

Assessing the Vulnerability of Sundarban Island to Sea Level Rise and Estuarine Dynamics

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Abstract: *The Sundarban region, the world's largest mangrove ecosystem and a vital coastal wetland, is situated in the deltaic complex of the Rivers Ganga, Brahmaputra, and Meghna, shared between India (38%) and Bangladesh (62%). This region is highly vulnerable to environmental changes, particularly sea level rise, coastal erosion, and frequent cyclonic storms. This study focuses on analyzing the dynamic changes in island areas and the impact of rising sea levels over time. The total area of the Indian Sundarban region is approximately 9630 sq. km., consisting of 102 islands, of which 54 are inhabited with a population of over 4.2 million. The findings indicate that while some islands (like Ghoramara or Jambudwip) are gradually disappearing due to submergence, new land formations (accretion) are also occurring in certain pockets. Factors such as natural subsidence, tidal activities, destruction of mangrove vegetation, and reduced freshwater flow significantly influence these estuarine dynamics. The study emphasizes the urgent need for proper environmental management and sustainable conservation strategies to protect this fragile ecosystem.*

Keywords: Sundarban Rise, Coastal Erosion, Island Change, Climate Change, Sea Level Rise, Estuarine Dynamics, Submergence, Accretion, Satellite Imagery, Tidal Channels

I. INTRODUCTION

The Sundarban region is located in the delta formed by the Ganga, Brahmaputra, and Meghna rivers, shared between India and Bangladesh. In India, it is geographically positioned between 21° 32' and 22° 40' N latitude and 88° 30' and 89° 00' E longitude. It is bounded by the river Hooghly on the west and the Ichamati-Kalindi-Raimangal on the east. The region is renowned for its dense mangrove forests, which provide a unique habitat for the endangered Bengal Tiger and rich biodiversity.

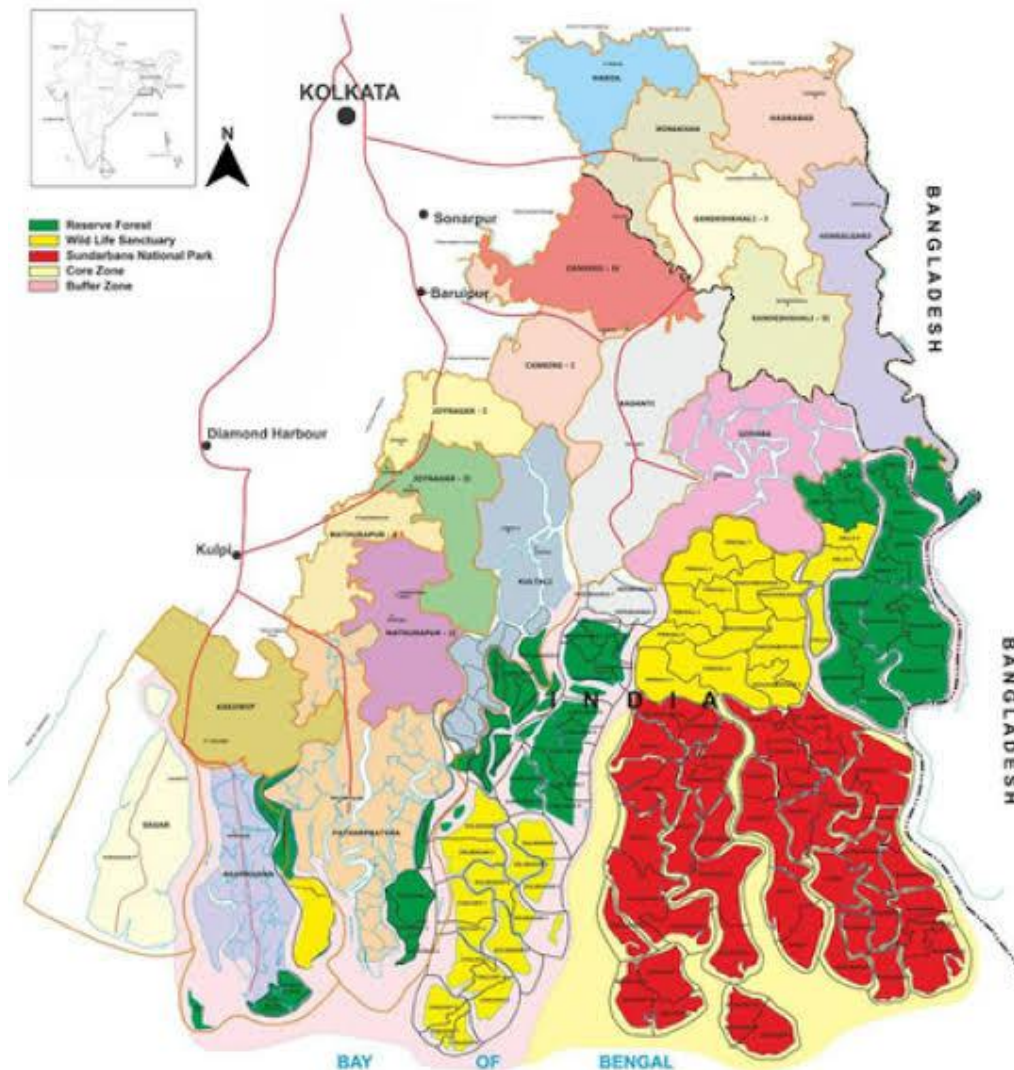
The Indian portion of the Sundarbans covers about 9630 sq. km., where the Reserved Forest occupies nearly 4260 sq. km. The area is spread across two administrative districts: South 24-Parganas (13 blocks) and North 24-Parganas (6 blocks).

