

Spatial Distribution of Blue Carbon

Indian Sundarbans Mangrove Region

Evaluation of Coastal Canopy Health and Biomass Estimation

Biomass distribution across the Indian Sundarbans is spatially heterogeneous and is strongly influenced by salinity, freshwater availability, mangrove species composition, and local environmental conditions. The relatively higher biomass zones are concentrated mainly in the western sector, particularly around Lothian Island and Prentice Island, where comparatively favourable freshwater conditions and lower salinity support greater mangrove growth and biomass accumulation. The spatial pattern therefore indicates that areas with better freshwater influence tend to support denser and more productive mangrove vegetation.

The mangrove ecosystem also represents a major blue-carbon resource. A recent assessment estimates approximately 36.5 Mt C, equivalent to about 134 Mt CO₂e or 134 million carbon-credit equivalents. At an indicative carbon price of US\$50–200 tCO₂e⁻¹, the stored carbon represents a potential gross value of approximately ₹5.5–22 lakh crore. The estimated carbon-credit value of selected mangrove patches is approximately ₹1.0–5.2 lakh ha⁻¹.

In contrast, lower biomass zones are generally associated with the central sector, particularly around Bonnie Camp and Sajnekhali, where higher salinity, reduced freshwater influence, and sedimentation-related environmental stress can limit mangrove development. The mapped distribution therefore suggests a general decline in biomass from the relatively productive western mangrove areas toward the more saline and environmentally stressed central regions of the Indian Sundarbans.

