

Carbon Sequestration in the Sundarbans Mangrove Forest and Chilika Lake Ecosystems

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The Climate Challenge & Our Research Focus



The Climate Challenge

- Rising CO₂ levels contribute to global warming and climate change.
- Protecting natural carbon sinks is crucial for achieving net-zero carbon goals.



Our Research Focus

- **Objective:**
 - Analyze, model, and visualize carbon sequestration in the Sundarbans and Chilika Lake using satellite data & machine learning models.

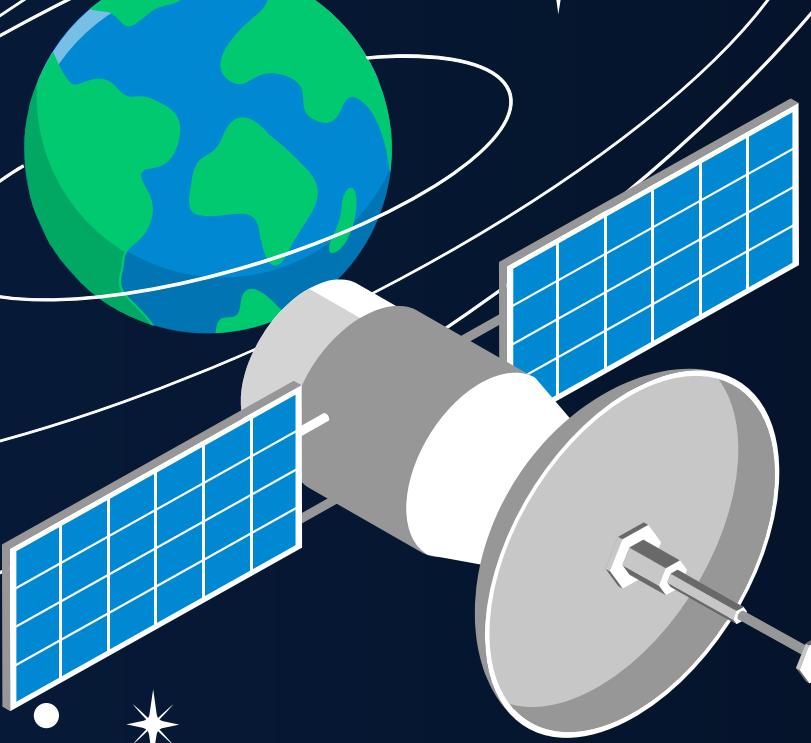
Methodology Overview

Workflow Diagram:

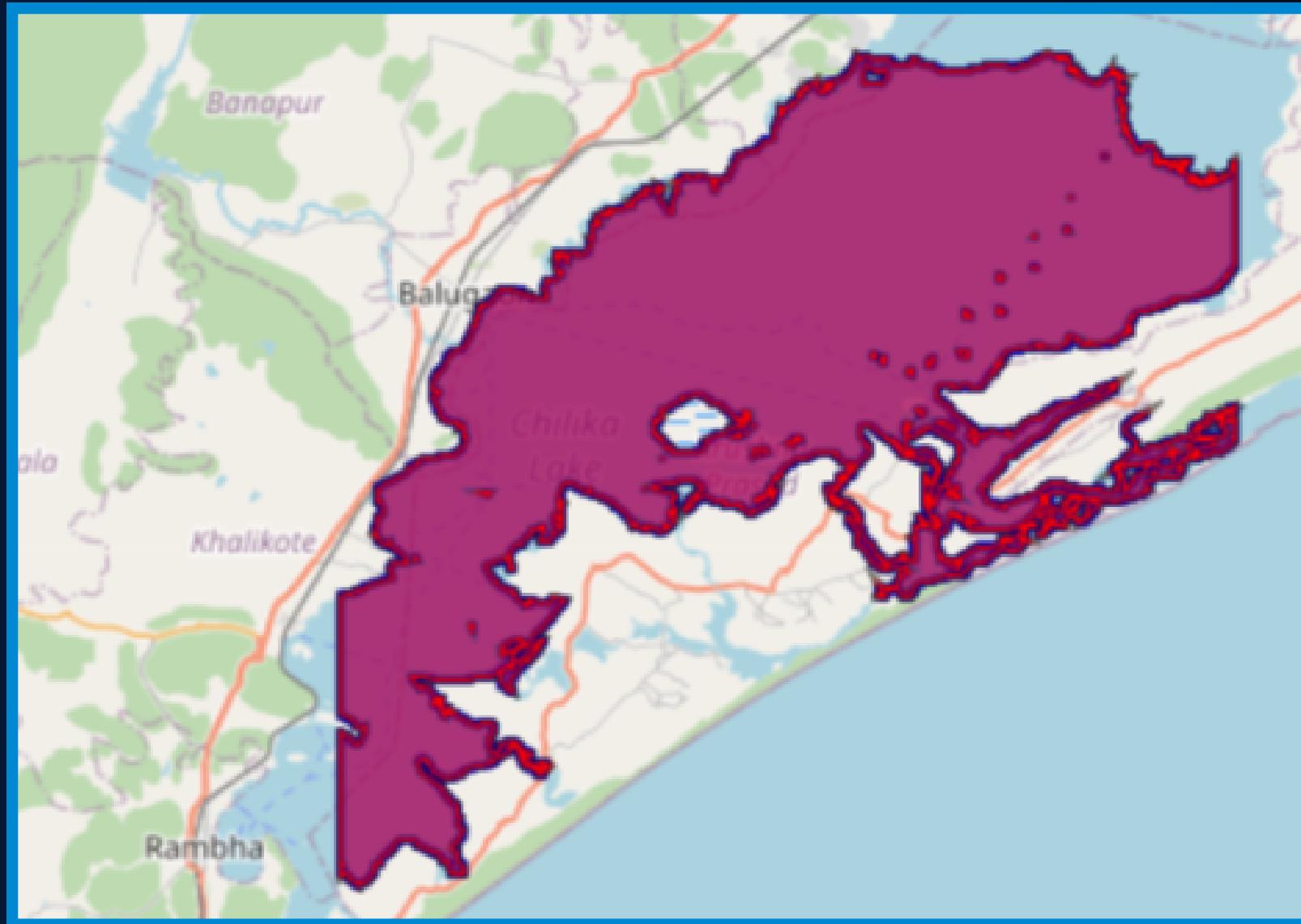


- a. Data Collection (Landsat, SRTM).
- b. Preprocessing (cloud masking, compositing).
- c. Mangrove identification (NDVI, NDWI, elevation) & Chilka Lake.
- d. Carbon estimation (AGB, BGB, water).
- e. Temporal analysis (annual/seasonal trends, change detection).
- f. Future projections (Random Forest/SARIMA).

Locations



Chilika Lake

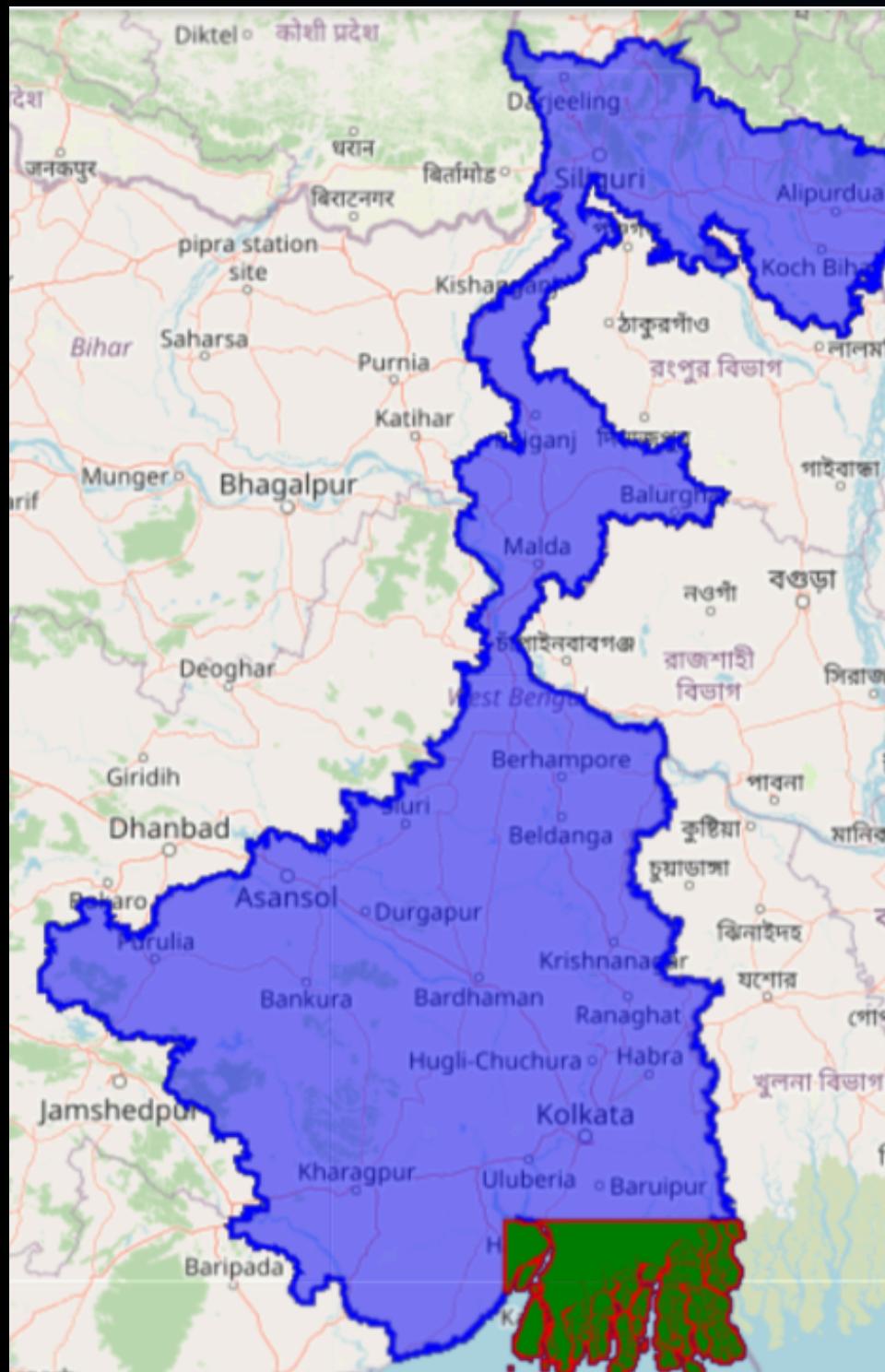


Mangrove Forest (India)

