Eco. Env. & Cons. 30 (August Suppl. Issue) : 2024; pp. (S453-S457)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i05s.070

Monitoring Mangroves in Thane Creek region, Maharashtra using GIS and Remote Sensing Techniques

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(Received 22 March, 2024; Accepted 7 May, 2024)

ABSTRACT

Mumbai and the Indian mainland are separated by Thane Creek, a coastal inlet. It is a diversified habitat that is home to many different plant and animal species, including flamingos and mangroves. Wetlands are crucial to a region's eco-hydrological sustainability. They are a vital component of human existence since they provide for a wide range of necessities, including energy, biodiversity, water purification, transport, climate regulation, etc. The greatest area of mangroves in Mumbai is found in Thane Creek. Mangroves are intertidal trees that can withstand salt and provide a variety of ecological services, including habitat provision, carbon sequestration, and nutrient cycling. GIS mapping is an effective method for researching and addressing problems with the coastal environment. With regard to land use and land cover, water quality and pollution, habitat loss and restoration, etc., GIS can assist in tracking changes and effects on the coastal environment. Due to its abundance of natural resources and delicate ecosystems, the coastal zone has been crucial for both economic development and ecological rehabilitation. By providing significant coverage, mapping, and classification of land cover elements like vegetation, soil, water, and forests, remote sensing techniques have proven to be potent tools for the monitoring of the Earth's surface and atmosphere on a global, regional, and even local scale. Thane Creek has been included in India's list of Ramsar wetlands; in order to preserve the wetlands; scientific, technical, and socio-economic cooperation must be adopted. This paper explores some of remote sensing and GIS-based approaches for mangrove monitoring in Thane Creek.

Key words: *Mangroves, GIS, Remote Sensing, Thane Creek, Ramsar site.*

Introduction

Thane Creek (Long. 72°.55′ to 73°.02′ E and Lat. 19°.00′ to 19°.15′ N) is a tropical coastal ecosystem surrounded by mangroves along India's central west coast. The Ulhas River is joined by a small connection near Thane city by the 26 km long Thane creek that extends north from the Mumbai harbour bay. The creek is shallow and narrow in the north where Ulhas River enters it through a small connection, and it widens and deepens as it gets closer to the Arabian Sea. Thane creek is India's first Ramsar site (designation date:13-04-2022) within a metropolis and is the largest wetland of international significance in Maharashtra (The Times of India, Dec 22, 2022, p.1-3). The mission of the Ramsar Convention is "Conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world"

(United Nations: The Sustainable Development Knowledge Platform. "Ramsar Convention on Wetlands").Wetlands are submerged or water saturated lands, natural or man-made, inland or coastal, permanent or temporary, static or flowing, vegetated or non- vegetated, which necessarily have a land-water interface. The Thane creek has a total area of about 65.211 sq.km (Ramsar Sites Information Service). Its mangrove forests provide nurseries for several fish species, sustaining the local fisheries, and also act as a natural buffer against floods, cyclones and seawater intrusions, enhancing the resilience of surrounding areas to such climate-related hazards. Using satellite data, the Normalized Difference Vegetation Index (NDVI) is a frequently used index for evaluating the health and cover of vegetation. Its range is -1 to 1. Higher numbers indicate denser and better vegetation.

Objective

Monitor and map changes in distribution of mangroves in Thane Creek-Ramsar Site region over a period of 30 years (1993-2023) using GIS and remote sensing techniques. Also, calculate shrub (mangrove) density of the study region which would be helpful to analyse changes in mangrove density over time.

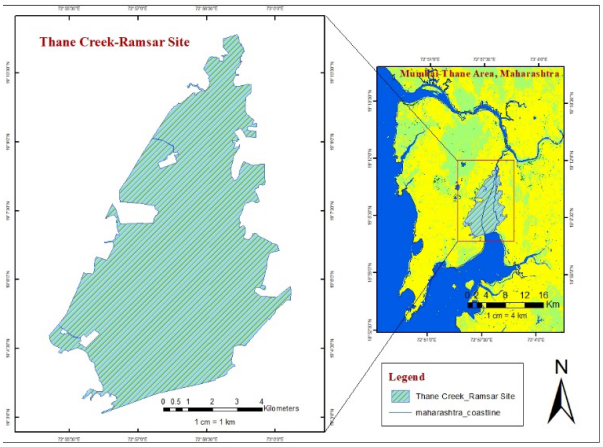

Fig. 1. Study Area: Ramsar Site of Thane Creek region, Maharashtra

Study Area

The Ramsar Site of Thane Creek region in Thane district of Maharashtra is shown in Fig.1.

