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Environmental migration, livelihood insecurity, and adaptive capacity in coastal areas: A study of the Indian Sundarbans

Tirtha Ghosh
Research Scholar, Department of Social Work, Visva-Bharati University, West Bengal, India
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Abstract
Environmental migration in coastal areas is increasingly shaped by the interaction between environmental stress and livelihood insecurity. This study examines how repeated environmental disasters contribute to environmental migration in the Indian Sundarbans, with particular attention to livelihood loss, asset destruction, and declining capacity to recover in place. A qualitative research design was adopted, based on ten Focus Group Discussions conducted across ten villages in five administrative blocks, involving 60 participants who had experience of migration. The findings show that repeated environmental disturbances, including cyclones, riverbank erosion, and sea-level-related changes, affect agricultural land, fisheries, freshwater resources, housing, and other livelihood assets. These repeated losses progressively reduce household livelihood security and make recovery from subsequent environmental shocks more difficult. Migration emerges through this cumulative process, particularly when traditional livelihood activities and local employment opportunities become insufficient to sustain households. The findings further indicate that environmental migration is not a uniform or entirely voluntary response, but may range from temporary movement to longer-term livelihood-driven migration as households' ability to adapt and remain in place becomes increasingly constrained. The study highlights the importance of understanding environmental migration in coastal areas through the interconnected processes of repeated environmental stress, livelihood vulnerability, and declining adaptive capacity.

Keywords: Environmental migration, livelihood vulnerability, coastal areas, environmental disasters, adaptive capacity, Indian Sundarbans, livelihood insecurity migration

Introduction

Climate change has emerged as a major environmental and socio-economic challenge for all of the human kind, but its impact more visible particularly towards communities whose livelihoods depend closely on natural resources and climate-sensitive activities [1, 3]. Literature shows that climate-related hazards can disrupt livelihoods, damage household assets, and weaken the capacity of vulnerable households to recover from repeated shocks [4, 5]. These impacts can also influence human mobility, as households experiencing persistent livelihood insecurity may consider migration as one among several possible responses to environmental and economic stress [5, 6]. However, the relationship between climate change and migration is neither direct nor uniform; migration responses vary according to the severity and type of environmental stress, household resources, livelihood conditions, and the capacity to migrate or adapt in place [1, 6, 8].

The Indian Sundarbans provides an important context for examining these interconnections. Located in the Ganga–Brahmaputra–Meghna delta, the region is characterised by low-lying islands, tidal rivers, extensive mangrove ecosystems, and communities whose livelihoods depend substantially on agriculture, fisheries, and other natural-resource-based activities [9, 10]. The region is exposed to multiple and overlapping environmental hazards, including tropical cyclones, storm surges, riverbank erosion, flooding, saline intrusion, and sea-level-related changes, which can interact to intensify social and ecological vulnerability [11, 12].These environmental pressures have significant implications for local livelihoods, particularly through damage to agricultural land, declining agricultural productivity, disruption of fishing and other resource-based activities, and deterioration of freshwater resources [12, 13]. Consequently, environmental change in the Sundarbans cannot be understood only in terms of physical exposure to hazards; its significance also lies in how repeated environmental stresses interact with existing livelihood and socio-economic vulnerabilities.

Although previous studies have examined environmental hazards, livelihood vulnerability, and migration in the Indian Sundarbans, there is still a need to better understand how these processes interact over time. Existing research has documented the impacts of climate-related hazards on agriculture, fisheries, natural-resource-based livelihoods, and household vulnerability [9, 10, 12, 13]. Other studies have shown that environmental stress can influence migration, but migration is also shaped by household resources, livelihood conditions, and the ability to adapt in place [6–8]. However, less attention has been given to how repeated environmental disasters, livelihood loss and limited adaptive capacity together shape environmental migration in the Indian Sundarbans.

Against this background, the present study examines how repeated environmental disasters contribute to environmental migration in the Indian Sundarbans. It focuses on the loss of livelihoods, assets, and living spaces, as well as the ways in which communities respond to these changes. Based on qualitative data from ten villages across five blocks, the study draws on community experiences of recurring climatic events to examine the relationship between climate-related livelihood vulnerabilities and the different migration pathways adopted by communities in the Sundarbans.

