Impact of Uncontrolled Tourist Waste on Water Quality Degradation at Cox's Bazar Sea Beach: A Remote Sensing and GIS-Based Approach

Photo: The Daily Star

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Area of Interest

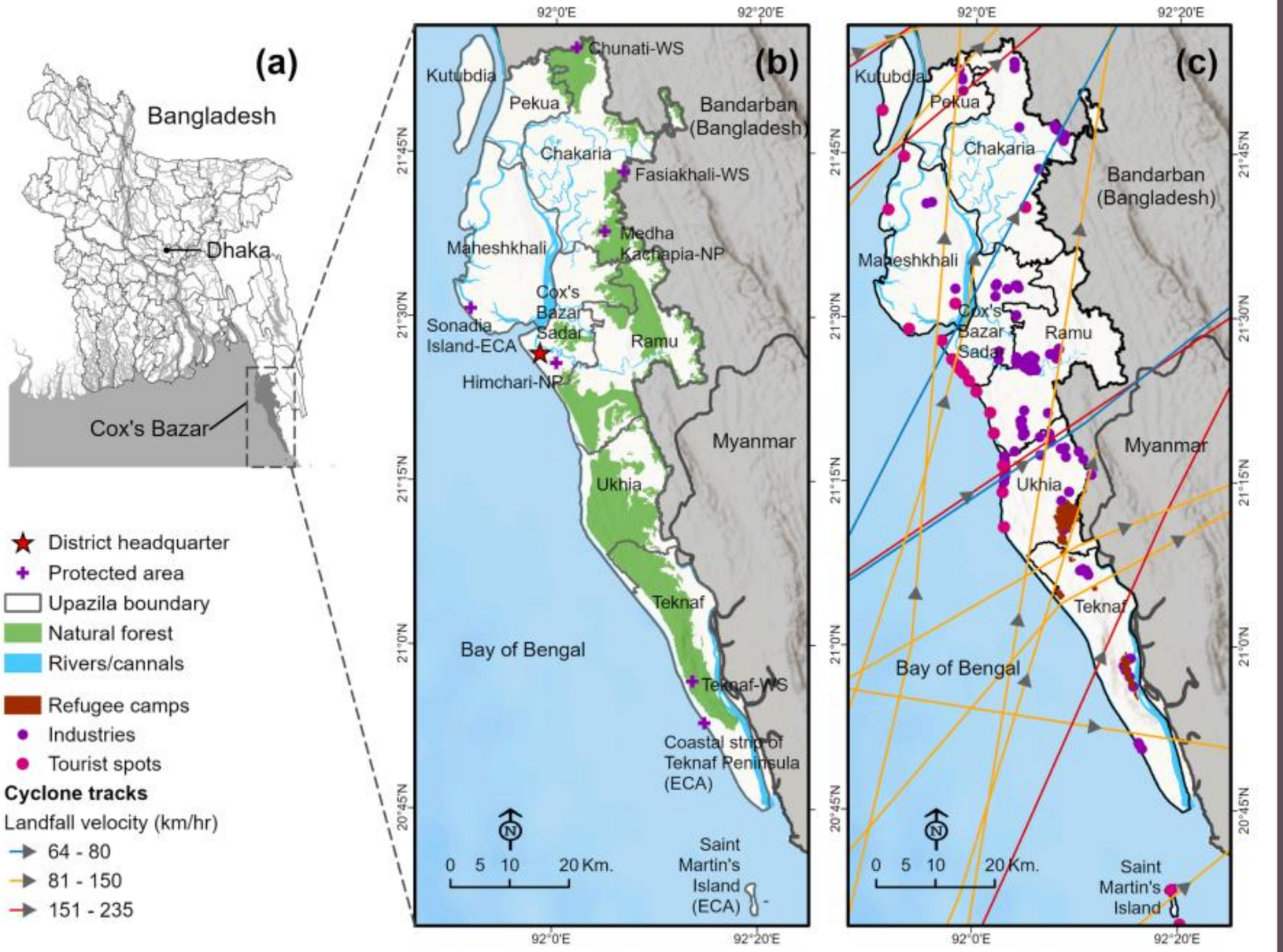
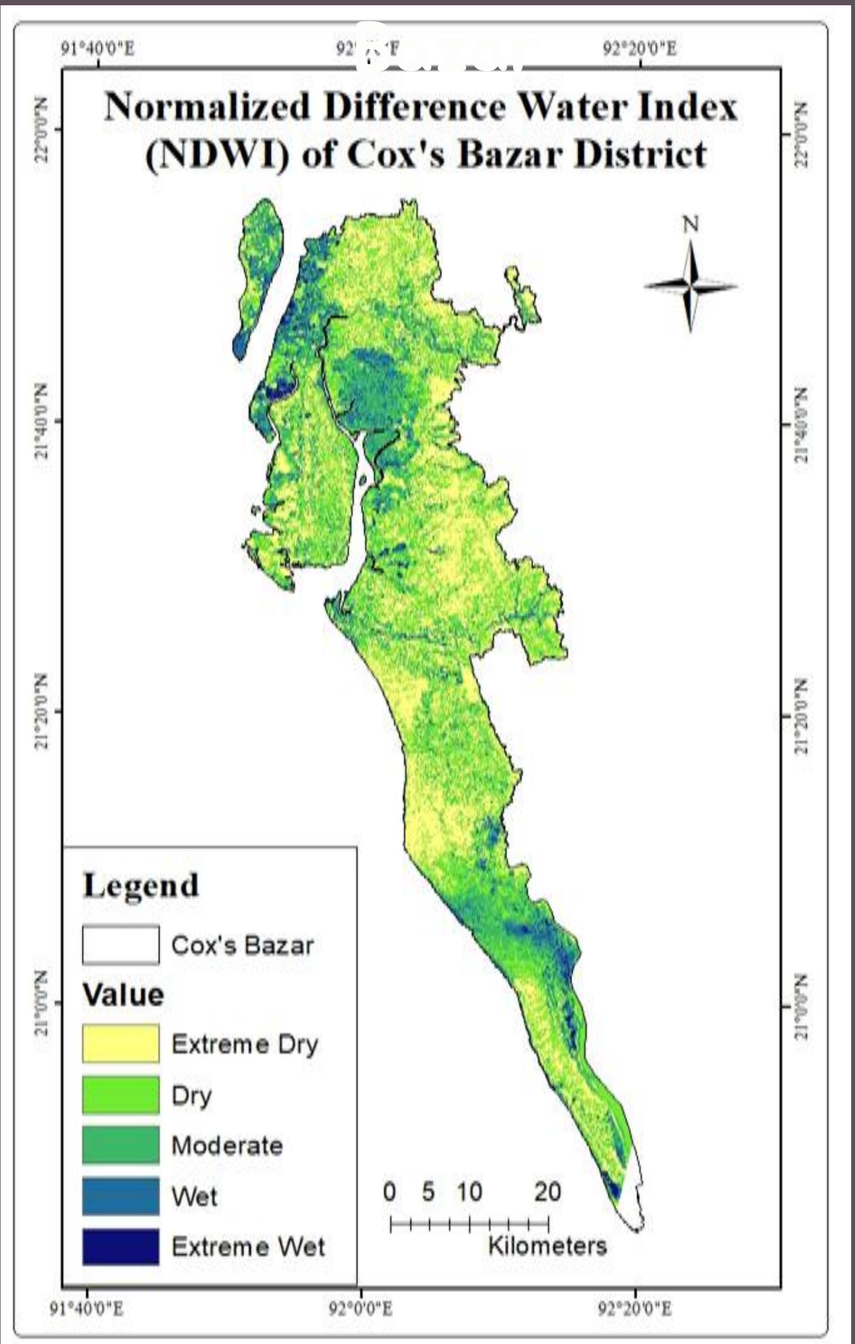


