ENVIRONMENTAL MIGRATION IN SUNDARBANS

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INTRODUCTION

The Sundarbans, the largest delta in the world, is spread over a vast area of approximately 10,000 km (sq.) ranging from 21◦320 to 22◦400N and 88◦050 to 89◦510E in it's spatial extent with 38% of the mangrove forest present in India and 62% in Bangladesh. While Sundarbans is one of the most prominent ecological zones of our planet serving as the foundation of life-support systems, it is also one of the most climatically vulnerable zones in the world. Sundarbans sustain the livelihood of thousands of people as they depend on the mangrove for agriculture, fishing and forest-based occupations as well as by acting as a "natural buffer" against coastal erosion and storm surges. Alarmingly, shoreline erosion has accounted for approximately 27% of mangrove loss globally since 2000. Major ongoing anthropogenic climate changes exert severe economic pressure on the Sundarbans, a loss which is unaffordable for our planet in times of such stark environmental crisis, making the protection of the mangroves even more crucial. Against this backdrop, factors such as rising sea levels, saline water intrusion, and progressive mangrove degradation are forcing the communities to relocate. Unlike sudden natural disasters like cyclones, this is a slow onset of a climate catastrophe. Up to 35% of the remaining mangrove has been lost over the last 50 years.

The Bay of Bengal is experiencing a continuous sea-level rise of approximately 3.14mm per year, which is significantly higher than the national average. In certain ports, such as Diamond Harbour, the rise is estimated at 5.16 mm per year, accelerating the intrusion of salinity into croplands and freshwater. The Ghoramara Islands, aka the "sinking islands", located at the south of the Sundarbans Delta, once spanning more than 20sq km, have been reduced to an area of merely 5sq km.

This paper will investigate how climate-induced sea-level rise and other factors mentioned above are degrading the ecological impact and in effect, are a cause of human displacement as well. Furthermore, this research adopts a multidimensional approach that examines various frameworks, which in turn provides us with an analysis of the aforementioned topic.

METHODOLOGY

This paper adopts a multidimensional approach that combines ecological assessment, socio-economic analysis, and demographic review. The empirical basis rests on secondary data drawn from satellite imagery, tide gauge records, government surveys, and established institutional reports. The central aim is to interrogate how slow-onset climate stressors in the Sundarbans translate into livelihood erosion and displacement. The analysis proceeds in three steps.

1. First, ecological evidence is assessed using data from INCOIS tide gauge measurements, NASA satellite altimetry, and remote sensing studies between 2000 and 2020. These datasets are used to document sea-level rise, shoreline erosion, and mangrove degradation, with case evidence from Ghoramara Island illustrating localized shrinkage and its implications.

2. Second, socio-economic vulnerabilities are examined through government and institutional sources, including NITI Aayog's Multidimensional Poverty Index (MPI), NFHS-5, and ecosystem valuation studies. These highlight how salinity intrusion, agricultural decline, and poverty intersect to reduce adaptive capacity, while also foregrounding gendered impacts and livelihood insecurity.

3. Third, demographic and migration patterns are analysed through Census records (2001–2011), NSSO migration data, and studies by the Mahanirban Calcutta Research Group (2022). These allow for the identification of intra-delta migration trajectories, long-term relocation to Kolkata and beyond, and demographic stagnation in erosion-prone blocks.

Through this triangulation of ecological data, socio-economic indicators, and demographic records, the paper establishes how structural vulnerabilities and environmental degradation collectively drive displacement in the Sundarbans.

LITERATURE REVIEW

This section would present the literature on climate-driven displacement, which is interlinked into three themes, namely (A) conceptual and empirical work on the slow onset of climate change. (B) The ecological evidence that will document the evidence of the fluctuating biophysical changes, and lastly, (C) how the socio-economic and the studies done by the government, which examines the loss of livelihood, the weak policy frameworks and poverty convert the climate change factors into migration.

