

## Saline Scars and Broken Levees: The Impact of Cyclones on Sundarbans' Agriculture and Aquaculture

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### Abstract

Tropical cyclones pose a significant threat to the vulnerable Sundarban region, the largest mangrove forest globally, situated along the Bay of Bengal coast. In this article, we will delve into the profound effects of cyclones on agriculture and aquaculture in the Sundarbans and explore potential strategies to mitigate their impact. Cyclone-induced flooding, soil degradation and changes in agricultural trends severely affect crop yields and livelihoods. Aquaculture infrastructure destruction, water quality deterioration and stock loss disrupt the thriving aquaculture industry. Mitigation measures such as salt-resistant seed cultivation, integrated farming practices, mangrove restoration and livelihood diversification are discussed. Urgent conservation efforts are crucial to safeguard the Sundarbans' unique biodiversity, including the iconic Royal Bengal Tigers and sustain the livelihoods of millions relying on this fragile ecosystem. As cyclone frequency increases due to climate change, proactive measures and community resilience building are imperative for the Sundarbans' long-term sustainability and resilience.

**Keywords:** Impact, Mitigation strategies, Tropical cyclones, Sundarbans

### Introduction

The offspring of the ocean and atmosphere, tropical cyclones are propelled by the heat from the sea, strong planetary winds, temperate westerlies, easterly trades and their own intense activity. The name "cyclone" comes from the Greek word "Cyclos," which means the coils of a snake. The phrase was coined by Henry Peddington due to the similarity between spiraling sea serpents and tropical storms in the Arabian Sea and Bay of Bengal. Cyclones in India are categorized based on the following factors: storm surges, excessive rainfall and the strength of the accompanying winds. One of the worst-hit areas in the globe by cyclones is the Indian subcontinent. With an 8118 km long coastline, the subcontinent is vulnerable to around 10% of all tropical cyclones that occur worldwide. Most of these originate over the Bay of Bengal and hit India's east coast. Every year, five to six tropical cyclones form on average, with two or three of them having the potential to be severe. The Bay of Bengal experiences more cyclones than the Arabian Sea. May-June and October-November are the months when tropical

cyclones occur frequently. In the North Indian Ocean (the Bay of Bengal and the Arabian Sea), cyclones of severe severity and frequency have a bi-modal pattern, with a primary peak in November and a secondary peak in May. Winds from the storm can be felt for hundreds of kilometres from its core. They regularly create flooding and strong storms that result in considerable property damage and fatalities because they absorb large volumes of water. They could encounter gusts of at least 119 km h<sup>-1</sup>. Cyclones that make landfall can unleash destructive storm surges, or tsunami-like flooding. They can be the most lethal part of a storm and are only marginally affected by wind velocity. In the Bay of Bengal area, cyclones have killed hundreds of thousands of people in recent decades (Anonymous, 2023), destroying vegetation and lowering soil fertility. The Sundarbans, a unique and ecologically fragile region spanning the delta of India and Bangladesh, is renowned for its dense mangrove forests, diverse wildlife and vital role in the ecosystem. However, the region's vulnerability to cyclones poses a significant threat to both its agricultural and aquacultural sectors.

### Article History

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### Sundarbans: At a Glance

The Sundarbans, the largest unbroken stretch of mangrove forest globally, covers around 9,630 square kilometres (Figure 1). This includes 5,363 square kilometres of reclaimed land and 4,267 square kilometres of safeguarded mangrove forests. An additional 6,000 square kilometres (approximately 60%) of continuous mangroves extend into neighbouring country Bangladesh. The Indian portion of the Sundarbans falls under West Bengal's jurisdiction specifically in South 24 Parganas district. The Indian sector of the Sundarbans delta, situated between latitudes 21°40' N and 22°40' N and longitudes 88°03' E and 89°07' E, is an integral component of the greatest fluvio-marine delta in the world, the Ganga-Brahmaputra, situated near the meeting point of the Bay of Bengal.

The Indian portion of the Sundarbans delta has been of utmost concern for WWF-India since 1973, because of its distinct biodiversity. While it shelters a substantial population of untamed tigers and various creatures, it is also a delicate and susceptible zone where over 4.5 million people live. Securing the future of the Sundarbans, its diverse life forms and its inhabitants requires a holistic strategy. This should include long-term strategies that combine climate adaptation and conservation, as well as short-term actions like promoting sustainable livelihoods, providing access to clean energy and effectively managing human-wildlife conflicts.