Methodology

This study adopts a qualitative research design to understand environmental migration and the experiences of communities affected by environmental disasters in the Indian Sundarbans. The study focuses on how disasters affect livelihoods and living conditions and how communities respond these challenges through adaptation and migration.

Study Area and Sampling

The study was conducted across five administrative blocks in the Indian Sundarbans. Two villages were purposively selected from each block, resulting in a total of ten villages. The villages were selected to capture communities exposed to different environmental hazards, including cyclones, riverbank erosion, flooding, and sea-level-related changes. Purposive sampling was used to include participants with different livelihood and demographic backgrounds.

Data Collection Methods

Primary data were collected through ten Focus Group Discussions [FGDs], involving a total of 60 participants. One FGD was conducted in each selected village, with participants including farmers, fisherfolk, women, and youth. All the respondents of these Focus Group Discussions are migrants and are actively engaged in migration for the last 1 years and more. The discussions focused on environmental disasters, livelihood changes, migration experiences and decisions, adaptation practices, and perceptions of government support.

Data Analysis

The data collected through the Focus Group Discussions were analysed using thematic analysis. The discussions were reviewed to identify participants' accounts of environmental hazards, livelihood changes, household losses, adaptation responses, and migration experiences. Relevant statements were coded according to recurring patterns and similarities across the ten study villages. The codes were then grouped into broader themes related to physical vulnerability, livelihood insecurity, and environmental migration. Particular attention was given to how repeated environmental losses affected households' ability to recover and sustain their livelihoods in place, and how these conditions influenced migration decisions. The themes were subsequently compared across the study locations to identify common patterns and differences in participants' experiences.

Ethical Considerations

All participants provided informed consent before participation. Confidentiality and anonymity were maintained throughout the research process. Participants were informed about the purpose of the study and their voluntary participation.

Research Findings

This section presents the findings on environmental migration in the Indian Sundarbans. It examines how cyclones, riverbank erosion, and sea-level-related changes affect households, livelihoods, and living conditions, and how these environmental pressures contribute to migration.

The findings show that environmental vulnerability in the Sundarbans is closely associated with three major hazards: cyclones, riverbank erosion, and sea-level rise. These hazards affect homes, agricultural land, fisheries, freshwater resources, and other livelihood assets. Repeated environmental losses increase household insecurity and reduce the ability of families to recover from such shocks. For some households, these conditions contribute to temporary, seasonal, or longer-term migration. The following sections examine these vulnerabilities and their links with migration in relation to cyclones, riverbank erosion, and sea-level rise.

1. Physical Vulnerabilities Related to Cyclones

The field findings show that cyclones cause extensive damage to housing, infrastructure, and livelihood assets in the study villages. Participants reported damage to roads, electricity lines, houses, fishing equipment, and other essential assets, disrupting daily life and economic activities. The collapse of houses during cyclones also creates risks of injury and death, including incidents associated with electrocution. The destruction of trees, mangroves, and standing crops further affects households dependent on agriculture and natural resources. These repeated losses increase household vulnerability and make recovery more difficult after each disaster. One participant described the repeated loss of household assets:

“Whenever a cyclone comes, we have to start again. The roof is damaged, the house is damaged, and whatever we have kept inside also gets destroyed.”

This account illustrates how cyclones create repeated material losses that place additional pressure on already vulnerable households.

A particularly significant impact of cyclones is storm-surge-induced saltwater intrusion into agricultural fields and freshwater ponds. Participants reported that storm surges and tidal flooding can overwhelm weak embankments, inundating agricultural land and affecting its productivity for several years. Focus group discussions further indicated that some farmers had not seen their land fully recover even years after a cyclone. Salinization of freshwater ponds also affects fish stocks that contribute to household food and income. The resulting decline in agricultural and aquacultural productivity reduces household income and weakens the capacity of families to cope with subsequent environmental shocks.