Due to its low elevation and geographical proximity to the Bay of Bengal, the Sundarbans are exceptionally vulnerable to:

- **Sea Level Rise:** Increasing the risk of permanent submergence of low-lying islands.
- **Coastal Erosion & Cyclones:** Frequent storms accelerate the loss of land along the estuary.
- **Sediment Deposition:** While some areas suffer land loss, others experience land gain through the accretion of alluvium.

Since the late 18th century, human activities and premature reclamation of land (over 3500 km of earthen embankments) have altered the natural flow of the delta. Understanding these complex environmental changes is essential for effective disaster management, environmental protection, and the sustainable development of this UNESCO World Heritage site.





Sundarban : A Developing Estuary

Sundarban estuary is still forming due to **sediment deposition** and **tidal action**, causing continuous **erosion and accretion** of islands.

High tides frequently flood islands, supporting **mangrove species** like *Avicennia* and *Ceriops*.

Satellite studies show **new islands forming** and **others eroding**, indicating dynamic land changes.

Human Habitation

Out of 102 islands, many are **reserved forests**, while inhabited islands depend on **embankments** for protection.

If embankments break, **saline water floods villages**, causing major risks.

Ghoramara–Lohachara Case

Significant **land loss and submergence** observed.

Some islands have already disappeared, making people **homeless**.

Rising **sea levels and erosion** are key causes.



Study Findings

Southern islands are **highly vulnerable to erosion, flooding, and sea-level rise.**