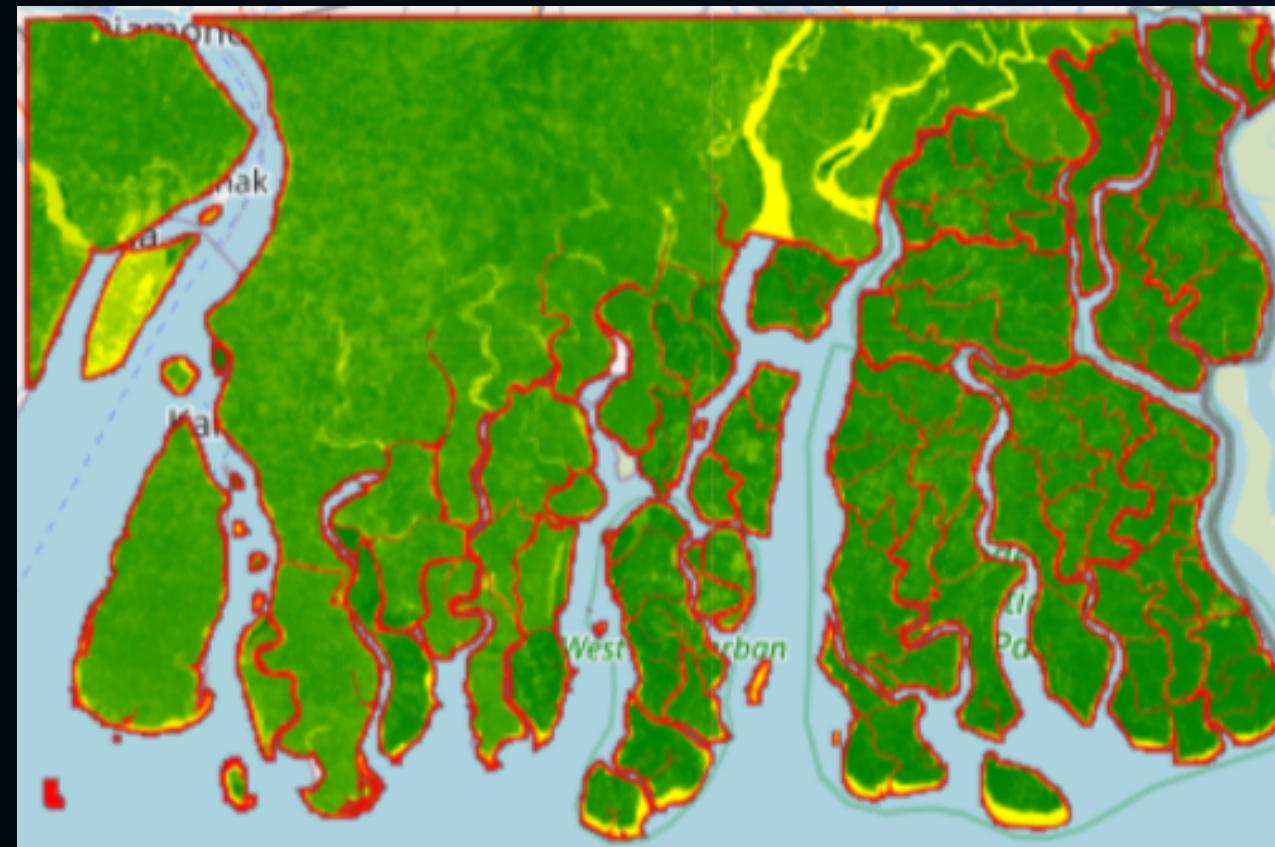


Sundarban Mangrove Forest

Taking intersected area



Region of Interest



Sundarbans Mangrove Carbon Analysis

Total Area: 521872 hectares

Mangrove Area: 72927 hectares (14.0%)

Carbon Stock: 32,598,436 tonnes C

Annual CO₂ Absorption: 729,272 tonnes CO₂

Mangrove Forest



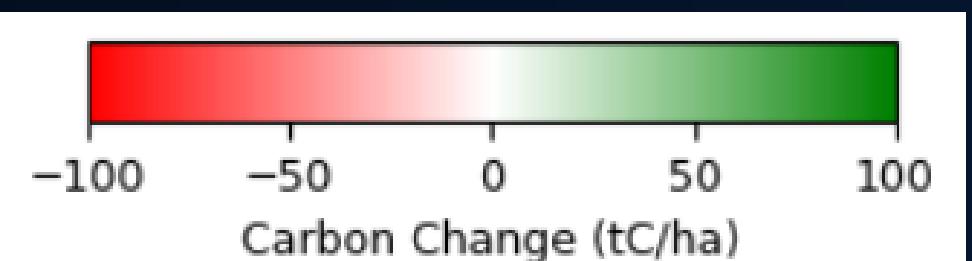
Sundarban Mangrove Forest Analysis

Carbon Change Analysis

Base Year: 2018

Compare Year: 2024

Legend:



===== SUNDARBANS CARBON ANALYSIS SUMMARY =====

Analysis Period: 2018 to 2024

--- MANGROVE EXTENT ---

Initial Mangrove Area (2018): 53,062.59 hectares

Final Mangrove Area (2024): 54,529.38 hectares

Change: 1,466.79 hectares (2.76%)

--- CARBON STOCKS ---

Initial Carbon Stock (2018): 23,718,976.87 tonnes C

Final Carbon Stock (2024): 24,374,631.51 tonnes C

Change: 655,654.64 tonnes C (2.76%)

Current CO₂ Absorption Rate: 545,293.77 tonnes CO₂/year

--- FUTURE PROJECTIONS (by 2029) ---

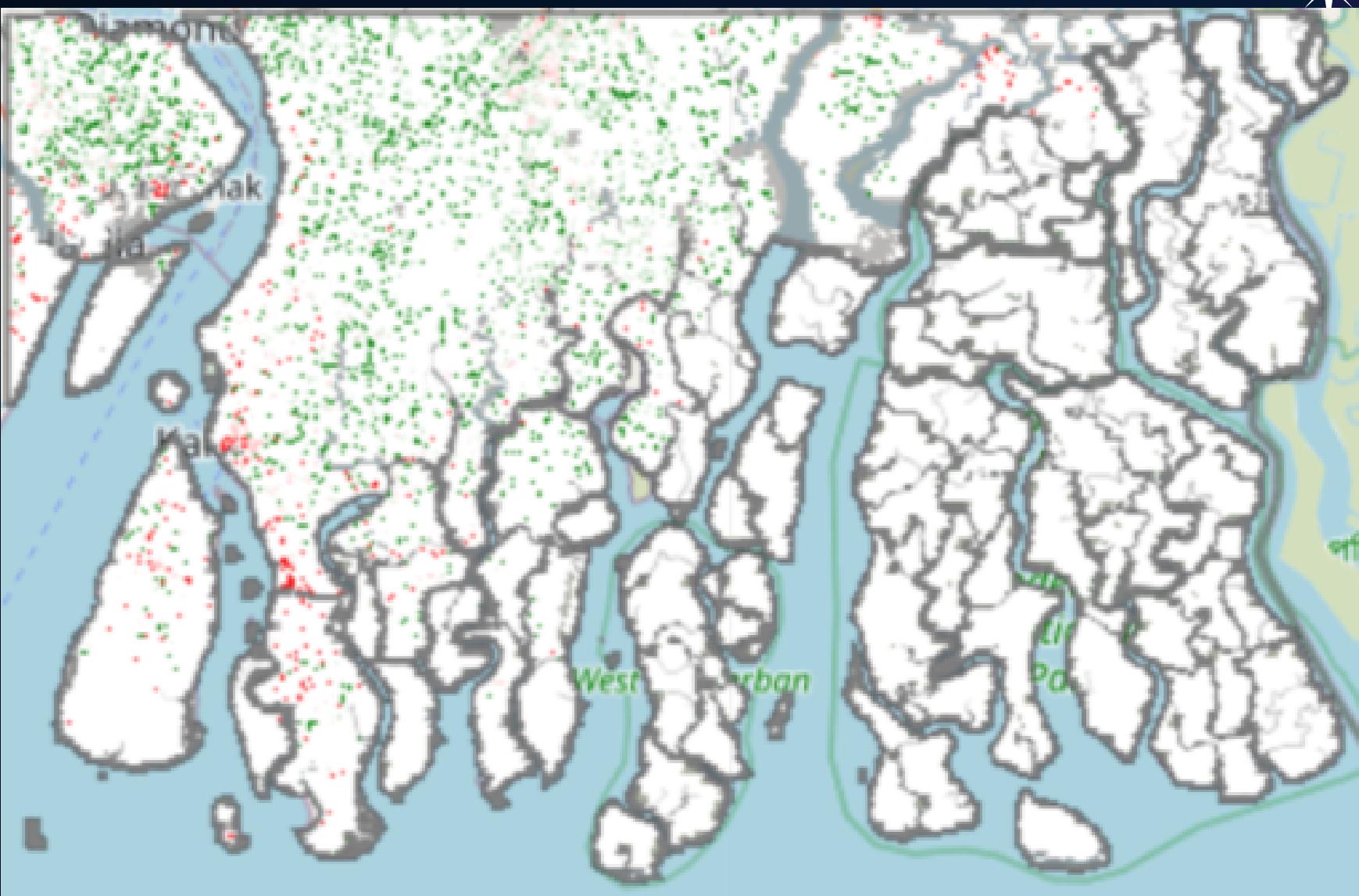
Projected Mangrove Area: 53,897.25 hectares

Projected Change from 2024: -632.13 hectares (-1.16%)

