SALINITY DYNAMICS AND STRUCTURAL VULNERABILITY: FORECASTING RISKS TO THE BLUE ECONOMY IN THE LOWER GANGETIC DELTA USING AI

Indrani Dhar[1,] *, Sana Ahmed[2], Prosenjit Pramanick[2] and Abhijit Mitra[2]

[1]Department of Architecture, Rani Rashmoni School of Architecture under Sanaka Educational Trust group of Institutions, West Bengal, Paschim Bardhaman, Malandighi, Kanksha - 713212, India

[2]Department of Oceanography, Techno India University, West Bengal, EM 4/1 Salt Lake, Sector V, Kolkata 700091, India

* Corresponding Author Email ID: indranidhar68@gmail.com

ABSTRACT

The sustainability of the Blue Economy, a vital driver of national GDP and climate-resilient coastal development relies heavily on environmental factors, particularly salinity. This study analyzes a 40-year (1984–2024) salinity dataset (mean of three seasons, namely premonsoon, monsoon, and postmonsoon) from two key estuarine zones in the north-western Bay of Bengal, namely Digha and Haldia. Using optical refractometry, Mohr-Knudsen verification, and a Nonlinear Autoregressive (NAR) neural network, the research forecasts salinity trends through 2050. Digha, a hub tourism and fish landing activities, shows rising hypersalinity (projected up to 34.08 PSU), posing serious corrosion risks to Blue Economy infrastructure. In contrast, Haldia is an industrial port that exhibits a declining salinity trend (10.06 PSU), suggesting reduced corrosive threats. These divergent patterns stem from differences in geomorphology, freshwater inflow, and anthropogenic influences. The study underscores the urgent need for location-specific policy responses, including anti-corrosive construction, cathodic protection, and updated infrastructure design at high-risk zones like Digha. The integration of AI-driven forecasting proves crucial for proactive planning. This research offers a pioneering, data-driven model for salinity-informed resilience strategies, highlighting the necessity of aligning environmental intelligence with Blue Economy infrastructure development to ensure sustainability in an era of climate uncertainty.

Keywords: *Blue Economy, Salinity, Digha, Haldia, Corrosion, Nonlinear Autoregressive (NAR) neural network model*

1. INTRODUCTION

The Blue Economy has emerged as a transformative paradigm for coastal nations aiming to integrate economic growth with environmental sustainability. It encompasses a wide range of ocean-based industries such as fisheries, aquaculture, coastal tourism, port operations, marine biotechnology, and renewable energy, contributing significantly to national GDPs and employment while ensuring ecological resilience. For countries like India, with vast coastal stretches and rich marine biodiversity, the Blue Economy holds immense potential for fostering inclusive growth, alleviating poverty, and addressing the challenges posed by climate change. However, the sustainability of this sector is inextricably linked to the dynamic interplay of environmental variables that influence coastal and estuarine ecosystems. Among these, salinity stands out as a critical factor affecting both ecological balance and the structural integrity of marine infrastructure.

In estuarine and coastal regions, salinity is the key player, governed by the balance between freshwater inflow from rivers and saline intrusion from the sea. This variability influences a wide array of ecological and economic activities, from the productivity of brackish water aquaculture and fishery yields to the longevity of port and tourism infrastructure. A persistent rise or decline in salinity can alter species composition, damage ecosystems, and accelerate material degradation, thereby