- *Slow onset of climate change*

While dramatic weather events (floods, earthquakes, forest fires) make headlines and highlight the immediate impact of climate change on people's lives, the slow onset of climate change is more likely to impact migration. Substantiating this, the slow onset process is more incremental to the loss of livelihood and the assets relying on that. It's a strained cause-and-effect relationship, where there is a forced-staged driven migration, for example, seasonal labour is permanently relocating. The groundswell report by the World Bank analyses the mass internal migration happening in Southern Asia, highlighting coastal areas as the critical hotspots.

- *Biophysical change: The empirical evidence*

The biophysical changes, including remote sensing, tide gauge data and forest inventories, converge on the data that there is a steady ecological decline. The INCOIS reports and various other studies have analysed how factors such as tide gauge and regional oceanography convey to us how there is a localised sea-level rise in the Bay of Bengal. Between 2000 and 2020, the Sundarbans faced a net loss of approximately 29 km² of mangroves, with 110 km² lost to erosion. There were regeneration efforts through plantation, which partially offset the losses, but the gains of these efforts were largely outside the mangrove belt, which further raised concerns about long-term ecological stability. The ocean-facing islands, such as Dalhousi and Bhangaduni, recorded the highest erosion, amounting to a loss of 11.6 km² and 10.9 km² respectively, which as a result, contributed to a total 49 km² loss across nine islands many of which were critical tiger habitats.

The Ghoramara islands have become one of the stark illustrations of the biophysical changes currently happening. In the last six decades, more than half of Ghoramara's land has been submerged. It has lost 75% of its original area, going from 20 km² to 5 km². This loss is largely a result of the erosion from riverine actions, sea-level rise, etc. Over the past 30 years (as of 2015), more than 600 families have been displaced as well and two-thirds of the island's population have left, relocating to nearby islands such as Sagar. This shows us that these biophysical changes have an immediate socio-ecological repercussion. The loss of land is a threat to both subsistence crops and cash crops, whilst it also undermines the resilience of the communities living there.

- *Socio-economic factors*

In the current context, the socio-economic studies and government reports provide critical analysis of how livelihood loss and poverty amplify the impacts of climate stressors in the Sunderbans. The Niti Ayog's multidimensional poverty index data reveals a persistent deprivation rate in basic fundamental hygiene of the communities living there. The 24 north and south parganas are the most violently affected by the sea-level rise and the salinity intrusion. These are the indicators for the vulnerabilities that the communities face, and as a result, migrate when all forms of livelihood come crashing down.

The cumulative effect of these socio-economic studies underscores that migration in Sunderbans is not just a response to environmental stress, but it is the outcome of the underlying intersections which are entrenched in poverty and a weak institutional framework.

Section 1

Environmental Stressors in the Sundarbans

The Sundarbans, which literally translates to 'Beautiful Forest', spans both the Republic of India and People's Republic of Bangladesh and is regarded as one of the most climate vulnerable regions where communities face threats not just from cyclones but also from a more insidious danger. Something that goes unnoticed because of its slow, incremental nature – rising sea levels, which in turn lead to their own set of dangers.

What distinguishes the crisis in the Sundarbans from the numerous others around the world is that the displacement here is not caused by just the sudden disasters but also slow onset stressors which unfold over decades and gradually but certainly undermine the ability of people to survive on the land. These stressors apart from the already mentioned rising sea levels include phenomena like saline intrusion into soil and aquifers and the degradation of the mangroves themselves.

The importance of spelling out each of these stressors individually is because policymakers often attribute the migrations occurring in the Sundarbans solely to disasters like cyclones but evidence shows that change in baseline environmental conditions also play a huge role in making the aforementioned cyclones so destructive (degraded mangroves and weakened coastline lead to a worsening of cyclone impact) and are also responsible for ensuring that people don't return after a disaster.