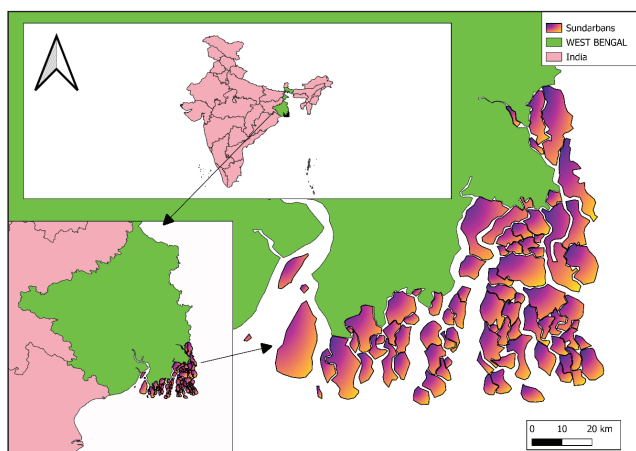


Figure 1: Location of Indian Sundarbans

### Sundarbans and Cyclone: Terms Associated to Each Other

The Sundarbans, a vast deltaic mangrove forest region, is uniquely positioned along the Bay of Bengal's coastline, making it particularly vulnerable to cyclones. Several factors contribute to the Sundarbans' susceptibility to cyclonic events:

- 1. Geographic Location:** The Sundarbans is situated in a low-lying coastal area, making it prone to flooding from storm surges and heavy rainfall associated with cyclones. This deltaic region frequently observes property damage and human casualties due to tropical cyclones and tidal surges.
- 2. Deltaic Formation:** The complex network of waterways and mangrove islands in the Sundarbans creates a natural barrier that can both mitigate and exacerbate cyclone impacts.

While mangroves can absorb some of the storm's energy, they can also channel and intensify floodwaters.

- 3. Sea Level Rise:** The Sundarbans see more flooding as a result of storm surges during cyclones being amplified by increasing sea levels brought on by climate change.
- 4. Climate Change Effects:** The Sundarbans is experiencing the effects of climate change, including higher sea surface temperatures, which can fuel the intensity of cyclones.

### Impact on Agriculture

#### 1. Crop Damage and Loss

Cyclone-induced floods submerge fields, destroying crops and making the land unsuitable for cultivation. Saline water intrusion further exacerbates the problem, rendering the soil infertile and reducing agricultural productivity. Cyclone Amphan caused significant damage to mature crops and trees, particularly those yielding cash crops such as betel leaves and betel nuts. Across West Bengal, approximately 88,000 hectares of paddy fields and 200,000 hectares of vegetable and sesame crops suffered substantial destruction.

#### 2. Soil Degradation

Erosion and sediment deposition alter the soil composition, depleting essential nutrients and affecting crop growth. Over time, repeated cyclone impacts lead to long-term soil degradation. In 2009, the cyclone Aila's strength has caused seawater to inundate delta farmlands, making them unproductive for several upcoming years. Approximately 17,800 hectares of agricultural land might have suffered due to the intrusion of saline seawater. Besides erosion, the creation of new water channels could result in villages being flooded by saline water overflow.

#### 3. Water-logging in Agricultural Lands

The delta is saucer-shaped in structure due to un-systemic construction of embankments and intensive siltation within river channels. The agricultural land faces water-logging problem and it results in unsuitable for cultivating *Kharif* vegetable crops.

#### 4. Change in Trend of Agriculture

Post cyclone Aila in 2009, the production of Aman and Boro paddy has reduced significantly as salinity of the land has increased significantly. Lack of freshwater irrigation resulted in low production of paddy during the Rabi season. The production has shifted from paddy to vegetables but that has also been impacted by the changing patterns of rainfall which makes difficult economic situation of the farmers.

#### 5. Impact of Fruit Production

Sundarbans is a significant hub of fruit production in West Bengal. Banana, Sapota, Coconut, Papaya, Palm and Date palm was cultured in the homestead region of the Sundarbans delta. The production has been damaged significantly due to the cyclones and it has questioned the food security of the locals too. As these are expensive, it has resulted in nutrient shortage for the locals.

#### 6. Livelihood Disruption

For the communities in the Sundarbans, agriculture is a

primary source of income. Cyclone-related losses disrupt livelihoods, pushing families into financial instability and poverty. Cyclone Yaas, occurring in 2021, resulted in the destruction of approximately 71,560 hectares of horticulture and 2.21 lakh hectares of agriculture, leading to a combined financial loss of Rs. 20,000 crores according to the West Bengal government.

### Impact on Aquaculture

The Sundarbans is renowned for its thriving aquaculture industry, which includes shrimp, fish and crab farming. However, cyclones cast a shadow over this sector as well:

#### 1. Destruction of Infrastructure

Cyclones damage aquaculture infrastructure such as ponds, hatcheries and embankments, disrupting the normal breeding and rearing cycles of aquatic species. During Amphan in 2020, around 58,000 hectares of ponds, usually utilized for cultivating crabs, prawns and fish, have been adversely impacted. Moreover, approximately 8,000 fishing boats have been harmed, leading to a temporary halt in fishing activities by the fishermen.