Fig. 1. Location of the study area in Bangladesh (a) and it's ecological features (b). Figure (c) shows tropical cyclone tracks making landfall in the area between 1960 and 2022, tourist spots, and location of industries. Note: ECA- Ecologically Critical Area, WS-Wildlife Sanctuary, and NP-National Park. This figure was adapted from Roy and Depellegrin [54].

(Roy et al., 2024)

NDWI map of Cox's



Why are we concerned?

THE BUSINESS STANDARD

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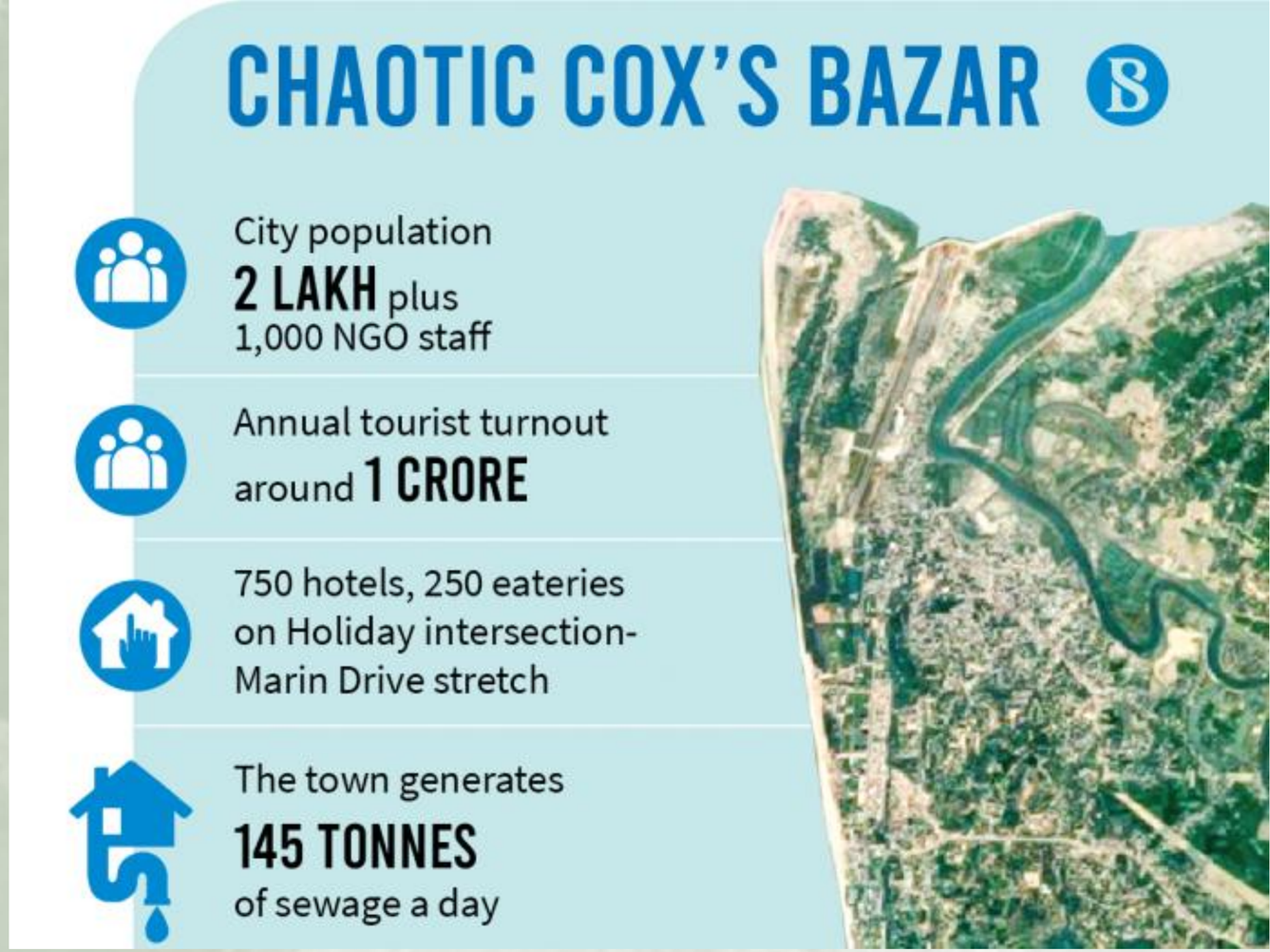
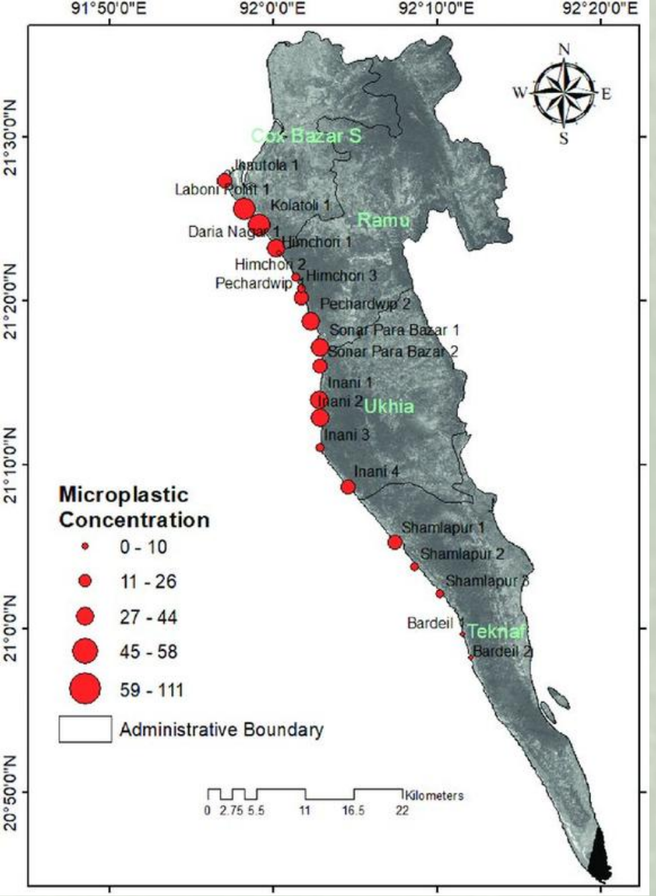
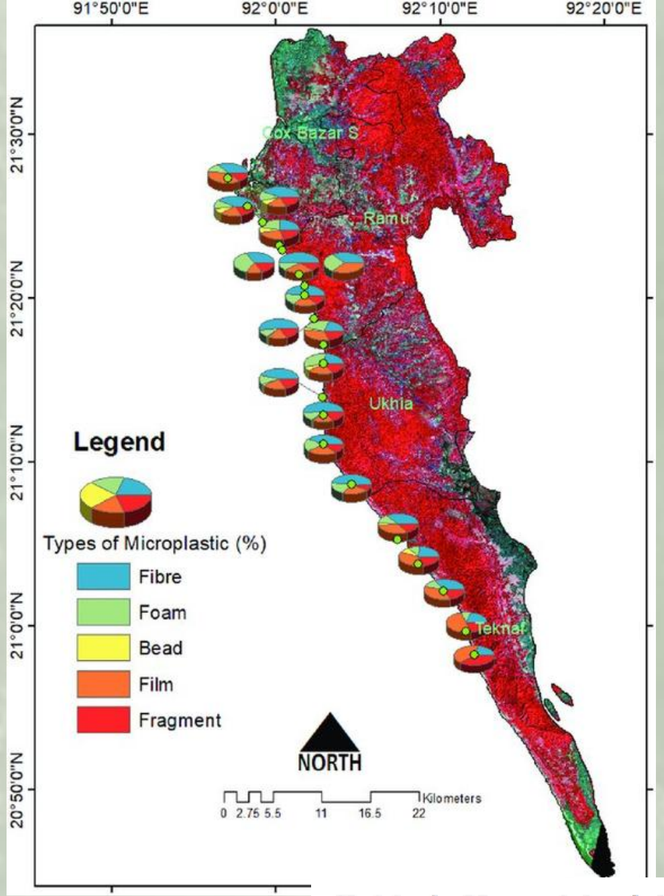
"Our guests can enjoy the sea view from the rooms. But the **piled-up garbage on the beach is an eyesore** that sends a negative first impression of the city," said Akramul Bashar Chowdhury, chief executive officer at the Sea Princess Hotel.