The effect of saltwater intrusion on agricultural productivity was also reflected in participants' accounts. One farmer explained:

“The water entered our fields and the soil became salty. Even after so many years, the land does not give the same amount of rice as before.”

This experience is further illustrated by another farmer who reported:

“Before Aila, we used to get 12 bags of rice from one bigha of land, but now we are only able to harvest 7–8 bags.”

Together, these accounts indicate that the effects of cyclones extend beyond immediate physical damage. The decline in agricultural productivity reported by participants points to the persistent effects of salinity on farming livelihoods and the difficulties households face in restoring their previous levels of production. Such prolonged livelihood losses can reduce household income and weaken the resources available for recovery from subsequent disasters.

The findings also indicate that cyclones generate different forms of mobility. Immediately after a cyclone, households

may evacuate to cyclone shelters or temporarily stay with relatives in safer areas. Such movement is primarily short-term evacuation or displacement rather than migration. One participant explained:

"After the cyclone, we first went to stay with relatives because our house was damaged. But after cyclone we find that we lost so much of our different livelihood assets and as jobs in the village is also not available, some of our family members had to go outside the village to find work."

This account also illustrates how temporary displacement can be followed by livelihood-driven migration when households are unable to restore their sources of income. Where damage to land, housing, and livelihoods persists, households may therefore consider moving elsewhere to secure income or safer living conditions. Cyclone-related mobility in the study area can consequently be understood as a continuum ranging from immediate evacuation and temporary displacement to temporary and potentially longer-term migration.

2. Physical Vulnerabilities Related to River Erosion

The findings show that households living close to rivers are particularly exposed to the loss of land and damage to embankments. When riverbanks erode or embankments collapse, agricultural land and homesteads become exposed to tidal water, sometimes forcing families to leave their homes. For households that depend on land for both residence and cultivation, the loss of even a small portion of land can have serious consequences for their ability to maintain their livelihoods.

"The river is taking our land little by little. We do not know when the next part of our homestead will disappear. Once the land is gone, there is nowhere else for us to build."

This account reflects how erosion is experienced not simply as a physical environmental process but as a continuing threat to household security. Unlike a single disaster event, river erosion can gradually reduce the land available for housing and cultivation, leaving families uncertain about the future. The loss of land also reduces the assets that households can rely on when facing other environmental or economic shocks.

The failure of embankments further increases this vulnerability. Participants reported that breaches in earthen embankments allow saline tidal water to enter agricultural fields and surrounding settlements. Such flooding can damage crops immediately, while the subsequent increase in soil salinity can reduce agricultural productivity for a longer period. The findings therefore indicate that embankment failure creates both an immediate physical risk and a longer-term livelihood problem.

"When the embankment breaks, the water destroys everything—our fields, houses, and ponds. Even after the water goes down, the land remains infertile for several years. The fish in the ponds die, and the grass that we depend on for our livestock also gets destroyed."

The effects are particularly serious for households dependent on agriculture. Saline water entering agricultural fields can reduce the productivity of land and make cultivation increasingly difficult. As agricultural income declines, families may be required to depend on other sources of employment. This creates additional economic pressure, particularly for households with limited land and few alternative livelihood opportunities.

River erosion has also affected fishing-based livelihoods. Focus group discussions indicated that participants perceived a decline in both the quantity and diversity of fish available in local rivers. For households traditionally dependent on fishing, this reduction has weakened an important source of food and income.

"Earlier, going to the river meant that we would return with enough fish to sell. Now we spend more time in the river but get much less fish."

The decline in fishing opportunities adds another layer to the livelihood insecurity created by land and agricultural losses. Households that lose access to productive land while also experiencing declining fishing opportunities have fewer options for sustaining their income within the village. Some participants therefore described turning to alternative and often insecure forms of work outside their traditional occupations.

"When farming and fishing are no longer enough, we have to look for work elsewhere. We do not leave because we want to; we leave because there is less work here."