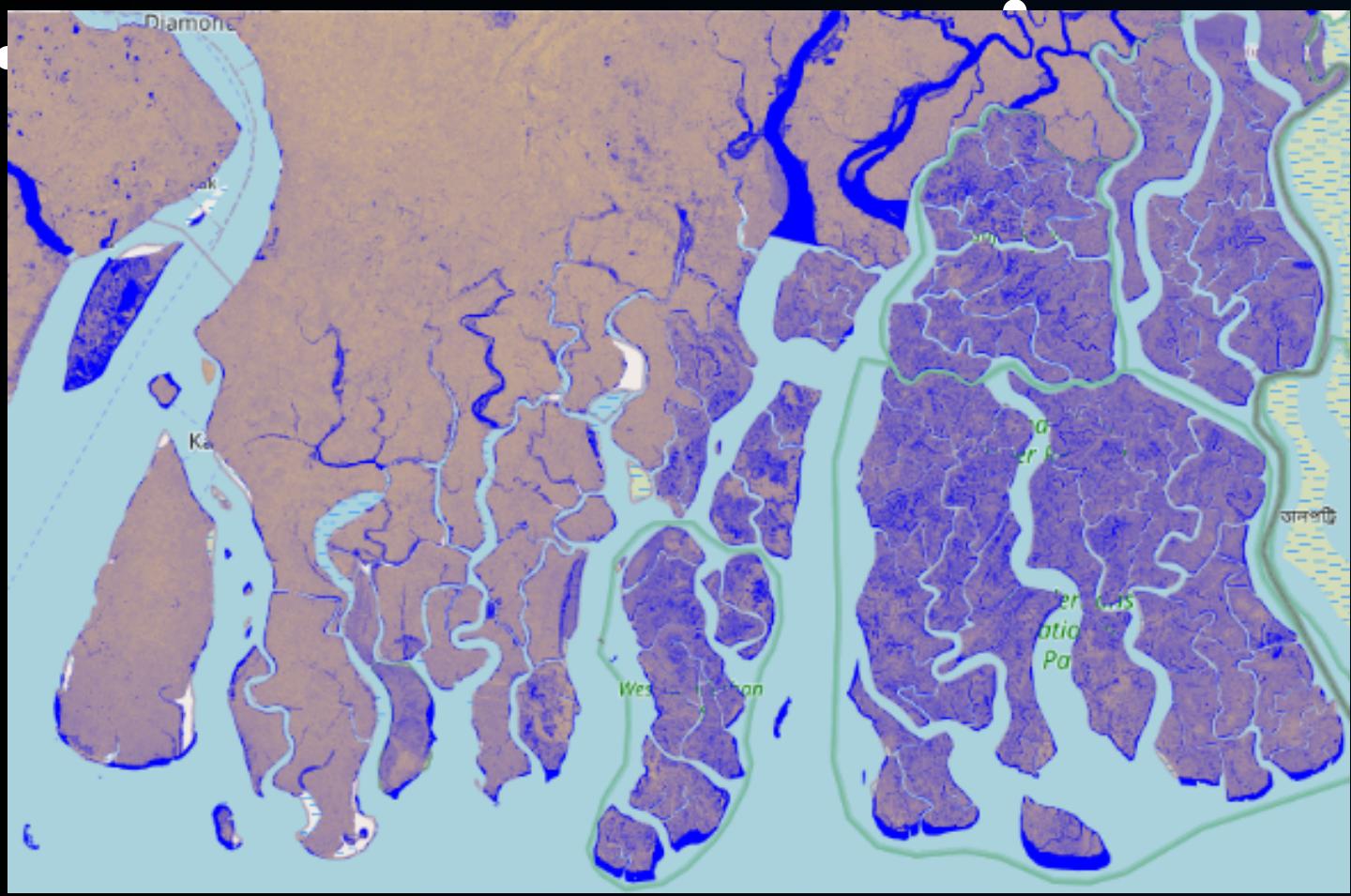
Projected Carbon Stock: 24,092,071.52 tonnes C

Projected Change from 2024: -282,559.99 tonnes C (-1.16%)