Sea Level Rise Trends from Indian National Centre for Ocean Information Services show that the Bay of Bengal has been experiencing a sea level rise at an average of 3.28 mm in the past two decades. This figure might sound small but when accumulated over decades, it becomes a significant inundation into an already low lying area of land with 70% of the Sundarbans lying within 1 m of sea level. Global studies suggest that with moderate emissions, there will be a 37 to 40 cm rise by 2050 which will further increase flooding pressure. This will primarily be driven by two drivers:

Thermal Expansion: As global temperatures rise and oceans warm, water expands and sea levels rise, analysis by National Aeronautics and Space Administration using Argo profiling floats tells us that one-third of the global sea-level rise observed by satellite altimeters since 2004 is caused by thermal expansion.

Melting of Glaciers and Ice Sheets: Oceans absorb 90% of the earth's warmth which causes the melting of glaciers and ice sheets which then adds more water into the ocean. In a study by the University of Zurich, it was established that glacial melting has significantly been accelerated over the last three decades leading to a loss of ice that has already reached 335 billion tonnes per year, which contributes to 30% of the current rate of sea level rise.

Now all of these have many local consequences for the Sundarbans like Shoreline Erosion which is where land literally disappears into the water reducing habitable and cultivable areas. It is also eating away the region's natural storm barriers and has caused significant net land loss in Sagar and Bakkhali–Namkhana Islands and has also led to large-scale degradation of mangrove forests.

Another consequence of the same is chronic inundation, areas that used to flood only during extreme tides are now regularly underwater during daily normal high tides. Between 1983 and 2003, the annual maximum tidal range in the eastern and central regions increased by 0.75m. These incremental changes in tidal levels have only modest short-term effects like slightly amplifying storm surges during cyclones, their long-term effects are far more serious. Damage of croplands by raising salinity in the soil due to the intrusion of saltwater is one.

As sea levels rise and embankments grow weaker, the saltwater perforates and seeps into the soil and ground water. This also happens through surface flooding and subsurface entry of salinity into soil and aquifers. This leads to a salinity intrusion of both soil and ground water making it difficult to grow crops

or to drink local ground water. Multiple studies in the Sundarbans document the rising salinity in soils and surface waters especially after cyclones altering the chemistry of the soil and reducing nutrient availability.

The concrete embankments promoted as part of climate adaptation to fight this in the Sundarbans do more harm than good. They do a moderately good job of keeping salinity out but they simultaneously do an amazingly good job of trapping salinity and reducing soil fertility.

Rice and many other staple crops cannot tolerate high salt concentrations so yield of these crops declines considerably leading to the abandonment of agricultural land which in turn reduces food supply and employment, giving people all the more reason to migrate out of the Sundarbans. When marginal farming becomes unviable and leads to losses, farmers turn to seasonal migration and when these same losses become chronic, they permanently migrate out of the Sundarbans.

Image 1: After the monsoon ends in September and the soil dries, salt from groundwater or seawater rises to the surface, leaving white patches. Salinity builds through winter and peaks by May, making winter crops hard to grow in the coastal Sundarbans. Photo: Vaishnavi Chandrashekhar.

Source: Link

Remote sensing studies conducted from 2000 to 2020 record 110 km² mangrove loss through erosion in parts of the Sundarbans Reserve Forest (with some local gains via plantations but still a net negative). This loss in mangroves leads to a loss of buffer in storm surges as mangroves shield the coast from the worst of the storms. Apart from storm protection they carry out erosion control and their roots trap sediment. They act like sponges and slow water flow while storing excess rain helping in flood mitigation. We also have Mangroves to thank for the 75 billion pounds of carbon a year (globally) that they sequester. All of the above mentioned are vital natural defences that reduce disaster losses and help slow our planet down from reaching climate tipping points but continued degradation will have a serious impact on their ability to do the same and reduce the service potential of the Sundarbans as a whole meaning that policymakers will care even less about it than they do now.