Predictive models show further **land loss in coming years.**

Objectives of Study

Analyze **erosion–accretion process.**

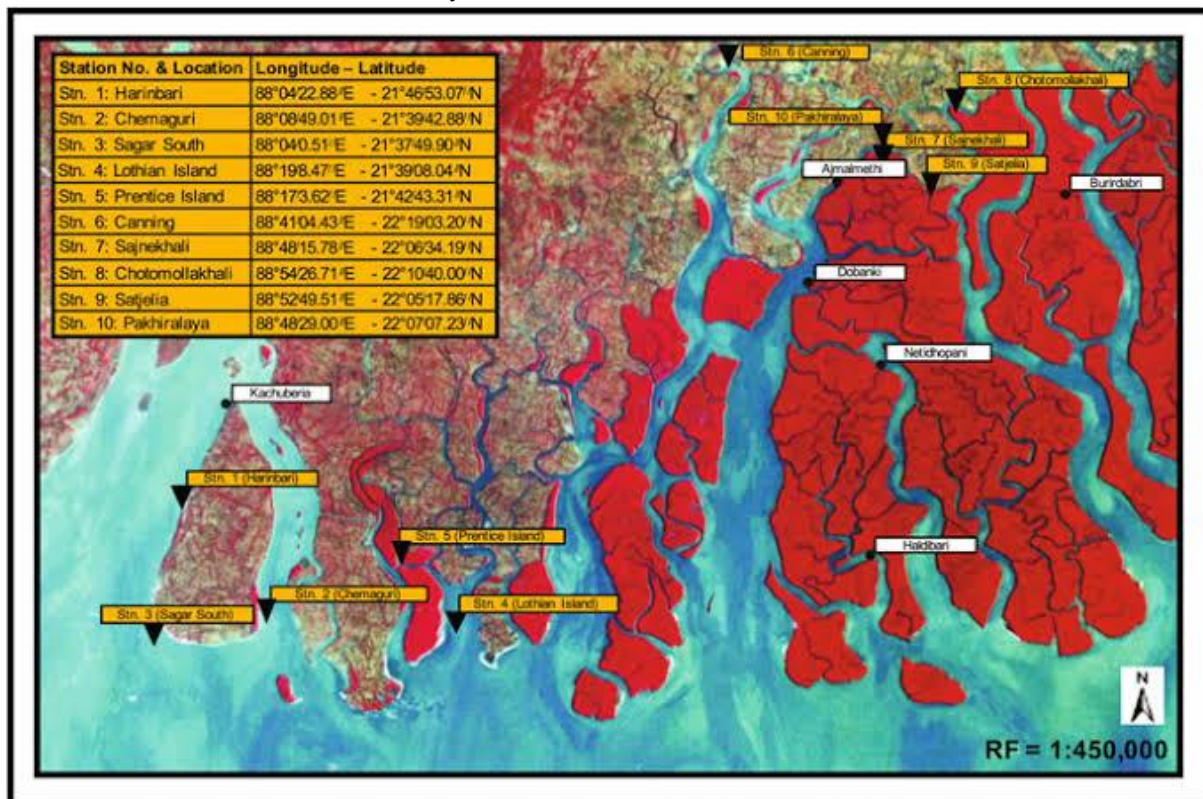
Study impact of **sea-level rise and global warming.**

Test causes of **island disappearance.**

Methods

Used **satellite data (IRS, GIS)** and field analysis.

Selected vulnerable islands for detailed study.



II. RESULTS & DISCUSSION

Sundarban is **highly dynamic:**

Some islands show **erosion (land loss)**

Others show **accretion (land gain)**

Ghoramara Island → continuous decrease in size

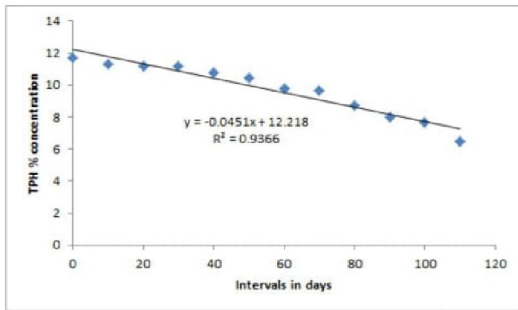
Nearby islands → some **increase in land & mangroves**

Main cause of change:

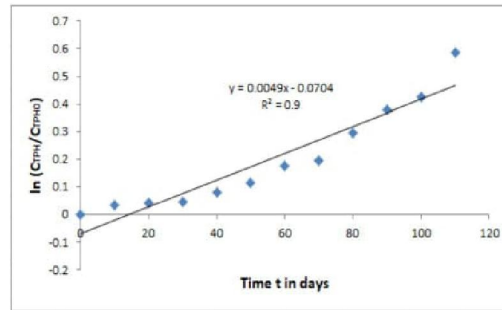
Tidal currents + sediment deposition (primary)

