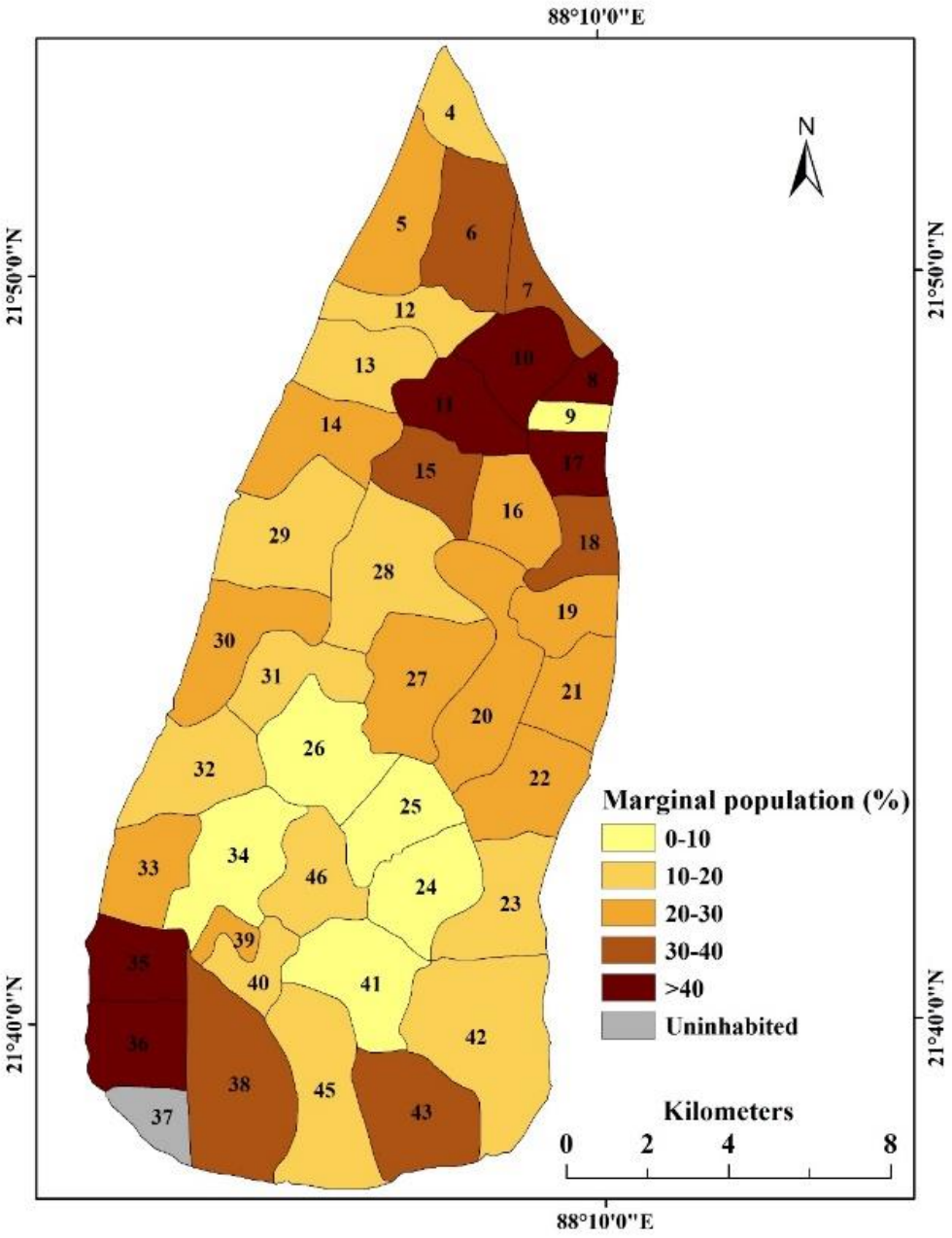


Figure 4.6: Concentration of marginalised population in Sagar Island. *The numbers given on the mouzas are JL No. See Table 4.9 for the identification of the mouzas. (Created by using Census of India, 2011 data in ArcGIS platform.)*

It can be observed that the concentration of marginalised populations is higher in the northeastern and southwestern parts of the island. The central eastern part of the island has a moderate share of the marginalised population. The south-central part of the island has a very small share of the marginal population. Within the western coastal region, the northern and central coastal belt has a relatively low concentration of marginalised populations.

### 4.4.6 Economic activities, workforce, and livelihood

Agriculture, fishing, tourism, transportation, crab collection, and prawn seed collection, are the common economic activities of the inhabitants. Forest product collection also provided livelihood on the Island (Saha and Ghosh, 2015). The Ganganagar Mela offers seasonal jobs for a sizeable population on the island (Saha and Ghosh, 2015). According to Basak (2004), the Gangasagar Mela creates an estimated 67,500 man-days in informal jobs.

Table 4.10: Village-wise percentage of workforce within total population

| Village | Workforce (%) | Village | Workforce (%) |
|---|---|---|---|
| Mahendraganj | 26.17 | Muri Ganga | 40.33 |
| Kastala | 31.84 | Beguakhali | 41.53 |
| Harinbari | 32.81 | Chandipur | 41.54 |
| Sibpur | 34.01 | Kachubaria | 41.89 |
| Mandirtala | 34.52 | Debimathurapur | 42.12 |
| Bamankhali | 34.81 | Naraharipur | 42.40 |
| Chemagari | 35.19 | Radha Krishnapur | 43.23 |
| Phuldubi | 35.58 | Dhablat | 43.30 |
| Narayani Abad | 35.64 | Kaylapara | 43.68 |
| Ramkrishnapur | 35.79 | Mrityunjoynagar | 44.23 |
| Companion Char | 36.20 | Haradhanpur | 44.47 |
| Rudranagar | 36.29 | Sapkhali | 44.66 |
| Gangasagar | 36.32 | Gobindapur | 44.82 |
| Sumatinagar | 36.58 | Khas Ramkarerchhar | 45.45 |
| Bankimnagar | 36.83 | Manasadwip | 45.73 |
| Sikarpur | 37.69 | Krishnanagar | 46.32 |
| Mahishamari | 38.58 | Khan Saheber Abad | 46.46 |
| Dhaspara | 38.73 | Kirtankhali | 47.32 |
| Purrusottampur | 39.29 | Bishnupur | 47.77 |
| Nagendraganj | 39.42 | Natendrapur | 51.31 |
| Kamalpur | 39.70 | **Sagar Island** | **40.05** |

*Data source: Census of India, 2011*

The Gangasagar Mela (GSM) provides a seasonal economic benefit for a limited time to the Island but results in environmental degradation year after year by the aggregating increase of inorganic and organic wastes that eventually results in poor quality of water, land, and air (Saha and Ghosh, 2015). An estimated 67,500 man-days of jobs are created in the informal sector during the occasion of GSM.

Table 4.11: Village-wise agriculture-dependent workers within the total workforce

| Village | Agriculture dependent workers (%) | Village | Agriculture dependent workers (%) |
|---|---|---|---|
| Ramkrishnapur | 87.79 | Mrityunjoynagar | 69.28 |
| Gobindapur | 84.79 | Bankimnagar | 68.20 |
| Sapkhali | 83.72 | Naraharipur | 67.79 |
| Sumatinagar | 83.71 | Dhablat | 66.37 |
| Haradhanpur | 83.68 | Manasadwip | 65.47 |
| Kaylapara | 81.47 | Sibpur | 65.45 |
| Natendrapur | 81.32 | Kachubaria | 64.87 |
| Khas Ramkarerchhar | 81.04 | Harinbari | 64.58 |
| Debimathurapur | 80.58 | Sikarpur | 63.94 |
| Dhaspara | 79.91 | Khan Saheberabad | 63.41 |
| Bamankhali | 79.24 | Bishnupur | 61.89 |
| Chemagari | 78.96 | Krishnanagar | 59.03 |
| Phuldubi | 77.64 | Purrusottampur | 58.24 |
| Mandirtala | 77.57 | Muri Ganga | 55.78 |
| Companir Char | 76.64 | Rudranagar | 54.64 |
| Mahishamari | 76.50 | Radha Krishnapur | 54.30 |
| Mahendraganj | 74.94 | Kamalpur | 51.66 |
| Kirtankhali | 72.85 | Chandipur | 51.02 |
| Beguakhali | 72.08 | Kastala | 46.33 |
| Narayani Abad | 70.85 | Gangasagar | 40.88 |
| Nagendraganj | 69.60 | **Sagar Island** | **68.33** |

*Data source: Census of India, 2011*

Almost 60% population of Sagar Island is non-worker while around 40% participates in the workforce. 21.30% population is the main worker and 18.73% is in the category of marginal worker among the total population.

Table 4.12: Village-wise percentage of cultivator and agricultural labour within workforce

| Village | Cultivator | Agricultural labour | Village | Cultivator | Agricultural labour |
|---|---|---|---|---|---|
| Kirtankhali | 48.98 | 23.87 | Ramkrishnapur | 22.14 | 65.65 |
| Bishnupur | 41.48 | 20.41 | Naraharipur | 21.22 | 46.57 |
| Natendrapur | 40.83 | 40.50 | Bamankhali | 20.76 | 58.48 |
| Sapkhali | 39.28 | 44.43 | Muri Ganga | 20.02 | 35.76 |
| Khas Ramkarerchhar | 37.13 | 43.91 | Phuldubi | 20.01 | 57.63 |
| Manasadwip | 35.17 | 30.30 | Khan Saheber Abad | 19.96 | 43.45 |
| Gobindapur | 34.69 | 50.10 | Harinbari | 18.99 | 45.59 |
| Radha Krishnapur | 32.50 | 21.80 | Krishnanagar | 18.51 | 40.52 |
| Haradhanpur | 31.02 | 52.66 | Dhablat | 18.50 | 47.87 |
| Nagendraganj | 29.68 | 39.92 | Mandirtala | 17.71 | 59.87 |
| Mrityunjoynagar | 29.64 | 39.64 | Sikarpur | 17.54 | 46.39 |
| Chemagari | 28.44 | 50.52 | Companir Char | 17.38 | 59.27 |
| Sumatinagar | 27.05 | 56.66 | Narayani Abad | 16.10 | 54.75 |
| Purrusottampur | 26.99 | 31.25 | Gangasagar | 15.87 | 25.01 |
| Mahishamari | 26.10 | 50.40 | Sibpur | 15.86 | 49.59 |
| Kamalpur | 25.83 | 25.83 | Chandipur | 15.59 | 35.43 |
| Kaylapara | 24.75 | 56.71 | Kachubaria | 14.06 | 50.82 |
| Mahendraganj | 24.64 | 50.29 | Kastala | 13.51 | 32.82 |
| Rudranagar | 24.07 | 30.56 | Beguakhali | 13.09 | 58.98 |
| Bankimnagar | 23.69 | 44.51 | Dhaspara | 5.84 | 74.07 |
| Debimathurapur | 22.61 | 57.97 | **Sagar Island** | **24.61** | **43.72** |

*Data source: Census of India, 2011*

Among the total workforce, 68.33% of workers are dependent on agriculture (cultivators and agricultural labourers). The rest of the 31.77 % of workers are engaged in other economic

activities. Ramkrisnapur, Gobindapur, Sumatinagar, Sapkhali, Haradhanpur, Kaylapara, Natendrapur, Khas Ramkarerchar, and Debimathurpur have more than 80% share of the agriculture-dependent population among the total workforce. Kastala and Gangasagar have less than 50 % share of the agriculture-dependent population among the total workforce (see Table 4.11 for details).

The proportion of agricultural laborers is significantly higher than cultivators on the island (Table 4.12). Among the total workers, 24.61 % people are cultivators and 43.72 % people are agricultural labour. Although all the villages individually do not show the same structure. Kirtankhali, Bishnupur, Manasadwip, Radhakrisnapur, and Natedrapur have a higher share of cultivators than agricultural labourers. An interesting point to note here is many villages have significantly higher no of agricultural laborers than cultivators. For example, Dhaspara has only 5.84% of agricultural labour while it has 74.07% of agricultural labourers.

# CHAPTER 5: ENVIRONMENTAL CHALLENGES IN SAGAR ISLAND

The global climate is changing (WMO, 2024; Pörtner et. al., 2019; Church and White, 2011) and it is changing fast (Reidmiller, 2017; Mohanty, 2020). The impacts of climate change are already impacting ecosystems globally (IPCC, 2018). In the last few decades, global warming has caused significant reductions in the polar ice cover, including ice sheet and glacier mass loss, decreased snow cover, and thinner Arctic Sea ice (Pörtner et. al., 2019). Another effect of climate change is increasing ocean heat content which plays a crucial role in rising sea levels through thermal expansion (Church and White, 2011). Every region on Earth is already experiencing the effects of climate change, with many reported extreme events and variations in weather and temperature (WMO, 2024). India witnessed 250 extreme events between 1970 and 2005 (a span of 35 years), but the number increased to 310 in just 14 years between 2005 and 2019 (Mohanty, 2020).

The location and geo-climatic conditions of the Sundarban put the region in a vulnerable position. Changing climate along with anthropological activities has led to several changes in the environment of the Sundarban. The Sundarban environment is experiencing gradual deterioration (Mistri and Das 2020). The case of Sagar Island is not different from the rest of Sundarban. Along with that, Sagar Island is relatively more exposed to storm surges, coastal flooding, cyclones, and coastal erosion due to its location at the extreme southwest of ISD. Sagar Island is frequently affected by environmental hazards due to its coastal geomorphological dynamics (Mallik et. al., 2023). Coastal floods and coastal erosion are very common on the island due to tidal surges, storm surges and tropical cyclones. Regional hydro dynamics also play a major role in the shoreline changes in Sagar Island. The course of the Ganga River has shifted eastward due to the neo-tectonic eastward tilt (Blasco, 1997), resulting in a drastic reduction in freshwater inflow into the Hooghly estuary. Consequently, the Island is experiencing a hydrodynamic imbalance (Ghosh et. al., 2001) and rapid erosion of coastal areas (Hazra and Ghosh, 2016; Bandyopadhyay, 1997; Gopinath and Seralathan, 2005; Mondol, 2013).

Changing climatic and weather phenomena, environmental conditions, and exposure to the wrath of hazards have been creating serious threats to the ecosystem of Sagar Island. The environmental challenges of Sagar Island are discussed below with the help of available literature, secondary data analysis, and Primary data collected from field surveys.

### 5.1 Air Temperature

According to the 5th Assessment Report by IPCC (2013) Between 1951 and 2012, the global average temperature rose by approximately 0.12°C per decade. Projections indicate that over the next century, average global temperatures could increase by anywhere from 1.8°C to 5.8°C, leading to a rise in sea levels ranging from 9 to 88 centimeters grossly (IPCC, 2013) Human-induced global warming has raised temperatures by about 1.0°C above pre-industrial levels, and it is projected to reach 1.5°C between 2030 and 2052 if current trends persist (IPCC, 2018). It will have long-lasting effects on the climate system, including sea level rise and related impacts (IPCC, 2018). Between 1901 and 2018, India experienced an average temperature increase of approximately 0.7°C (UNICEF, 2024). The rising temperature is affecting crop production in India (Lal et. al., 1998). The temperature in the Sundarban region has been increasing at a rate of 0.019°C per year, affecting both land and sea (Hazra et. al., 2010). Between 2002 and 2009, the surface air temperature in the Sundarban increased by approximately 0.1058°C per year (Hazra et. al., 2010). Bhattacharya (2007) estimated that an increase of 2°C mean air temperature in coastal areas will decline the production of paddy yield in high-yield lands by 0.75 tonnes per hectare, and in low-yield lands by 0.06 tonne per hectare.

### 5.2 Rainfall

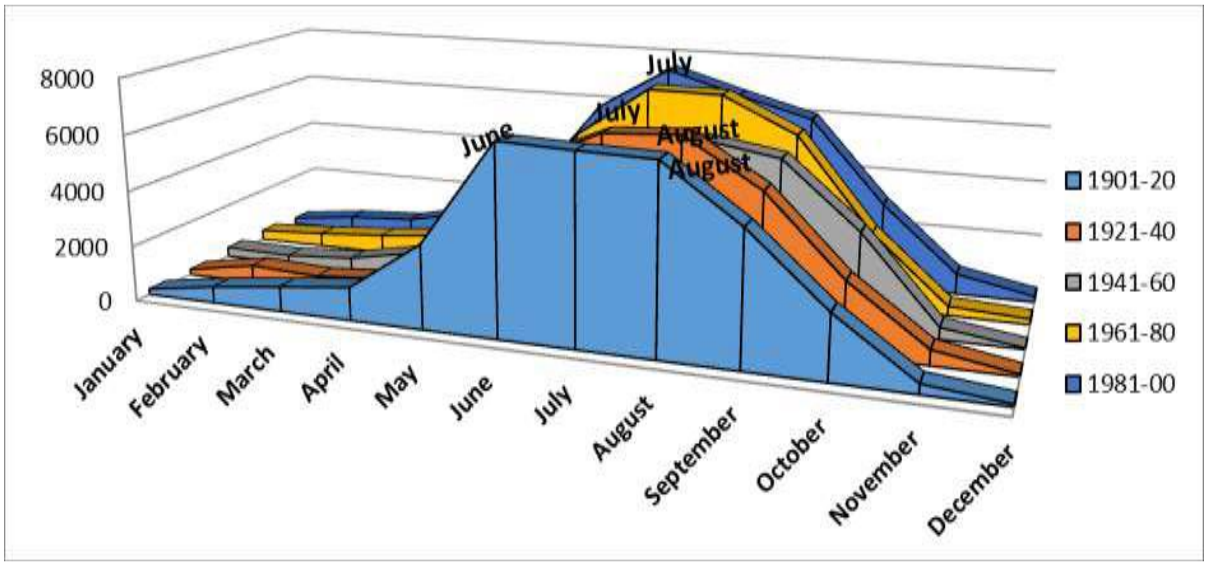


Figure 5.1: Change in rainfall peak during 1901 to 2000 (Data Source: IMD, Alipore station)

*Image source: Hajra and Ghosh, 2016*

The nature of rainfall in Sundarban is uncertain; it varies from year to year (Chand et. al., 2012). During the monsoon season, rainfall over the Bay of Bengal has increased at a rate of 0.0041

mm/hr. (Hazra et. al., 2010). According to the West Bengal State Action Plan on Climate Change (2012) between 1901 and 2003 in the monsoon season, rainfall in Indian Sundarban increased by approximately 91 mm. Similarly, during the post-monsoon season, there was a continued increase in rainfall by 25 mm (WBSAPCC, 2012). The study also presents that the rainfall during winter and pre-monsoon seasons in this region decreased by 14.5mm and 6.7mm, respectively. Over the past few decades, there has been a noticeable shift in the monsoon onset date, with it being delayed by 5-10 days (WBSAPCC, 2012). The changing pattern and uncertainty of rainfall directly impact the agricultural system of Sagar Island moreover the Sundarban.

### 5.3 Sea Surface Temperature

A key sign of ocean warming is the rise in sea surface temperature. In the Bay of Bengal, sea surface temperature has been rising at a rate of 0.5°C per decade since 1980, significantly higher than the global average of 0.06°C per decade (Ghosh, 2012). The warming ocean leads to the thermal expansion of ocean water. The Warming Ocean also plays a crucial role in the development and strengthening of tropical cyclones (Gary et. al., 1979; Mohanty, 2020). The rising sea surface temperature also contributes to increased evaporation, precipitation, and cyclone formation.

### 5.4 Sea Level Rise

The continuous increase in global temperature has persistently led to the melting of snow and polar ice caps, as well as the thermal expansion of seawater, thereby exacerbating the rise in global sea levels (Narendr et. al., 2022; Oppenheimer et. al., 2022). The global mean sea level rose at a rate of 1.7 mm per year from 1901 to 2010, but this increased to 3.2 mm per year between 1993 and 2010 (Knutti et. al., 2013). The rate of global sea level rise further increased to 3.6 millimeters per year between 2006 and 2015 (Pörtner et. al., 2019). Increasing sea levels significantly affect densely populated coastal and island areas (Anthoff et. al., 2006). In addition to the global sea-level rise, the local relative sea-level rise will exacerbate the situation for the Sundarban (Sánchez-Triana et. al., 2020). Rising sea levels, coupled with intricate hydrodynamic forces, are contributing to many challenges in the ecosystems of the Sundarban (Hajra and Ghosh, 2016). The gradual land subsidence at a rate of 2.9 mm per year exacerbates the effects of rising sea levels in the Sundarban region (Brown and Nicholls, 2015).