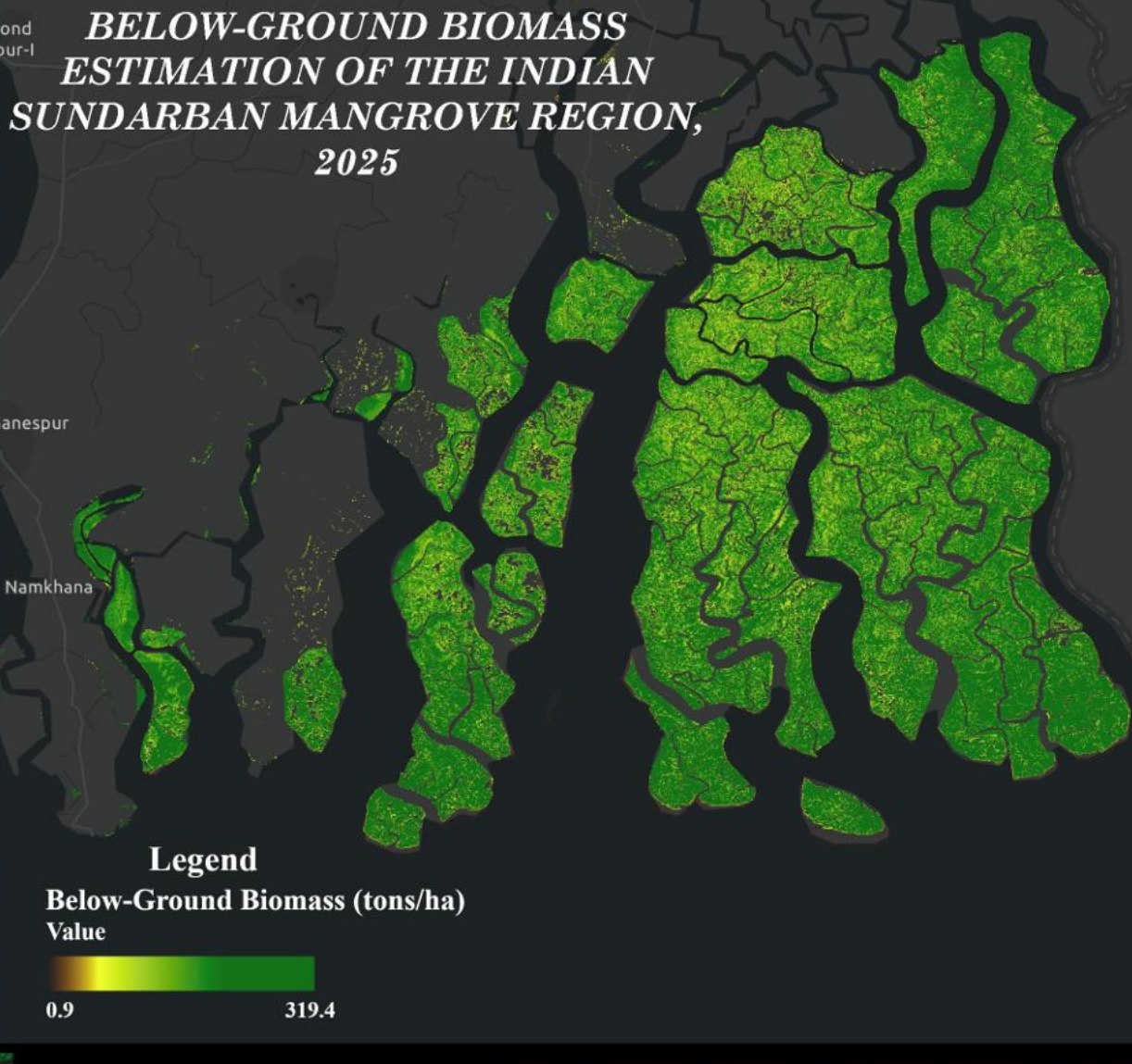
Total Biomass Estimation

Total biomass was estimated by combining the spatially derived above-ground biomass (AGB) and below-ground biomass (BGB) raster datasets:

$$\text{Total Biomass} = \text{AGB} + \text{BGB}$$

The resulting raster represents the total woody biomass (Mg ha⁻¹) stored across the mangrove ecosystem within the study area.

BELOW-GROUND BIOMASS ESTIMATION OF THE INDIAN SUNDARBAN MANGROVE REGION, 2025



Above-Ground Biomass (AGB) Estimation
Cloud-masked Sentinel-2 Surface Reflectance imagery was used to derive the Normalized Difference Vegetation Index (NDVI). NDVI was then used as the predictor in an empirical exponential model to estimate above-ground biomass (AGB):

$$\text{AGB} = 23.027 \times e^{(3.5204 \times \text{NDVI})}$$

where AGB represents above-ground biomass and e is the natural exponential constant. The model follows the remote sensing-based vegetation biomass estimation framework of Myeong et al. (2006).

Citation: Myeong, S., Nowak, D. J., & Duggin, M. J. (2006).

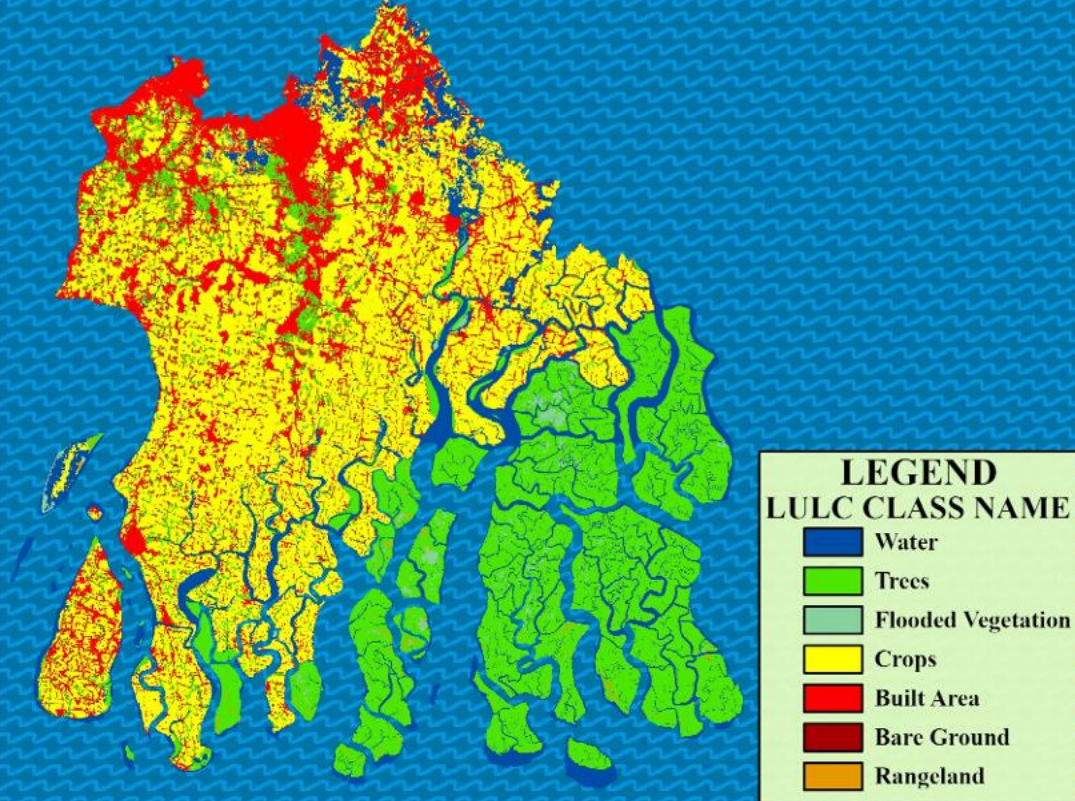
Below-Ground Biomass (BGB) Estimation
Below-ground biomass (BGB) was estimated from the calculated above-ground biomass (AGB) using a standard root-to-shoot ratio:

$$\text{BGB} = \text{AGB} \times 0.49$$

where BGB is below-ground biomass and AGB is above-ground biomass. The conversion factor 0.49 represents the root-to-shoot ratio adopted for biomass estimation following standard international forestry guidelines. Source: IPCC Guidelines for National Greenhouse Gas Inventories, AFOLU.