Ghoramara Island is a tiny island in the Sundarbans delta about 90 kilometres south of the capital city of West Bengal. Ghoramara Island used to be connected to Sagar Island in the early 20th century but by the middle of the century water levels rose and you could travel between both during low tide by

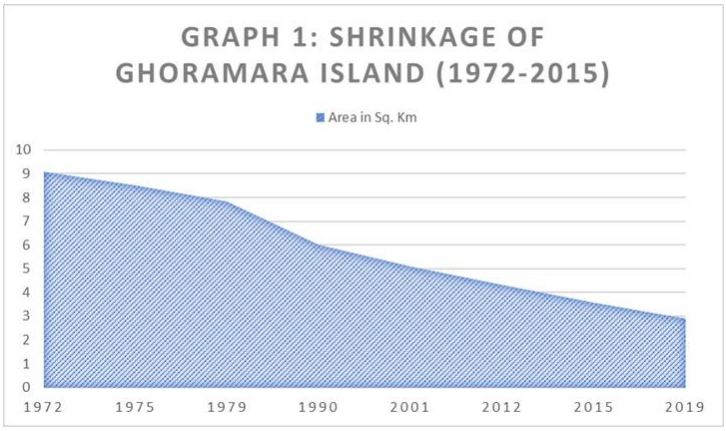
swimming a few minutes. Today it takes 40 minutes to travel the distance between the two. This is mainly due to the rapid erosion in Ghoramara Island.

Ghoramara island, which once used to be home to over 40,000 people just has about 3,000 left today. From 26 km^2 ,it has now shrunk to single digits. Lohachara, a neighbouring island, is totally gone while Khasimara area of Ghoramara is fast disappearing. Only crumbling dirt embankments separate the houses of the remaining few from the water, with the island facing frequent flooding in the monsoons. Apart from the failing embankments, the Island's salt inundated fields have caused a collapse in agricultural yield . This has forced residents to sell assets and move to the mainland.

In the past sixty years, more than half of Ghoramara has been submerged , with homes, schools and farmlands lost to the water, even government offices have not been spared. The post office in Ghoramara was once a two storied building on 36 acres of land serving the thousands of residents of the island but the entire post office went underwater 12 years ago. Today the post office is a single 80 ft^2 room as four villages of Ghoramara have been gobbled up by the water in the past few decades while three others have been partially submerged.

Year	**1972**	**1975**	**1979**	**1990**	**2001**	**2012**	**2015**	**2019**
Area in Sq. Km	9.09	8.51	7.83	5.99	5.11	4.33	3.56	≈2.88

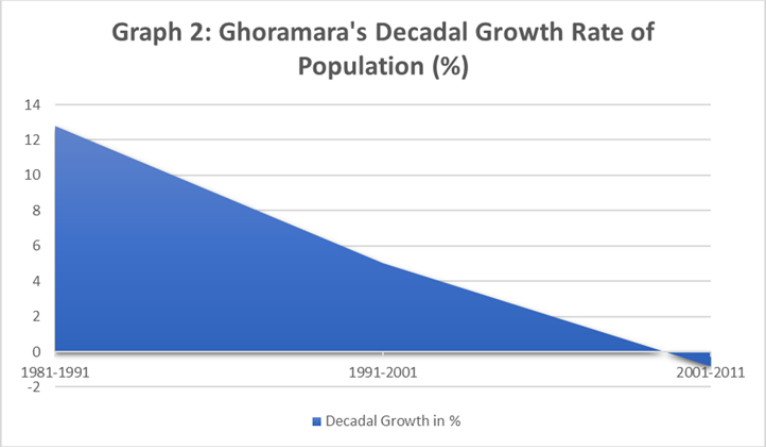
Table 1: *Changing Area of Ghoramara island (1972-2015) (Source)*



The island has undergone severe and continuous land loss over the last six decades as demonstrated by the above table and graph. In 1972, the island covered 9.09 km². By 2015 this had shrunk to 3.56 km² and had further reduced to around 2.88 km² by the year 2019. This represents a 70% decline in land area within less than half a century. The physical driver of this land loss is relative sea level rise, which has accelerated in recent years. It rose from 2.26 mm a year in 2002 to 12 mm in 2014 and by another 2.9 mm in 2019. Of these figures are on top of the sea-level rise along the Indian coast (average increase of 1.7 mm a year).