### 5.5 Water Transparency

Water transparency in the rivers of Sundarban and the nearby ocean has decreased over time. Between 1980 and 2007, water transparency in the Sundarban decreased from 7.0 cm to 9.0 cm, declining at a rate of 2.3 cm per decade (Mitra et. al., 2009) due to high erosional-accretional activities and churning that, in turn, resulted in a high proportion of suspended solids particles in the water bodies (Mistri and Das, 2020). The water transparency of western Sundarban is lesser in comparison to eastern Sundarban (Mistri and Das, 2020). The reason behind this is less freshwater flow in the rivers of western Sundarban than in the eastern part. Low water transparency reduces the penetration of sunlight deep inside the water which hampers the growth of phytoplankton. Eventually, that reduces the quantity of fish in the ecosystem.

### 5.6 Tropical Cyclone

With rising temperatures, cyclonic storms have become more frequent and intense (Woodruff et. al., 2013; Narendr et. al., 2022). In India between 1970 and 2019, the frequency of cyclonic events grew twelvefold (Mohanty, 2020).

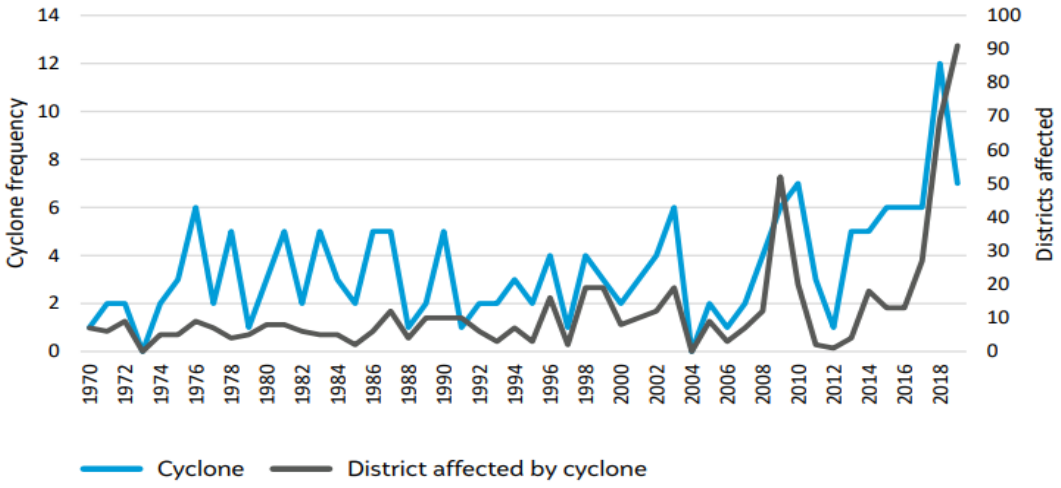


Figure 5.2: Rise in cyclonic events and affected districts in India from 1970 to 2019

*Image source: Mohanty, 2020*

Tropical cyclones, usually form in May, June, October, November, and, occasionally, in December in the Bay of Bengal. Chakraborty (2015) has listed more than 35 tropical cyclones between 1909 and 2009 that affected the ISD. One of the major events occurred on 25$^{th}$ May

2009, the severe cyclone Aila along with the spring high tide created havoc in the ISD which affected the region massively (Pal and Ghosh, 2018).

Tropical cyclones impact Sagar Island very frequently (Mandal and Mahapatra, 2010) leading to serious challenges for the inhabitants. Although the intensity and impact of the events vary in different areas of the island. Between 2018-2022, three cyclones impacted Sagar Island namely Bulbul (09.11.2019), Amphan (20.05.2020), and Yaas (26.05.2021). Cyclone Bulbul had a lesser impact than Cyclone Amphan and Cyclone Yaas on the area. Cyclone Amphan affected the whole island with high-speed winds. Damage by the wind was lesser at the time of cyclone Yaas but most of the coastal villages were severely impacted by catastrophic coastal flood.

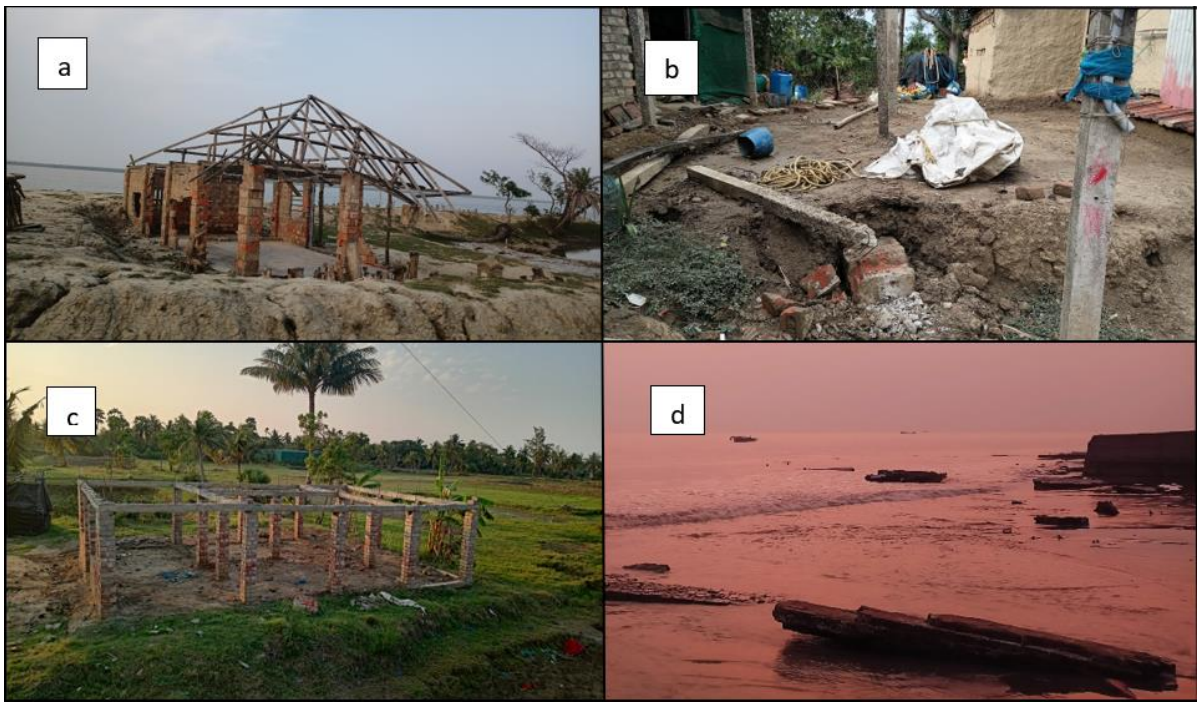


Plate 5.1: Destruction of infrastructure by cyclone Yaas (a) a ruined house at Muriganga (b) a damaged house at Mrityunjaynagar (c) a destroyed house at Bankimnagar (d) infrastructural ruins at Gangasagar beach

During the field survey, many inhabitants of Sagar Island have expressed that they have never experienced such a devastating cyclone as Yaas in their lifetime. The cyclone fell on land during high tide, with winds surpassing 135 km/h, causing massive waves in the Bay of Bengal that led to embankment collapse, breach, and overtopping in many parts of the island. The event of Amphan was also destructive but less than Yass. During Amaphan, less area was

affected by flood compared to Yass. But severe damage has been done to betel vines, houses, and other infrastructures. A resident of Mrityunjaynagar stated that:

*"Amphan has destroyed many betel vines in our area, and many houses were also damaged by high-speed wind, but cyclone Yaas was far more devastating, as both wind and water created havoc together."*

### 5.7 Erosion and Accretion

Rising sea levels, storm surges, tropical cyclones, and fluvial actions all pose significant risks to tropical coastal areas situated along estuaries (Valderrama-Landeros and Flores-de-Santiago, 2019). The Sundarban delta region is experiencing several changes due to complex hydrodynamic forces (Hajra and Ghosh, 2016). A great number of islands have disappeared under the sea, forcing countless people to be uprooted from their lands. A study by Hazra et. al. (2010) has shown that between 2001 and 2009, the Indian Sundarban underwent a significant geographical transformation, where the total area declined from 6402.09 sq. km. to 6358.048 sq. km.; this was a consequence of 64.162 sq. km. of erosion, while a smaller fraction, 20.120 sq. km., expanded due to accretion, culminating in a net loss of 44.042 sq. km. over the period. The southern islands of the Sundarban have much higher rates of erosion than other places (Hazra et. al., 2010). The islands of Bedford, Lohachara, and Suparibhanga have been entirely submerged, leading to the displacement of a significant number of people who have become environmental migrants (Ghosh et. al., 2014; Hajra and Ghosh, 2016). The villages of Baisnabpara and Khasimara have vanished due to erosion on the western side of Ghoramara Island, resulting in significant outmigration, (Ghosh and Sengupta, 1997). Similarly, the complete erosion of Bishalaksipur village on the southern end of Sagar Island has happened (Bandyopadhyay, 1997).

According to Bandyopadhyay et. al. (1993), the yearly patterns of wind, rainfall, and tidal dynamics seen on the island have a substantial impact on the coastline erosion seen in Sagar Island; the monsoon season (June–September) is when most coastal erosion happens. It is a time of year marked by strong waves, more tropical storms, and rising sea levels from increased freshwater inflow. Tropical cyclones, formed in October and November and, occasionally, in December, can contribute to coastal erosion. On the other hand, calmness prevails in the Bay of Bengal and the Hooghly estuary throughout the late post-monsoon season (December–January), which lowers the rate of erosion. During a serious tropical cyclone, a few hours of intense wave and storm surge action could be equivalent to several years of regular erosion by

waves. Both the eastern and western sides of the island have faced a significant amount of erosion (Ghosh et. al., 2001). In the northern part of Sagar Island, mudflat erosion is notable while in the southern part, the process of delta formation has caused accretion (Ghosh et. al., 2001). Constant modification of shorelines has been observed by the marine and riverine geomorphic processes like erosion, accretion, and wave action that result in changes in agricultural practices (Hajra and Ghosh 2014) and other economic activities.

To better understand the morphological behaviour of the near-shore environment of Sagar Island, a detailed analysis of shoreline positions and evolving patterns has been done with the help of Landsat images (OLI 8, 2013, 2018, and 2023) gathered from USGS Earth Explorer (Figure 5.3). The manual digitization method has been used for shoreline extraction of all consecutive years (2013, 2018, and 2023) using ArcGIS 10.8 software, and DSAS (in ArcGIS software) uses this vector as input to analyse changes in the permanent waterline during the last ten years. To compute the coastal change rates on both a spatial and temporal scale, this study considered two DSAS parameter functions: End Point Rate (EPR) and Linear Regression Rate (LRR) (Bera and Maiti, 2019). Transects are drawn for both banks of the chosen shorelines at 50-meter intervals. Village-wise total erosion has been computed (Table 5.1) by adding up all inter-transect eroded areas of the village. After that, the percentage of eroded area to the total area of each coastal village is calculated.

The erosion-accretion map (Figure 5.3) demonstrates the variation in the morphological behaviour along Sagar Island's coastline. A significant rate of erosion has been seen in most of the southern and eastern coastal zones except in a few patches where accretion has taken place. South-western coastal areas of Mahishamari and Beguakhali also faced erosion. Most of the western coast has been safe from erosional activity. Extremely affected areas of the island are the coastline of Mahishamari, Shibpur, Gobindapur, Ramkrisnapur, Gangasagar, Beguakhali, Chemaguri and Sikarpur. On the other hand, the coastal areas of Chandipur, Radha Krishnapur, Naraharipur, Krishnanagar, and Sapkhali are showing a higher rate of accretion.

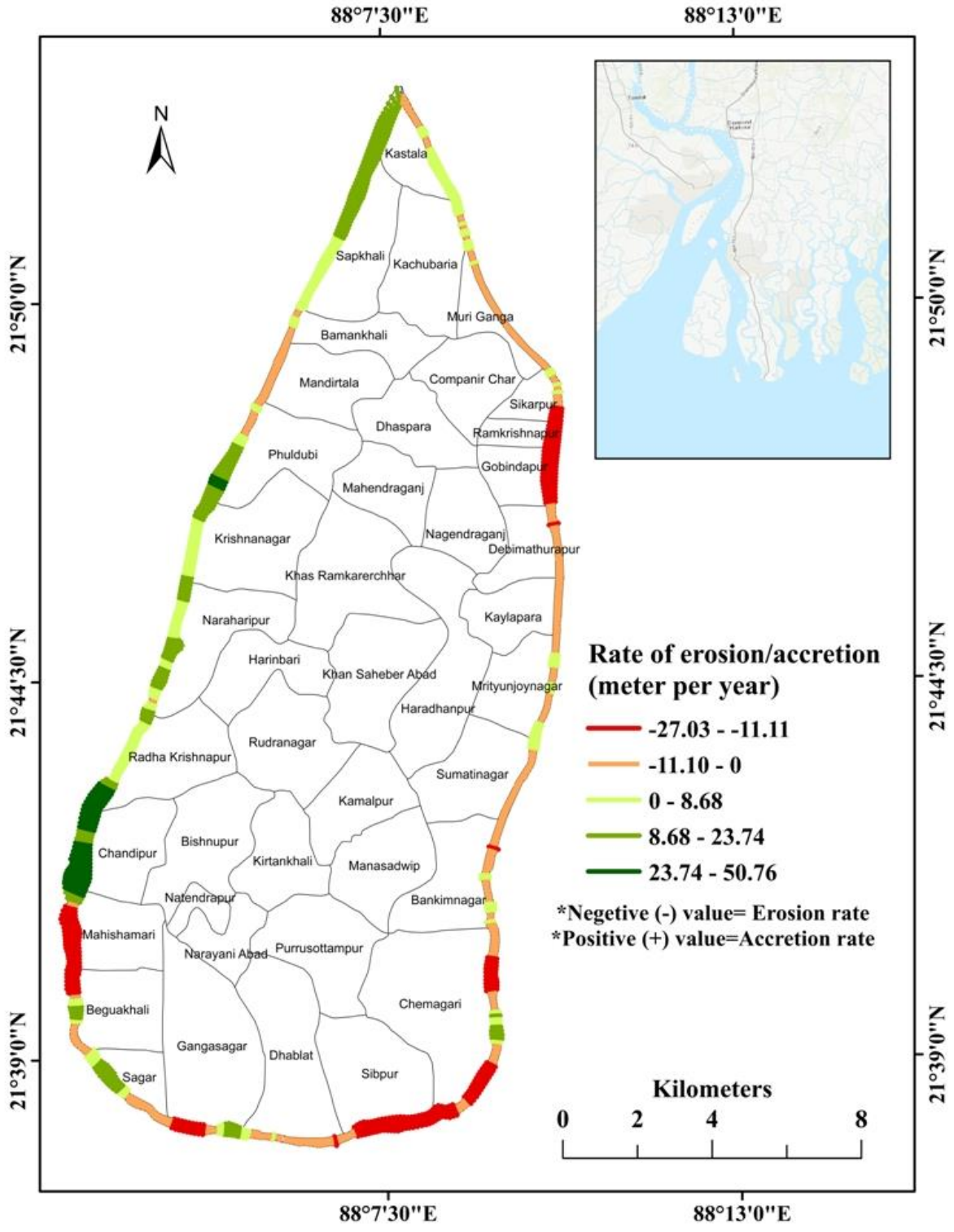


Figure 5.3: Rate of erosion and accretion around Sagar Island (2013-2023). *Source: Landsat 8 – 9 OLI/TIRS images (Path-Row: 138/45) to extract different year's shorelines (2013,2018 and 2023) and transect creation and change detection has been done with the help of the DSAS tool in ArcGIS platform*

Table 5.1: Percentage of eroded area (2013-2023) of coastal villages

| Village name | Total area (sq. km.) | Erosion (sq. km.) | Erosion (%) |
|---|---|---|---|
| Sikarpur | 1.43 | 0.27 | 19.29 |
| Gobindapur | 2.93 | 0.53 | 17.93 |
| Ramkrishnapur | 1.39 | 0.24 | 16.89 |
| Bankimnagar | 3.08 | 0.51 | 16.72 |
| Chemagari | 8.52 | 1.33 | 15.62 |
| Mahishamari | 4.44 | 0.65 | 14.56 |
| Debimathurapur | 2.95 | 0.43 | 14.50 |
| Muri Ganga | 4.98 | 0.65 | 13.14 |
| Kaylapara | 3.58 | 0.32 | 8.93 |
| Sibpur | 8.92 | 0.73 | 8.14 |
| Kastala | 2.99 | 0.24 | 8.06 |
| Beguakhali | 6.49 | 0.45 | 6.95 |
| Sumatinagar | 6.05 | 0.39 | 6.44 |
| Mrityunjoynagar | 4.93 | 0.30 | 6.11 |
| Mandirtala | 6.82 | 0.38 | 5.64 |
| Dhablat | 11.43 | 0.55 | 4.84 |
| Gangasagar | 12.26 | 0.34 | 2.81 |
| Phuldubi | 6.28 | 0.17 | 2.75 |
| Bamankhali | 4.64 | 0.12 | 2.55 |
| Kachubaria | 7.39 | 0.05 | 0.69 |
| Naraharipur | 6.83 | 0.02 | 0.31 |
| Chandipur | 2.93 | 0.00 | 0.00 |
| Krishnanagar | 8.69 | 0.00 | 0.00 |
| Radha Krishnapur | 7.35 | 0.00 | 0.00 |
| Sapkhali | 8.62 | 0.00 | 0.00 |

*Source: Eroded area calculated in ArcGIS software based on Figure 5.2.*

Table 5.1 shows the total eroded area and percentage of the eroded area of each village. 21 out of 25 settled coastal villages have faced land loss due to erosion. Six villages out of them have lost more than 10 % of their total area.

Over a decade, distinct patterns of shoreline alteration were observed throughout the coastal zones, and there was a notable special variation in the rate of erosion and accretion. The pattern of erosion and accretion is very dynamic. The geomorphic forces are constantly changing the shape of the island which in turn impacts the land-use pattern and economic activities in the island.

### 5.8 Coastal Flooding

One of the most significant problems that coastal people currently face is Coastal flooding (Woodruff et. al., 2013). The location and geo-climatic conditions of Sagar Island put the area in a vulnerable position to coastal flooding. Tidal flooding is a very common type of coastal flooding that frequently occurs on this Island particularly in the month of June-September when the local sea level rises due to heavy rainfall in the Indian subcontinent. The rising global sea level is continuously increasing the risk of tidal flooding in the coastal areas. Flooding due to storm surges is generally more impactful than tidal flooding. The occurrence of both high tide and storm surges makes the flood more powerful. The embankments in many areas of the Island are not good enough to prevent breaches and overtopping during storm surges. The island is exposed to high-velocity winds and sea waves, particularly during the season of monsoon. Destructive surges occur when high-speed wind coincides with spring tide. The occurrence of tropical cyclones creates comparatively more destructive coastal floods in Sagar Island moreover the Sundarban than floods caused by other reasons.

From the field observation and information collected from local people, it is evident that the inhabitants of the island have been seriously impacted by coastal floods in the last few years. When asked the question of which hazard has negatively impacted their life the most, the majority of the people said coastal flood.

In the period between 2018 and 2022, most of the coastal villages were affected by floods while the inland villages were safe from floods due to their distance from the shore.

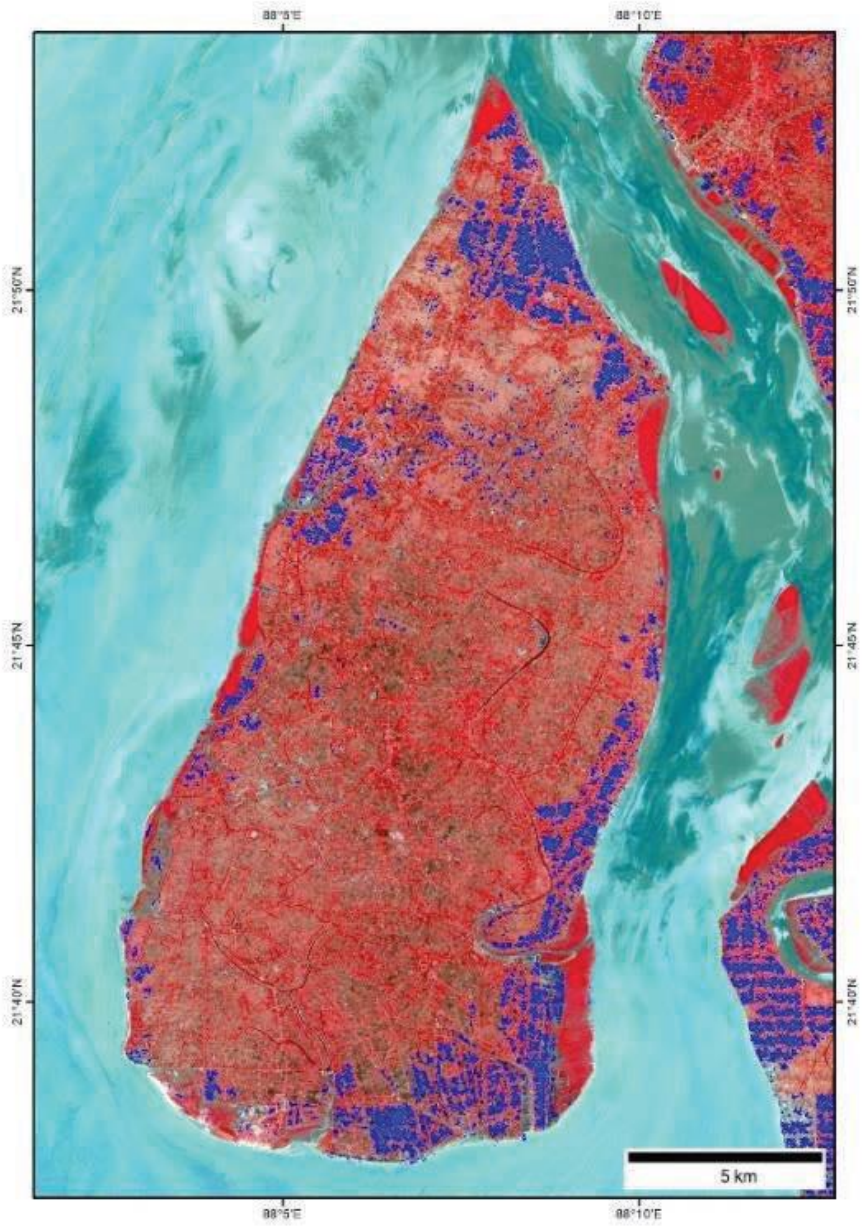


Figure 5.4: Inundated areas of Sagar Island in July 2021 due to cyclone Yaas

*Image source: EDGWB, 2021*

Villages that did not have concrete embankments or forest cover along the coast are affected the most by the intrusion of coastal waters. Most of the southern villages except Dhablat have earthen embankments.