Projected CO₂ Absorption Rate: 538,972.52 tonnes CO₂/year



Sundarban Mangrove Forest Indices



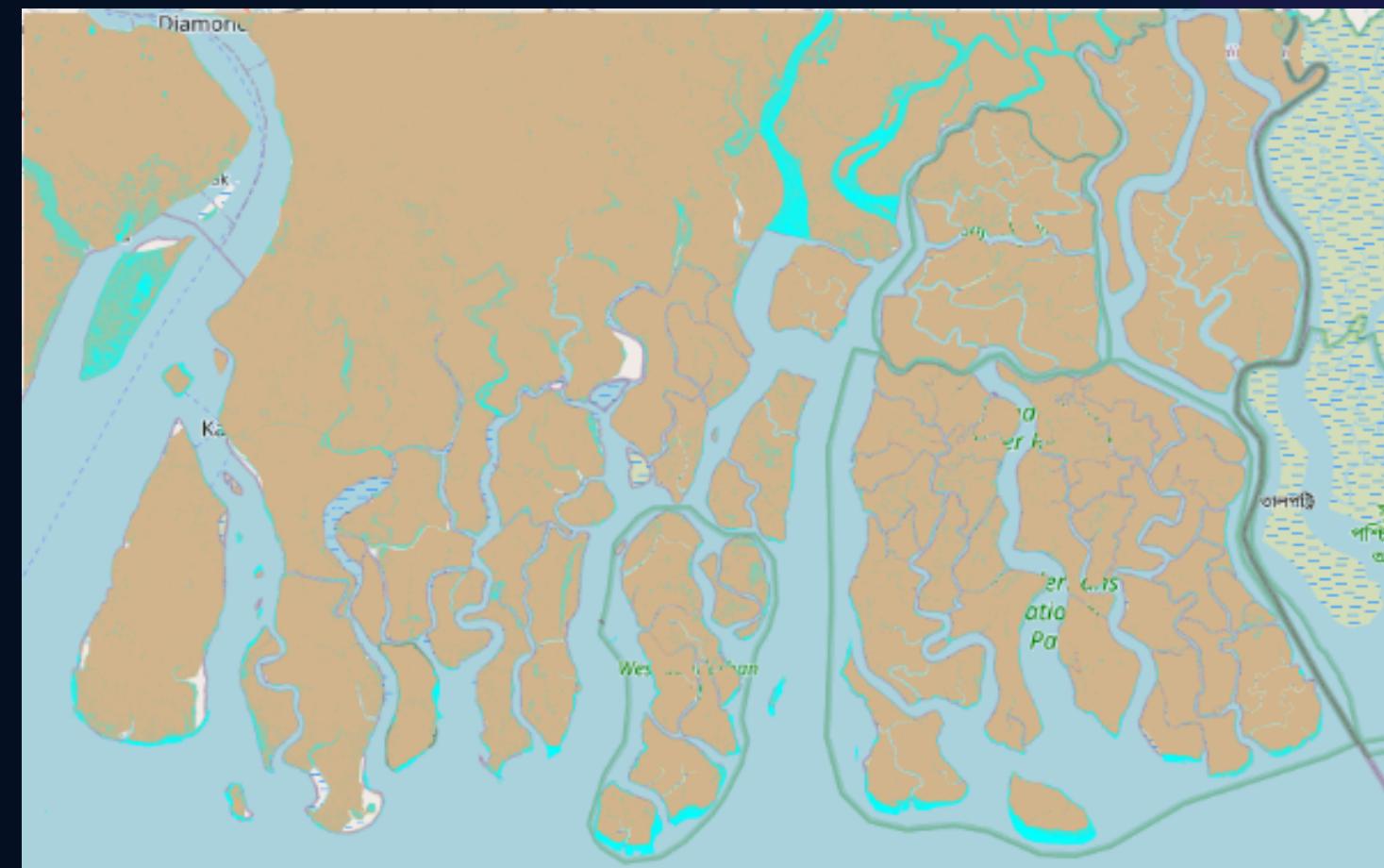
MNDVI



NDVI

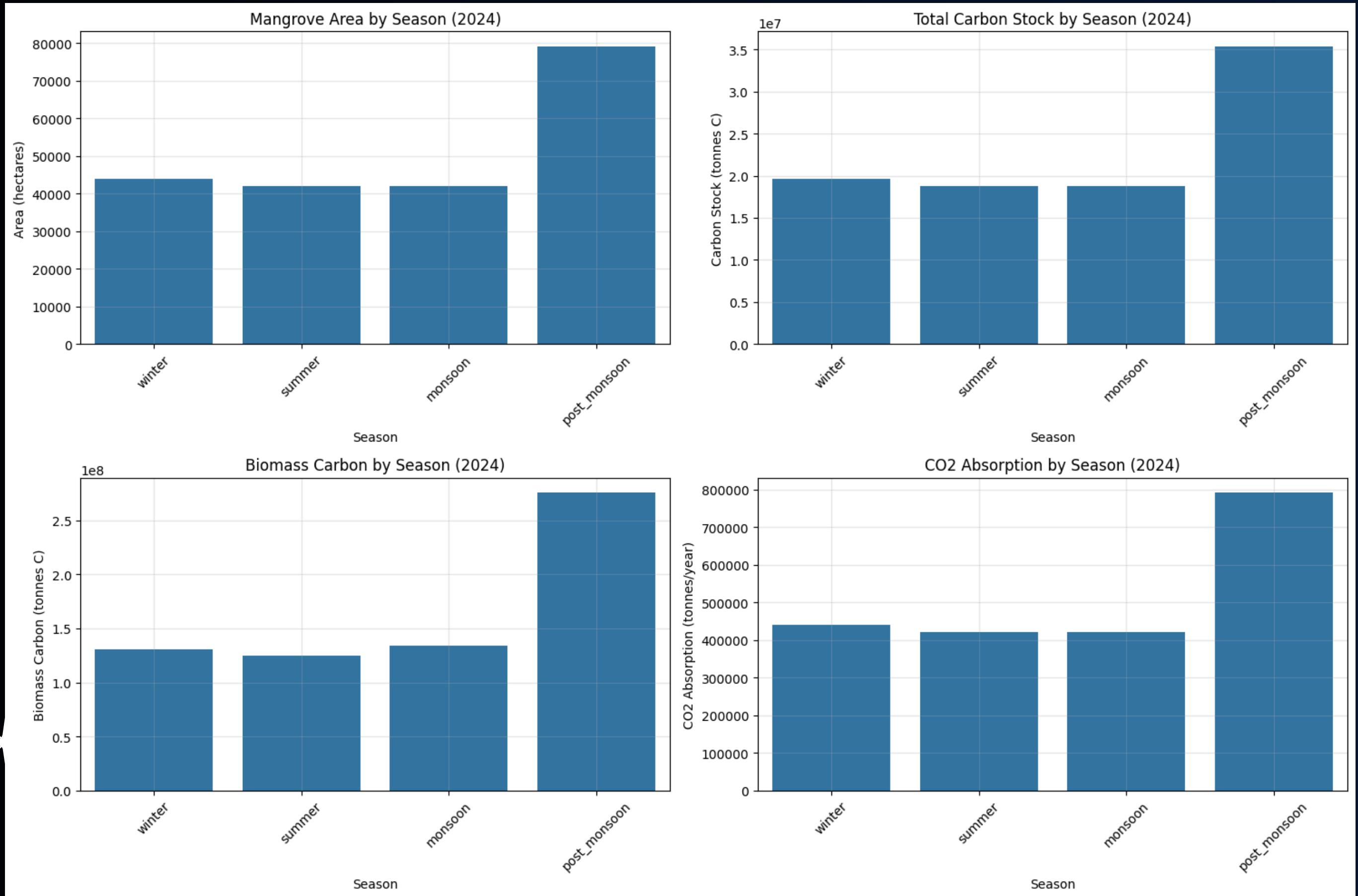


EVI



NDWI

Seasonal Analysis

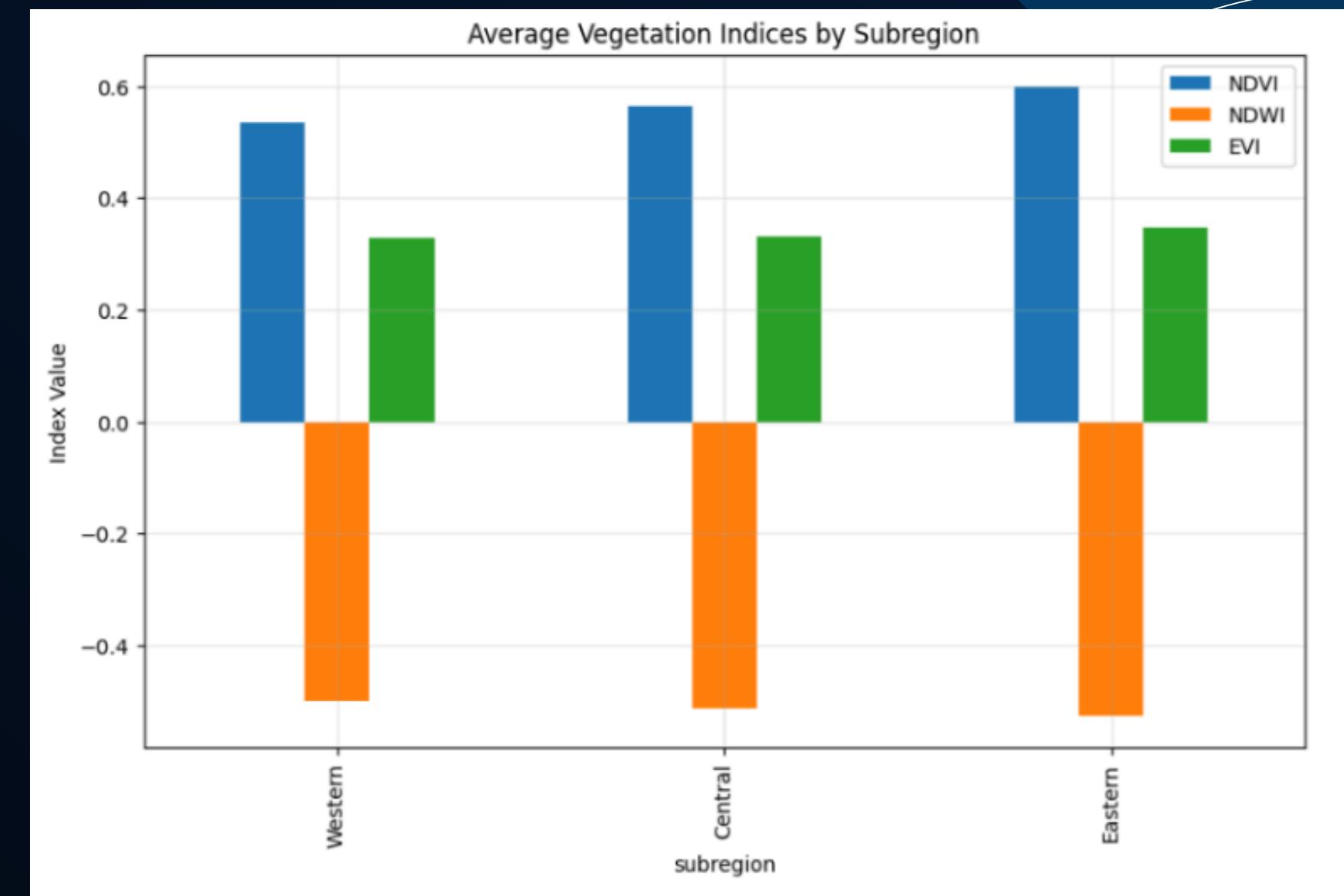
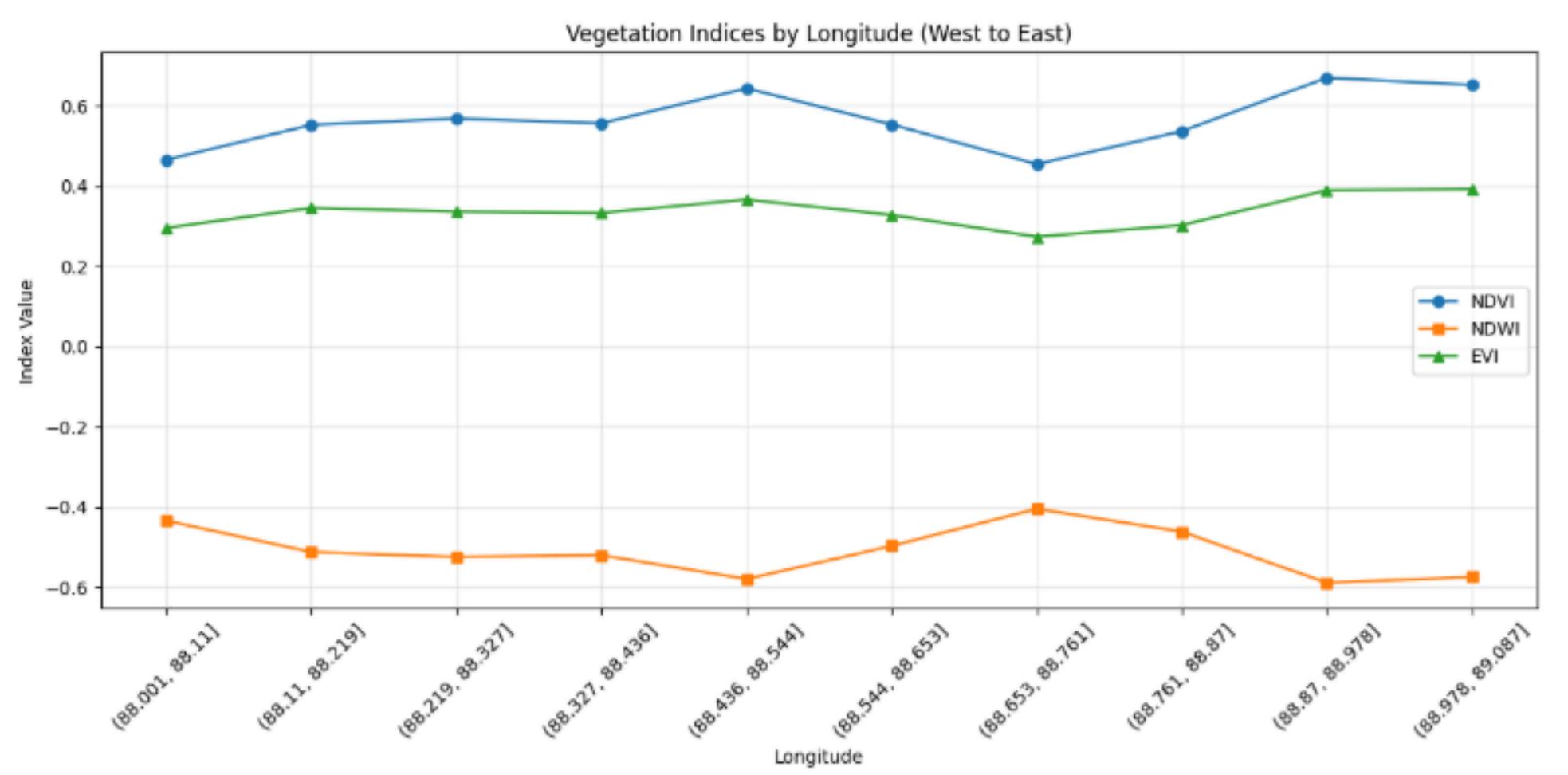


Temporal Analysis Approach

Key Temporal Techniques Used

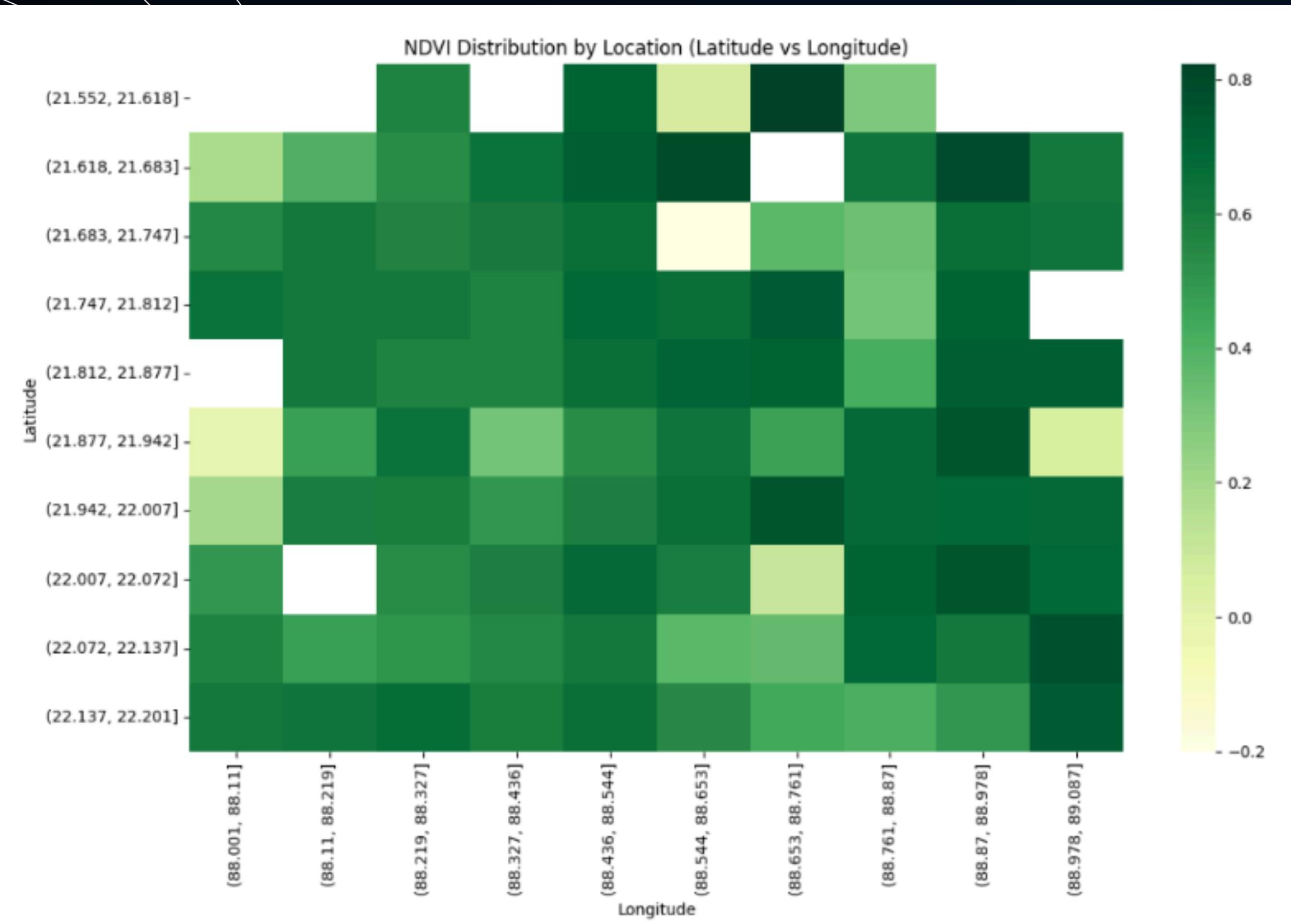
Approach	Description
Time Series Composites	Yearly/seasonal median pixel composites to minimize cloud/noise effects.
Pixel-Wise Differencing	Subtracts carbon pool values between two years for change detection.
Machine Learning	Predicts future trends using regression on historical temporal data.
Zonal Statistics	Aggregates carbon metrics annually/seasonally for the entire Sundarbans region.

