

Ecological Assessment of Coastal Vegetation and Soil Quality in the Bay of Bengal Region: A Case Study of Purba Medinipur and Balasore Districts

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Abstract

The coastal districts of Purba Medinipur (West Bengal) and Balasore (Odisha) along the Bay of Bengal represent ecologically sensitive regions increasingly threatened by environmental and anthropogenic stressors. This study provides a comprehensive ecological assessment focusing on vegetation diversity, soil conditions, seasonal variation, and land-use change. Field surveys conducted across ten selected sites employed quadrat sampling to evaluate species composition, frequency, and abundance. A total of 68 plant species belonging to 29 families were recorded, with Fabaceae emerging as the most dominant, indicating strong ecological adaptability and nitrogen-fixing capacity. Halophytic species like *Rhizophora mucronata* and *Avicennia marina* were prevalent in mangrove zones, while monoculture plantations of *Casuarina equisetifolia* dominated human-modified areas. Seasonal analysis revealed that species like *Ipomoea biloba* showed marked post-monsoon abundance, highlighting phenological responses to climatic factors. GIS-based land-use analysis from 2017 to 2024 showed nearly a 50% decline in vegetation cover and a doubling of built-up areas, underscoring rapid coastal degradation. The findings highlight urgent conservation needs, emphasizing habitat restoration, sustainable land-use practices, and the integration of indigenous ecological knowledge. This study contributes valuable insights for evidence-based coastal ecosystem management and biodiversity conservation in

eastern India's vulnerable coastal belts.

Key Words: Coastal Ecosystems, Vegetation Diversity, Halophytes, Land-Use Change, Fabaceae Dominance

Introduction

Coastal ecosystems are dynamic and ecologically significant zones that play a critical role in biodiversity conservation, shoreline protection, and supporting the livelihoods of millions of people. In India, the eastern coast along the Bay of Bengal is particularly vulnerable due to frequent cyclones, sea-level rise, saline intrusion, and unregulated development (Nayak, 2002; Dutta et al., 2013). The coastal districts of Purba Medinipur (West Bengal) and Balasore (Odisha) exemplify this vulnerability. These regions represent a complex landscape comprising mangrove forests, estuaries, sand dunes, saline marshes, and anthropogenically modified zones such as agricultural lands and plantations (Ghosh et al., 2015).

The ecological balance of these coastal belts is being disrupted by both natural and human-induced factors. Over the past decades, habitat degradation due to infrastructural expansion, tourism-related development, and the replacement of native vegetation with monoculture plantations—particularly *Casuarina equisetifolia*—have led to biodiversity loss and altered ecosystem functions (Kathiresan & Bingham, 2001; Das & Bandyopadhyay, 2013). At the same time, increasing soil salinity and coastal erosion further compound ecological stress, directly impacting vegetation patterns, species distribution, and soil fertility (Chakraborty & Mukhopadhyay, 2019).

This study seeks to evaluate the ecological status of vegetation and soil quality in these coastal zones through field-based observations, species frequency-density analysis, and GIS-based land-use monitoring. By identifying dominant flora,

particularly halophytes and stress-tolerant species, and analysing land degradation trends, the study aims to contribute towards evidence-based conservation strategies for sustaining coastal biodiversity and ecosystem services in this sensitive region.

Materials and Methods

This study was conducted in ten coastal locations across Purba Medinipur (West Bengal) and Balasore (Odisha), chosen for their ecological sensitivity and floristic diversity. Field-based vegetation assessments were carried out using the quadrat method—10×10 m for trees, 5×5 m for shrubs, and 1×1 m for herbs—across varied habitats (Misra, 1968; Kershaw & Looney, 1985). Species frequency, density, and abundance were calculated to determine ecological dominance. Seasonal surveys were conducted in pre-monsoon, monsoon, and post-monsoon periods. Ethnobotanical data were collected through semi-structured interviews with local residents, traditional healers, and forest officials (Kala, 2005). Remote sensing and GIS (QGIS software) were employed to assess vegetation change from 2017 to 2024 using Landsat and Sentinel-2 imagery (Jensen, 2007; Lillesand et al., 2015). Plant specimens were preserved, authenticated using regional floras, and documented in herbarium sheets for future reference (Jain & Rao, 1977).