These findings suggest that river erosion contributes to migration through a gradual erosion of livelihood security rather than through displacement alone. The loss of land, repeated embankment breaches, salinization, and declining fishing opportunities collectively reduce the capacity of households to sustain their livelihoods in place. For some households, this pressure contributes to distressed or livelihood-driven migration, particularly when alternative sources of income are limited. Thus, river erosion should be understood not only as a process of physical land loss but also as a process that progressively narrows the livelihood options available to vulnerable households.

3. Physical Vulnerabilities Related to Sea-Level Rise

The findings show that households in low-lying areas face the gradual loss of habitable and agricultural land as water increasingly affects areas used for settlement and cultivation. The loss of land is particularly serious for households whose livelihoods depend on agriculture, as the decline in available productive land reduces both household income and food security. In some cases, repeated land loss also forces families to relocate their homes.

"The water is coming closer to our homes every year. We have already lost parts of our agricultural land, and we are always worried that the next time it will be our house."

The loss of land is accompanied by increasing salinity in agricultural fields and freshwater sources. Even where land has not been completely submerged, saline water can reduce soil quality and agricultural productivity. Participants reported declining crop yields and increasing difficulties in continuing traditional agricultural activities. This creates pressure on households to look for alternative sources of income when farming can no longer provide sufficient returns.

"The land is still there, but it is not giving us the same yield as before. The soil has become salty, and every year it becomes harder to grow crops."

The findings therefore indicate that sea-level-related environmental change affects households not only through the physical loss of land but also through the gradual deterioration of the resources needed to sustain livelihoods. For families dependent on agriculture and other natural-resource-based activities, this creates a continuing process of livelihood insecurity. When productive land and other

livelihood resources decline, households have fewer opportunities to recover within the village.

Repeated displacement also creates considerable emotional and financial insecurity. One elderly participant described the repeated loss of his homes:

"The house you see now is my fourth one—my previous homes were all lost to the ocean. I don't know where I will go if this one is destroyed too, as I had to take a loan to build this small house."

This account illustrates that environmental displacement is not necessarily a single event. Repeated loss of housing can require households to rebuild several times, increasing their financial burden while creating uncertainty about whether the next home will remain secure. The experience also shows how environmental change can gradually reduce a household's sense of security and attachment to place.

For some households, these conditions contribute to migration. However, migration does not necessarily represent a freely chosen response to environmental change. As agricultural productivity declines, land is lost, and homes become increasingly insecure, migration may become one of the few available ways to secure income or physical safety. The findings therefore suggest that sea-level-related environmental change contributes to migration through a gradual narrowing of livelihood and residential options. In this context, migration can emerge as a response to accumulated environmental losses rather than as a single reaction to a particular disaster.

Discussion

The findings of this study demonstrate that environmental migration in the Indian Sundarbans is best understood as a cumulative livelihood process rather than a direct response to individual environmental disasters. Participants' experiences show that repeated environmental disturbances gradually affect agricultural land, fishing opportunities, housing, freshwater resources, and other livelihood assets. As these losses accumulate, households become less able to recover from subsequent shocks and increasingly face difficulties in sustaining their livelihoods in place. This supports recent research showing that climate-induced migration generally operates through indirect pathways in which environmental pressures interact with socioeconomic and livelihood conditions rather than producing migration automatically [14, 15].

An important finding of the study is therefore the temporal dimension of environmental vulnerability. The participants' accounts indicate that the significance of an environmental event does not end with the event itself. Damage to productive resources may continue to affect households for several years, while repeated shocks can occur before previous losses have been fully recovered. Recent research on climate-induced migration in the Global South similarly emphasises the importance of considering multiple and compounding climate stressors and the socioeconomic processes through which they influence mobility [14]. The present study adds a qualitative household-level perspective to this argument by showing how repeated losses gradually reduce the ability of households to maintain their livelihoods in their place of origin.