The southern, south-western, south-eastern, and north-eastern parts of the island have faced most of the damages due to flooding in recent years. On the southern part of the island, the coastal areas of Gangasagar village experienced coastal floods at the time of cyclone Yaas. Some areas of Chemaguri village were affected in the southern part, the earthen embankments

have been broken a few times between 2018 to 2023; the most severe damage occurred at the time of cyclone Yaas. The southern coastline of the village of Sibpur has also faced a similar experience to the southern part of Chemaguri. Ramen Das, a resident of Sibpur, age 28, stated:

*"At the time of Yaas, the embankment collapsed, and a whole lot of water entered our area at once. It is like the ocean has opened up and decided to pour all the water into our village."*

In recent years the condition of Dhablat, the adjacent western village of Sibpur has improved after the construction of Aila Bandh in 2018. After 2018 direct intrusion of coastal water has become a rare occurrence. At the time of Cyclone Yaas, there was a significant amount of overtopping of coastal water but no damage has been done to the embankment by the hit of the cyclone. A 67-year-old retired teacher, resident of Dhablat, explained:

*"The ocean was not this close. It was far away. It is our luck that we got Aila Bandh which has stopped the aggression of the ocean. The condition of Sibpur is much worse. Destruction of embankment is common there. At the time of Yaas sea water overtopped the Aila Bandh. The earthen embankment of Sibpur collapsed and huge water has entered our area from that side also."*

In the southwest of the island, villages like Beguakhali and Mahishamari have been affected by coastal floods for several years in the past. While the coastal flood frequently affects the coastal areas of Mahishamari, the people of Beguakhali have experienced a safer situation in this context after the construction of Aila Bandh in 2018. Madhab Mondol a 52-year-old farmer stated with joy that:

*"We are saved because of the presence of Aila Badh otherwise it would have been disastrous in the recent cyclones like Yaas, Amphan and Bulbul.''*

The villagers of Mahishamari reported that the embankments have broken, breached, and washed away many times in recent years due to devastating cyclones like Bulbul, Amphan, and Yaas and periodic coastal floods in monsoon. Soma Maity 37-year-old woman stated:

*"Our family along with many others from our village (Mahishamari) has lost our lands in the river, and many agricultural lands near the coastline have become unfertile due to coastal flooding in recent years. We faced extreme trouble in three cyclones one after one."*

The southeastern coastal villages like Bankimnagar, Sumatinagar, and Mrityunjaynagar have been affected by floods a few times, particularly the incident of cyclone Yaas was the most

damaging to these villages. Among these villages, Bankimnagar stands out to be the most vulnerable to coastal floods. From 2016 to 2022 some parts of this village have been affected in every monsoon by coastal floods continuously. A resident of the central coastal part of Bankimnagar stated with sadness:

*"Our area has been facing flood continuously for seven years, every monsoon we face huge trouble by the intrusion of salt water."*

The north-eastern villages like Kachuberia, Muriganga, and Sikarpur have also faced the turmoil of flood several times.

The eastern part of Chemaguri village is protected from coastal floods due to the presence of mangroves. A similar observation was found during the survey in areas like Ramkrishnapur, Gobindapur, Debimathurapur, Kaylapara, Chandipur, Naraharipur, etc. that the presence of mangroves on intertidal spaces has proven to be an absorber of the wave force.

For the people of Sagar Island, Coastal floods are a serious environmental challenge that impacts their lives and livelihoods. Coastal flooding commonly results in a series of disruptive incidents like an increase in soil salinity, and an increase in the salinity of inland water bodies which results in losses of agriculture and aquaculture. Additionally, the contamination of water bodies due to high salinity often leads to a scarcity of fresh drinking water for humans, domestic animals, and wild animals. Destructive floods also damaged the infrastructure. Such incidents significantly hamper the economy.

In summary, most of the environmental parameters are gradually deteriorating on the island, as a result creating serious challenges to the inhabitants of the island. The inhabitants are facing serious issues in natural resource-based economic activities, which are directly hampering their livelihoods. The next chapter thoroughly discusses the condition of livelihoods on Sagar Island.

# CHAPTER 6: LIVELIHOOD IN SAGAR ISLAND

The traditional livelihoods in the island are under threat of climate change, environmental degradation, and anthropogenic issues. Most of the inhabitants engaged in natural resource-based economic activities are facing losses or going through uncertainty. Consecutive disasters have shattered the economy of the region in recent years. Although effective evacuation plans and strategic management have led to a reduction in loss of life due to disasters the severity of losses and damages to livelihoods, and properties do not appear to be diminishing over time in the Sundarban (CEEW, 2015). The case of Sagar Island is the same as its counterparts of the rest of the Sundarban.

The inhabitants are mainly engaged in the agriculture, fishing, and tourism sectors on the island. Many people on the island are engaged in multiple economic activities for their livelihood. Many activities are done simultaneously throughout the year while many activities are strongly tied with seasons. Change of season plays a role in the temporary shift of livelihood options on the island in a cyclical way around the year.

### 6.1 Agriculture

In Sagar Island agricultural sector is one of the main sources of livelihood. Agriculture provides direct and indirect employment to many inhabitants of the island. According to the Agricultural Census of India (ACI) 2015-16, the net shown area is 105.30 sq. km which is 41.85% of the total area of Sagar Island. The gross cultivated area on Sagar Island is 147.09 square km (ACI, 2015-2016).

As sources of irrigation are very limited on the island, most of the farmers practice mono-cropping depending on rainwater availability in the season of monsoon. Some farmers are able to save the rainwater in their ponds for later use. Some of the cultivators who do not store enough water or do not have a pond to store buy water from other ponds for Ravi crop cultivation. Most of the farmers are not able to produce Ravi crops due to the unavailability of irrigation. There are concerns in the season of monsoon also; the cultivators of Sagar Island along with many other areas of India are facing issues of unpredictable rainfall. Insufficient information on rainfall patterns and the lack of crop scheduling based on this information lead to frequent water stress and occasional crop failure (Mandal et. al., 2015).

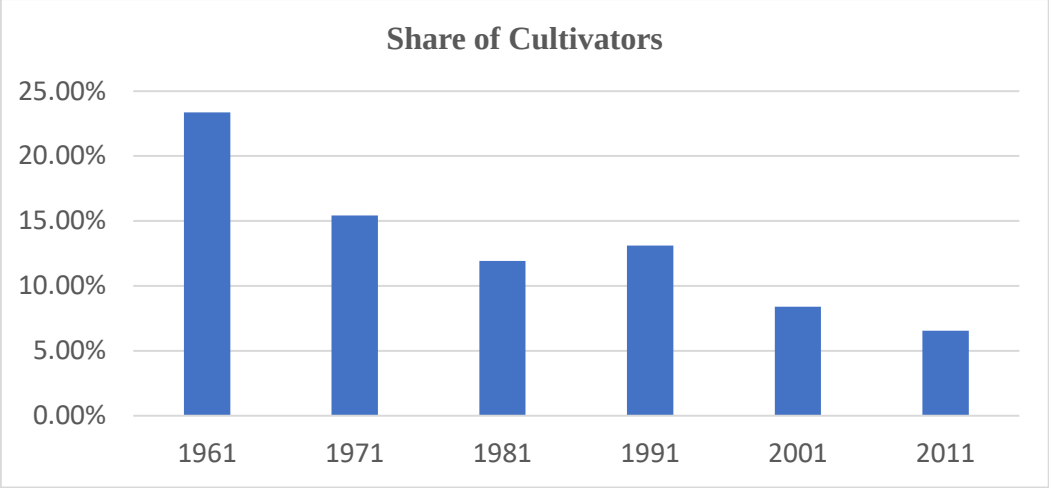


Figure 6.1: Percentage of cultivators (main worker) in total population of Sagar Island from 1961 to 2011

*Data source: Census of India*

Figure 6.1 illustrates a significant decline in the percentage of cultivators on Sagar Island from 1961 to 2011. Starting at approximately 23.36% in 1961, the number of cultivators dropped sharply to 15.42% by 1971 and continued to decrease to 11.93% in 1981. There was a slight increase to 13.11% in 1991, possibly due to specific socio-economic or environmental factors. However, the downward trend resumed, with the number of cultivators falling to 8.39% in 2001 and further to 6.54% by 2011. Overall, the trend shows the percentage of cultivators in the total population has declined on the island.

Chilli and watermelon were cultivated extensively as commercial agricultural products on the island. However, while watermelon cultivation has completely disappeared, chili production persists, although on a significantly reduced scale. Paddy is the major crop produced on the island from the reclamation of the island covering the highest gross cropped area while Betel leaf or 'Paan' is the cash crop of the island. Other than that, vegetables, pulses, sunflowers, etc are cultivated on the island.

### 6.1.1 Betel leaf cultivation

Betel, a dioecious plant, is cultivated for its heart-shaped leaves which is an important cash crop across southeast Asia. Farmers in several Indian states, including Assam, Andhra Pradesh, Bihar, Gujarat, Odisha, Karnataka, Madhya Pradesh, Rajasthan, West Bengal, Maharashtra, and Uttar Pradesh cultivate betel in approximately 50,000 hectares of land (Bhardwaj, 2023). The favourable soil moisture in these regions has contributed to the growth of the betel leaf

industry over the past few decades (Bhardwaj, 2023). The betel, being a perennial crop, provides year-round employment opportunities and is often called the 'Green gold of India' (Guha, 2006). In the eastern part of India, West Bengal holds a significant position in betel leaf production (Mondal et. al., 2019).

Within the last two to three decades, the betel vine became a popular cash crop on Sagar Island. During the survey, the respondents of Sagar Island shared that there is a strong cultural tie between Medinipur and Sagar Island as most of the Island's settlement was developed by the migrated people of Medinipur. People of Sagar Island started Betel cultivation following the success of Medinipur's betel farming. Betel was proven to be high-income generating compared to other agricultural products. Thus, betel cultivation has become a commercial agricultural product on the island.

The betel plant demands careful attention and specific climate conditions. It thrives in mild temperatures, around 10°C in winter and 40°C in summer (Bhardwaj, 2023). Any fluctuations beyond these optimal conditions can significantly harm the yield and quality of betel leaves. Betel farming is done in vineyards locally called "Pan Boroj." In Sagar Island, Boroj is a locally constructed artificial structure designed to control sunlight exposure, temperature, and humidity. It also serves as a protective shield for betel plants, safeguarding them from the powerful winds associated with severe weather events. It represents a traditional adaptive measure used by communities to establish a favourable microclimate for cultivating betel leaves. Making and maintaining a Boroj is quite challenging and costlier work economically in Sagar Island. Due to economic issues, many cultivators cannot afford to engage in betel cultivation.


Plate 6.1: a) outside and b) inside structure of a Pan Boroj

Generally, the shape of boroj is either square or rectangular, depending on the shape of the land where it is constructed. Commonly, the height of the boroj ranges from 6-8 meters and it varies

according to the farmer's comfort while harvesting leaves or tending to the vines. The boundaries are fenced by bamboo pillars, straw, coconut leaf, and other thatch materials. To enhance the durability of the structure, certain cultivators have started to employ synthetic materials known as "shade nets," which they secure to concrete pillars. Inside the fences, the main structure of a boroj is generally made of bamboo and sticks, to provide stability. The vertical straws provide support to the climber plants that grow along the structure. As direct sunlight hampers the growth of betel plants, a roof is made above the vineyards with teachers. Straws and coconut leaves are commonly used to make the roof of the boroj to give shade from blazing sunlight. In summer when the amount of solar insolation is higher the farmers make the roof thicker by adding more layers of thatches.

The island faces frequent saline water inflow, particularly during storm surges, resulting in soil pH increase, rendering it less suitable for sensitive crops like betel vine. To mitigate salinity, an extensive process of soil treatment is done. Both organic and inorganic components are used in the soil. Respondent cultivators have stated that they have increased the use of fertiliser use to cope with the fertility issue of the soil. Betel is a water-intensive crop; a continuous supply of water is essential year-round for betel cultivation. Other than the rainy season the area generally faces scarcity of freshwater. Thus, for irrigation purposes, cultivators save rainwater in the ponds. In recent years frequent coastal floods have created a serious water crisis by salinizing pond water in many areas of the island.

Plate 6.2: Earthen structure surrounding betel vines to protect from inundation at Kachuberia

To protect betel vines from inundation, cultivators on the island have adopted a strategy of surrounding the vines with elevated earthen structures. While this method is not effective against heavy flooding, it does protect the vines from minor water inflows.

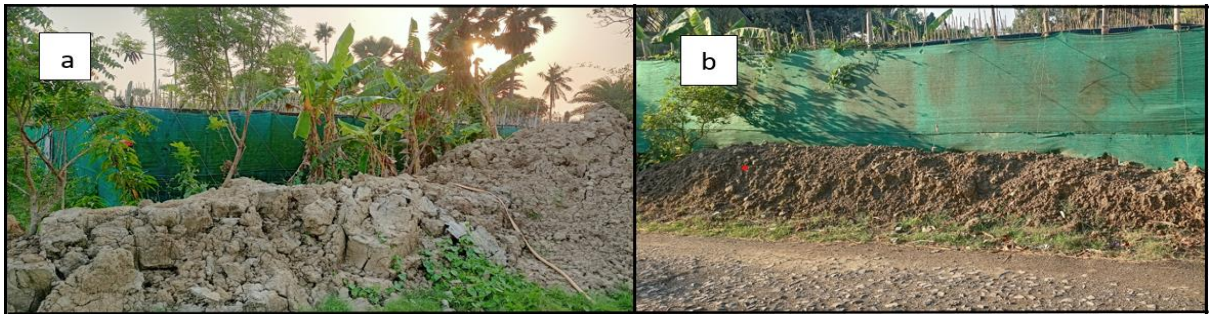


Plate 6.3: Preparation of earthen structures to protect the betel vines from inundation at (a) Bankimnagar and (b) Haradhanpur

**Challenges in betel cultivation**

**a. High-speed winds, cyclones and floods**

Betel plants are vulnerable to high-speed winds and cyclones. During cyclonic events, strong winds can destroy the entire structure of the betel vine leading to serious damage to the plants. Even if the structure is knocked down by the wind, the plants fall to the ground and become vulnerable to diseases, potentially leading to stunted growth, poor-quality leaves, or plant mortality.

After cyclone Aila in 2009, betel cultivators on Sagar Island faced damage to their vines. Many respondents have reported that they stopped cultivating betel after facing destruction in Aila. While others spent significant amounts to revive their vines. A few even shifted to other occupations or migrated for employment. A 47-year-old respondent stated:

*"I started betel farming in 1998. Aila damaged my whole vine. I did not have sufficient money to make a new vine again. I migrated to Kerala for employment."*

In 2019, Cyclone Bulbul caused partial damage to some vines, while Cyclone Amphan in 2020 resulted in more significant damage due to stronger winds on the island. The aftermath of Cyclone Amphan dealt a severe blow to betel cultivators across the island. Just a year later, Cyclone Yaas struck, impacting the vines. Despite Yaas having slightly lower wind speeds than Amphan, the damage was significant. The farmers struggled to recover in such a short period. Additionally, the massive storm surge during Yaas flooded the coastal areas of the island further affecting the coastal vineyards on the islands. In this context, a respondent from Kachuberia stated:

*"After Cyclone Amphan, my vine was damaged, and although I managed to revive it, the cyclone Yaas destroyed it completely…….. Now I do not have enough courage or financial condition to rebuild a vine again."*


Plate 6.4: Destroyed vines in recent cyclones and subsequent flooding at (a) Bankimnagar (b) Sumatinagar (c) Muriganga (d) Kachuberia

In recent years frequent coastal floods in certain parts of Sagar Island created disturbances to betel cultivators. These floods lead to soil salinization, which is detrimental to betel plants. Additionally, the floods affected irrigation sources, such as ponds, exacerbating water scarcity for plants in several areas of the island. In this context, a cultivator of Bankimnagar shared an extremely bad situation:

*"Our area is facing floods every monsoon for 6-7 years. There is no way we can cultivate in this condition."*

In recent times, many cultivators from Bankimnagar, Sumatinagar, Muriganga, Kachuberia, Mrityunjaynagar, and other parts of the island have become migrant labourers due to the problems created by hazards, particularly after the impact of the Amphan and Yaas cyclone.

### b. Issue related to the market

Cultivators often do not get fair price of the product. A bundle locally called ‘Gochh’ is a small unit of betel leaf that is gathered together to sell. The number of betel leaves in a Bundle is increasing with time which is a major concern for the Cultivators. Typically, a bundle consists of 50 leaves. However, buyers often request more leaves in a bundle without paying extra. In recent times, this situation has escalated, with some buyers demanding up to 300 leaves per bundle.


Plate 6.5: Gochh having a) 250 and b) 300 betel leaves

### c. Higher incidence of diseases

Betel leaf production is facing risks all over India due to unpredictable regional rainfall and temperature fluctuations (Bhardwaj, 2023). The situation on Sagar Island is also similar. Many cultivators have shared that the production of good-quality leaves has decreased in recent years and the incidence of different diseases has increased in betel leaves. They have a speculative stand about the reasons for these increasing diseases. They have mentioned mainly two reasons behind these increasing diseases and low productivity: climate change and soil fertility loss.

*“The prevalence of vine diseases has surged in recent years……. As far as I know, it is happening due to increasing rainfall and temperature. Other than that soil may be a reason.”*

Table 6.1: Common diseases found in betel plants on Sagar Island

| Disease | Local name | Characteristics | Reasons |
|---|---|---|---|
| Leaf Spot or Anthracnose | Angari | Light to dark brown irregularly shaped and sized spots in leaves surrounded by a yellow halo. | Rain and high humidity favour the development of this disease. |
| Bacterial Leaf Spot | Angari | Small water-soaked lesions on leaf blades lead to premature defoliation. | Favourable conditions for this disease are High temperature and high relative humidity. |
| Chlorosis | -- | Leaves become yellow | loss of Chlorophyll |
| Sclerotial Wilt or Collar Rot | Togra | Stem darkens, then leaves turn yellow and become soft and loose then droop off. | Mainly occurs during June-September and is caused by Sclerotium rolfsii or Sclerotia. Sclerotia can spread through soil, tools, seedlings, water, wind, and possibly via seeds. |
| Black Spots | Chiti or Hamchiti | Leaves become full of small black spots | Mainly noticed in winter due to fog or temperature fluctuations. |

The increasing occurrence of Angari disease (Leaf Spot or Anthracnose) is the main concern for the cultivators. It was rare before, many cultivators did not even know about such diseases, and now it has become very common. After the cyclone Yaas this disease has damaged many vines.

*"Angari disease has increased in recent years. We did not even hear about this 20-25 years ago"*


Plate 6.6: Diseases in betel plant: (a) Bacterial Leaf Spot (b) Leaf Spot or Anthracnose (c) Sclerotial Wilt or Collar Rot

The frequency of the disease Togra (Sclerotial Wilt or Collar Rot) has also increased. Other diseases like Hamchiti (Black Spots) and Chlorosis were always common in the vines of this island.