Sea-level rise is **not the only reason**

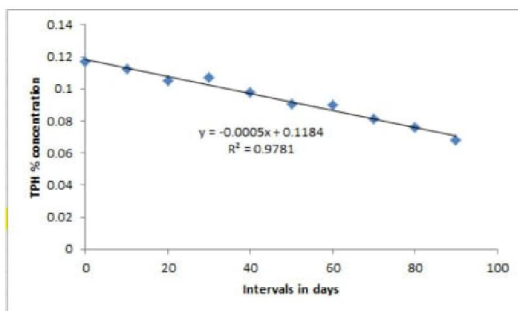




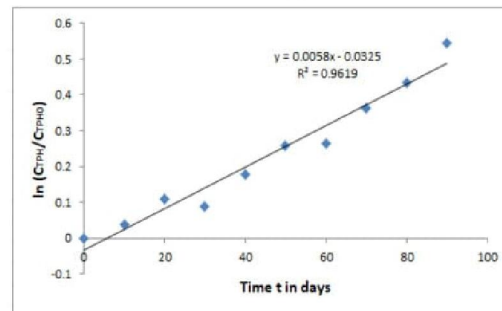
(a)



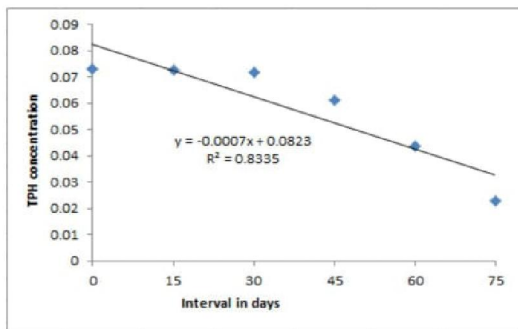
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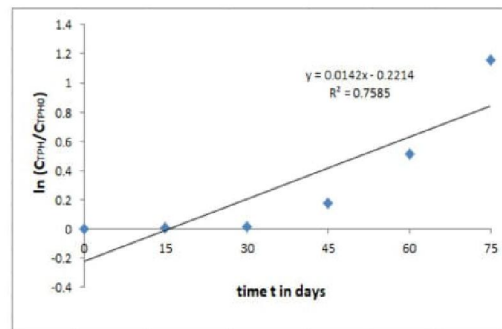
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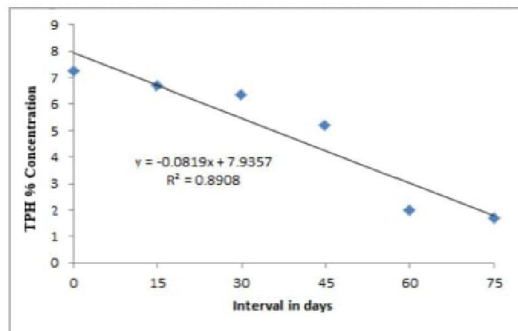
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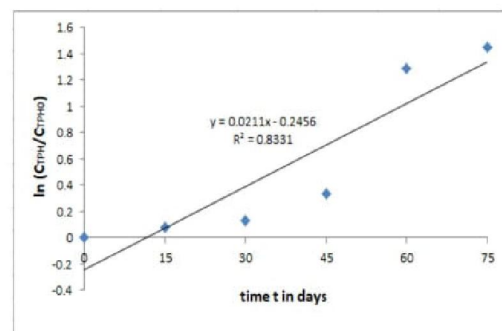
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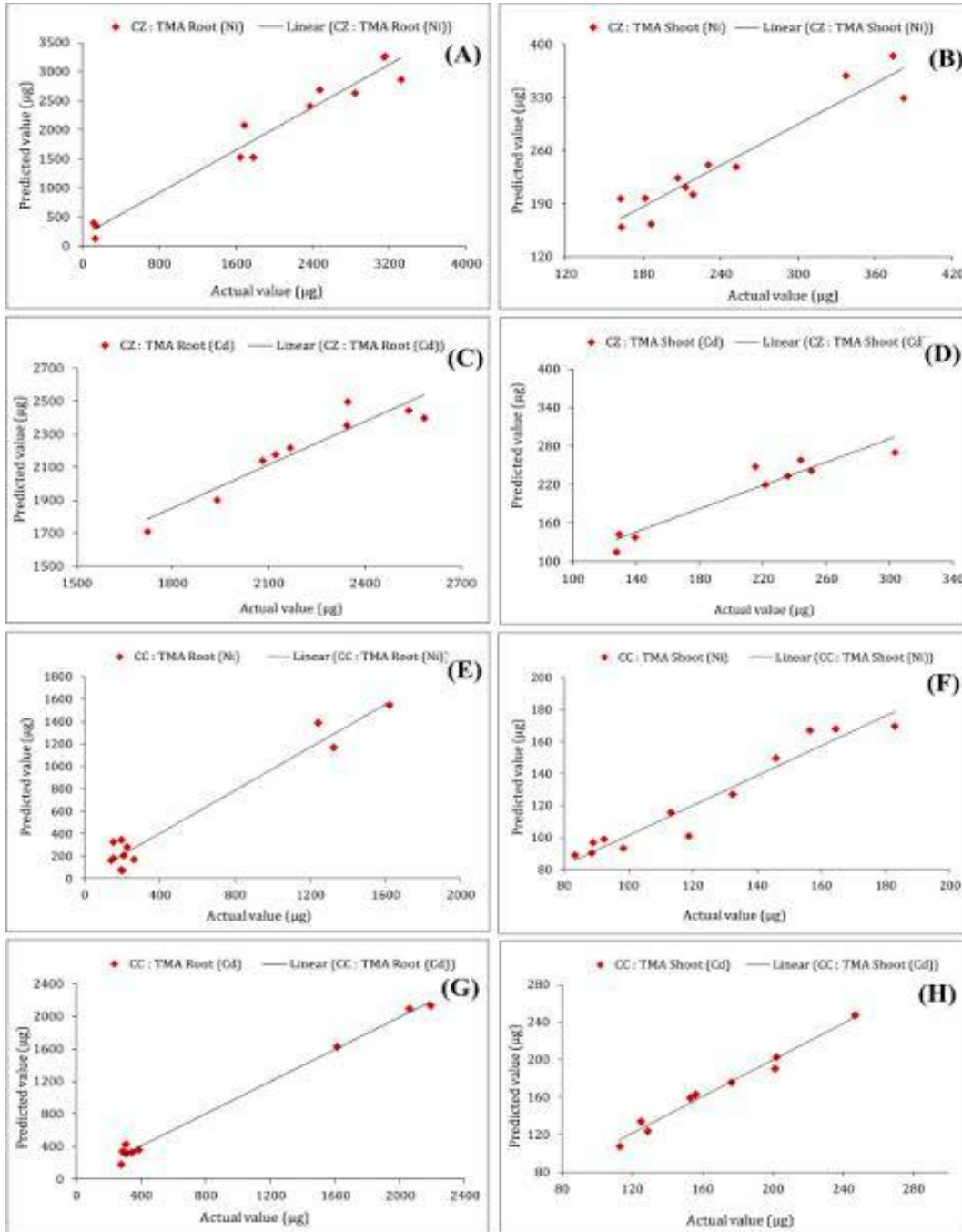