Vegetation Indices Visualisations

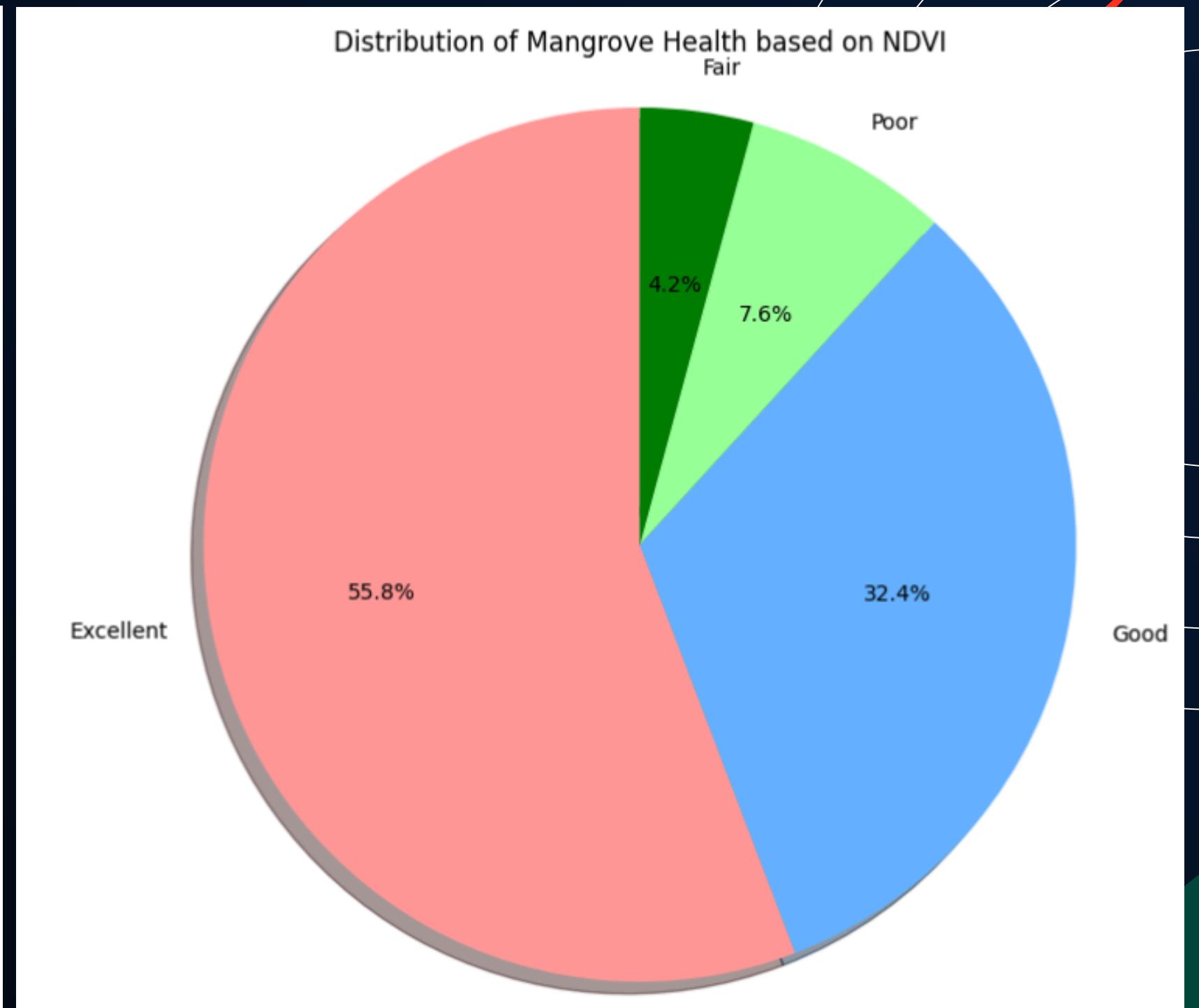


NDVI Distribution

NDVI Distributions Heatmap



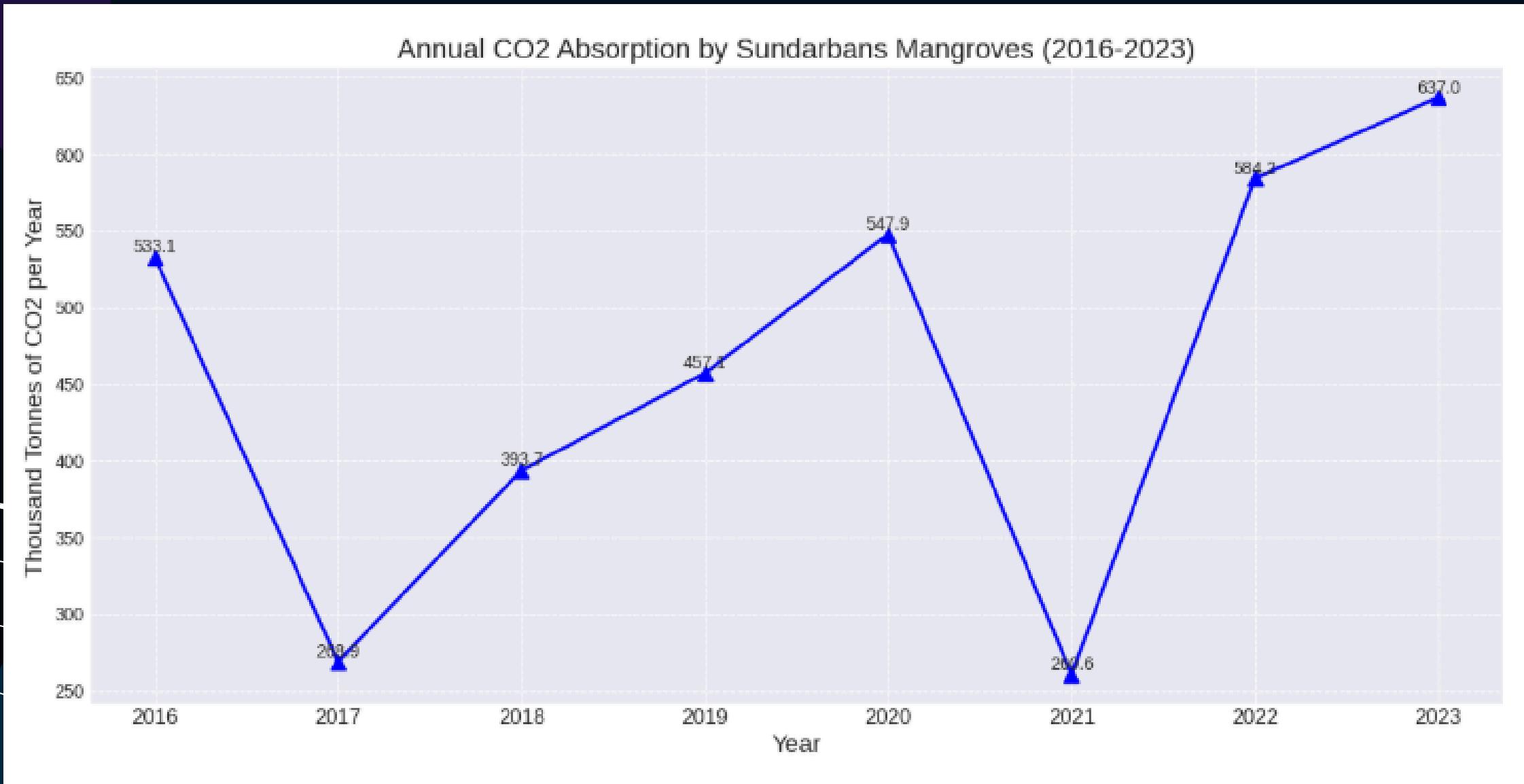
Mangrove Forest Health



Carbon Sequestration by Mangrove

The relationship works like this:

- Lower atmospheric CO₂ concentration → Less CO₂ available for absorption
- Less CO₂ available → Reduced carbon sequestration by mangroves



During COVID-19 lockdowns in 2021, there was a substantial reduction in:

- Vehicle traffic
- Industrial activity
- Overall fossil fuel consumption
- General pollution levels

This led to lower CO₂ emissions globally

Chilika Lake *



Chilika Lake Carbon Sink Statistics:

Total Area: 61,968.77 hectares

Average Carbon Sequestration Rate: 5.69 tons CO₂/ha/year

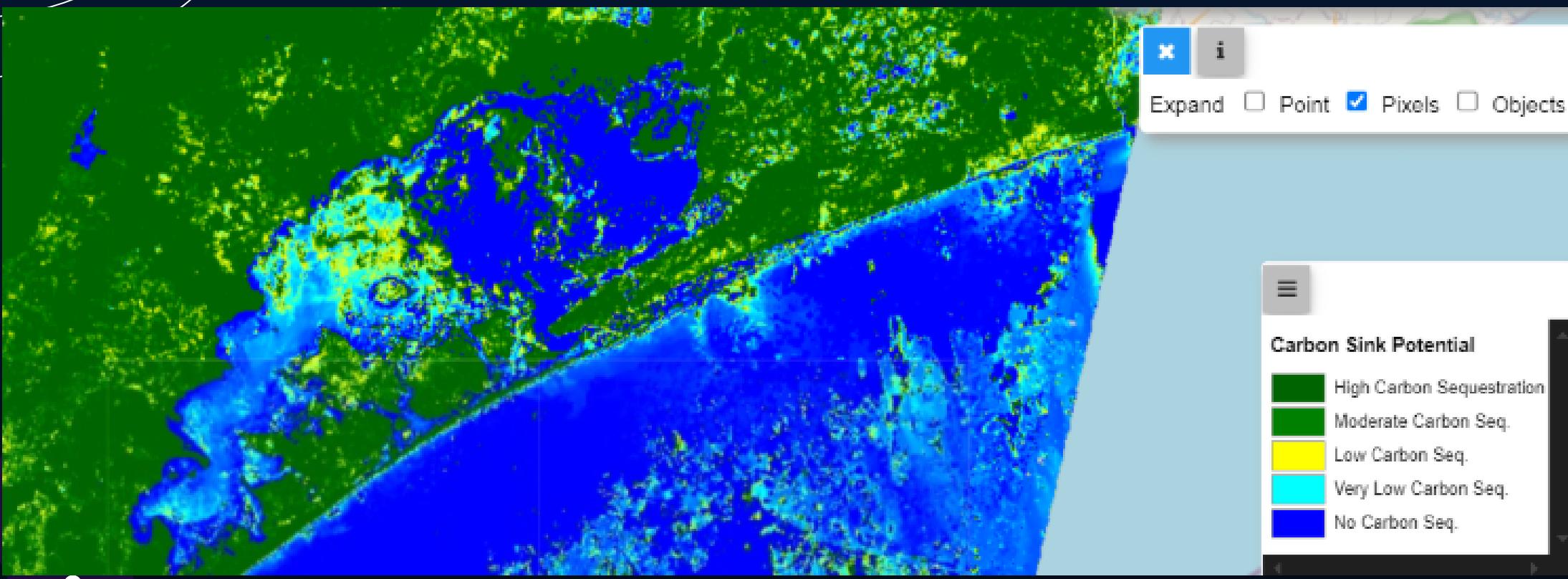
Minimum Rate: 1.00 tons CO₂/ha/year

Maximum Rate: 25.00 tons CO₂/ha/year

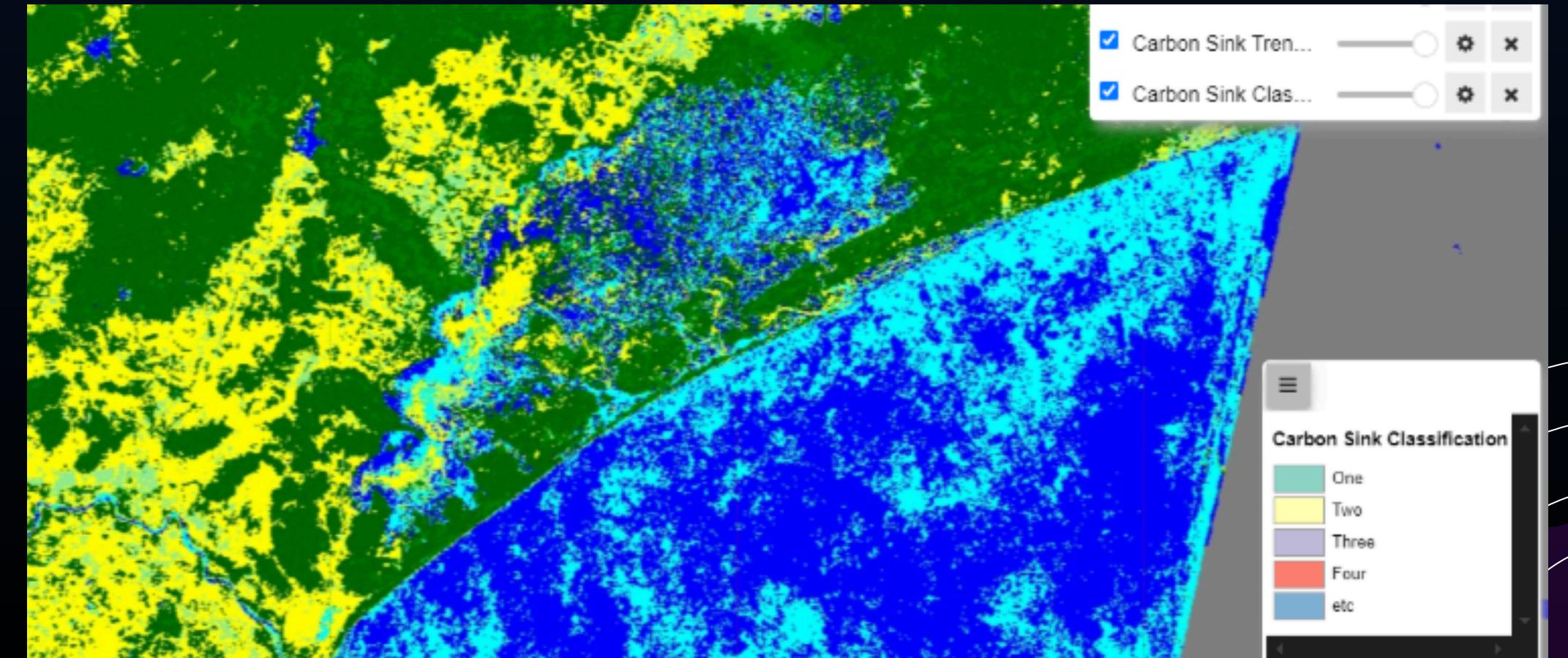
Total Annual Carbon Sequestration: 258,288,207,777.94 tons CO₂/year

Analysis Period: monsoon 2020

Carbon Sink zones in Chilka Lake



Analyzing carbon sequestration trends over time:

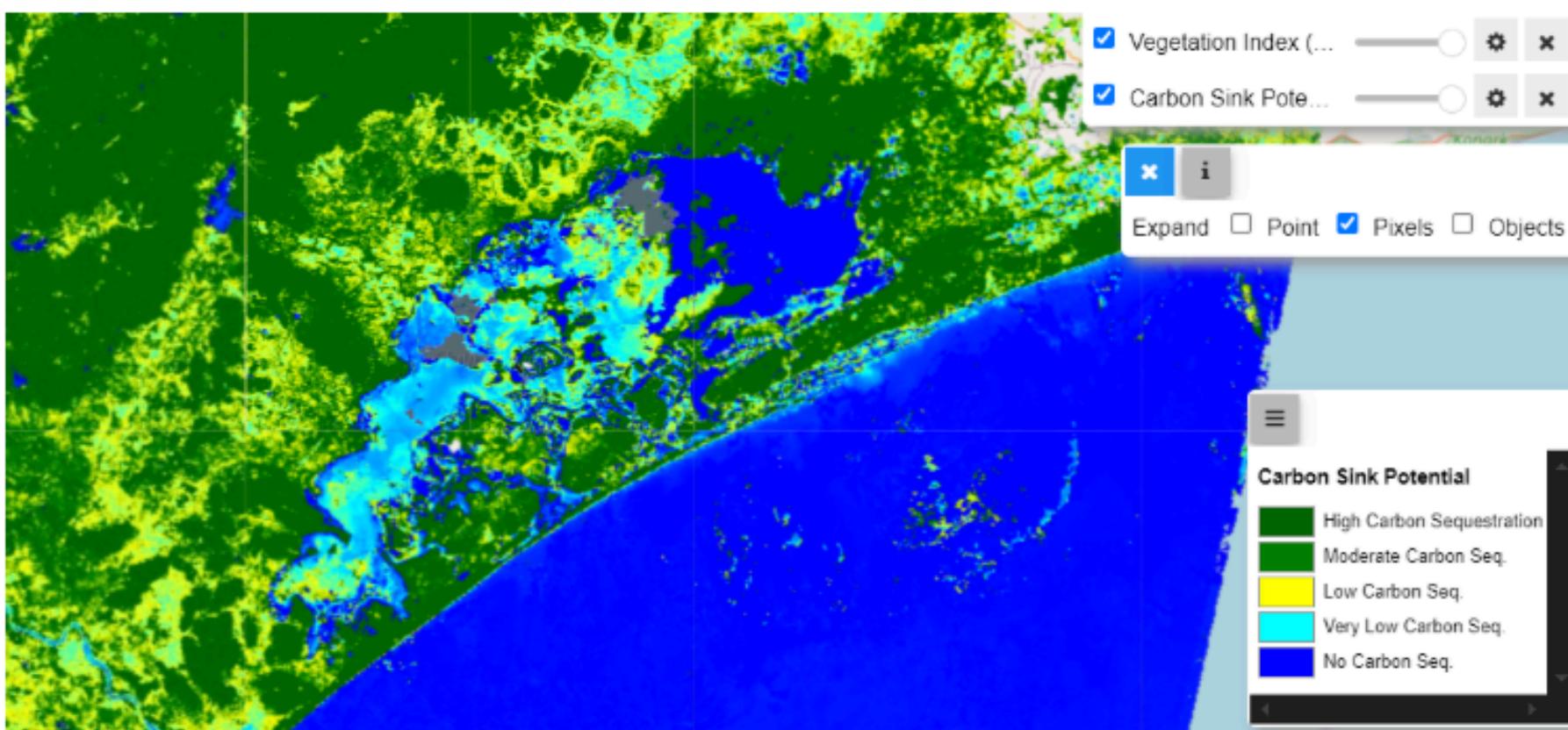


Analyzing carbon sink zones for current period:

Seasonal Carbon Sequestration

Winter Season carbon sequestration

Carbon sink function during winter season:

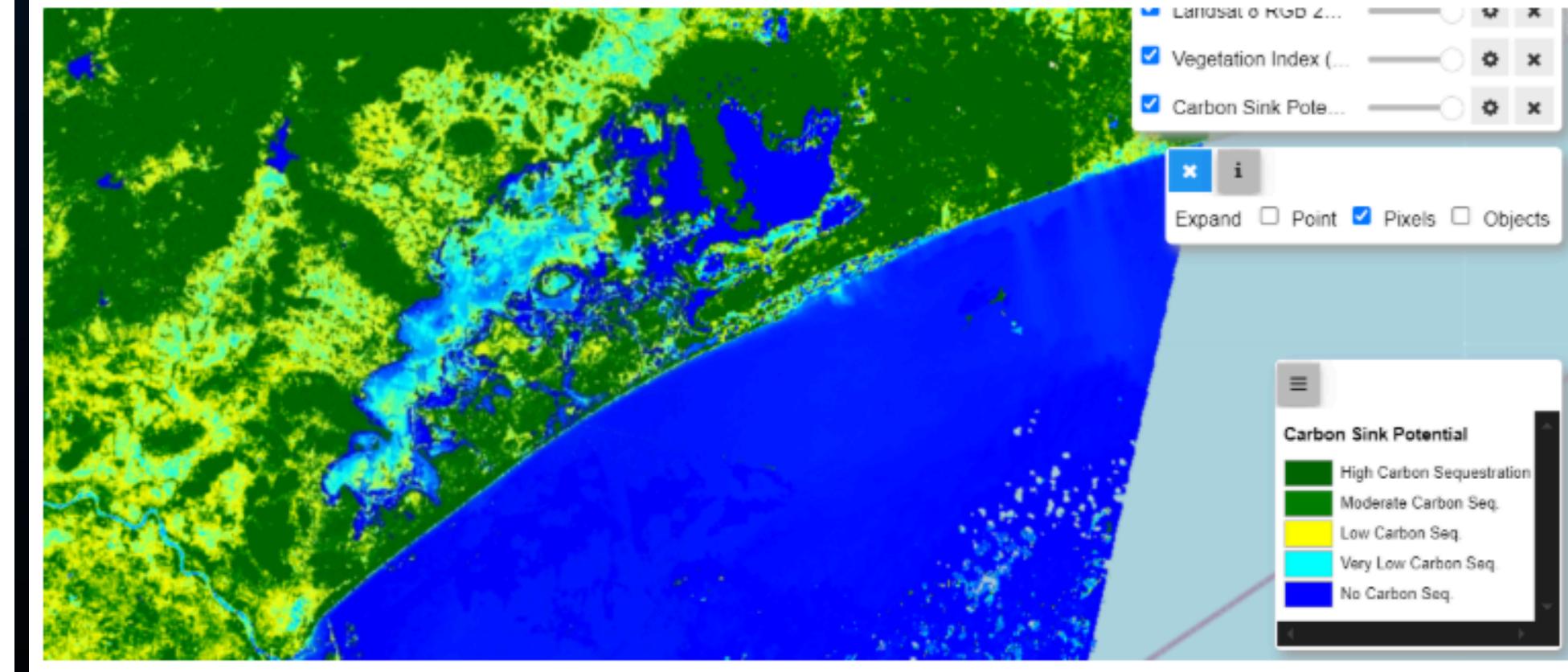


Average Rate: 5.49 tons CO₂/ha/year

Total Sequestration: 237,350,260,149.87 tons CO₂/year

Summer Season carbon sequestration

Carbon sink function during summer season:

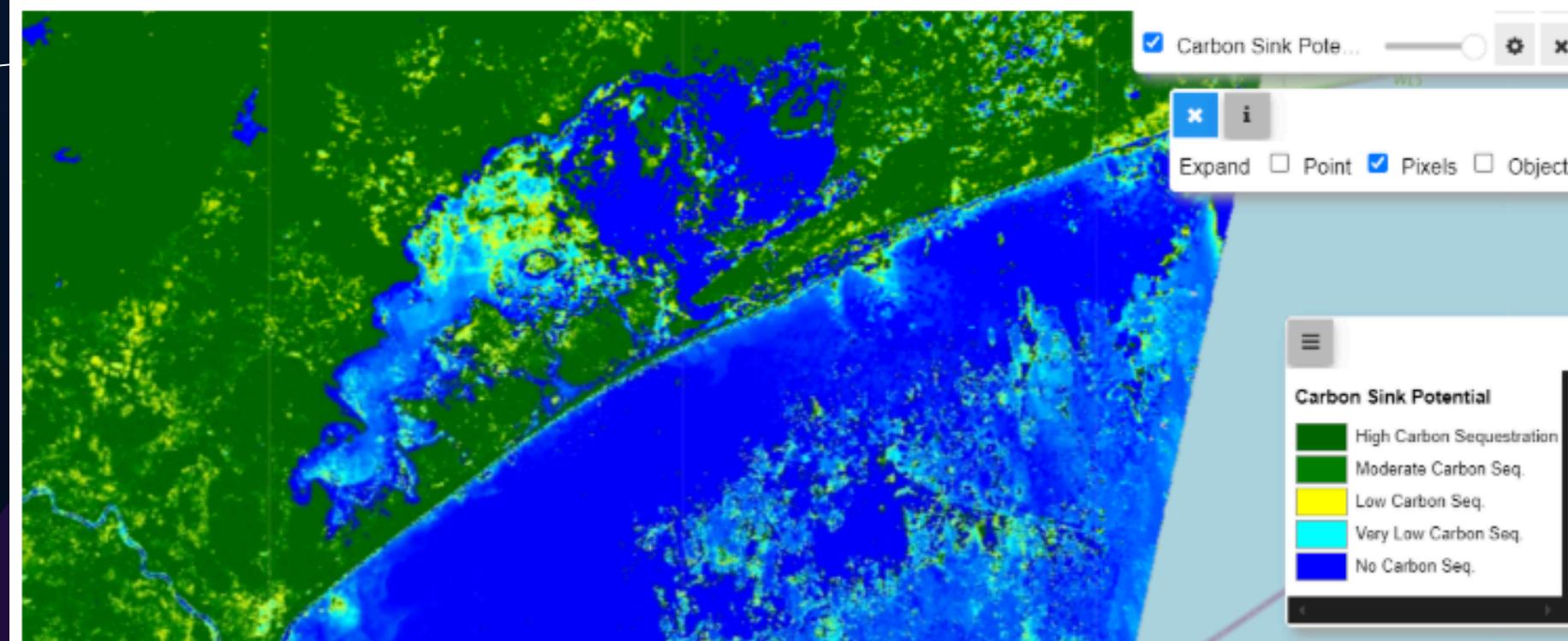


Average Rate: 6.77 tons CO₂/ha/year

Total Sequestration: 307,592,423,995.35 tons CO₂/year

Seasonal Carbon Sequestration

Carbon sink function during monsoon season:



Average Rate: 5.69 tons CO₂/ha/year

Total Sequestration: 258,288,207,777.94 tons CO₂/year

Post-monsoon Season
carbon sequestration

Monsoon Season
carbon sequestration

Carbon sink function during post-monsoon season:



Average Rate: 5.42 tons CO₂/ha/year

Total Sequestration: 246,242,717,351.06 tons CO₂/year

Carbon Sink analysis summary



Identifying highest carbon sink zones in Chilika Lake...

High Carbon Sink Area: 15,170.22 hectares

Percentage of Lake: 24.48%

These areas sequester approximately 303,404.40 tons CO₂/year

(based on average sequestration rate of ~20 tons CO₂/ha/year for high sink areas)

===== CARBON SINK ANALYSIS SUMMARY =====

Total Lake Area: 61,968.77 hectares

Average Carbon Sequestration Rate: 5.69 tons CO₂/ha/year

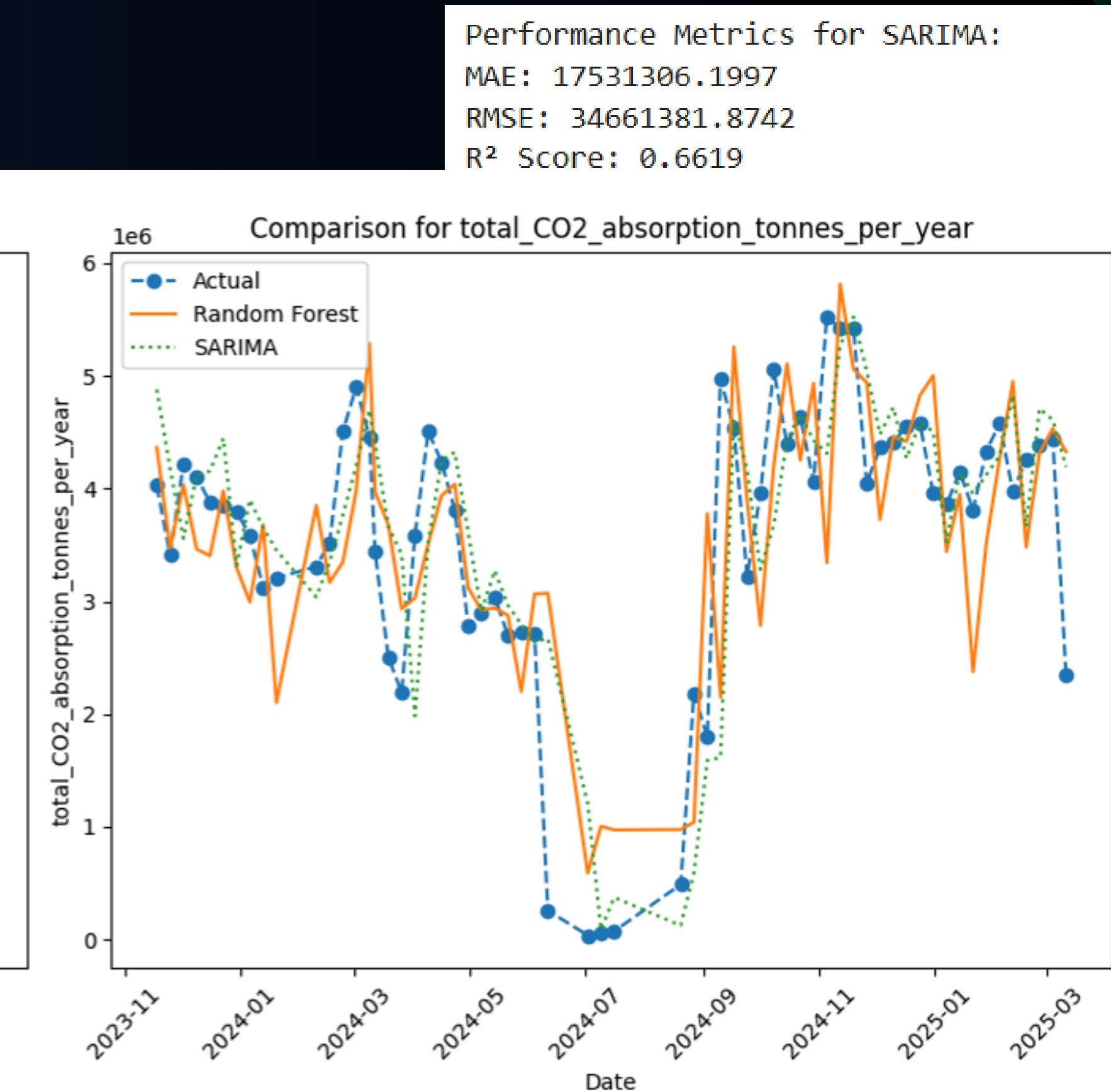
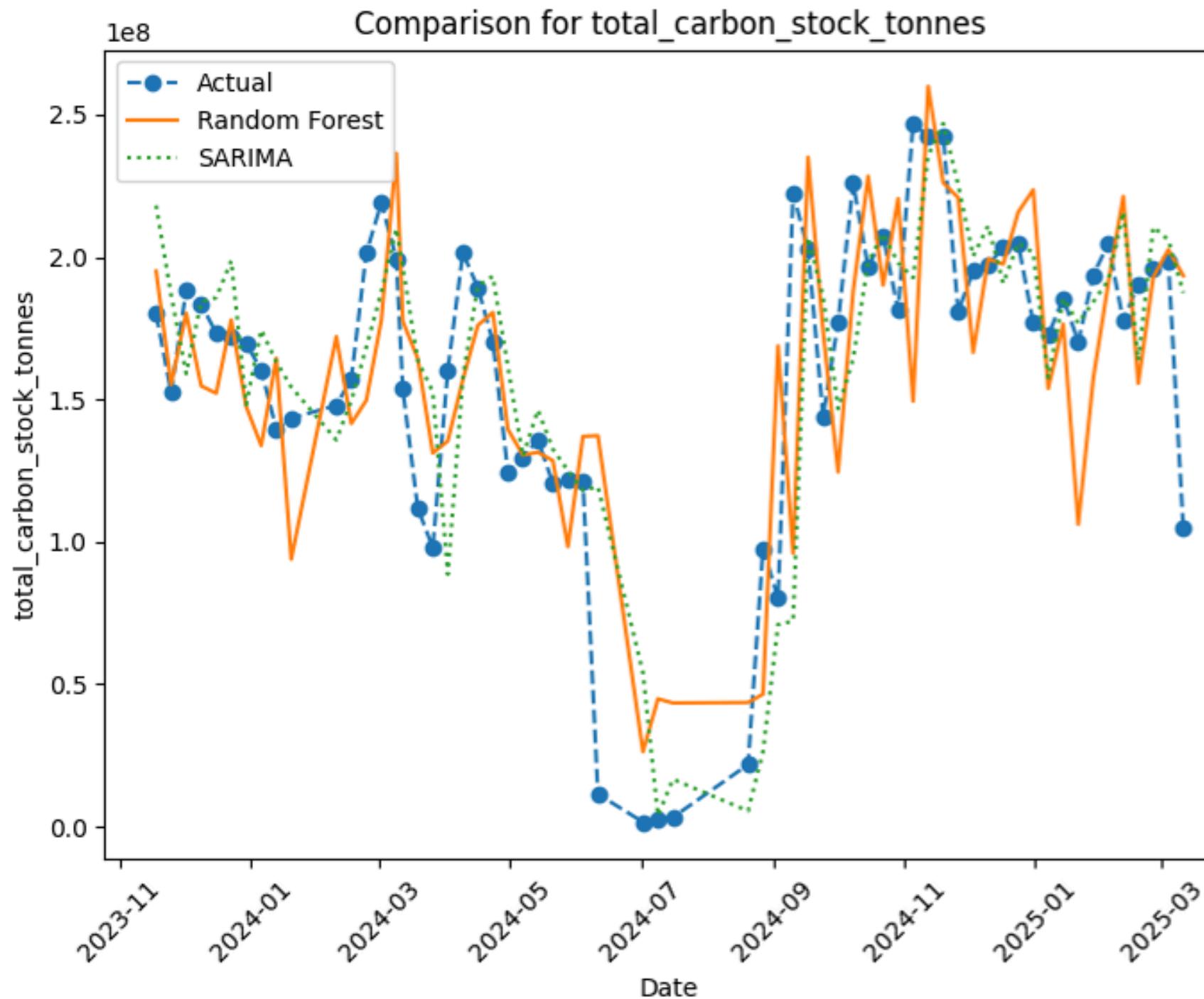
Total Annual Carbon Sequestration: 258,288,207,777.94 tons CO₂/year