Year	**1981-1991**	**1991-2001**	**2001-2011**
Decadal Growth in %	12.79	5.04	-0.83

Table 2: *Ghoramara's Decadal Growth Rate of Population (%) (Source)*



The above population data and graph of Ghoramara indicate a steep decline in population growth eventually ending up in a negative growth rate of -ve 0.83 percent signalling a population decline as a direct consequence of climate change as demonstrated above. It is important to reiterate that this entire catastrophe is a consequence of the previously discussed environmental stressors like sea level rise, saline intrusion and the degradation of the mangrove ecosystem. This case is the perfect microcosm for what is being replicated all across the Sundarbans:

Sea Level Rise → Erosion → Salinity → Mangrove Loss → Agricultural Land Loss → Livelihood Collapse → Migration

Image 2: *1988 Island Boundary (Yellow Polygon)*

Image 3: *1988 Boundary Superimposed on 2022 Island*

Image 4: *2022 Island Boundary (Yellow Polygon)*

The above 3 images collectively illustrate the shrinkage of Ghoramara Island over time. *Image 2: 1988 Island Boundary (Yellow Polygon)* establishes the boundary of the island in 1988. *Image 3: 1988 Boundary Superimposed on 2022 Island* allows a direct visual comparison, clearly highlighting the land lost between 1988 and 2022. Finally, *Image 4: 2022 Island Boundary (Yellow Polygon)* shows the current island extent. These images provide a good visual microcosm of what is happening in the Sundarbans but to illustrate this even better, a timelapse of the same from 1984 to 2022 has been linked below: **Click to View**. This case study depicts the larger story of the Sundarbans where incremental but relentless environmental stressors over decades set off a chain reaction that ended in forced migration.

What began with the loss of a few trees and saline soil soon spiralled into collapsing livelihoods and abandoned villages. It shows us how migration in the Sundarbans is not an abrupt response to cyclones as often portrayed but the culmination of long term factors that erode the population for decades.

Section 2

Political Economy Constraints and Institutional Gaps in India's Climate Adaptation Framework

In the Sundarbans, environmental stressors are not abstract statistics but the lived reality of daily struggle. While cyclones and storms dominate disaster narratives and reinforce the perception that displacement is primarily driven by sudden shocks, the empirical reality is far more complex. Migration in this region rarely unfolds in days or weeks; it is a gradual process, stretching across years or generations, shaped by structural and cumulative pressures. Among the most pervasive pressures is water salinity, which undermines agriculture, depletes fisheries, and erodes the viability of honey collection – three pillars of the local economy. Saltwater intrusion renders fertile land unproductive, directly threatening food security, while also contaminating rivers and aquifers, leaving households without access to potable water. The increased burden of water collection, particularly on women, highlights the intersection of environmental degradation and social vulnerability.

The economic importance of nature is corroborated by valuation data. In the Sundarbans, regulating and maintenance services – such as coastal protection and ecosystem regulation – contribute an estimated US $2,020/ha/year, while provisioning services like fisheries and forest products add further US $362/ha/year. These figures underscore the immense economic burden when climate disasters erode ecosystems on which communities depend. (Kanan, Masiero and Pirotti, 2024).

Unlike the visible devastation of extreme weather events, gradual displacement emerges stems from chronic livelihood insecurity and declining resources. It compels communities who have inhabited the Sundarbans for centuries to abandon ancestral territories and rebuild under precarious conditions elsewhere. This trajectory is shaped not only by environmental change but by poverty, inequality, and gendered burdens, rendering migration a necessity rather than a choice.

I. Village abandonment and intra-delta migration

The first and most immediate form of displacement in the Sundarbans is not the leap to distant cities, but the abandonment of villages and the search for safety within the delta itself. From eroding riverine chars to the relatively "higher" ground of nearby islands, communities are repeatedly forced to relocate as erosion and salinity undermine the viability of life. Ghoramara and Mousuni face continual desertion, with many residents moving first to Sagar Island before some ultimately attempt the urban periphery of Kolkata.