**d. Lack of proper technical knowledge and financial constraints**

Several small and marginal farmers expressed a lack of knowledge regarding cultivation practices, including appropriate fertilizer use and disease control measures. They also face financial constraints. Marginal and small farmers face most of the brunt of the challenges like the impact of hazards, and increasing diseases due to lack of capital to reinvest. Adapting to challenging situations is relatively easier for medium to large farmers.

### 6.1.2. Paddy cultivation

After the reclamation of the island, across generations, farmers on Sagar Island, have cultivated rice on their plots of land, striving to make a livelihood. According to the agricultural census of India 2015-16, the gross cultivated area in Sagar Island is 147.09 square km. Paddy cultivation is mainly subsistence in nature. Cultivation of paddy is done primarily for household consumption. Not all cultivators engage in the commercialization of paddy at the marketplace; of those who do, the quantity sold is often minimal.

Plate 6.7: Paddy field with a small pond for irrigation

Changing elements in the climate of the region have hampered paddy cultivation in the Sundarban region (Mistri and Das 2020). There are concerns in the season of monsoon; the cultivators of Sagar Island and many other areas of India are facing issues of unpredictable rainfall.


Plate 6.8: Salinisation at Mahishamari due to coastal inundation

Flooding and salinization pose significant challenges to paddy cultivation on the Island. Post-flooding, the affected lands often remain uncultivable for 2-5 years due to persistent salinity.

Soil salinity poses environmental risks due to physical, chemical, and biological degradation, impacting sustainable cultivation. Salinity affects rice fields in tropical and sub-tropical regions to varying extents (Datta, 1981). Rice, which can tolerate moderate salt levels, is commonly grown in coastal soils with reasonable success (Jena and Rao 1988). During the dry season, salt injury and a lack of high-quality irrigation water exacerbate the situation. (Mandal and Sarangi, 2011). Farmers often increase fertilizer application, including nitrogen, in the soil to counteract salt toxicity. Excessive soluble salts in coastal paddy fields harm seed germination, plant survival, growth, and nutrient balance due to osmotic pressure, hindering moisture and nutrient absorption.

Plate 6.9: A vast amount of paddy fields in Bamkinagar mouza has transformed into fallow land by salinisation due to consecutive flood events

### 6.1.3 Other crops


Plate 6.10: a) Vegetable cultivation for household consumption b) sunflower cultivation for commercial purpose

On the island, vegetables are primarily cultivated for household consumption. Most households grow a variety of vegetables in their premises or backyards, including leafy greens, bitter melon, ridge gourd, onions, potatoes, ladies' fingers (okra), and chilies. Bitter melon and ridge gourd are also grown as cash crops, but not in significant amounts. Additionally, pulses such as khesari (grass pea) and oilseeds like sunflowers are cultivated on the island.

The flood caused by cyclone Yaas has significantly impacted vegetable cultivation on the Island. The irrigation sources (ponds) were salinized due to which many were not able to cultivate vegetables. In many areas of the island, land become salinized due to which vegetable cultivation has also been paused for a substantial period. In this context, a resident of Bankimnagar narrated:

"*In my area, previously onion, and potato were cultivated. After Yaas, it is stopped. Before Yaas with the help of pond water, we cultivated our lands."*


Plate 6.11: (a) Bitter gourd and (b) ridge gourd cultivation as cash crops

Some cultivators of the island have started to cultivate 'Brahmi' a few years ago. Brahmi or Water Hyssop scientifically known as 'Bacopa Monnieri,' a small succulent herb with multiple branches, thrives naturally in wet soil, shallow water, and marshy areas. It is Moderately salt tolerant, can grow in brackish water, and can also tolerate occasional inundation of salinised water. In 2016, the State Medicinal Plants Board of West Bengal introduced Brahmi cultivation in Bakhhali village, Namkhana administrative block. Subsequently, farmers on Sagar Island adopted brahmi farming, and it is currently cultivated grossly across 450 acres there (Bose, 2020). Although the cultivation of Brahmi is very low in terms of gross area the lucrative returns have encouraged farmers to engage in Bramhi cultivation. NGOs and nonprofit organisations like Sagar Krishi Unnayan Cluster and Swami Vivekananda Youth Cultural Society have played a role in taking up the cultivation of this herb using organic methods. The

topography and agroclimatic conditions make Sagar Island very ideal for growing Brahmi. The State Medicinal Plants Board (SMPB) collected Brahmi samples from 40 locations in West Bengal and found that the samples from South 24 Parganas, particularly Sagar Island had high phytochemical levels which signifies a greater quality of the herb cultivated in Sagar Island (Bose, 2020). The success of Sagar Island farmers shows that medicinal and aromatic plant-based cropping systems can usher significantly higher profits for growers compared to traditional crops. The success of Sagar Island farmers shows that medicinal and aromatic plant-based crops can usher significantly higher profits for growers compared to traditional crops.

### 6.2 Fishing and Allied Activities

Fisheries are an intricate socio-ecological system that uses labor-intensive methods for harvesting, processing, and distributing marine and inland water resources. Small-scale fisheries (SSF) support over 90% of the 120 million people working in the global fisheries sector and they account for two-thirds of the fish catch intended for direct human consumption, playing a vital role in food security, poverty reduction, and boosting local and national economies (FAO, 2015). There is no universal definition for small-scale fisheries due to their vast diversity, encompassing both low-capital and low-tech fishing methods, basic processing, and marketing, as well as capital-intensive advanced and sophisticated technology used by fishers (FAO, 2015). For example, Indian fisheries are far from uniform, spanning various social and economic classes and communities of fishers and fishery workers, with most fitting under the broad term “small-scale” (Jadhav, 2018). In India, more than 2.8 crores of people were engaged in fishing and fish farming in 2020 (Ministry of Fisheries, Animal Husbandry and Dairying, 2020). In addition to this, many more people are engaged along the value chain of this sector.

Within Indian States West Bengal ranks second in fish production (18.24 lakh tones) after Andhra Pradesh and third in fisherman population (32,36,261) after Uttar Pradesh and Bihar in 2020 (Ministry of Fisheries, Animal Husbandry and Dairying, 2020).

According to a report by FAO (2008), the number of full-time fishers has decreased over the past thirty years, while the number of part-time fishers has increased significantly, particularly in Asia due to the worsening conditions of the ecosystem and related decline in the availability and actual fish catch. The condition of the Indian Sundarban follows a similar trend to its other counterparts in Asia. The aquatic ecosystems of Indian Sundarban have worsened due to the exploitation of the marine ecosystem (Das et al, 2018), and the change in

water quality (Mitra et. al., 2009; Mistri and Das 2020). The number of fish and other aquatic resources in the region has declined over time. Although bottom trawling is prohibited within 12 nautical miles of the coastline, small fishers of Sagar Island claim that trawlers begin trawling just 1 km from the coast, which harms the aquatic ecosystem resulting in declining fish production.

### 6.2.1 Fishing on Sagar Island

Fishing plays a crucial role in the economy of Sagar Island. Some fishers venture out with watercraft, while others, by choice or necessity, cast their nets and other fishing equipment along the coast and in the winding canals. The islanders use both Motor engine boats and hand-boats to catch fish. In some cases, rafts are also used to catch fish in the rivers and canals. Small hand-boats were typically used for riverine fishing. Fishers who do not manage a large sum of capital are still opting for smaller hand-boats. A Motor boat having one- or two-cylinder size of 20-22 feet long costs more than 1 lakh rupees. Boats having 1-2 cylinders typically fish within 5 km from the coast and generally get to catch smaller fish. Relatively bigger boats having 4-6 cylinders (Trawler) can easily travel more than 5 km into the deep sea to catch bigger size fish along with smaller fishes.

The boats that are used for trawling are called trawlers or draggers. Trawling is an industrial method of fishing that involves pulling a fishing net, that is heavily weighted to keep it on the seafloor, through the water behind one or more boats. The net used for trawling is called a trawl. This principle requires netting bags that are towed through water to catch different species of fish or sometimes targeted species. Trawls are often called towed gear or dragged gear. Bottom trawling significantly impacts the environment by destroying seabed habitats, resuspending sediments that alter water chemistry, and reducing light penetration. This practice also leads to biodiversity loss by physically altering the seabed and catching non-target species, known as bycatch, which further depletes marine populations. Bottom trawling is banned In India within 12 nautical miles of the coast, yet small fishers and other inhabitants of Sagar Island claim that trawlers begin their operations just 1 km from shore. In other coastlines of India, venturing 12 nautical miles out leads to deep sea waters. However, in the northern Bay of Bengal, even after 12 nautical miles, the waters remain shallow due to the deltaic region. Bottom trawling up to 30-40 km from the Sundarban coastline is harmful to the ecosystem.

Riverine fishing, once a reliable source of income, has seen a steady decline in catch due to a notable decline in fish populations. Traditional fishers attribute this to the large trawlers that

harvest vast quantities of fish from the deep sea, leaving fewer fish near the island. The practice of bottom trawling, in particular, poses a significant threat to the livelihoods of these small-scale, traditional fishers.

In the Sundarban, several species have experienced a noticeable decline. Among them, Amblypharyngodon mola, Gudusia chapra, Chanda nama, Chitala clitala, Macrobrachium lamarrei, etc have seen a significant population decline. Along with many other species, the catch of a highly demanded fish species Hilsa (Ilish) has declined over time, which is attributed to the excessive number of licensed fishing trawlers. Approximately 15,000 trawlers operate from the Ganga estuary to the Bay of Bengal, obstructing the Hilsa's migratory path during spawning and return (Bhaduri, 2020). Between 2002 and 2015, the number of fishing boats increased by 25%, while the catch of Hilsa declined by 13% (Das et. al., 2018). Between September 15 and October 24, Hilsa fishing is off-limits, with the restriction extending to five days before and after each full moon. Additionally, Hilsa under 23 cm in length cannot be sold, transported, or stored during this period. Despite a ban on nets with mesh holes smaller than 90 mm, such nets are frequently used, leading to the regular capture of a significant number of juvenile Hilsa. The fishing of juvenile Hilsa continues mainly in the absence of surveillance by the authorities. Additionally, hundreds of nets, each 1 to 2 km long, block the estuary's mouth. In this regard, A Govt official of Sagar Block narrated:

*"Juvenile Hilsa fishing is banned in India; fishers are only allowed to catch more than 500-gram size of fish using larger nets that do not catch fish smaller than 500 grams weight. Fishing with the Trawling method is prohibited as it destroys the ecosystem of the bottom of the sea. But still, many fishers practice this method. Sometimes they are caught by doing so and penalised by the authorities."*

### 6.2.2 Dry fish production

Drying marine fish is prevalent in coastal zones across India. In West Bengal, this practice is limited to the districts of 24 Parganas and Purba Medinipur. These dried fish have demand both in domestic and international markets and contribute significantly to employment opportunities for coastal communities. Fish drying is a seasonal livelihood activity on Sagar Island, with the peak period occurring from September to February. During the rest of the year, the activity is less common, particularly in the rainy seasons. Common fishes that are dried on the island are Tauri boi (Liza Persia), Rupapatia (Lepturacanthus Savala), Tapra (Opisthopterus Tardoore), Ruli (Coilia Dussumieri), Vola (Panna Microdon), Lahara (Harpadon Nehereus), etc.


Plate 6.12: a) Women are grading the fish by their size on the embankment of Sumatitinagar b) women collecting the dried fish near Gangasagar beach c) open-air sun-drying of fishes at Gangasagar. d) dried fish (final product) laid at Bankimnagar

Fish drying at Sagar Island typically takes place in the open sun on the coast, using plastic sheets, nets, mats made of palm leaves, or sometimes in the ground without any layers on it. The local community lacks access to advanced facilities for drying freshly caught fish, relying instead on traditional methods. This often involves spreading the fish out in the open air, which can be less efficient and more susceptible to weather conditions and contamination. To improve fish drying efficiency and safety, local communities can use alternative methods such as solar dryers, smoking, salting, electric dehydrators, and oven drying. These methods enhance the quality of the product and offer better protection against weather and contamination compared to traditional open-air drying.

While male members are engaged in fishing the female members sometimes the children are also engaged in the process of fish drying. They mostly stay in temporary houses built near the coast for the whole season of fish drying. Although they get to engage in some cash-earning activity they have to manage a low-quality life with very less household assets and facilities in these temporary houses. Another problem with this activity is seasonality which is the same with many other activities on the island.

Fish drying activity in some areas of the Island is facing a serious issue due to land erosion. Villagers of the East Coast (Sumatinagar, Bamkimnagar) have reported that this activity has declined significantly in their area as they have lost the lands upon which they used dry fish.

### 6.2.3 Crab collection

Crabs are prized treasures in both local and international markets. Their resilience allows them to endure long periods out of water at cooler temperatures, making them perfect candidates for live export and domestic sales. Many Crab collectors on Sagar Island have stated that they have noticed a decline in the availability of crabs over the years. Despite this downturn, the increasing market prices for crabs have provided a crucial financial incentive, encouraging them to continue this activity as a viable livelihood option. The higher prices have helped offset the reduced catch to some extent, making it still economically a feasible livelihood option for them to persist in their traditional occupation.

### 6.2.4 Shrimp fry (meen) collection

The collection of shrimp fry from rivers, creeks, and canals once served as a significant livelihood for the inhabitants of the island. However, this practice has experienced a notable decline over time. This decline can be attributed primarily to two factors: the reduced availability of shrimp fry in natural aquatic systems and the decreasing local demand for this resource. Nowadays shrimp collection does not even generate a minimum day wage. In this context, Laksmi Mondol narrated

*"By caching meen (shrimp fry) I could not even earn 150-200 rupees on most days. 15-20 years ago, that was not the case; one could have easily earned similar or even more than a day wage."*

### 6.2.5 Aquaculture

Both fresh water and brackish water aquaculture are present on the island. The freshwater aquaculture species cultivated on Sagar Island include Rohu (Ruhi), Catla (Katla), Pangasius (Pangash), Indian Tilapia (Telapiya), Butterfish (Rupchada), Mrigal (Mrigel), etc. Freshwater aquaculture on Sagar Island is traditionally practiced in small ponds within the household premises, predominantly for household consumption. In case of surplus that is sold in the local market. The island features numerous such ponds, with most households owning at least one. While some families possess two or more ponds, others do not have any. These ponds also serve multiple household functions, including washing utensils, bathing, etc. In addition to this,

freshwater aquaculture is practiced for commercial purposes in large ponds, which may be owned by individuals or a few families, as well as in land-shaping ponds primarily excavated for agricultural irrigation, and in low-lying, inundated paddy fields. The greatest threat to freshwater aquaculture on the island is coastal flooding, as these fish species are not tolerant to salinity changes and succumb rapidly. In recent years particularly at the time of cyclone Yaas cultivators have faced huge losses due to coastal floods. In this regard, Pintu Mondol grieved that:

*"Salinised water caused severe damage to aquaculture in our area. After the cyclone (Yaas) I found dead bodies of fishes here and there. The freshwater fishes I put on my pond were not there although some telapiya and other marine fishes were there in my pond."*

Brackish water aquaculture in Sagar Island is conducted within extensive artificial enclosures, known locally as 'Bheries,' which are mainly constructed in coastal swamp areas or low-lying areas using earthen dykes. Bheries are shallower than ponds and no official process of land conversion is needed to develop a Bheri from other types of land. After the destruction of Cyclone Aila in 2009, brackish water aquaculture has been adopted by many well-off individuals in Indian Sundarban. A large area of Sundarban was flooded by Aila which in turn salted thousands of acres of Agricultural land. The saltwater intrusion by flood generally depresses the productivity of the agricultural lands for a few years. The economically viable alternative is then to change the characteristics of the land from agricultural land to saltwater fisheries. The revenue from these fisheries is quite higher than agricultural revenue. These fisheries need saltwater supply over all the year. Pipelines or narrow canals are made connecting the nearest river to maintain the supply of saltwater.

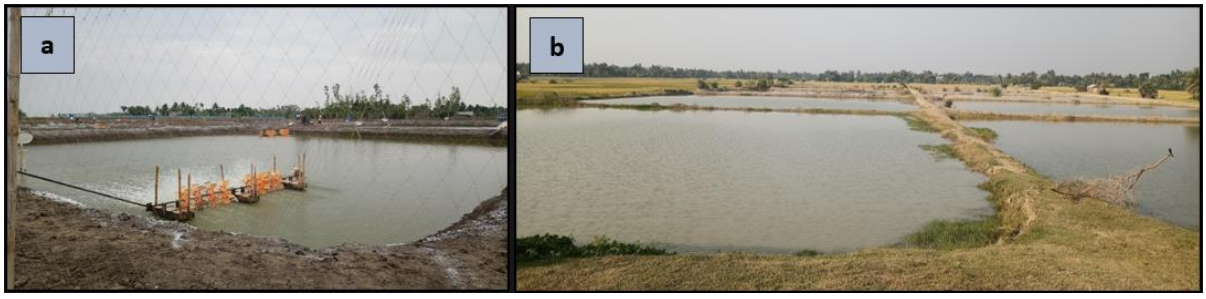


Plate 6.13: Brackish water bheries: (a) agricultural land transformed into bheries in Bankimnagar for shrimp cultivation (b) abandoned bheries in Gangasagar mouza after the prohibition by local authorities in 2021

Brackish water cultivation is highly regulated. The Coastal Aquaculture Authority (CAA) is now the primary body responsible for issuing licenses for brackish water aquaculture in India. Previously, the Marine Products Export Development Authority (MPEDA) handled this. The Marine Products Export Development Authority (MPEDA) granted licenses exclusively for the cultivation of Tiger Shrimp (Penaeus monodon) locally named Bagda Chingri. However, the current practice shows a significant decline in Tiger Shrimp farming, with most farmers shifting to the cultivation of White leg shrimp (Litopenaeus vannamei or Penaeus vannamei), locally known as Venami. This shift has occurred despite the absence of official licenses for Venami cultivation. Introduced to the island in 2013, Venami shrimp farming has largely supplanted Bagda shrimp due to its higher yield and higher profit in cultivation. However, it is important to note that Venami cultivation is associated with substantial environmental pollution. Shrimp cultivation on Sagar Island occurs biannually. In terms of scale, one lakh shrimp can be cultivated in a 2000 square kilometer area, requiring an investment of approximately 8-10 lakh INR for each season. Due to the need for high investment commercial fisheries are mainly owned by economically well-off individuals. Brackish water ecosystems experience significant losses due to coastal flooding. During such events, fish can easily escape from the bheries and Ponds. Additionally, the higher salinity of ocean water introduced during floods can lead to increased fish mortality. Like freshwater aquaculture brackish water Aquaculture was also severely impacted by Coastal floods during Cyclone Yaas. In this context, Probhat Giri narrated:

*"Fish worth crores of rupees were lost due to Cyclone Yaas, especially Dhablat, Benuban, Fuldubi, and Naraharipur mouzas bearing most the brunt of the damage."*

Another risk in shrimp cultivation is disease attacks, disease attacks lead to serious loss of farmers. After 2019 the profits of shrimp cultivators started declining due to lower selling prices which have become a cause of distress for the cultivators.

While many farmers practice Polyculture in freshwater ponds, the brackish water aquaculture on the island is predominantly monocultural. Polyculture offers a more sustainable alternative to monoculture by enabling the reutilization of waste products from one species by another. In the context of shrimp aquaculture, polyculture presents a viable solution to several longstanding issues, including environmental pollution, disease outbreaks (Fitzsimmons, 2001), and declining market prices. Integrating multiple species from various trophic levels with shrimp can mitigate these challenges. However, successful implementation of shrimp

polyculture requires a thorough understanding of the candidate species and the design of an appropriately structured culture system (Wang et. al., 2021).

Freshwater aquaculture presents a lower risk of disease outbreaks compared to brackish water aquaculture. However, it is more vulnerable to coastal flooding and saline water intrusion. In contrast, brackish water aquaculture, while having a higher risk of disease, offers a degree of protection against salinity intrusion. Nonetheless, severe floods can cause significant damage to both types of aquaculture systems, leaving neither unharmed.

The regulatory framework governing brackish water aquaculture requires significant clarification from local authorities. Currently, enforcement appears to be reactive, with restrictions only being imposed following complaints. This inconsistent application of regulations creates uncertainty for stakeholders. This selective restriction process creates ambiguity and hinders the development of brackish water aquaculture. Local authorities must establish clear, comprehensive guidelines to ensure equitable and effective measures. The Coastal Regulation Zone (CRZ) regulations aim to safeguard coastal ecosystems by imposing restrictions on environmentally harmful aquaculture practices in ecologically sensitive areas. These regulations mandate the adoption of sustainable practices to ensure the long-term health of these ecosystems. Local authorities and organizations, both governmental and non-governmental, can play a crucial role in promoting sustainable brackish water aquaculture practices on the island. This includes the use of eco-friendly feed, effective waste management, and the maintenance of biodiversity. By doing so, it might be possible to create a clear space for brackish water aquaculture.