Results and Discussion

The coastal regions of Purba Medinipur and Balasore revealed substantial ecological heterogeneity and anthropogenic influences across

various habitat types, including mangroves, sand dunes, and plantations. A total of 68 plant species representing 29 botanical families were documented. Among these, the Fabaceae family emerged as the most dominant (16 species), followed by Moraceae (5 species) and Arecaceae (4 species). This dominance is detailed in Table 1, which summarizes the number of species under the major botanical families observed in the study area. The ecological prevalence of Fabaceae highlights its adaptability and role in nitrogen fixation in saline-prone soils (Singh et al., 2010; Magurran, 1988).

Table 1: Dominant Plant Families Identified in the Study Area.

Family	No. of Species
Fabaceae	16
Moraceae	5
Arecaceae	4
Meliaceae	3
Rhizophoraceae	3
Others (24)	37

Field-based quadrat surveys across the study sites revealed that *Casuarina equisetifolia*, *Cocos nucifera*, and *Rhizophora mucronata* were among the most frequently encountered species. These species exhibited high frequency percentages in their respective ecological zones, indicating both natural dominance (e.g., mangrove-associated species) and anthropogenic plantation efforts. Table 2 presents the frequency distribution of dominant species across mangrove, plantation, and transitional zones, reflecting their ecological niches and adaptability.

Table 2: Frequency (%) of Key Species in Different Habitats.

Species	Mangrove Zone	Plantation Zone	Transitional Zone
<i>Rhizophora mucronata</i>	84%	10%	0%
<i>Avicennia marina</i>	80%	12%	6%
<i>Casuarina equisetifolia</i>	0%	93%	42%
<i>Ipomoea biloba</i>	0%	20%	88%

The high frequency of halophytic species such as *Rhizophora mucronata* and *Avicennia marina* in mangrove zones confirms their role in shoreline stabilization and sediment trapping (Kathiresan & Bingham, 2001). In contrast, species like *Casuarina equisetifolia* dominate plantation zones, suggesting human-mediated ecosystem modification. Vegetation abundance also varied across seasons. For example, *Ipomoea biloba* showed post-monsoon dominance with a mean abundance of 7.1 individuals/quadrat, indicating its preference for moisture-rich, sandy habitats. Table 3 presents the mean seasonal abundance of selected dominant species across pre-monsoon, monsoon, and post-monsoon periods, highlighting phenological variations and stress adaptability.

Table 3: Mean Species Abundance Across Seasons.

Species	Pre-Monsoon	Monsoon	Post-Monsoon
<i>Ipomoea biloba</i>	3.2	4.8	7.1
<i>Casuarina equisetifolia</i>	5.5	6.0	6.8
<i>Avicennia marina</i>	4.6	4.9	5.0

The stability of *Casuarina equisetifolia* and *Avicennia marina* across seasons suggests their tolerance to coastal environmental fluctuations, while seasonal peaks in *Ipomoea biloba* support earlier findings on pioneer

herbaceous colonizers in disturbed coastal zones (Ghosh et al., 2016).

GIS-based analysis of land-use change between 2017 and 2024 further supports field observations. Vegetation cover decreased by nearly 50%, while built-up areas doubled, especially in tourism-prone regions like Digha and Talsari. This intensifies ecological stress on native flora and disrupts natural regeneration cycles (Das & Bandyopadhyay, 2013).

The dominance of Fabaceae and the decline of native halophytes underscore the need for habitat restoration, improved land-use planning, and the promotion of salt-tolerant species in coastal afforestation programs.

Conclusions

The ecological assessment of coastal zones in Purba Medinipur and Balasore highlights significant biodiversity supported by native and halophytic species, with Fabaceae emerging as the dominant family. However, the growing influence of anthropogenic activities—especially monoculture plantations and urban expansion—has led to a notable decline in vegetative cover and ecosystem stability. Seasonal variations and GIS-based analyses further reveal the vulnerability of these habitats to environmental stress. To ensure long-term sustainability, conservation strategies must prioritize native species restoration, controlled land-use practices, and the integration of traditional ecological knowledge in coastal management efforts.

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