High Carbon Sink Area: 15,170.22 hectares (24.48% of lake)

High Sink Annual Sequestration: 303,404.40 tons CO₂/year

Machine Learning

Performance Metrics for Random Forest:
MAE: 30056795.6449
RMSE: 51774802.9475
 R^2 Score: 0.2456



Performance Metrics for SARIMA:
MAE: 17531306.1997
RMSE: 34661381.8742
 R^2 Score: 0.6619

Carbon Sequestration Policy Framework

Sundarbans Mangroves

- Implement Community Co-Management: Establish sustainable livelihood alternatives to reduce pressure
- Strengthen Transboundary Cooperation: Enhance India-Bangladesh collaboration for unified conservation

Chilika Lake

- Protect & Restore Seagrass Habitats: Target 25% increase in coverage by 2030
- Optimize Hydrological Management: Maintain optimal salinity gradients for carbon-sequestering vegetation
- Reduce Watershed Pollution: Implement buffer zones and control agricultural runoff.

API

Mangrove Carbon Metrics Prediction System

This application predicts future mangrove carbon metrics using time series models:

- Random Forest Regressor: Uses lagged values to predict future metrics
- SARIMA: Seasonal Autoregressive Integrated Moving Average model

Welcome to Mangrove Carbon Metrics Predictor

About This Application

This tool helps predict and analyze carbon sequestration metrics for mangrove ecosystems. It uses machine learning and statistical models trained on historical data to forecast:

- Total Carbon Stock (tonnes)
- Total CO₂ Absorption (tonnes per year)

The models incorporate seasonal patterns and historical trends to provide accurate predictions.

Data loaded successfully: 310 records from 2019-01-01 to 2025-03-11

Models loaded successfully

Why Mangrove Carbon Metrics Matter

Mangroves are powerful carbon sinks that:

- Store carbon in their biomass and soil
- Sequester CO₂ at rates higher than terrestrial forests
- Provide coastal protection and habitat for marine life

Monitoring and predicting carbon metrics helps in:

- Climate change mitigation planning
- Carbon credit certification
- Conservation prioritization

Mangrove ecosystems are vital carbon sinks

Mangrove Carbon Metrics Prediction System

This application predicts future mangrove carbon metrics using time series models:

- Random Forest Regressor: Uses lagged values to predict future metrics
- SARIMA: Seasonal Autoregressive Integrated Moving Average model

Make Predictions

Prediction Settings

Select Model

Random Forest

SARIMA

Both (Compare)

Forecast Horizon (months)

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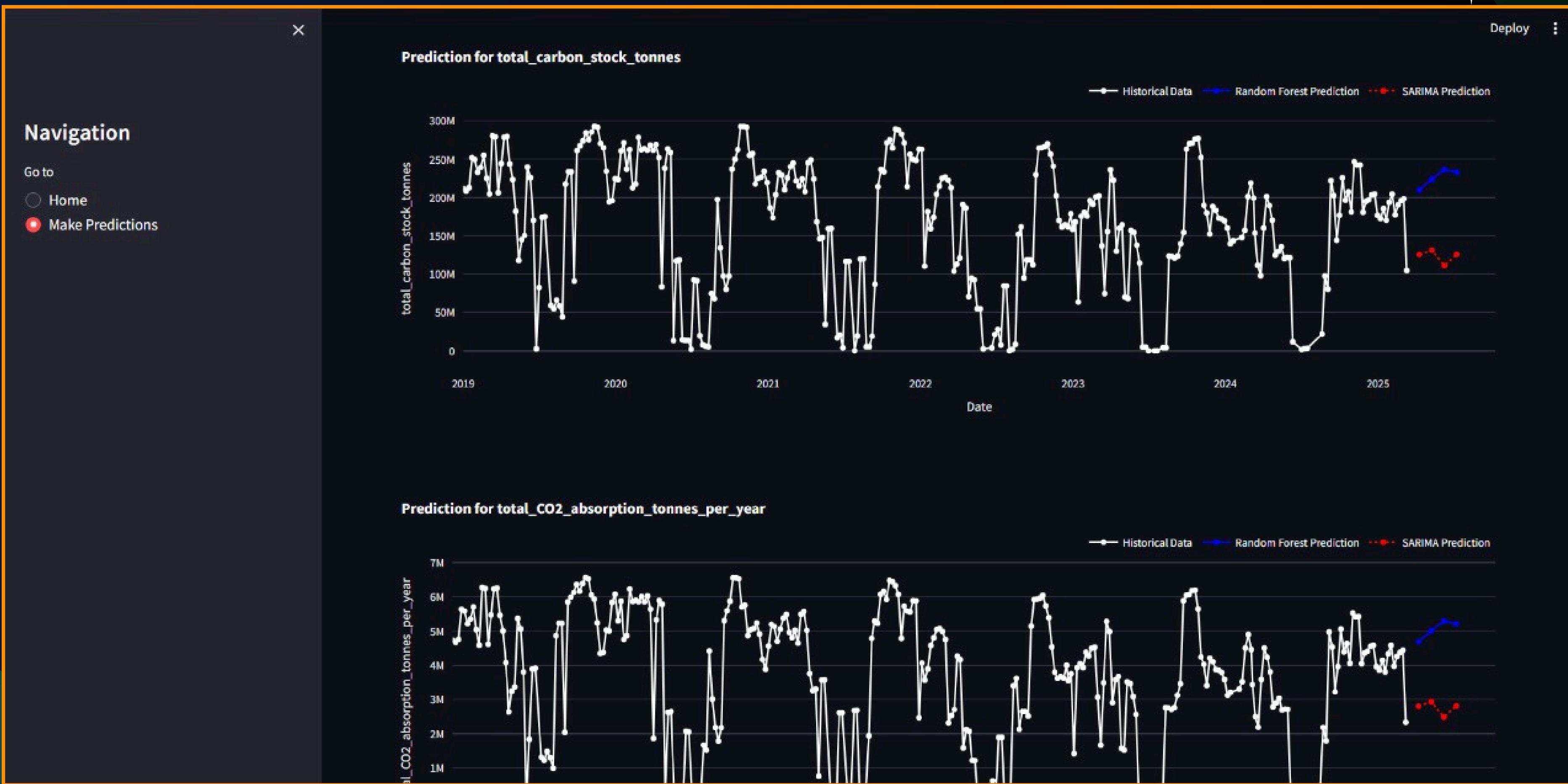
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Generate Predictions

Prediction Results

	RF_carbon_stock	RF_CO2_absorption	SARIMA_carbon_stock	SARIMA_CO2_absorption
2025-04-10 00:00:00	209,716,970.6382	4,691,654.8241	125,609,120.8941	2,810,054.0258
2025-05-10 00:00:00	223,939,855.8295	5,009,840.1752	131,339,024.6882	2,938,237.4598
2025-06-09 00:00:00	236,449,964.1405	5,289,708.37	111,261,985.729	2,489,058.439
2025-07-09 00:00:00	232,916,865.9318	5,210,668.1417	125,872,463.0183	2,815,910.7361

API



THANKS!

Does anyone have any questions?