Municipality can deal with only 20 tonnes. The rest of the human waste from the hotels and motels is carried straight into the rivers and the sea.

(Faruque, 2021)





(Tajwar et al., 2021)

Cox's Bazar, its primary tourist district, is experiencing **severe degradation of its physical and ecological environments** due to **anthropogenic disturbances** and climate change. **(Roy et al., 2024)**

Table 2: Heavy Metal Concentration in Water of Teknaf Coast

Sample ID	Cd-content	World Standard of Cd	Cu-content	World Standard of Cu	Fe-content	World Standard of Fe	Pb-content	World Standard of Pb	Zn-content	World Standard of Zn
Water Sample	---------- mg L^{-1} ----------									
Sample 01 (Inani Beach, Marine Drive)	0.20	0.11	0.37	0.90	3.43	3.40	1.10	0.03	0.29	0.5
Sample 02 (Sonarpara, Marine Drive)	0.23	0.11	0.34	0.90	2.48	3.40	0.01	0.03	0.26	0.5
Sample 03 (Himchari, Marine Drive)	0.36	0.11	0.48	0.90	1.55	3.40	1.46	0.03	0.10	0.5
Average	0.27		0.40		2.49		0.86		0.22	

Source: Ahmad, 2018 and Rashid et al. 2015* (*World Standard of Heavy Metals)

Objectives

Primary Goal

Minimize environmental degradation caused by uncontrolled tourist waste at Cox’s Bazar.

Specific Goals

- **Identify optimal waste collection points.**
- **Plan smart waste disposal strategies**
- **Provide a GIS-based visual decision-support system for stakeholders.**

Water Quality Map Preparation

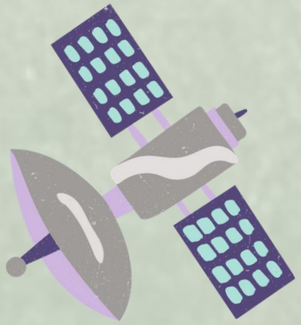
Study Periods

Pre-lockdown (high tourist activity)	**Lockdown** (restricted tourism)	**Post-lockdown** (resumed tourism)

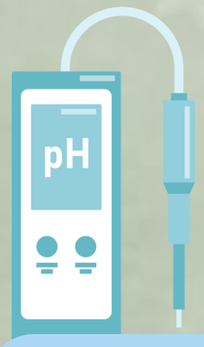
Indicators

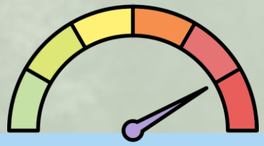
Focus on water quality parameters like **turbidity, chlorophyll-a, Total Suspended Solids (TSS)**, and other relevant proxies measurable **via satellite imagery.**

Data Collection



Obtain **high-resolution satellite images (Sentinel-2, Landsat-8)**





Collect **in-situ water quality measurements (pH, TSS, DO)** for calibration and validation

Collect data on **tourist numbers and waste management practices** in Cox's Bazar during the study periods

Data Processing

Perform **atmospheric correction** and Mask out clouds, shadows, and non-water areas.

Extract Water Quality Parameters

Calibrate **satellite-derived indices with ground-truth data** for accuracy

Map spatial **distribution of water quality parameters** for each timeframe.

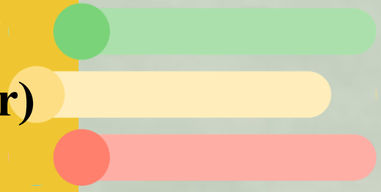
Calculate Water Quality Index (WQI)

Normalize water quality indicators to a scale (0 to 100).

Assign **weights to parameters based on their importance to overall water quality**

Compute WQI using a weighted arithmetic mean

Categorize water quality (e.g., Excellent, Good, Poor) based on thresholds

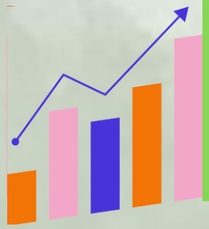


Analyze and Compare Results

Compare WQI for pre-lockdown, lockdown, and post-lockdown periods.

Ident**ify patterns correlating** tourist activity with changes in WQI.

Detect **hotspots** of water quality degradation



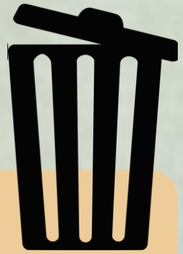
Compare **WQI trends with tourism activity** data and waste management practices

Waste Management Framework

Data Collection

Tourism Data

- Tourist **influx patterns** (seasonal and daily).
- **Popular tourist hotspots** along the beach.
- **Current waste disposal practices**.