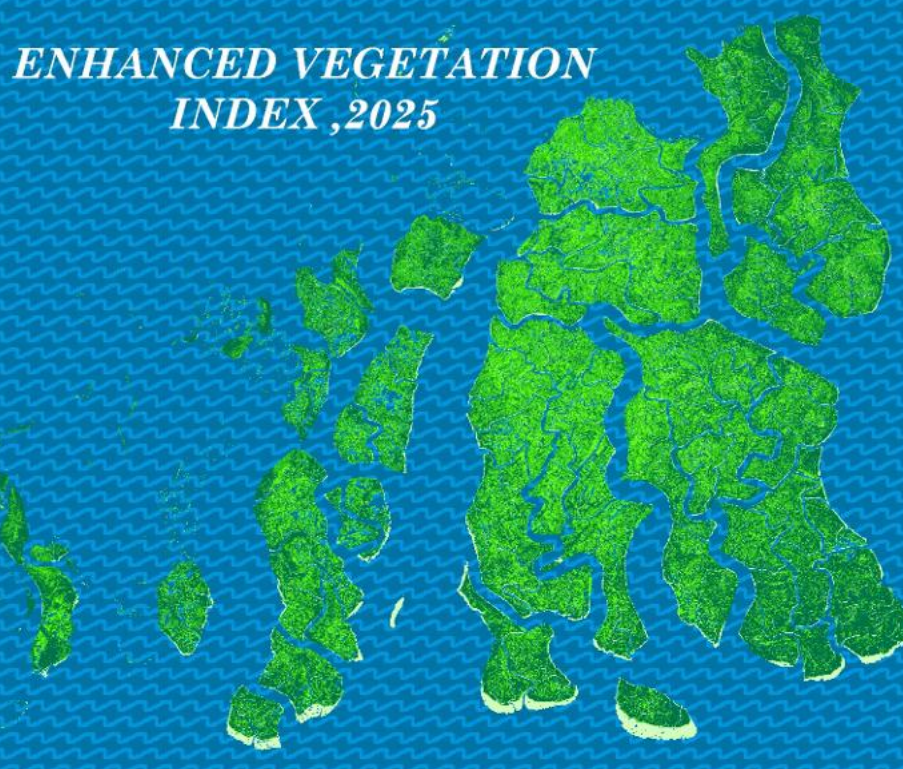
The Indian Sundarbans supports approximately 4.43 million people and sustains regional livelihoods through agriculture, fisheries, aquaculture, forestry, and allied activities. The region contains about 315,500 ha of agricultural land, while South 24 Parganas records approximately 495,720 tonnes of paddy production and about 389,099 tonnes of annual fish production (2021–22). Source: Department of Sundarban Affairs, Government of West Bengal; District Administration, South 24 Parganas.

LAND USE LAND COVER MAP (LULC) OF SOUTH 24 PARGANAS, 2025



The 2025 LULC map of South 24 Parganas shows a distinct north-to-south transition, with cropland and built-up areas concentrated in the north and centre part, while mangrove vegetation dominates the southern Sundarbans. Tidal channels, water bodies, and flooded vegetation characterize the intertidal landscape. The classification achieved a Kappa coefficient of 0.6831, indicating substantial agreement with the reference data.

ENHANCED VEGETATION INDEX, 2025



NORMALIZED DIFFERENCE VEGETATION INDEX, 2025



INTRODUCTION

The Indian Sundarbans form the western part of the Sundarbans mangrove ecosystem, located within the Ganges-Brahmaputra-Meghna delta along the Bay of Bengal. The region comprises an extensive tidal landscape of rivers, creeks, mudflats, islands, and salt-tolerant mangrove forests. The broader Indian Sundarbans region covers approximately 9,600 km², including about 4,267 km² of mangrove forest. The Sundarbans National Park was inscribed as a UNESCO World Heritage Site in 1987 under Criteria (ix) and (x) for its exceptional ecological processes and biodiversity. The ecosystem provides important functions including coastal protection, biodiversity conservation, carbon storage, and support for local livelihoods, making it a highly significant and environmentally sensitive coastal ecosystem in South Asia.

CANOPY HEIGHT MAP OF THE SUNDARBAN MANGROVE REGION, 2020