#### 2. Water Quality Impact

Cyclone-induced flooding can lead to an influx of brackish water from the sea, affecting water quality in aquaculture ponds and negatively impacting the health and growth of farmed species. During Aila, the presence of saline water intrusion from the Bay of Bengal led to alterations in surface water characteristics such as salinity (increase of 25.2%), pH levels (increase of 25.03%) and dissolved oxygen (decrease of 5.53%) content (Mitra *et al.*, 2020).

#### 3. Loss of Stock

The intense winds and flooding associated with cyclones can cause fish and shrimp stock mortality. Valuable breeding stock can be lost, leading to long-term repercussions for the aquaculture industry. Due to Yaas cyclone, the calculated value of shrimp losses in solely Purba Medinipur district of West Bengal amounted to approximately Rs 900-1,000 crores, which translates to around \$130 million (Anonymous, 2020).

### Mitigation Measures Adopted

#### 1. Usage of Salt-Resistant Seeds

Historical records mentioned that various salt-tolerant paddy has been cultivated in Sundarbans prior to settlement in the area. With expansion of human settlement in this region, the paddy culture shifted to freshwater agriculture. But while it got exposed to cyclones, the salt-tolerant paddy was reintroduced to deal with the changing climate. As there are no scope for High-Yielding-Varieties (HYVs) to grow for many seasons here, varieties like Nona Swarna (minimum tolerance), Dudhersar (medium tolerance), Darsal, Nona Bokra, Talmugur (high tolerance) *etc.* are being cultured. While few are fetching premium price in the market, it needs more focus so that the farmers do not return to the old HYVs which damages the ecosystem of Sundarbans. In addition to these, drought- and salt-tolerant field crops including cotton, melons and chiles are grown on rain-fed highlands,

partially irrigated highlands and medium-sized fields with mildly salinized conditions.

#### 2. Shrimp and Brackish-Water Fish Farming

Following the 1970s, the state saw a dramatic change in the way shrimp were farmed, gradually incorporating the usage of brackish water from West Bengal's deltaic region into a system of mixed shrimp and fish farming. When the central and state governments worked together to advance shrimp farming with an eye toward exports and expand coastal aquaculture in the 1980s, the practice took off. Integration of fish, shrimp and salt-tolerant paddy cultivation can also be used to mitigate the risks of cyclones. Carp, Tilapia, Catfishes *etc.* could be ideal options to cultivate under the integrated farming practices. Excavated ground intended for rainwater storage can be utilized for two purposes: (a) fisheries and (b) life-saving or protective watering of second crops, primarily commercial crops like vegetables and spices.

#### 3. Mangrove Restoration

Increasing mangrove restoration and conservation initiatives can act as a natural defence against tidal waves and storm surges. Through the absorption of wave energy and the reduction of erosion, mangrove afforestation along susceptible coasts can help lessen the effects of storms. This also includes restoration of mangrove ecosystem which can be achieved by sustainable harvesting of mangrove products, including timber and firewood, as well as other marine products like fish, crabs and shells.

#### 4. Livelihood Diversification and Social Protection

Enhancing livelihood diversification programs like ecotourism, other revenue streams and microenterprise growth might lessen the reliance of nearby populations on industries susceptible to cyclones, such as aquaculture and agriculture. Furthermore, disadvantaged communities can be protected from losses caused by cyclones by offering social protection mechanisms such microfinance services, livelihood assistance grants and crop insurance. Creation of Self-Help groups, livestock farming, cash for work schemes has a positive impact on the locals of Sundarbans especially the females (Jain *et al.*, 2016).

The Tagore Society, inspired by the cooperative movement initiated by Sir Daniel Hamilton in 1902, continues its efforts to uplift the Sundarbans despite challenges. Recognizing the need to diversify livelihoods, the society, with support from the MS Swaminathan Research Foundation (MSSRF), aims to implement a three-crop pattern, seeking solutions to long-standing agricultural limitations (Chakraborty, 2021). By promoting community-based initiatives and advocating for sustainable practices, such as mangrove restoration and afforestation, the society strives to mitigate the impacts of cyclones and safeguard the Sundarbans' ecosystem and livelihoods. Through education and advocacy, the Tagore Society empowers local communities to adapt and thrive in the face of environmental challenges, fostering resilience and sustainability in the Sundarbans.

### Conclusion

Mangroves are the lung of aquatic ecosystem for its wide oxygen producing capacity. The ecosystem is also known as nutrient trap and as an ecotone it holds diverse groups of aquatic flora and fauna. The biggest mangrove forest in India, the Sundarbans is the sole mangrove habitat used by Royal Bengal Tigers, a keystone species of the forest ecosystem. It also has wide role in the growth and economy of the local people. In the recent times due to climate change and pollution the frequency of cyclones has increase in the Indian subcontinent. As a result, strong cyclone falls into the Sundarbans and results in the loss of plant and animal species. Due to cyclone forest cover has already decreased and is reducing in an alarming rate. In this situation the government and scientific stakeholders need to devoid more time for the conservation of this ecologically important and sensitive ecosystem.

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