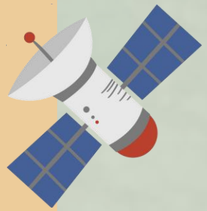


Waste Management Data

- Locations of **existing waste bins, collection points**, and disposal facilities.
- **Waste types and volumes generated** (biodegradable, non-biodegradable, etc.).

Geospatial Data:

- **Base maps from OSM** for roads, pathways, and facilities.
- **Satellite imagery** (Sentinel-2, Landsat-8) for land-use analysis.
- **Topographical and hydrological data** (e.g., slope, drainage patterns)



Socioeconomic Data:

- Input from **local authorities, businesses, and residents.**
- **Surveys** of tourist awareness about waste disposal practices.

GIS and OSM-Based Model Development

1 Mapping Tourist Activities and Waste Generation Hotspots

Use GPS and OSM to:

- Map **tourist density in real-time.**
- Identify **high-waste generation zones** (e.g., picnic areas, marketplaces, beach entries).

Perform **density analysis using heat maps to** highlight critical **pollution hotspots.**

2 Optimal Placement of Waste Collection Points

Tools and Analysis
Use a **buffering technique** to determine the **service area for each waste bin or collection point.**

OSM Integration:
Add **geotagged waste bin locations** and service routes as layers in OSM for public awareness.

3

Create a centralized waste management database linked to the GIS model to optimize routes and schedules.

4

Mapping Tourist Pathways:
Map major tourist movement routes (entry points, pathways, and attractions) using OSM and GPS tracking.

5

Implement designated pathways with waste bins strategically placed along the route.

Visualization and Outputs

GIS-Based Maps

Interactive maps showing:

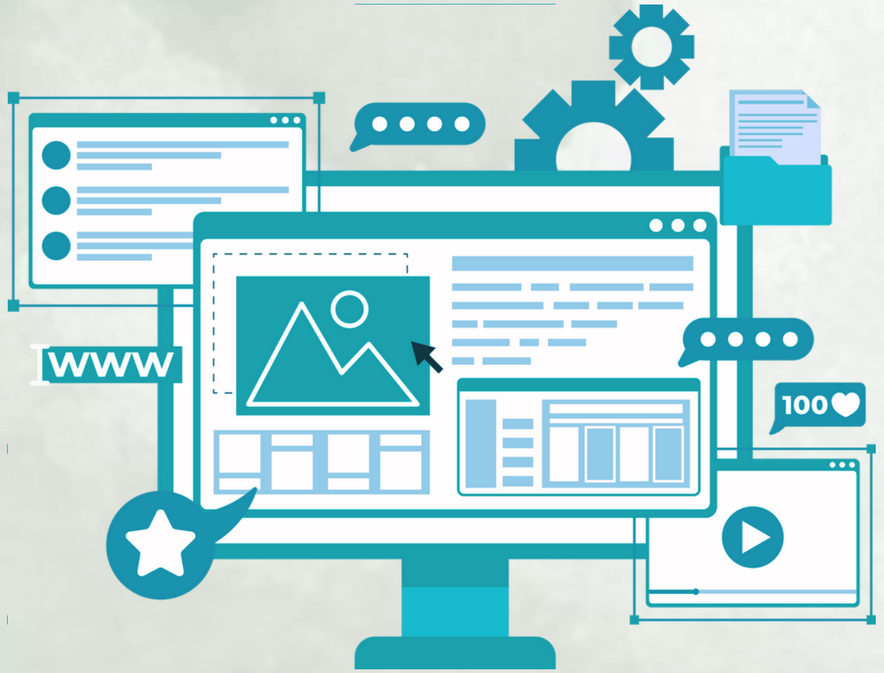
- Waste collection points.
- Tourist density hotspots.
- Waste disposal facilities.
- Optimal waste collection and disposal routes.

Web Map Application:

Build a web application integrating OSM layers for public access.

Include features for:

- Locating the nearest waste bins.
- Real-time monitoring of waste management.



Implementation and Monitoring

Engagement with Stakeholders: Collaborate with local authorities, waste management companies, and the tourism department.

Engagement of the youth of the area for **updating real time data in the web map**.

Educate tourists on waste segregation and responsible disposal using the GIS-based platform.

Thank You