### 6.2.6 Role of authorities and organisations in protecting the fishery sector

The fishery department of the state puts a complete ban period of 61 days for fishing of all species from April 15 to June 15 in the bay and surrounding areas every year. The enforcement of the ban is a strategic measure aimed at promoting the breeding of fish and conserving fish stocks within the marine ecosystem. During this period, the government extends financial assistance to registered fisher families, ensuring their livelihoods are supported while contributing to the sustainability of marine resources.

Block fishery department actively engages in providing ‘Matsyajibi Credit Cards’ to the fishers of the island. In the year 2022-2023, they provided 195 new cards. One of the main benefits of this card includes rupees two lakh life insurance. They also provided old-age fisher pensions to approximately 102 people in the same period. The Block Fishery Department has

implemented several initiatives aimed at supporting Tiger Shrimp cultivators and promoting alternative livelihoods among farmers and fishers. These initiatives include the distribution of essential inputs such as fish seed, potassium, and lime to enhance shrimp cultivation practices. Additionally, the department is facilitating the provision of e-rickshaws, either through direct distribution or partial financial assistance, to offer alternative livelihood opportunities. Furthermore, the government is supplying chicklings and ducklings to farmers and fishers, thereby encouraging diversification and resilience in their livelihoods. These measures collectively aim to bolster the economic stability and sustainability of the local communities engaged in aquaculture and agriculture.

Following the Yaas cyclone, the “Duare Tran” project was initiated to address the losses incurred in the aquaculture and fishing sectors. Applications were collected to document the damages sustained by aquaculture operations, fishing boats, and equipment, and these claims were verified through a systematic assessment process. Compensation was disbursed as follows: INR 5,000 for partial loss and INR 10,000 for complete loss in aquaculture; INR 5,000 for partial loss and INR 10,000 for complete loss of fishing boats; and INR 2,600 per fishing net lost. This structured approach aimed to provide financial relief to those affected, thereby supporting the recovery and sustainability of local livelihoods.

Despite the implementation of numerous programs and initiatives by authorities aimed at supporting fishers, the intended benefits often fail to reach the most vulnerable and needy individuals within this community. This discrepancy can be attributed to several factors, including bureaucratic inefficiencies, lack of awareness among fishers about available resources, and the socio-economic barriers that impede access to these benefits. Consequently, the effectiveness of these programs is significantly undermined, leaving many fishers without the necessary support to sustain their livelihoods. This issue necessitates a critical examination of the existing frameworks and the development of more inclusive and accessible mechanisms to ensure equitable distribution of resources.

Thirteen fishing cooperatives have been formed over time on the island in different areas that help fishers in several ways. These are listed in Table 6.2. These fishing cooperatives with a total membership of approximately 1300-1400 individuals, play a crucial role in facilitating access to government aid, information, and guidance. These cooperatives serve as vital conduits for resources and support, significantly enhancing the livelihoods of their members.

Table 6.2: Fishing cooperatives on Sagar Island

| | |
|---|---|
| 1. | Sagar Samudrik Matsyajibi Samabay Samity |
| 2. | Sagar Matsyajibi Marine Samabay Khuti Samity Ltd., Sagar |
| 3. | Dk. Sagar Maa Ganga Marine Samabay Khuti Samity Ltd. Beguakhali, Sagar |
| 4. | Chemaguri Baluchar Marine Samabay Khuti Samity Ltd. Chemaguri, Sagar |
| 5. | Sagar Sangam Marine Matsyajibi Khuti Samity ltd. Mahishamari, Sagar |
| 6. | Mahishamari hatipitia marine matsajibi khuti samabay samity Ltd, Mahishamari |
| 7. | Sagar Khal Tapoban Marine Matsyajibi Khuti samity Ltd. Prasadpur |
| 8. | Naraharipur Agradoot Marine Matsyajibi Khuti Samity Ltd. Naraharipur |
| 9. | Ban-Upokul Samudrik Marine Matsyajibi Khuti Samity Ltd. Mahishmari |
| 10. | Sagar Samudrik Mahila Matsyajibi Samabay Ltd. Khasrankar |
| 11. | Chakfuldubi Matsyajibi Samabay Samity Ltd. Chakfuldubi |
| 12. | Maa Bishalakshmi MatsyajibiSamabay Marine Khuti Samiti Ltd. Sumatinagar |
| 13. | Maa Ganga Matsyasikari Khuti Samiti Ltd. Sumatinagar |

*Source: Field survey*

However, a substantial segment of the population engaged in fishing and related activities remains outside these cooperatives, thereby facing considerable challenges in accessing similar benefits. The inclusion of these individuals into the existing cooperatives is imperative. By broadening the membership base, the cooperatives can ensure a more equitable distribution of resources and support. This inclusivity would not only enhance the overall resilience of the fishing community but also foster a more cohesive and sustainable approach to managing the fisheries sector. Furthermore, it would enable a more comprehensive representation of the community's needs and challenges, thereby facilitating more effective advocacy and policy-making. Therefore, it is recommended that concerted efforts be made to integrate all individuals involved in fishing and related activities into the cooperatives. This can be achieved through targeted outreach programs, awareness campaigns, and the simplification of membership procedures. Such measures would ensure that the benefits of cooperative membership are extended to all, thereby promoting a more inclusive and sustainable fishing industry.

### 6.3 Tourism, Transportation and Allied Activities

Growing economies worldwide are driving an increasing demand for tourism, transforming it into a lifestyle choice embraced across different cultures (Holden, 2016). While tourism is a

well-established industry, research in this field remains relatively small, new, and focused inwardly (Buckley, 2011). Tourism involves various service-based activities across different industries and consumer spending categories (Eadington and Redman, 1991). As a popular pilgrimage destination, Sagar Island experiences several economic activities providing services to tourists.

### 6.3.1 Tourist spots

The Kapil Muni Ashram in Gangasagar Mouza holds mythological significance to the believers of the Hindu religion. It is believed to be the place where Sage Kapil Muni, associated with Samkhya philosophy, built an ashram and stayed. Gangasagar holds mythological ties with stories of Lord Shiva, Devi Ganga, and King Sagor. This rich mythology has made Gangasagar the place for rituals, prayers, and spiritual activities. These rich mythological stories appeal to pilgrims and travelers. Keeping faith in mythology, lakhs, and lakhs of pilgrims from across India and some neighbouring states visit the ashram and take a dip in the holy water at the confluence of River Bhagirathi and the Bay of Bengal. The Gangasagar Beach also provides a scenic beauty to the tourists. Sagar Lighthouse at Beguakhali and the beach near this is another location that appeals to the tourists.

### 6.3.2 Major occasions for tourist visits

The most important event is the Gangasagar Mela, which is the biggest fair in West Bengal and one of the biggest in India, takes place pivoting the auspicious period of Makar Sankranti which generally falls either on the $14^{th}$ or $15^{th}$ of January. Lakhs of religious tourists from all over India visit the island for this occasion. Tourists also come from Nepal, Bhutan, and Bangladesh. Other important occasions boosting the island's religious tourism are Magh Purnima, Buddha Purnima, and ‘Sawan ka Mahina.’ Magh Purnima corresponds to the full moon day in the Bangla month of Magh, typically falls in either January or February, and it is another occasion around which tourists mostly residents of nearby districts come to visit Gangasagar. Buddha Purnima, commemorating the birth of the Siddhartha Gautam Buddha, falls either in April or May and is another event when tourists from the other parts of South 24 Parganas, north 24 Parganas, and other surrounding districts come to visit the Island. ‘Sawan ka Mahina,’ a Hindi term used to represent the reverence of the whole month of Sawan (Hindi) or Shravan in Bengali, which covers the end half of July and the first half of August is a sacred month to Hindu devotees who worship Lord Shiva. It is believed to be the favorite month of lord shiva. According to the Skanda Purana, Goddess Parvati’s rigorous fasting during this time led to her

union with Lord Shiva, further enhancing the month's significance. This month many Hindu devotees visit the island, particularly Hindi-speaking people from the states of Uttar Pradesh and Bihar.

### 6.3.3 Seasonal distribution of tourists

The quantity of tourists fluctuates around a year. No of tourists is maximum in December and January month due to the event Gangasagar Mela. The frequency of tourists decreases after the fair. In February and March still, there are significant tourists to keep the tourism-related businesses running at a good profit. Pivoting the occasions of Magh Purnima and Buddha Purnima there is still a significant number of tourists come to the island. In May, June, and the first half of July the frequency of tourists is very low. The month of Sawan or Shravan (the end half of July and the first half of August) is another time when there is a significant frequency of tourists is observed. These events peak the frequency of incoming visitors. A decade ago, 8-9 months of the year were almost without visitors making the tourism-related businesses seasonal. The pattern has also been changed. Now there are a decent number of tourists almost during the whole year. During the survey on June 2023, Bimal Das, engaged in the transportation business very joyfully said:

*"The number of tourists has surged in Gangasagar mela even all over the year. Now the business can go on for almost the whole year. A decade ago, that was not the case, we could only make money for 3-4 months. And if we talk about the condition of two decades ago very less tourists were there compared to now; mainly at the time of Ganga Sagar Mela, other events were not even considerable. We used to actively work for only 60-70 days in a year."*

### 6.3.4 Growth in the number of tourists

The number of tourists is increasing over time on the island. Approximately 65 lakh pilgrims from across India visited Sagar Island to take a sacred dip at the confluence of the Ganga River and the Bay of Bengal during the Ganga Sagar Mela (Singh, 2024). According to a report 'Anandabazar Patrika' the number was 51 lakhs (Priyankar, 2023). A report by 'The Indian Express' (2018) says that the state govt has claimed the number of tourists in 2018 was more than 20 lakhs. The report also says this number was around 15 lakhs in 2017. In 2008 5 lakhs tourists visited the Gangasagar Mela as reported in 'The Statesman' (Law, 2008) and in 2007 the number of tourists was 3 lakhs as reported in 'The Telegraph' (Chattopadhyay, 2007).

Table 6.3: Frequency of tourists visiting Gangasagar Mela

| Year | No. of tourists at Gangasagar mela | Claimed by (as mentioned in the source) | Source |
|---|---|---|---|
| 2024 | 65 lakhs | Arup Biswas (Minister for Sports and Youth Affairs, Power, and Housing in the Govt. of W. B.) | The Hindu (2024, January 15) |
| 2023 | 51 lakhs | Arup Biswas (Minister for Sports and Youth Affairs, Power, and Housing in the Govt. of W. B.) | Anandabazar Patrika (2023 January 16) |
| 2018 | 20 lakhs | Govt. of West Bengal | The Indian Express, (2018, January 14) |
| 2017 | 15 lakhs | Govt. of West Bengal | The Indian Express, (2018, January 14) |
| 2008 | 5 lakhs | Govt. of West Bengal | The Statesman (2008 January 15) |
| 2007 | 3 lakhs | South 24 Parganas District officials | The Telegraph (2007 January 15) |

During the survey, local people of the island particularly those who are engaged in tourism and allied activity also reported the rising potential of the tourism sector. After the lockdown phase of COVID-19, there has been a significant surge in the number of tourists coming to Gangasagar Mela. In this context, Dhiman Maity an automobile driver working in the transport sector mentioned:

*"There is a 70-80 percent increase in the number of tourists in Ganga Sagar Mela in the year just after the lockdown phase (2023) compared to the year before the lockdown phase (2020)."*

Along with Gangasagar Mela, the number of tourists is rising on other religious occasions also. Tourism in Sagar Island is becoming more regular from only being a seasonal sector. Tourists have been present throughout the year in recent times. As Basudeb Mondol dictated:

*"20-25 years ago exempt from Gangasagar Mela there were no tourists for the rest of the year. There were not any countable tourists on other occasions like Budhha Purnima, Magh Purnima, or other festivals."*

### 6.3.5 Transportation

The transportation sector in Sagar Island is greatly dependent on tourist inflow. To understand the characteristics, patterns, and trends of this sector mainly group discussion and interview methods of data collection were adopted. Interviews and group discussions with people who are engaged in this sector were conducted in June 2023. Questions regarding their engagement and income, seasonal fluctuations, and temporal change in the sector were asked. To understand the current employment scenario in transportation services, the number of different types of vehicles is identified along with their ownership status and type of service. Although the exact no of different vehicles is not found some approximate numbers have been figured out by interviewing several persons engaged in the sector. Buses, four-row Microvans, SUVs, Auto-rikshaws, and E-rikshaws provide transport services to tourists. Mostly the owner of these vehicles is the driver himself sometimes the driver is hired as a salaried worker by the owner. Both the owners and drivers of these vehicles are mostly residents of the Island. There are the main two types of transport systems of motor vehicles in Sagar Island: (i) Reserved and (ii) Shared.

#### 6.3.5.1 Reserved transportation

SUVs, Microvans are used as reserve vehicles that carry around 8 tourists mostly coming from other states to visit Gangasagar. The local people of Sagar Island do not use these reserve vehicles for their usual journeys. Only in case of urgency like medical purposes sometimes they use these vehicles. They pick up passengers from Kachuberia Ghat and take them to Kapil Muni Ashram. The vehicles generally wait there for two to two and half hours and again pick up the same passengers to return them near Kachuberia ghat. Some vehicles also do trips from Benuban. Generally, the fare for non-AC SUVs and microvans ranges between 1500-1800, and AC SUVs are around 2400 for the full trip. But at the time of Gangasagar Mela, they charge higher, up to 5000 rupees.

On June 2023 the total no of service providing vehicles to the tourists was 450-500. In 2008 the total no was around 40 comprised of ambassador taxis (Subcompact Sedan) and SUVs. 2009 microvans were introduced on the island for transportation. In 2015, the number of vehicles became 450-500. Before the cyclone Yaas (2021) number of vehicles surged to 700-750. Cyclone Yaas has caused a heavy amount of water surge in the Kachuberia mouza that has damaged most of the reserve cars that were garaged at the Kachuberia stand. The good thing is no car has been flooded away in the river. To repair the damaged cars an average of 40000-45000 rs was spent. One vehicle owner Subhash Maiti stated:

*"Just after the cyclone passed, I went to see my vehicle at the Gass pump station (near Kachuberia ferry ghat) and saw that my car was half submerged in water. I had to spend 55 thousand rupees to repair it."*

Many of the owners had not been able to spend that much amount. After the cyclone Yaas lockdown also impacted the sector severely. There was no income due to the shutdown of transportation services. Due to this issue, many owners sold their vehicles and shifted to other occupations. Among them, some have bought e-rickshaws and now work as a driver of their e-rickshaws. Many migrated out for employment and worked as a salaried driver in other states. Among them some are still working as a migrant some have returned. In this context, Ashoke Jana narrated:

*"My vehicle has been damaged in the flood. Estimated Repairment cost was huge. So, I sold that. Then, worked in Kerala for one year. Now I work as a driver in another person's vehicle"*

The total number of vehicles has decreased to around 470 in 2021. Last year (June 2022- June 2023) only 7 new vehicles were added to be reserved private cars. In the context of carrying capacity, while this total number of vehicles is less for peak seasons (November end to March), it is higher than needed for the off-seasons (rest of the month). A reserve vehicle has the potential to make 2-3 trips in a day. But it does not happen except for the time ranging from the end of November to mid-February. So, the private reserve vehicle union follows the serial no system. According to the serial no system, one vehicle makes 1 trip per two days. To be more precise one vehicle makes 17-18 trips per month on average in the rest of the 8 months. Thus, some of the owners have two vehicles or more to get a higher income by at least getting 1 trip every day per two vehicles. One single driver drives two vehicles on different schedules. But in the last week of November, the owners hire one driver per vehicle. Which creates seasonal employment in the sector. This continues until mid-February. In this period one car

makes two trips per day on average. The tourist density is increasing in the off-seasons also as we have discussed earlier. Although the sharp inequality of tourist frequency between Gangasagar Mela season and the rest of the year has decreased it has not still solved the issue of over-employed vehicles in the off-seasons. However, employment in this sector has increased over time. The total no of drivers working as main workers is around 400 in 2023. The number is significantly higher than compared to 10-12 years ago. In this context, Narayan Debnath said:

*"A few years ago, I used to work here for 3-4 months a year, and the rest of the time I worked in other states. Now I have become a full-time driver here……. Many like me became full-time drivers."*

The no of drivers driving two vehicles is around 75. The rest of the drivers are self-owners. The number of self-owner-drivers is around 300. A salaried driver gets around 9000 rupees per month. If the owner of the car is the driver himself then his average earning is 20000-25000 per month.

Looking at the economic opportunity of the growing number of tourists many inhabitants are shifting from traditional economic activities like agriculture and fishing to tourism-related businesses. In this context, Bikash Giri shared his career journey:

*"After making losses in agriculture for two years consecutively, I joined the transportation business in 2011……. I have two tata sumo cars now. Tourists are increasing. I am thinking of buying one more vehicle after this Durga puja and involving my younger brother also."*

#### 6.3.5.2 Shared transportation

Buses, Microvans, SUVs, Auto-rikshaws, and E-rikshaws are vehicles that serve in shared mode. In June 2023 the total no of Buses, Microvans, and Auto-rikshaws that serve in shared mode was around 300 on the island. Among them, the total no of buses was 17. In 2015 the number was around 28. The number decreased to 5 in 2021. The rise in smaller vehicles has caused the buses to run at a loss. Local people started to use smaller vehicles as the waiting time was less than buses. After the lockdown, the growing number of tourists has revived many of the shutdown buses. The number increased to 17 on June 2023. Only 3 auto-rikshaws were there before the lockdown. On June 2023 the number raised to around 100. The no of Microvans and SUVs was around 180 in June 2023.

The e-rickshaws serve both tourists and local passengers. E-rikshaws have provided an alternative way of livelihood to many local job seekers. Before 2020 there were very few E-rikshaws. In 2013 only around 50 E-rikshaws were there on the Island. After the lockdown phases in 2022, the number increased significantly. Two e-rickshaw factories were built on the island that served the demand for e-rickshaws. Many people started serving in the transportation sector as buying and maintenance costs were cheaper for E-rikshaws than Auto-rikshaws or other vehicles. In June 2023, there are more than 2000 E-rikshaws on Sagar Island. The no of e-rickshaws has grown suddenly. The sudden rise has made this work saturated. It shows that people are desperate for their livelihood, wherever they see an opportunity they try to fit in that. In this context, Pijush Debnath shared:

*"I used to be a daily labour in 'Pan Borojs.' Amphan and Yaas had destroyed many Borojs, there was no work. I took a loan from a group (Self-help Group) and bought a 'Toto' (Local name of E-rikshaw) …… Now I am earning better than that."*

People who engaged early in e-rickshaw transport service are complaining that there has been a surge of e-rickshaw drivers within one year that has led to a decrease in earnings. In this context, Dilip Mondol said:

*"One year ago, I used to earn 700-800 rupees a day on average. Now the count of e-rikshaws has become more than needed. So, the earnings have gone down. Now I earn 400-500 rupees per day."*

Many have said that working in transportation services is better than working in the agricultural sector. Regarding this Gourav Das narrated:

*"Firstly, there is not much profit in agriculture, then, there is the risk of bad weather and hazards. It is better doing this work"*

Many respondents have expressed that profitability is higher in driving e-rikshaws than cultivating or working as a daily labourer in the local area. Given this, Badal Guha stated:

*"Earning 250 per day is also better than cultivating or working as a daily labour. There is very little availability of work in a year (as daily labour). At least I earn most of the days now by driving an e-rikshaw."*

It is observed that people have shifted to this sector from traditional sectors.

#### 6.3.5.3 Ancillary works in transportation

With the increase in vehicles number of mechanics has also increased. To understand the scenario of this work three vehicle mechanics were interviewed during the survey period. There were only 6 motor vehicle repair shops in 2015 which has increased to 10 in 2023. All of them migrated for employment outside the island and engaged as a salaried worker in motor vehicle repair shops. After gaining experience they decided to return home (Sagar Island) and start their own business. All of them opinionated that this work would flourish on the island if the number of vehicles increases and the trend of tourists increasing continues. In this regard, Manas Manna, an automobile mechanic stated:

*"The demand for repairing work is increasing with time. My income has risen to 20,000 per month in 2023 from 15,000 per month in 2019……. I used to work at a mechanic shop in Kolkata. After learning the work, I started my shop here."*

These are examples of return migration where migration has benefitted the local economy differently other than just providing remittances.

There are only two petrol pumps on the island one at the north (near Kachuberia ferry ghat) and another at the south (near Gangasagar bus stand). Observing this scarcity many shops along the main road, and other important roads have started selling Petroleum in plastic bottles as a product.

Focus Group discussions with motorcycle mechanics also reveal that the motorcycle repair business has also been proven to be a good income-generating business. The number of motorcycle mechanics also increased with time. In 2013 only 10 motorcycle mechanics were there on the island all of them were situated along the main road (Kachuberia-Rudranagar-Gangasagar road). On June 2023 an estimated 80 motorcycle mechanics were there on the island among them 30 were along the main road and 50 were in other locations.