For these households, migration is not a single rupture, but a series of incremental moves: first to neighboring islands, then to the urban fringe. What is framed as "adaptation" often functions as a cycle of displacement as families settle on marginal, flood-prone lands and confront the same pressures again. Agriculture's collapse is central. As resources dwindle, households turn to restricted forest areas, exposing themselves to growing risks of wildlife attacks –tigers alone account for an average of three reported deaths annually.

The human geography of the delta bears these testimonies of climate stress: abandoned villages, swelling settlements on relative stable islands and communities straining to absorb newcomers. Intra-delta migration thus marks the first stage of climate displacement: local options are exhausted before families are pushed beyond the delta.

II. Long-term relocation to Kolkata and other Indian states

As erosion and salinity render successive islands uninhabitable, migration within the delta becomes a temporary reprieve. Households are then compelled to seek more permanent futures outside the delta. Kolkata and its urban periphery emerge as primary destinations because they are close enough to maintain ties with home while offering wage labor in the informal economy – construction, small workshops, street vending and domestic work – typically accessed through kinship networks and labor contractors, with little formal support on arrival.]Migrants are absorbed into informal settlements marked by overcrowding, precarious housing, poor sanitation, and limited access to health care and schooling, conditions that mirror the vulnerabilities they sought to escape.

Migration also extends beyond West Bengal. Men move seasonally or cyclically to other Indian states via informal contractors, filling low-wage, insecure jobs where demand for cheap labor is high. For many households, this is not a definitive resettlement but a stop-start likelihood strategy– periods of urban work interspersed with returns for planting, repairs, or crisis response at home. Far from providing stability, long-term relocation often exposes displaced populations to a different form of marginalization, entrenching insecurities through hazardous work, high living costs, and fragmented access to services.

III. Census/migration data: 13% population relocated (2000-2010)

Census records reveal clear demographic shifts in the Sundarbans over the past two decades. Between 2001 and 2011, population growth slowed markedly in erosion-prone blocks such as Hingalganj and Sandeshkhali in North 24 Parganas, as well as in Gosaba and Kultali in South 24 Parganas. The 2011 Census shows that while these sub-districts still contained large rural populations, growth rates were stagnant or in some villages even negative, reflecting out-migration driven by riverbank erosion and salinity intrusion. By contrast, relatively stable islands such as Sagar, Namkhana and parts of Basanti continued to register net gains, absorbing displaced households from neighboring shrinking villages.

At a broader level, the Primary Census Abstract confirms that South 24 Parganas, which contains much of the delta, had more than 1.8 million households by 2011, but density figures far exceeded the state average, underscoring vulnerability. The decadal variation also indicates that population growth in these coastal districts lagged behind inland districts, a sign of democratic stress. Meanwhile the National Sample Survey Office's migration surveys report that West Bengal consistently records some of the highest out-migration rates nationally, with environmental degradation among the primary push factors. Migration from the Sundarbans thus represents not only displacement from the agricultural sector, but a deeper reconfiguration of the region's human geography – away from subsistence farming and toward precarious urban wage labor.

IV. Gendered impacts: male migration vs vulnerabilities for women/children

In the Sundarbans, climate migration is also profoundly gendered. Men are usually the first to leave seeking employment in Kolkata or further afield, while women remain behind to sustain households. This pattern has produced the feminization of agriculture, with women increasingly responsible for farming and natural resource management, despite lacking recognition or secure land rights. In West Bengal, less than 12% of cultivators hold land titles in women's names[6], according to the latest Agricultural Census (2015-16), limiting their access to credit, subsidies, and state support.

With male absence, women experience acute time poverty, forced to shoulder household care, cultivation, and the arduous task of fetching water as salinity destroys freshwater ponds. Evidence from West Bengal demonstrates that women previously outside the labor force are now compelled to take up

casual wage work, all while continuing to carry primary caregiving roles.NFHS-5 data documents rising domestic violence, and early marriages, reflecting the breakdown of traditional coping strategies.