The variety of flowering plants in Thane Creek is abundant. Mangroves are flowering plants that can withstand salt. The coast of Maharashtra has a wide variety of mangrove species.Thane Creek has the following Mangrove species: *Avicennia marina, Avicennia officinalis, Sonneratia alba, Sonneratia apetala, Aegeiceras corniculatum, Excoecaria agallocha, Brugueira cylindrica, Brugueira gymnorhiza, Ceriops tagal, Rhizophora mucronate, Rhizophora apiculate* and *Acanthus illicifolius* (Ramsar Sites Information Service). There are several Mangrove associates as well like *Salvadora persica, Clerodendrum inerme, Hygrophilaschulli, Sesuvium portulacastrum*, etc.

Different mangrove species thrive in different sections of an intertidal zone due to variations in the water conditions and tidal forces operating at varying intensities.

Data and Methodology

Vegetation indices are recognized to be spectral band measurements in the VNIR regions (Bannari *et al.*, 1995). The Landsat mission in 1972 is linked to the creation of spectral vegetation indicators. Specifically, to measure and track vegetative cover, Pearson and Miller (1972) created the first vegetation indices, the Ratio Vegetation Index (RVI) and Vegetation Index Number (VIN) (Pearson *et al.*,

Grey Mangrove (*Avicennia marina*) Sea pursalne (*Sesuvium portulacastrum*) Holy mangrove (*Acanthus illicifolius*)

Fig. 2. *Avicennia marina, Sesuvium portulacastrum* and *Acanthus illicifolius* (Photo Credit: Niketan Thakur-2022)

1972]. The Normalized Difference Vegetation Index (NDVI) was first presented by Rouse *et al.* (1973) in response to Pearson and Miller (1972). It is currently extensively used in environmental and land cover research. In addition to measuring vegetation greenness, the Landsat Normalized Difference Vegetation Index (NDVI) is helpful for determining changes in plant health and comprehending vegetation density.

Landsat 5 Thematic Mapper (TM) (1993), Landsat 7 Enhanced Thematic Mapper Plus (ETM+) (2003), Landsat 8 Operational Land Imager (OLI)/Thermal Infrared Sensor (TIRS) (2013) and Landsat 9Operational Land Imager (OLI)/Thermal Infrared Sensor (TIRS) (2023) data of Thane Creek region were used for studying the mangrove cover changes over time using NDVI analysis from USGS earth explorer website. ArcGIS software used for Image Analysis and map generation.