Discussions with four 'three-wheeler open loader van' (Locally called 'Bhotbhoti') drivers disclose that in June 2023 an estimated one hundred people are driving these vehicles to provide service of goods delivery within the island. While the number was only four or five a decade ago. They also shared that they are generating better income than their previous work. All of them have more than 11000 rupees average monthly Income.

### 6.3.6 Accommodation and food & beverage industry

The way transportation industry has grown looking at the opportunity of tourism, other industries like the food and beverage industry, and the accommodation industry did not grow much on the island. One reason behind this is most tourists do not spend the night on the island; they enter in the morning and exit in the evening. Persuading tourists to stay more days will provide these industries huge opportunity to grow.

The accommodation facilities for tourists are mainly present at Gangasagar mouza surrounding the Kapil Muni Ashram. The food and beverage services are also mainly around the Ashram. Other than that, tourists also avail of this service from local shops and stalls for food and beverages present at other nodal points like Kachuberia and Benuban Ferry Ghat. The supply side of food and beverages is comprehensively lower than the tourist demand. Discussions with tourists have provided the understanding that the variety of food and beverages is very low. Many tourists were seriously complaining about the availability of evening snacks at Gangasagar. Providing satisfactory food and beverage supply could easily enhance the tourist's experiences. There is a huge scope for business in the food and beverage industry pivoting around tourism. Local authorities could play a role in informing local people about this gap and try to manage this industry to provide necessary services to tourists. Tourist satisfaction will lead to an increase in the spent days and the possibility of revisits.

### 6.3.7 Potentiality of the tourism sector to generate employment

Globally Tourism is an emerging sector and it has the potential to create notable employment opportunities. Before the COVID-19 pandemic, the Travel & Tourism sector was at its peak, contributing 10.4% to the global GDP (World Travel & Tourism Council, 2019). However, due to the pandemic's impact, its share in GDP dropped to 7.6% in 2022 and rose to 9.2% in 2023 (World Travel & Tourism Council, 2023). In 2019, the travel and tourism sector contributed 10.1% to total employment and by 2033, the travel and tourism sector is expected to create 207,496,000 new jobs, representing 13.4% of total employment, with an annual growth rate of 3.2% from 2023 (World Travel & Tourism Council, 2023).

The economic benefits of coastal tourism are well-recognized, with financial investment and profit being the most tangible aspects (Ghosh, 2012). The number of tourists is booming on the island. This rapid increase in tourist arrivals on the island presents a unique economic opportunity. However, to fully capitalise on this potential, it is crucial to implement effective planning and management strategies. To enhance the tourism sector in Sagar Island a study by

Hajra and Ghosh (2021) has suggested that significant focus should be placed on infrastructure development, environmental crisis management, tourist satisfaction, and promotion. By carefully coordinating infrastructure development, environmental conservation, and visitor experiences, the island can achieve economic gains.

Sagar Island already has a mythological significance and popularity among religious tourists of the Hindu religion. But they only visit Kapil Muni Ashram and Gangasagar beach. Some also visit the Beguakhali lighthouse and beach. Only Gangasagar remains the prime spot for tourist destinations. The authorities have established rudimentary infrastructure for Beguakhali Beach as a scenic destination, but it remains insufficient to elevate it to a prominent tourist spot. Further development and promotion are necessary.

Coasts, with their unique features, attract tourists by offering diverse experiences through the combination of sun, sea, and sand (Ghosh, 2011). The unique ecosystem of Sagar Island is characterized by resource combination at the interface of land and sea offering beaches and scenic beauty (Hajra and Ghosh, 2014). Developing more locations as tourist spots may persuade religious tourists to stay more days and visit those places. That will distribute the economic gain to other areas of the island. For Example, there are places like Chandipur Beach and Sagar Beach that have captivating natural scenic beauty that has the potential to become destinations for eco-tourism. Developing these lesser-known locations could broaden the scope of tourism beyond religious pilgrimage, fostering nature-based tourism as well. Although having scenic beauty these places are lacking in good transportation network, availability of drinking water, and other facilities around these spots. By providing these facilities these spots can be developed as scenic tourist spots which are lacking in Sagar Island.

To develop and popularise these less-known places putting attractive posters of these spots on roads via which tourists come to visit Gangasagar and the Surrounding Kapil Muni Ashram will persuade many among the lakhs and lakhs of visitors who already come to the island to visit Gangasagar. To promote tourism and attract new visitors who may not be aware of the island's beauty and significance, developing an attractive website and running social media campaigns could be a good option in this digital era.

Collaboration among local government bodies, tourism authorities, and environmental agencies is essential to develop a cohesive strategic plan for beach tourism. This plan should align the objectives of all participating organizations and facilitate seamless coordination. By

working collectively, they can improve beach management practices and promote sustainable tourism.

Promoting tourism can significantly strengthen the island's economy by generating livelihoods and employment opportunities for its residents, especially those facing challenges in traditional sectors like agriculture and fishing. Furthermore, diversifying tourism across various locations on the island will ensure a more equitable distribution of the benefits derived from this industry.

### 6.4 Other Livelihoods

Casual or daily labour jobs in betel vines, paddy fields, embankment construction, and pond digging which were very common in the island are also decreasing with time. Nowadays casual or daily labourers in the local area struggle to find work for a sufficient number of days each year. This issue is primarily due to population growth and a decline in traditional activities such as agriculture. Additionally, the mechanization of labour-intensive tasks, such as pond digging and embankment construction, has significantly reduced the availability of jobs for casual labourers. Tasks that were once performed manually are now often completed using machinery like JCBs and tractors, further diminishing job opportunities for these workers. Therefore, they are moving outside the Island in search of jobs.

Before the COVID-19 lockdown, most businesses and shops were concentrated along the main road (Kachuberia-Rudranagar-Gangasagar road) and key locations such as Rudranagar, Kalibazar, Kachuberia, and Chemaguri. However, during the lockdown, restrictions in these main areas led to the opening of new shops in less prominent parts of the island. Unfortunately, these new establishments do not necessarily generate substantial income. In many cases, the income is quite low, and the number of shops and services exceeds demand, resulting in disguised unemployment. Many such shopkeepers have out-migrated due to less income while female members or older members of the households are running these low-income shops. Many of these shopkeepers have chosen to migrate outside the island due to insufficient income, leaving female and older household members to manage these low-income generating shops.

# CHAPTER 7: MIGRATION FROM SAGAR ISLAND

Humans have frequently migrated to new locations throughout history as a means of adapting to changing environmental conditions and natural calamities (Black, 2001). Migration is a complex phenomenon, directed by many factors rather than a single controlling factor. Migration is being used as an important strategy to reduce vulnerability to environmental, economic, social, and political pressures through diversification of livelihood (ICIMOD, 2011). Major push factors that contribute to migration include poverty, population increase, landlessness, unemployment, chronic illnesses, etc. (Myers, 2002). Apart from push factors, pull factors also play an important role in attracting migrants. The destination area may have higher employment opportunities, wage rates, better amenities, better education, more peaceful and less vulnerable environment. So, migration should be investigated in a holistic approach by looking at both push factors from the source and pull factors at the destinations.

In the Indian Sundarban Delta migration is a noticeable strategy to get livelihood or employment opportunities (Mistri, 2019). A household survey study on Satjelia Island by Mistri (2013) found that in three-fourths of the households, at least one member migrates out from ISD for employment. Climate change and erosion have impacted the economy of the Indian Sundarban Delta which is associated with outmigration (Hajra and Ghosh, 2016).

### 7.1 Snapshot of Field Investigation

Here migration for livelihood or employment is the only focus of the study. Other purposes like study, marriage, travel, etc are not recorded during the survey. Any adult member of a household is considered to be a respondent among those who were available at the time of the survey. Information on the migrant members is collected from present members of the household. A person is considered a migrant only if he has moved outside the island to earn or make a livelihood. A household is considered a migrated household only if at least one member of the family has migrated for livelihood/job/employment within the last 365 days from the date of the household survey (April-May 2023). There were many cases where people migrated before and returned but within the last year, no member has been migrated or present at the destination. Those households were not counted as migrated households in samples of household surveys.

If all the members of a household are permanently migrated those are not included in household surveys. Although some information regarding their migration has been traced through neighbouring households.

If the whole household is migrated and not present on the island at the time of survey that household is not included in the household survey. Although some information has been collected from neighbouring households about their migration through special interviews. During the survey, there were many encounters with such cases. For example, a family from Sumatinagar mouza has been working in Kerala for two years after the destruction of cyclone Yaas. Ramesh Mondol a neighbour explains.

*"They were already dealing with poverty. Cyclone Amphan completely damaged their betel vines. So, they took a huge amount of loan to rebuild their vines but unluckily in the next year cyclone Yaas again hit our area; their vines were again destroyed. So, they have been forced to migrate for livelihood and to repay the loan."*

The majority of the migrants are male. Female migration for employment is much less from the island. There are cases of female migration where both husband and wife migrate together for earning. In those cases, both males and females work in the same workplaces or close locations. In some cases, females moved along with their husbands but only male members were mainly engaged in economic activities. In those cases, the male member is earning more than 30,000 per month. Although there are few cases where only a female member of a household is migrated. Four cases were found among 480 households where only a female member migrated.

Table 7.1: Sample size for the household survey

| Category | Migrants | Non-migrants | Total |
|---|---|---|---|
| Sample | 167 | 313 | 480 |
| Sex | 9 females; 158 males | 11 females; 302 males | 20 females; 460 males |

*Source: Primary data (household survey, 2023)*

In the case of migrated households, detailed information has been recorded for the individual with the highest income. Similarly, for non-migrated households, only one person's detailed information has been noted, specifically the individual with the highest income in the

household. Among 167 migrated households there were 32 households where more than one member migrated.

### 7.2 Destinations of the Migrants

Table 7.2 and Figure 7.1 represent the types of out-migration based on the administrative boundaries to which the inhabitants of Sagar Island have relocated for employment. Interstate migration from the island is dominant. 82.03 migrants have moved to other states of India. Only four (2.39%) of the 167 migrants have moved outside the country. Two of them have moved to Dubai (United Arab Emirates) and the other two have moved to Malaysia. All four of them are working as construction workers. Five members (2.99%) have migrated within the districts. Two of them have moved to Kakdwip, one to Diamond Harbour, one to Jaynagar, and one to Namkhana. 12.57% of the total migrants have migrated to the other districts of West Bengal.

Table 7.2: Category of migrants based on administrative boundaries

| Streams | Number migrated households | Percentage of migrated households |
|---|---|---|
| Intradistrict | 5 | 2.99 |
| Interdistrict | 21 | 12.57 |
| Interstate | 137 | 82.03 |
| International | 4 | 2.39 |
| Total | 167 | 100 |

*Source: Primary data (household survey)*

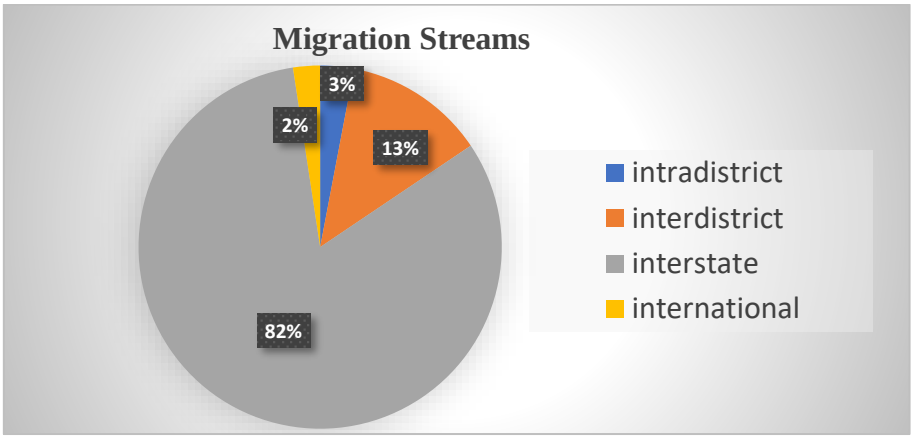


Figure 7.1: Proportion of migrants based on administrative boundaries.

*Source: Primary data (household survey)*

The proportion of inter-district migrants is shown in Figure 7.2. Kolkata is the preferred interdistrict destination for migrants followed by Bardhaman and South 24 Parganas.

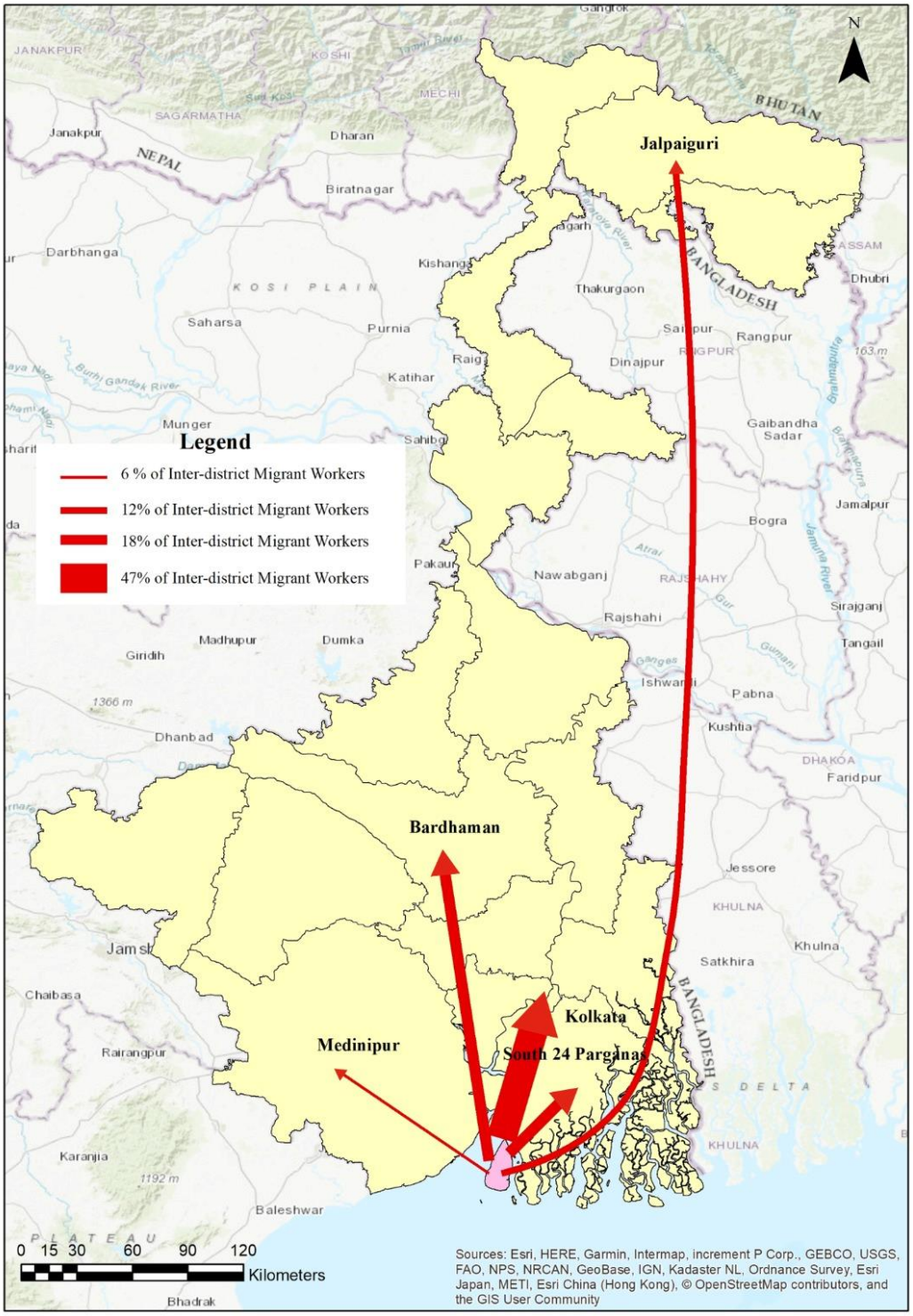


Figure 7.2: Destinations of inter-district migrants

*Source: Primary data (household survey)*

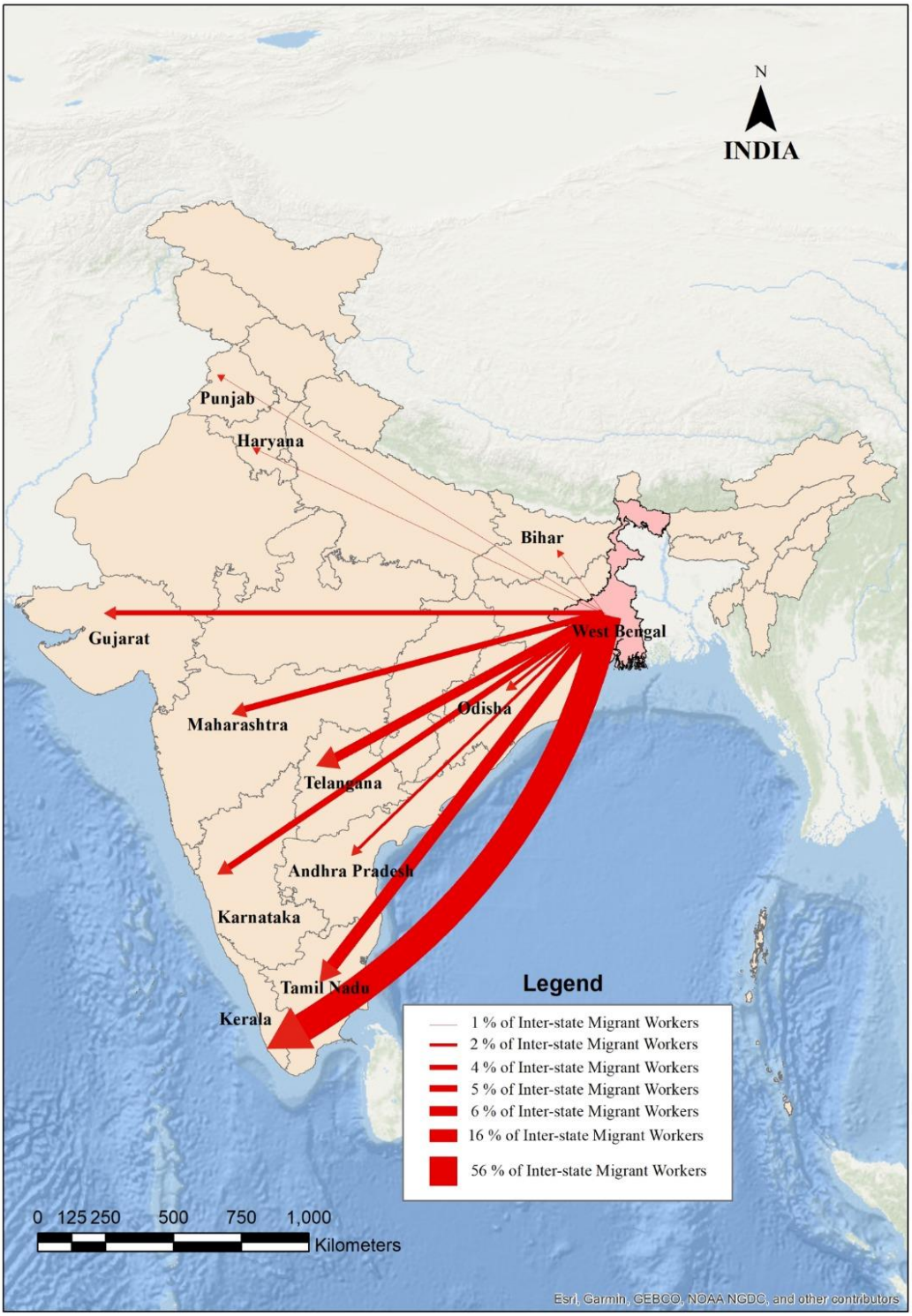


Figure 7.3: Destinations of inter-state migrants

*Source: Primary data (household survey)*

Within interstate migration (see Figure 7.3 and 7.4) as a preferred destination Kerala stands out with the highest number of migrants—77 individuals, constituting a significant 56.20% of the

total migrants in the dataset. Tamil Nadu follows closely with 14 migrants (10.22%), while Telangana has 13 migrants (9.49%). Andhra Pradesh accounts for 8 migrants (5.84%), Karnataka for 7 (5.11%), Maharashtra for 5 (3.65%), and Gujarat for 4 (2.92%). Additionally, other states collectively contribute 9 migrants, making up 6.57% of the total.