The findings also indicate that livelihood vulnerability is a central mechanism linking environmental change with migration. Participants did not describe environmental conditions alone as the reason for leaving. Rather, migration became necessary when environmental changes affected the resources through which households earned their livelihoods. Declining agricultural productivity, reduced fishing opportunities, loss of land, damage to houses, and limited local employment collectively narrowed the options available to households. This interpretation is consistent with recent research in the Indian Sundarbans, which identifies livelihood resources, income, occupation, landholding, infrastructure, and access to alternative livelihood opportunities as important dimensions of vulnerability [16, 17]. Thus, environmental migration in the study area appears to occur through the erosion of livelihood security, rather than through environmental exposure alone.

This finding is particularly important for understanding migration as a constrained livelihood response. Participants' accounts suggest that migration was often not described as an entirely voluntary decision. Households moved when remaining in the village became increasingly difficult because traditional livelihood activities could no longer provide sufficient income or security. Recent research on climate-related migration decisions similarly finds that migration choices are closely associated with households' access to in-situ adaptation opportunities, land, and other livelihood resources [8]. Migration can therefore represent an available response to environmental stress, but the ability to use migration as a strategy is itself influenced by household resources.

The study further demonstrates that environmental migration should not be viewed only as forced displacement. Participants' experiences reveal a continuum between temporary movement, livelihood-related migration, and longer-term relocation. This supports recent scholarship calling for a broader understanding of climate mobility that recognises migration as a process influenced by capability, choice, vulnerability, and adaptation rather than treating all environmentally related movement as forced displacement [18]. In the present study, migration emerges when households' capacity to recover and continue their livelihoods locally becomes increasingly constrained.

At the same time, the findings indicate that environmental vulnerability is economically differentiated. Households dependent heavily on natural-resource-based livelihoods are particularly exposed because the same environmental processes that affect their physical surroundings also directly affect their income-generating resources. Recent research from the Indian Sundarbans similarly shows that livelihood vulnerability is higher among communities with greater dependence on natural resources and fewer alternative livelihood opportunities, while better connectivity and diversified livelihoods can reduce vulnerability [16]. This suggests that environmental migration cannot be explained solely through the intensity of environmental hazards; it must also be understood through differences in household livelihood capacity.

Overall, the findings suggest a pathway in which repeated environmental exposure produces cumulative livelihood losses, these losses reduce household resilience and the ability to recover in place, and migration consequently becomes an increasingly important response. The process can therefore be conceptualised as:

Repeated environmental stress → livelihood and asset loss → declining recovery capacity → increasing livelihood insecurity → constrained migration.

This interpretation represents the main contribution of the study. Rather than treating environmental migration as the immediate outcome of a particular disaster, the findings show how migration can develop gradually through the accumulation of environmental and livelihood pressures. This is consistent with recent evidence that the relationship between environmental change and migration is heterogeneous and mediated by socioeconomic conditions [15]. It also reinforces the argument that climate mobility needs to be examined together with adaptation, vulnerability, and livelihood security rather than as an isolated migration outcome [18].

For the Indian Sundarbans, this has an important implication. Reducing environmental migration cannot depend only on post-disaster relief or physical protection from individual hazards. The findings suggest the need to strengthen the underlying livelihood capacity of households, including livelihood diversification, access to productive resources, recovery support, and opportunities that reduce dependence on increasingly vulnerable natural-resource-based activities. Recent research from the Sundarbans similarly indicates that alternative livelihood opportunities, connectivity, and access to basic services can reduce livelihood vulnerability [16]. Therefore, addressing environmental migration requires attention not only to environmental hazards but also to the conditions that determine whether households are able to remain and recover in place.

Conclusion

This study shows that environmental migration in the Indian Sundarbans is not simply a response to individual disasters but a cumulative outcome of repeated environmental stress and livelihood loss. Repeated damage to agricultural land, fishing resources, houses, and other livelihood assets reduces households' ability to recover and sustain their livelihoods in place. As livelihood opportunities decline, migration increasingly becomes a constrained strategy for securing income and household well-being. Overall, the findings highlight the interconnected role of environmental stress, livelihood vulnerability, and declining capacity to adapt in place in shaping environmental migration in the Sundarbans. Addressing this process therefore requires not only disaster response but also stronger livelihood resilience and alternative livelihood opportunities.

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