Children also shoulder the hidden costs of displacement. Rising school dropouts as boys enter wage labor and girls take on household care reinforce intergenerational vulnerability. In South 24 Parganas, NFHS-5 (2019-21) reports dropout rates above the state average, reflecting these pressures. Meanwhile, trafficking risks are acute: the NCRB (2022) records West Bengal as accounting for nearly 3% of India's trafficking cases with the Sundarbans flagged as a hotspot.

V. Structural vulnerability driving displacement: Persistent deprivation, shown by MPI and NFHS-5 data, limits resilience in climate-exposed districts, structurally channeling populations toward displacement.

Persistent deprivation forms the structural backdrop against which climate displacement in the Sundarbans unfolds. According to India's Multidimensional Poverty Index (MPI), South 24 Parganas registers an MPI of 0.147 with 30.6 of its population multidimensionally poor, above the West Bengal average of 21.3%. Nutrition, child mortality and schooling are among the leading sources of deprivation in the district (OPHI, India MPI District Tables, 2021).

According to India's Multidimensional Poverty Index (MPI) districts in West Bengal's deltaic zones register significant deprivations in health, education and living standards. Within West Bengal, South 24 Parganas, which encompasses much of the Indian Sundarbans, emerges as a hotspot of acute intra-district deprivation, particularly in nutrition, child mortality, and schooling outcomes.

These vulnerabilities are confirmed by NFHS-5 data: nearly 34% of children under five in the district are stunted, female literacy remains below the state average, and anemia affects more than 60% of women of reproductive age. Such deficits in basic capabilities translate into chronically weakened adaptive capacity. Households already struggling to secure nutrition, health and education cannot absorb additional shocks from cyclones, salinity, or land loss. The poorest often remain trapped in place, unable to finance even short-distance relocation, while those who do migrate frequently enter precarious urban labor markets characterized by low wages, informality, and exploitation. This dynamic creates what scholars call a "migration trap": poverty drives migration, but migration ultimately reproduces poverty's patterns rather than breaking them.

CONCLUSION

The Sundarbans today stand as a living testament to how gradual environmental stressors such as sea level rise, saline intrusion, mangrove loss and coastal erosion steadily erode livelihoods, entrench poverty and drive progressive displacement. These stressors reduce cultivable land, contaminate freshwater reserves and weaken the natural protection that mangrove forests once provided. The outcome is not only ecological decline but also deep social disruption. Communities that depend on agriculture, fisheries and forest products are increasingly caught in cycles of hardship and forced mobility. Demographic and survey evidence shows population stagnation or decline in erosion-prone blocks, while NFHS-5 and multidimensional poverty data reveal persistent gaps in nutrition, education and health that weaken adaptive capacity.

Policy responses must rise to meet this structural challenge. MGNREGA, the Mahatma Gandhi National Rural Employment Guarantee Act, illustrates both potential and limitation. It guarantees rural households up to one hundred days of wage employment, often through works related to soil, water and ecosystem management. In many states MGNREGA investments have improved water retention, soil fertility and even reduced distress migration. However, in the Sundarbans the benefits remain uneven. Implementation delays, limited funds, inadequate climate-sensitive planning and weak monitoring often diminish its impact. While MGNREGA should be retained and strengthened as a pillar of adaptation, it cannot stand alone.

Experiences from Bangladesh show that coastal afforestation and community-based adaptation programmes supported by UNFCCC combine ecological restoration with livelihood diversification and local governance. India's own adaptation measures, which include coastal zoning and regulation of setback lines, also offer tools for risk reduction. Building on these experiences, the Sundarbans requires a comprehensive policy that integrates ecological restoration, adaptation finance, social protection and participatory relocation where necessary. Such an approach can break the cycle of displacement and poverty, transforming the Sundarbans into a region of resilience and dignity.