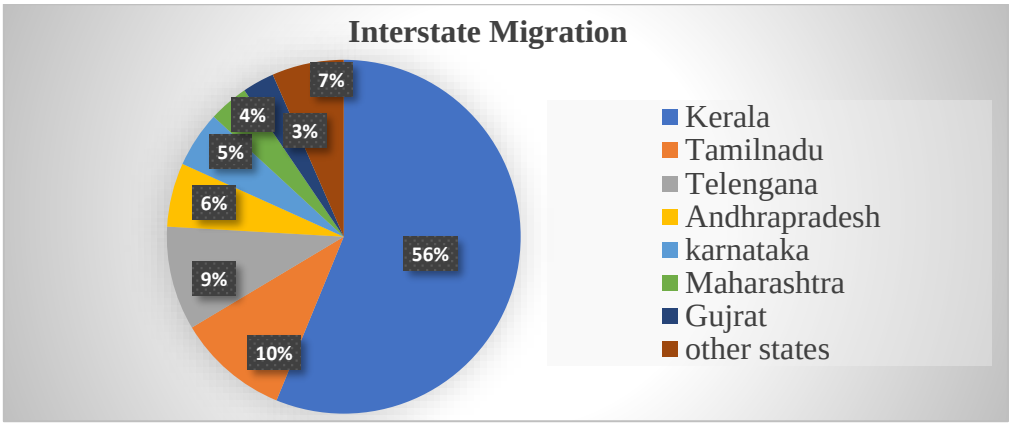


Figure 7.4: State-wise share of interstate migrants

*Source: Primary data (household survey)*

### 7.3 Occupation Before and After Migration

Table 7.3: Work engagement before and after migration

| | | **Work engagement at the destination** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **code** | **a** | **b** | **c** | **d** | **e** | **f** | **G** | **h** | **i** | **Total** |
| **Work engagement at Sagar Island** | **a** | 7 | 0 | 13 | 44 | 7 | 5 | 1 | 2 | 0 | 79 |
| | **b** | 1 | 2 | 4 | 17 | 6 | 2 | 0 | 0 | 0 | 32 |
| | **c** | 1 | 0 | 5 | 13 | 6 | 2 | 0 | 0 | 0 | 27 |
| | **d** | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| | **f** | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 2 |
| | **g** | 0 | 0 | 1 | 1 | 0 | 3 | 0 | 0 | 0 | 5 |
| | **h** | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 3 | 0 | 6 |
| | **i** | 0 | 0 | 3 | 9 | 1 | 1 | 0 | 0 | 0 | 14 |
| | **Total** | 9 | 2 | 26 | 88 | 21 | 15 | 1 | 5 | 0 | 167 |

***Code:*** *a. agriculture/aquaculture; b. fishing; c. daily/casual labour; d. construction worker; e. manufacturing worker; f. regular wage/salary earner; g. business/self-employed; h. transport &communication; i. non worker*

*Source: Primary data (household survey)*

Table 7.3 shows the work engagement of migrants before and after migration in detail. The findings from household surveys of the migrants suggest that a major portion of migrants, 47.3%, were previously engaged in agriculture or aquaculture, highlighting the vulnerability of these sectors in their livelihoods. Among this 47.3% (79 migrants) 76 migrants were mainly engaged in agriculture. Fishing was the second most vulnerable occupation, accounting for 19.2% of the migrants. Daily or casual labourers made up 16.2%, while 8.4% were non-workers before migrating. A smaller percentage 3.6%, were engaged in transport and communication, and the rest 5.4% were involved in other occupations. This underscores that most of the migrants were from the occupational backgrounds of natural resource-dependent activities.

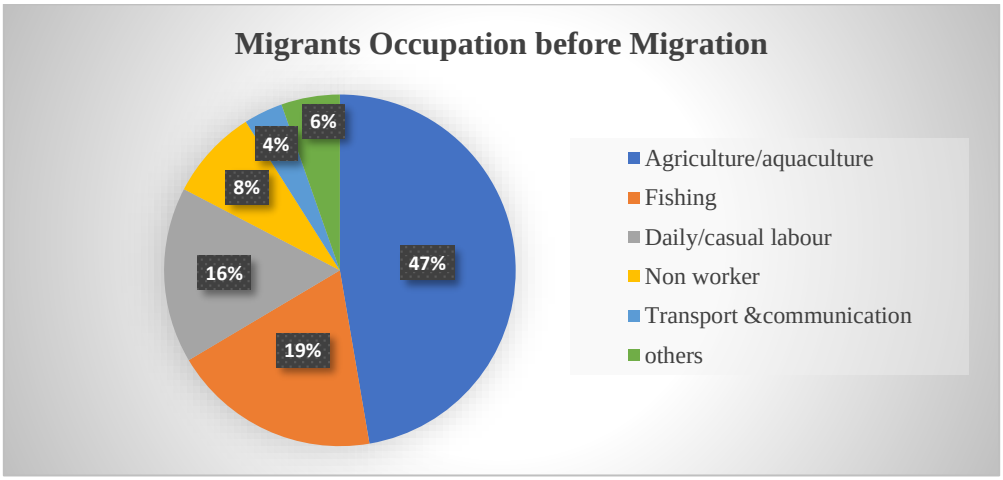


Figure 7.5: Migrants occupation at Sagar Island before migration

*Source: Primary data (household survey)*

Within 167 samples the majority of migrants, 52.7%, are engaged as construction workers at destinations, making it the most common occupation among them. Daily or casual labour is the second most adopted occupation at 15.6%, followed by manufacturing jobs at 12.6%. Regular wage or salary earners make up 9% of the migrant population, while those involved in agriculture/aquaculture represent 5.4%. Transport and communication jobs account for 3% of migrant occupations, fishing for 1.2%, and business or self-employment is the least common at only 0.6%. This data represents the diversity of employment distribution among migrants at their destination.

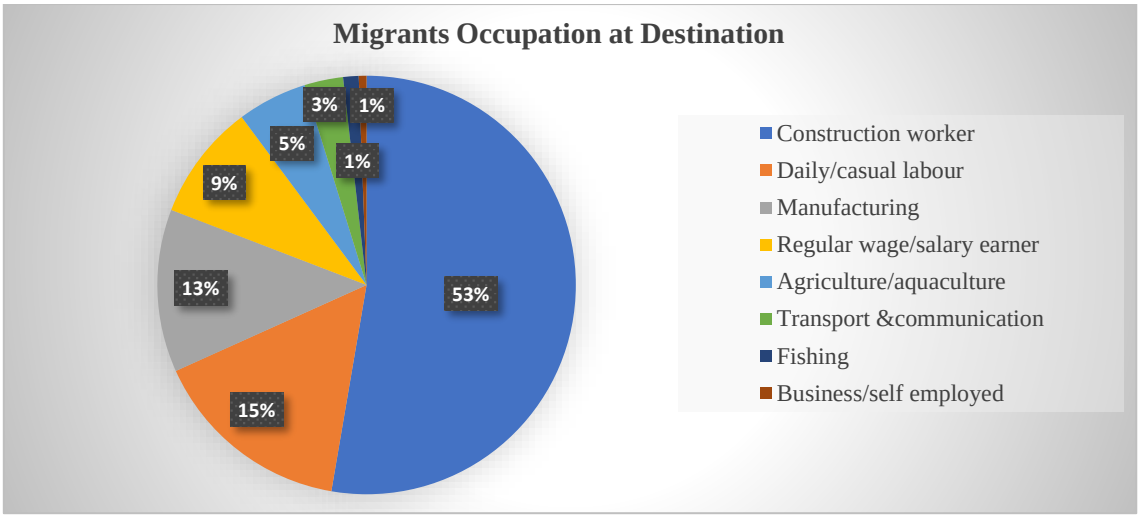


Figure 7.6: Migrants occupation at destination after migration.

*Source: Primary data (household survey)*

### 7.4 Reason for Migration

As discussed in the previous chapter the natural resource-based livelihoods have been declining over time people are forced to move outside the island to generate income. People's perception, network, knowledge, and experience about a destination play a vital role in preferring that place as a destination for migration. A destination can be chosen by accounting for multiple factors. To simplify the understanding of why migrants, choose a particular destination, Table 7.4 presents the preferred pull factors based on their views, considering only one factor among several. For intradistrict migration presence of Friends/Family members/Relatives is a preferred pull factor. Respondents have also mentioned the proximity as another important factor.

42.9% of the interdistrict migrants have chosen the destination primarily based on Higher wage rate/earning. 19% preferred the destination based on timely payment. Within the 137 samples of interstate migrants, 55% have marked higher wage rates/earnings as the primary reason for migrating to the destination. 31.4 % of interstate migrants chose the destination mainly based on greater job opportunities.

Table 7.4: Primary factors towards selecting the destination

| | Intra-district | | Interdistrict | | Interstate | | International | |
|---|---|---|---|---|---|---|---|---|
| Pull factors | N | Percent | N | Percent | N | Percent | N | Percent |
| Greater job opportunities (more choices of work, maximum no of employed days in a period) | 0 | 0.0 | 2 | 9.5 | 43 | 31.4 | 0 | 0 |
| Higher wage rate/earning | 1 | 20.0 | 9 | 42.9 | 76 | 55.5 | 4 | 100 |
| Timely payment | 0 | 0.0 | 4 | 19 | 9 | 6.6 | 0 | 0 |
| Better living conditions and other facilities | 0 | 0.0 | 1 | 4.8 | 6 | 4.4 | 0 | 0 |
| Friends/family members/relatives shifted before | 3 | 60.0 | 2 | 9.5 | 3 | 2.2 | 0 | 0 |
| Higher scope of business | 0 | 0.0 | 2 | 9.5 | 0 | 0 | 0 | 0 |
| Others | 1 | 20.0 | 1 | 4.8 | 0 | 0 | 0 | 0 |
| Total | 5 | 100 | 21 | 100 | 137 | 100 | 4 | 100 |

*Source: Primary data (household survey)*

Table 7.5: Primary factors to migrate out from the Island

| Push factors | Number of migrants | Percentage |
|---|---|---|
| Loss or less profit in occupation/lower wage | 77 | 46.11 |
| Seasonal work/lesser job opportunities | 70 | 41.92 |
| Payment issues | 18 | 10.78 |
| Other | 2 | 1.20 |
| Total | 167 | 100 |

*Source: primary data (household survey)*

Table 7.5 provides a detailed breakdown of the primary push factors driving migration among the 167 individuals. The data reveals that the most significant factor is economic instability, with 46% of migrants citing 'loss or less profit in occupation/lower wage' as their primary reason for relocating. This highlights the critical impact of financial insecurity on migration decisions. Seasonal work and limited job opportunities are the second most significant factors, accounting for 42% of the migration. This suggests that the lack of stable, year-round employment is a substantial driver of migration, likely pushing individuals to seek more consistent work elsewhere. Payment issues, such as delayed or insufficient wages, contribute to 11% of the migration. This indicates that even when jobs are available, the reliability and adequacy of compensation are crucial concerns for workers. Lastly, a small percentage (1%) of migrants cited other reasons for their relocation, which include a variety of personal or situational factors not captured by the primary categories.

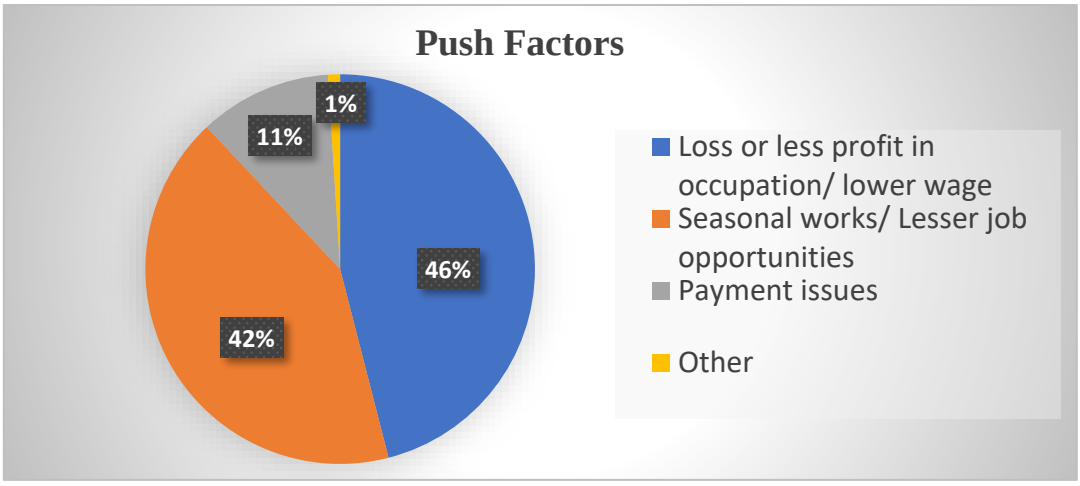


Figure 7.7: Primary factors to migrate out from the Island

*Source: Primary data (household survey)*

These numbers only present a simple view of push and pull factors. To deeply understand the reasons behind migration qualitative perspective is also needed. Analysis of the contents stated/narrated by the migrants during the open-ended discussion has provided a better view. Destinations are chosen by the Interstate migrants mainly based on three factors greater job opportunities, higher wage rate, and well-functioning payment process. Higher wage rate/ earning is certainly the dominant pull factor, but many other factors also play significant roles in the decision-making of the migrants. The daily/casual labourers do not get work throughout the year in Sagar Island while they can engage a significantly higher number of days in states

like Kerala, Tamil Nadu, Telangana, Andhra Pradesh, and other states. In this context, Ramesh Mondol stated:

*"If I stay in Sagar, I get work only 100-150 days a year while in Hyderabad I can work the whole year except the rainy days."*

Many migrants have mentioned they can earn more in a day by doing overtime or taking extra loads in contracts. As Dinesh Das narrated:

*"I have worked in Kerala and Tamil Nadu. There we can easily get extra work in a day. In Sagar, some seasonal work is there except that getting half days of work is difficult."*

The choices of work are also limited on the island. Moving out provides them with a variety of work. Although most workers engage in hard-working manual labour like construction workers, and brick manufacturing, they still find other opportunities like manufacturing labours, agricultural workers, janitorial workers, housekeepers, security guards, watchmen, etc if they want. As 58-year-old Dipendra Nath puts his situation in words:

*"I am a watchman at Kochi (Kerala). People like me who are relatively older or who have some physical inability to do jobs that need physical strength can also find jobs in other states. In Sagar, we do not have many options."*

Workers in Sagar Island often face delays in receiving their payments or not receiving the full payment. The delays can vary from short-term to long-term. For instance, crop producers pay agricultural labourers only after selling their products, while fishermen compensate fishing labourers after selling the caught fish. Occasionally, if the crop producers or fishermen themselves receive their dues late, the payment process becomes even slower. If the crop producers or fishermen face a loss the labourers often do not get full payment, and in extreme cases no payment at all. The experience of the workers who moved out is different. There are rare cases of payment delays or not receiving payments in interstate or inter-district migration. In this regard, a 47-year-old migrant labour stated:

*"We mostly do not get payment on time here (Sagar Island). Sometimes we get less, sometimes we do not even get it……. I worked in Kerala for five years but never faced a situation like this and I did not even hear such things from anyone in our area who worked in Kerala."*

Although the 100 days of work under the MNREGA scheme has been terminated on the island, several workers encountered problems receiving their previous payments. Some received only

partial payments, while others received no payment at all. This has also been a grief of the labourers and created an additional negative perception about the job scenario among the inhabitants. In this context, 52-year-old daily labour stated with hopelessness:

*"I have worked in the embankment construction for 36 days but did not get payment for a single day……. There are many like me in our village……. If the 100 days' work restarts again, we will not do it."*

Many migrants also expressed other factors like dignity, respect, and a good work environment. Migrants of Sagar Island have developed a perception that people of south Indian states are relatively more migrant-friendly and provide a better work environment than some of the north Indian states. Particularly Kerala has been a favourite destination of migrants in terms of staying and working in a good social environment. As Sudhakar Biswas stated:

*"I have worked in many states like Gujrat, Maharashtra, and Haryana. They misbehave and disrespect workers. But in Kerala, I never saw that kind of misbehaviour or disrespect. The people of Kerala behave nicely to us."*

### 7.5 Pattern of Migration

To understand the Pattern of out-migration, the return frequency of 167 migrants has been analysed and presented in Table 7.6.

Table 7.6: Return frequency of migrants at source

| Number of returns during the last 365 days | Number of migrants | Percentage |
|---|---|---|
| No return | 17 | 10.2 |
| Once | 87 | 52.1 |
| Two to four-time | 41 | 24.6 |
| Five to eleven times | 12 | 7.2 |
| Monthly/fortnight | 8 | 4.8 |
| Once in a week or more | 2 | 1.2 |
| Total | 167 | 100 |

*Source: Primary data (household survey)*

Among 167 migrants the majority (52.1%) made a single return to the Island, while 24.6% returned two to four times. Only 1.2% of migrants returned once a week or more frequently.

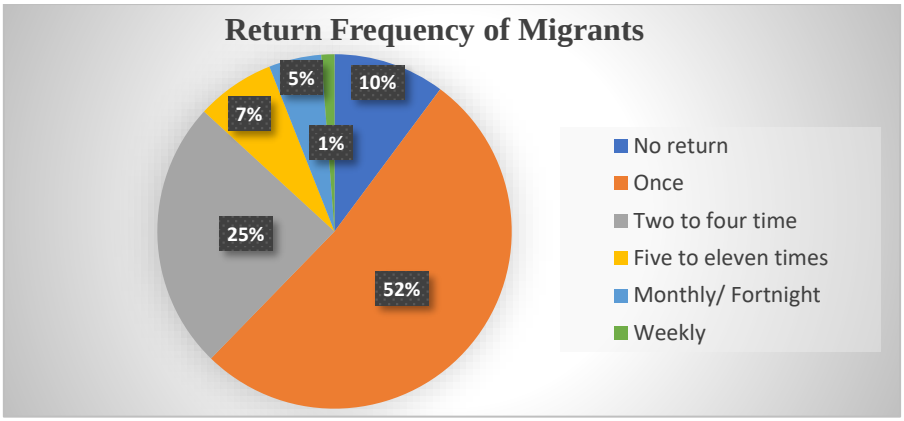


Figure 7.8: Return frequency of migrants at Sagar Island.

*Source: Primary data (household survey)*

Among 167 samples, 96.4% either have a specific time frame for return or express a commitment to return eventually. Specifically, 7.2% plan to return within one year, 16.8% within five years, and 38.3% within ten years. Additionally, 34.1% are uncertain about the time frame but express a commitment to return eventually, while only 3.6% have no intention of returning permanently.

Table 7.7: Possibility of migrants returning permanently to Sagar Island

| Intention to return home permanently | Number of migrants | Percentage of migrants |
|---|---|---|
| Within one year | 12 | 7.2 |
| within five years | 28 | 16.8 |
| Within ten years | 64 | 38.3 |
| Don't know the time limit but will return for sure | 57 | 34.1 |
| No intention to return | 6 | 3.6 |
| Total | 167 | 100 |

*Source: Primary data (household survey)*

These numbers confirm that most migrants are not willing to stay forever or shift permanently at their destination but they will migrate from time to time for work. They only move there mainly for earning reasons leaving behind their homes, family, and friends. During discussions, most migrants have emphasised that they migrate out mainly to mitigate economic stress and to maximise their earning potential for a better quality of life for themselves and their families on the island. In this context, a 38-year-old migrant labour narrated:

*"We do not like to stay in foreign states far from our home and family. But we do not have many options. I do not earn much here. Still, I stay four to five months here in a year. The rest of the time I go to Hyderabad."*

These patterns show the circulatory character of the migration of the inhabitants. Inhabitants of the island are opting for circular migration, moving between their homes and destinations. By doing so, they avoid committing exclusively to either the origin or destination, maintaining connections in both places. This approach allows them to maximize earning opportunities for themselves and their families.

### 7.6 Remittances

Remittances, the funds sent by migrant workers to their origin, play a vital role in improving the lives of their families. They offer a monetary source that helps households to meet their essential needs like food, healthcare, and education. This economic aid can alleviate poverty, improve living standards, and enhance the economic development of the recipient communities. Moreover, remittances often promote financial inclusion by increasing the use of formal banking services. During crises, such as natural disasters or economic downturns, remittances act as a lifeline, ensuring a consistent flow of funds to affected areas. Overall, remittances support socio-economic growth and stability, especially in rural areas.