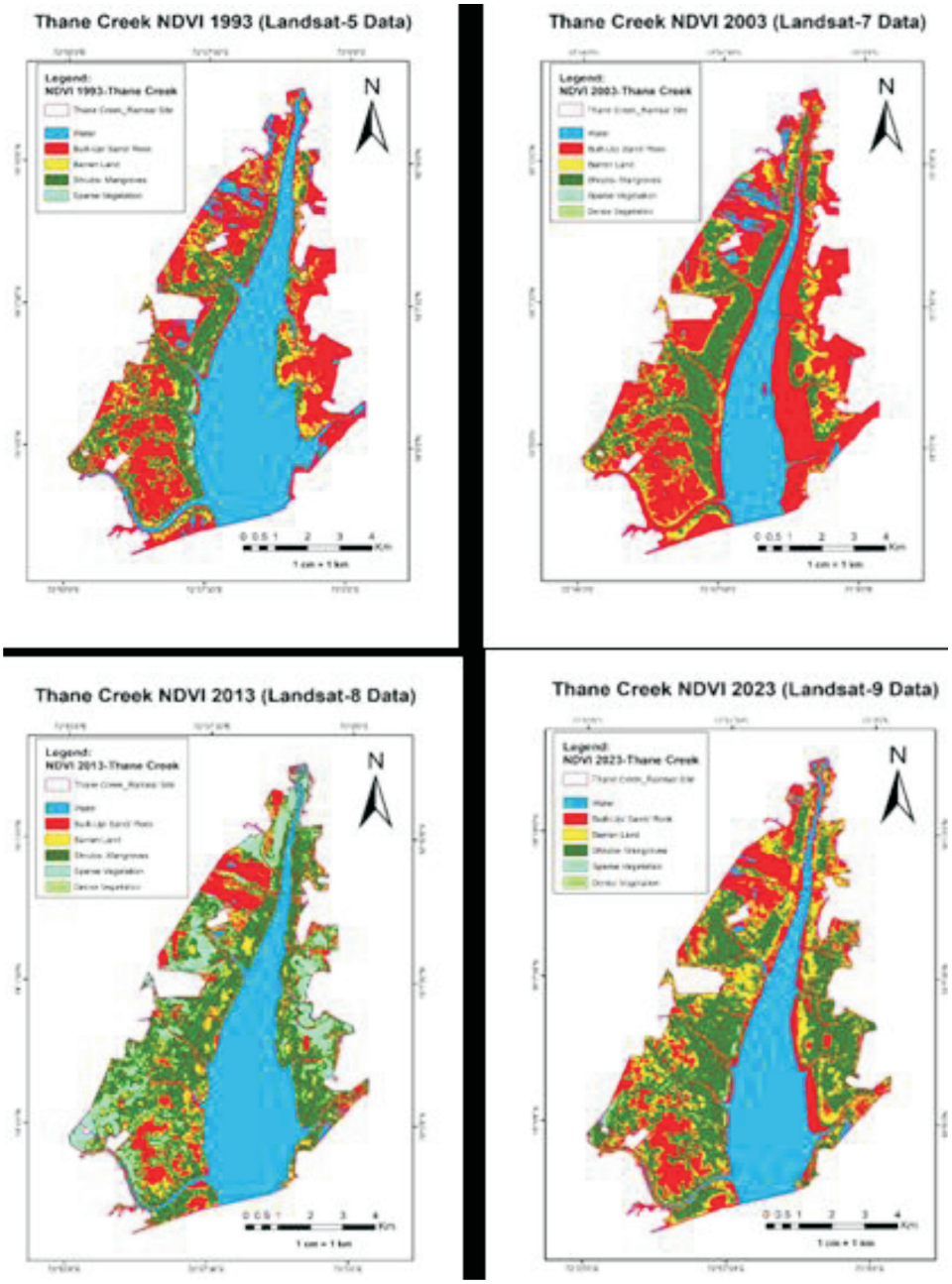

Fig. 3. NDVI maps of Thane Creek for the years 1993, 2003, 2013 and 2023

Normalized Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). The usual method of calculating NDVI is to divide the red (R) value by the near infrared (NIR) value. NDVI=(NIR-RED)/(NIR+RED).

In Landsat 5 and Landsat 7, NDVI = (Band 4 – Band 3) / (Band 4 + Band 3).

In Landsat 8 and Landsat 9, NDVI = (Band 5 – Band 4) / (Band 5 + Band 4).

The NDVI calculations, feature classification, image analysis and map generation were done using ArcGIS software. Akbar *et al.* 2019 studied appropriate ranges of the normalized difference vegetation index (NDVI) for major land cover type (Table 1). This was taken as a suitable reference data range for NDVI analysis of the study area.

Results and Discussion

The following results are observed after doing NDVI analysis and calculating the area of each feature class for the years 1993, 2003, 2013 and 2023:

From the Table 2 and the NDVI maps in Fig.3, it is clearly seen that the mangrove cover for the Thane Creek region-Ramsar site has increased from 12.623 sq.km. in 1993 to 23.678 sq.km. in 2013 and has remained stable at 23.516 sq.km. in 2023. To calculate the Shrub or Mangrove density, the area of the shrub class is divided by the total area of the study area density which will be a value between 0 and 1, with a value of 1 indicating that the entire study area is covered in shrubs. Therefore;

Shrub (Mangrove) Density = Area of the shrub(mangrove) class / Total area of the study area

The Mangrove Density is 0.1921 for 1993,0.2209 for 2003, 0.3603 for 2013 and 0.3579 for 2023 as per the calculations.

Table 1. NDVI range for major land cover type (Akbar *et al.,* 2019)

Feature Class	NDVI Range
Water	-0.28-0.015
Built-Up/ Sand/ Rock	0.015-0.14
Barren Land	0.14-0.18
Shrub (Mangroves)/ Grassland	0.18-0.27
Sparse Vegetation	0.27-0.36
Dense Vegetation	0.36-0.74

Conclusion

The study has shown that the mangroves in Thane Creek have reached saturation stage and have grown to their maximum extent landward. Increase in the mangrove cover obstructs the current flow of seawater towards the creek and creek water into the sea. This impacts the fish population in the area. Numerous factors are also compromising the ecological resilience and health of Thane Creek. Among these problems include invasive species, overfishing, sewage outflow, solid waste disposal, industrial effluents, oil spills, land reclamation, storm surges, sea level rise, erosion, and flooding. Use of GIS techniques may improve planning and decision-making for coastal development and conservation of wetlands by providing tools for stakeholder involvement, risk assessment, scenario analysis, and vulnerability mapping. The government and all parties involved should adopt a suitable management strategy for mangrove restoration and monitor its growth expansion. Real time monitoring and warning system is the need of the hour.

Conflict of Interest - None

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Table 2. Area of each feature class using NDVI analysis

Feature Class	1993 Area (sq.km.)	2003 (Area (sq.km.)	2013 (Area (sq.km.)	2023 (Area (sq.km.)
Water	25.6599	13.6809	19.8234	16.9137
Built-Up/Sand/Rock	20.8098	30.3552	7.93.08	14.5593
Barren Land	6.1659	7.0623	5.2515	10.1043
Shrubs-Mangroves	12.6234	14.5143	23.6781	23.51.61
Sparse-Vegetation	0.4536	0.0900	8.8911	0.6156
Dense Vegetation	~	0.0099	0.1377	0.0036
Total Area	65.7126	65.7126	65.7126	65.7126
Shrub (Mangrove) Density	0.1921	0.2209	0.3609	0.3579

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