(g)



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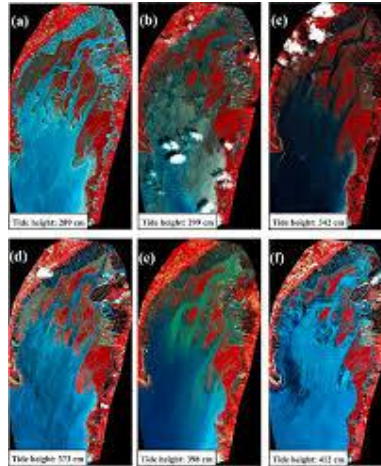


III. CONCLUSION

The Sundarban estuary is a highly dynamic and continuously changing landscape influenced by multiple factors such as siltation from rivers, natural land subsidence, and rising sea levels due to global warming. While sea level rise poses a threat, the region also shows resilience through natural processes like sediment deposition, which leads to the formation



of new islands even as others undergo erosion. Mangrove vegetation plays a crucial role in protecting islands by reducing tidal erosion and acting as a natural defence against climate impacts. However, increasing salinity may alter mangrove composition over time. The effects of climate change are not uniform across all islands, with inhabited and non-mangrove areas being more vulnerable. Therefore, effective adaptation strategies and conservation of mangroves are essential to sustain the ecosystem and protect these islands in the long term.



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