The use of remittances indirectly provides an idea of the reason to migrate (Table 7.8). In terms of use of remittances household consumption is the top choice for 40.1% of respondents, followed by improving housing conditions (20.4%) and debt repayment (10.8%). Education, financing working capital/new entrepreneurial activity, and health care also feature in respondents' preferences. Additionally, some respondents expressed uncertainty or did not provide a clear answer. Household consumption and improving housing conditions are essential for the islanders. Utilizing remittances for these needs highlights the economic pressure on migrants. Additionally, debt repayment is a significant factor indicating their economic vulnerability. Many respondents in the survey mentioned taking loans for investments in their economic activities, but due to incurring losses, they were compelled to migrate. A 34-year-old betel cultivator shared his grief:

*"My betel vine damaged in Amphan. Then I took a loan of 50,000 rupees from my wife's group (local self-help group for microloans) to rebuild it again……. Then Yaas cyclone came and destroyed my vine. Now I do not have any option left but to migrate out for livelihood and to repay the amount."*

Table 7.8: Preference of sectors for the usage of remittances

| Usage | 1st preference | | 2nd preference | | 3rd preference | |
|---|---|---|---|---|---|---|
| | Response | Percent | Response | Percent | Response | Percent |
| Household consumption | 67 | 40.1 | 32 | 19.2 | 21 | 12.6 |
| Improving housing condition | 34 | 20.4 | 22 | 13.2 | 24 | 14.4 |
| Debt repayment | 18 | 10.8 | 26 | 15.6 | 23 | 13.8 |
| Education | 16 | 9.6 | 18 | 10.8 | 20 | 12 |
| Financing working capital/new entrepreneurial activity | 14 | 8.4 | 28 | 16.8 | 16 | 9.6 |
| Health care | 6 | 3.6 | 14 | 8.4 | 19 | 11.4 |
| Savings | 3 | 1.8 | 4 | 2.4 | 16 | 9.6 |
| Others | 4 | 2.4 | 6 | 3.6 | 2 | 1.2 |
| Don't know/ no clear answer | 5 | 3 | 17 | 10.2 | 26 | 15.6 |
| Total | 167 | 100 | 167 | 100 | 167 | 100 |

*Source: Primary data (household survey)*

### 7.7 Future Scenario of Migration

To understand the migration scenario better future possibilities of migration have been measured by asking the respondents of the non-migrant households whether any of the members want to migrate or not for earning within the next three years. Among 313 non-migrant households, 68 have expressed that they want to migrate. 31 Among these 68 households have at least one member who had already migrated at least once and returned but not within the last 365 days. There were 2 cases where respondents mentioned that they bought lands outside the island to shift permanently in the future but the timeline was not fixed. Discussions with the locals during the field survey few inhabitants particularly from the environmentally vulnerable areas like the coastal areas of Shibpur, Bankimnagar, Kachuberia, Muriganga, and Mahishamari also expressed their will permanently move out from the island. They were worried about their safety on the island. Most of them do not have the financial

capability to shift permanently to elsewhere in a safer place. Tanmoy Maity a resident of Bankimnagar narrated:

*"The situation on the island is becoming dangerous day by day. Loss of land due to erosion, and excessive flood has made the area inhabitable. But we are helpless, neither the Government is helping us nor do we have enough money or wealth to buy land outside."*

In summary, it is observed that out-migration from the island was mostly done by males, for financial needs. Interstate migration is predominant. Southern states of India particularly Kerala provide notable destinations for a significant portion of these migrants. Many migrants were primarily engaged in agriculture and fishing before migrating from the island, emphasising that most migrants shifted from occupations that are dependent on natural resources. This is a continued trend towards more future migration.

# CHAPTER 8: CONCLUSION AND RECOMMENDATION

## 8.1 Conclusion

The global climate is undergoing a swift transformation, and its repercussions are already being felt across ecosystems worldwide. From melting polar ice caps to shifting weather patterns, the signs of climate change are unmistakable. These changes are not just abstract concepts; they are tangible realities affecting biodiversity, altering habitats, and challenging the resilience of both natural and human systems. The urgency to address these impacts has never been greater, as the delicate balance of our planet's ecosystems hangs in the balance. Climate change is a global issue, that cannot be tamed or tackled by local agencies or even by a single state. The local agencies can only take action against managing the impact of these issues at a local level. For long-term solutions worldwide actions should be taken very seriously. At a local level, some short-term actions are very necessary first to manage the consequences of climate change and related issues.

The study shows that natural hazards, including tropical cyclones, coastal floods, and erosion, pose significant threats to the ecosystem of Sagar Island. Tropical cyclones have repeatedly caused extensive damage to residential structures, infrastructure, and agricultural assets, leading to substantial economic and social disruptions. Coastal floods have exacerbated the challenges of the islanders by severely affecting the natural resources and agricultural systems, thereby undermining livelihood opportunities. Additionally, the aquaculture sector has suffered considerable setbacks due to the inundation of coastal areas, resulting in the loss of aquatic life and the degradation of water quality. Coastal erosion has also created issues by leading to the loss of arable land, displacing communities, and altering the island's landscape. These findings underscore the need for comprehensive disaster management strategies and sustainable development practices to mitigate the adverse impacts of these natural hazards on Sagar Island's ecosystem and its inhabitants.

Over the years, traditional natural resource-based occupations such as agriculture and fishing have significantly declined on the island. The percentage of cultivators has steadily decreased, reflecting a broader trend of diminishing agricultural activity. Historically, chilli and watermelon were extensively cultivated as commercial crops. However, while watermelon cultivation has completely disappeared, chilli production persists, albeit on a much smaller scale.

The current cash crop, betel leaf, is also facing a crisis primarily due to environmental hazards and changes in climatic conditions. These challenges have made betel leaf cultivation

increasingly difficult and less profitable. Similarly, paddy cultivation has become less viable, with farmers often incurring losses due to flood damage.

The uncertainty of agriculture as a livelihood has forced many residents to seek alternative means of income. As a result, agriculture on the island has become highly unpredictable and risky. Many farmers have transitioned to other occupations, such as small-scale trade, labor work, or migration to urban areas in search of better opportunities. Others are trying to explore new agricultural practices or diversifying their crops to adapt to the changing environmental conditions.

Riverine fishing, once a reliable income source, has declined due to reduced fish populations. One of the major reasons behind this is the excessive and unmindful catch of fish and the trawling method of fishing, especially bottom trawling, for depleting fish stocks near the island. In the Sundarban, species like Mourala (Amblypharyngodon Mola), Chapila/Chapla (Gudusia Chapra), Chanda/Chada (Chanda Nama), Chitol (Chitala Chlitala), and Kucha Chingri (Macrobrachium Lamarrei) have significantly declined. The catch of the highly demanded Hilsa (Ilish) has also decreased, attributed to the excessive number of licensed fishing trawlers.

Shrimp fry collection from rivers, creeks, and canals was once a key livelihood for island inhabitants. However, it has declined due to reduced availability and decreasing local demand. Today, shrimp collection does not even generate a minimum daily wage.

Coastal flooding poses a significant threat to freshwater aquaculture on the island, as these fish species cannot tolerate salinity changes and die quickly. During events like Cyclone Yaas, cultivators have suffered substantial losses due to coastal floods. Brackish water aquaculture although emerged as an alternative livelihood option in other parts of the Sundarban but on Sagar Island has not been able to capture significant attention due to regulatory issues. Along with those coastal floods and diseases in shrimp also put this occupation into volatility. MPEDA granted licenses for Tiger Shrimp (Bagda Chingri) farming on the island, but many farmers have shifted to cultivating White leg shrimp (Litopenaeus Vannamei) without official licenses, and due to that they sometimes face regulatory issues. During flood events, fish often escape from the bheries and ponds. The higher salinity of ocean water introduced into bheries during floods can also lead to higher fish mortality rates. Both freshwater and brackish water aquaculture were severely impacted by coastal floods during Cyclone Yaas. The losses were particularly significant in brackish water aquaculture due to the higher investment costs involved. After Cyclone Yaas many cultivators have shifted to other occupations.

The shift away from traditional livelihoods reflects the broader socio-economic transformations occurring on the island, driven by the need to adapt to a changing environment and its impacts on natural resources. Out-migration from the island has provided alternative sources of income for the islanders.

At least one member from 34.79% of households has been migrated once or more within the last 365 days of the date of the survey. It shows how the economy of the island has become dependent on migrants' income. Interstate migration is dominant at 82.03%, with 2.39% moving abroad as construction workers. Within the districts, 2.99% have migrated, and 12.57% have moved to other districts of West Bengal. Within interstate migration as a preferred destination Kerala stands out with the highest number of migrants.

Among the migrants, 52.7% are engaged as construction workers, making it the most common occupation. Daily or casual labour follows at 15.6%, with manufacturing jobs at 12.6%. Regular wage or salary earners constitute 9%, while those in agriculture/aquaculture represent 5.4%. Transport and communication jobs account for 3%, fishing for 1.2%, and business or self-employment is the least common at 0.6%. This data highlights the diversity of employment distribution among migrants at their destinations.

Findings show that 47.3% of migrants were previously engaged in agriculture or aquaculture, highlighting the vulnerability of these sectors. Fishers accounted for 19.2% of migrants, daily or casual labourers made up 16.2%, and 8.4% were non-workers before migrating. Additionally, 3.6% were engaged in transport and communication, while 5.4% were involved in other occupations. This underscores that most migrants shifted from natural resource-dependent activities.

Loss or less profit in occupation and lower wages is the main push factor for migration (46%), followed by seasonal work and limited job opportunities (42%). Payment issues account for 11%. Migrants from Sagar Island choose destinations based on job opportunities, higher wages, and reliable payment processes. While higher wages are the main attraction, other factors also influence their decisions. Migrants find more work opportunities in states like Kerala, Tamil Nadu, Telangana, and Andhra Pradesh, compared to Sagar Island where work is scarce year-round. They can earn more through overtime and extra loads in contracts. Work choices on the island are limited, prompting migrants to seek diverse job roles elsewhere, including construction, manufacturing, agriculture, janitorial work, housekeeping, security, and more. Payment delays and incomplete payments are common on the island, especially for agricultural

and fishing labourers, who are paid only after the sale of produce or fish. In contrast, interstate migrants rarely face such issues. The termination of the MNREGA scheme on the island has exacerbated payment problems, with many workers receiving partial or no payments, further tarnishing the job scenario. Additionally, migrants value dignity, respect, and a good work environment, finding southern states, particularly Kerala, more migrant-friendly and socially supportive than some northern states.

### 8.2 Recommendations

In recent times, Sundarban has received the attention of scientists and researchers looking into environmental, social, and economic distress. Many international organisations are also focusing on the issues of Sundarban. Considering the amount of research work and international donations the living conditions of the inhabitants have hardly improved (Ghosh, 2012). The cooperation among researchers has also been very little. Surprisingly, the government has not also given much attention to the research findings. Despite a large sum of research has been produced across prime institutions, there is no major database or information system based on the outcomes of these researches. It is challenging to find authenticated data on migration most of the time (Ghosh, 2012). Therefore, there is a need to create a major database system for migration. Village-level registers for migrants will provide micro-level information.

Most of the migrants from Sagar Island engage in circular migration leaving behind their family members, moving periodically between their homes and work destinations. This migration pattern is predominantly influenced by seasonal factors and the effects of recurring natural disasters. The seasonal scarcity of employment opportunities creates a cyclical crisis, intensifying the financial stress on individuals. Additionally, the frequent occurrence of disasters exacerbates their financial burden. Migration becomes a strategy to mitigate financial stress and enhance their earning potential, enabling them to sustain themselves and their families despite the challenging circumstances. By maintaining connections in both places, they avoid permanent relocation, thus balancing their economic needs with familial and social ties. Globally policymakers now acknowledge that migration is a natural process, including circular migration. Rather than trying to stop migration, the focus should be on ensuring that it occurs by choice rather than force (Newland, 2009).

Most migrants engage in low-skilled jobs in unorganised sectors at their destinations. To improve the conditions of migrants in low-skilled, unorganised sector jobs, policies should

focus on enforcing labour laws, providing vocational training, promoting ethical recruitment, extending social security benefits, developing inclusive policies, simplifying work permit processes, and establishing support systems. These measures can create a more equitable and supportive environment, enhancing migrants' contributions to both their host and home region. Furthermore, there is a need to create livelihood opportunities by analysing the potential of the island. There is a huge potential in the tourism sector in the area. The economic benefits of coastal tourism on Sagar Island are significant, with a rapid increase in tourist arrivals presenting a unique opportunity. Effective planning and management strategies are crucial to fully capitalize on this potential. A study by Ghosh (2021) emphasizes the need for infrastructure development, environmental crisis management, tourist satisfaction, and promotion to enhance the tourism sector. Sagar Island, known for its mythological significance, primarily attracts religious tourists to Kapil Muni Ashram and Gangasagar Beach. However, other locations like Beguakhali Beach, Chandipur Beach, and Sagar Beach, which have scenic beauty, lack sufficient infrastructure and promotion. Developing these areas could broaden tourism beyond religious pilgrimage and foster nature tourism. Promoting lesser-known spots through posters, websites, and social media campaigns can attract more visitors. Collaboration among local government bodies, tourism authorities, and environmental agencies is essential for a cohesive strategic plan that aligns objectives and promotes sustainable tourism.

Historically, the tourist arrivals at Gangasagar have centred around the Gangasagar Mela, leaving the rest of the year relatively quiet. However, in recent years, this pattern has been shifting. The island now sees a year-round influx of visitors. Festivals and occasions such as Magh Purnima, Buddha Purnima, and 'Sawan ka Mahina' have especially contributed to boosting religious tourism on the island. Observing the growth of tourists the transportation industry has grown but, other industries like the food and beverage industry, and the accommodation industry did not grow much on the island. The main reason behind this is most tourists do not spend the night on the island; they enter in the morning and exit in the evening. Tourist accommodation and food services at Gangasagar mouza are mostly centred around the Kapil Muni Ashram, with some additional services available at local shops near Kalibazar, Kachuberia Ferry Ghat, Rudranagar and Benuban Ferry Ghat. However, the supply of food and beverages falls short of demand, with limited variety. Improving these services could enhance the tourist experience. Local authorities could help bridge this gap by informing locals and managing the industry to better serve tourists, which could lead to longer stays of tourists and increased revisits.

Promoting tourism by developing other spots and providing satisfactory experiences to tourists can generate livelihoods and employment opportunities for the locals, especially those facing challenges in traditional sectors like agriculture and fishing. Furthermore, diversifying tourism across various locations on the island will ensure a more equitable distribution of the benefits derived from this industry that in turn significantly strengthen the island's economy.

Although the catch is decreasing prices of most of the common species of fish are increasing creating an advantage in the fishery industry. Appropriate regulation and guidance in fishing and aquaculture will ensure development in fishing-related activities. The state fishery department enforces a 61-day fishing ban from April 15 to June 15 every year along with many other smaller bans around the year for different species to promote fish breeding and conserve stocks. While some bans are grossly followed by fishers many were not obeyed seriously. By implying proper surveillance and punishment or penalty authorities can check the offences. Bottom trolling and unmindful catching of fish by large trawlers need to be strictly regulated to improve the quantity of fish in the ecosystem of Indian Sundarban.

The government provides financial aid to registered fisher families. The Fishery Department of Sagar Block issues 'Matsyajibi Credit Cards,' offering benefits like life insurance, and supports Tiger Shrimp cultivators with essential inputs. They also promote alternative livelihoods by distributing e-rickshaws and providing chicklings and ducklings to farmers and fishers. Post-Yaas cyclone, the "Duare Tran" project was launched to compensate for losses in the aquaculture and fishing sectors, offering financial relief based on the extent of damage. Despite these initiatives, many fishers of Sagar Island do not receive the intended benefits due to bureaucratic inefficiencies, lack of awareness, and socio-economic barriers. This calls for a review of existing frameworks to ensure equitable resource distribution.

With the cooperation of government authorities, the local fishing cooperatives of Sagar Island play a crucial role in enhancing the livelihoods of their members by providing resources and support. However, many individuals involved in fishing and related activities are not part of these cooperatives, limiting their access to similar benefits. Integrating these individuals into the local cooperatives is essential for equitable resource distribution and support. This inclusivity would strengthen the fishing community's resilience and promote sustainable fisheries management. Additionally, it would ensure a comprehensive representation of the community's needs, aiding effective advocacy and policy-making. Efforts to integrate all

individuals can include targeted outreach, awareness campaigns, and simplified membership procedures, fostering a more inclusive and sustainable fishing industry in the Island.

Although not getting enough returns most farmers of the Island cultivate traditional crops like Paddy as they do not have enough diversified knowledge about different crops. Authorities and organisations may step in to educate farmers about different crops and different methods of farming. There is a need to change in agricultural system on the Island. For example, Brahmi cultivation, though practiced in a limited area, has proven to be successful, motivating farmers of the island to adopt it. NGOs like Sagar Krishi Unnayan Cluster and Swami Vivekananda Youth Cultural Society have been instrumental in promoting organic Brahmi farming. This success highlights that innovative approaches to cultivating suitable crops by understanding the environment and market demand can be far more profitable than traditional crops.

Several small and marginal betel-leaf cultivators expressed a lack of knowledge regarding cultivation practices, including appropriate fertilizer use and disease control measures. They also face financial constraints. Unlike large farmers, small and marginal farmers are unable to produce high-quality betel leaf resisting them to generate good profit from the product. Marginal and small farmers face most of the brunt of the challenges like the impact of hazards, and increasing diseases. These farmers also have less knowledge about the market dynamics and bargaining power at the time of selling crops which reduces their profit share. Like fishing cooperatives, there is a need for agricultural cooperatives on the Island through which small and marginal farmers can unite and have a voice. Government authorities and non-profit organisations may engage with these cooperatives to educate them about better and sustainable ways of cultivation and support them in maximizing their profit margins. The island also lacks the facility of a crop storage system. Providing storage facilities to the farmers will give them confidence to safeguard their surplus amount of yields. The farmers will have the choice of selling these in times of high demand rather than high supply times in the market.

The region has been significantly impacted by hazards such as cyclones, coastal flooding, and erosion. These challenges have severely hindered both agriculture and aquaculture activities. Therefore, a comprehensive hazard management strategy is essential to mitigate these effects. Embankment plays a major role. The southern, south-western, south-eastern, and north-eastern parts of the island have faced most of the damages due to flooding in recent years. Villages that did not have concrete embankments or forest cover along the coast are affected the most by the intrusion of coastal waters. These weak zones (Sibpur, Gangasagar, Mahishamari, Muriganga,

Kachuberia and Bankimnagar) of coastlines need instant protection measures against floods. Concrete embankments particularly Aila Bandhs of Beguakhali and Dhablat have proven to be a good protection against flood and erosion on the Island. There is a plan by the Government to further expand the Aila Badhs in other coastal areas of the island but the progress of the work is lagging. Therefore, there is a need for faster implementations of the plan.

There are different viewpoints about the construction material of the embankments among the researchers, environmentalists, technicians, and Inhabitants of Sundarban. The choice is very tough between the earthen embankment and the concrete embankment. Environmentalists are not in favor of concrete embankments as the matter does not only include people but also the biodiversity moreover the ecosystem of the region. But there is another way of protection against the intrusion of water which is enlarging the height and width of earthen embankments. These larger embankments are locally called 'Hati-Badh.' These types of embankments are costly and take much more time and labour. But the longevity is far better than the traditional earthen embankments. In a few places, these embankments have proved to be a sustainable solution. One of them is Hati-Badh of Sandeler Bill in Hingalganj (Guhathakurata, 2021).

Coastal forests and vegetative covers under the right conditions, can transform into powerful bio-shields, safeguarding lives and precious assets from the wrath of cyclones, coastal floods, and coastal erosion by absorbing the force of the waves. The coastal forests of Chemaguri, Ramkrisnapur, Gobindapur, Kastala and Chandipur have proven to be safeguards against floods. To ensure ecological balance, it is crucial to conserve the existing forests and establish new vegetative covers, particularly around the coastlines.

Many inhabitants have suffered significant losses due to the destruction of houses and assets in recent cyclones. The coastal villages like Sibpur, Muriganga, Kachuberia, Bankimnagar, Mahishamari, Gangasagar, Dhablat, Radha Krisnapur (Bahir plot) and Sikarpur have faced most of the burnt. Historically, cyclones have easily destroyed weak structures, creating financial pressure to rebuild. This, in turn, reduces the funds available for investment in income-generating activities. While some residents have benefited from the government's Abash Yojna scheme, many have been left behind. An increase in the number of beneficiaries will certainly improve their financial condition. Also, a significant portion of government funds does not reach the intended beneficiaries. It is crucial to address this issue and penalize the corrupt individuals within the system to ensure fair distribution of aid.

In summary, to address the challenges faced by communities in the region, it is essential to increase awareness and implement community-based programs focused on climate change impacts, environmental sustainability, and conservation. Additionally, creating economic support initiatives will help local communities build sustainable livelihoods that are less vulnerable to environmental changes. To improve conditions for migrants in low-skilled, unorganised jobs, policies should enforce labour laws, provide training, promote ethical recruitment, extend social security, and establish support systems. Moreover, there is a need for inter-departmental coordination of the Government agencies on the island. Establishing a task force for inter-departmental coordination, involving NGOs for healthcare and education, empowering local bodies, and creating a comprehensive management plan with community input will enhance the well-being of the residents of the Island. Upgrading education, protecting the environment, promoting sustainable agriculture and eco-tourism, and improving infrastructure facilities would be a significant step. Integrating these efforts will create a holistic approach to benefit the people of Sagar Island.

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