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Comparative Study of LANDSAT-8 and SENTINEL-2A Images for Water Spread Area Analysis using NDWI Approach Wetland of Rajasthan: The Largest Saline Sambhar Lake

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ABSTRACT

The present study investigates the use of satellite remote sensing techniques to analyze the distribution and extent of surface water in Sambhar Lake, a prominent inland saline lake located nearly 80 kilometers southwest of Jaipur, Rajasthan. Given the ecological and hydrological significance of this lake, monitoring its water spread is crucial, especially in the context of fluctuating climatic conditions and increasing anthropogenic pressures. To carry out this assessment, satellite imagery from two reliable sources—LANDSAT 8 and SENTINEL-2A—was employed, focusing on their spectral capabilities in identifying surface water features. For LANDSAT 8, Band 3 (Green) and Band 5 (Near Infrared) were utilized, while for SENTINEL-2A, Band 3 (Green) and Band 8 (Near Infrared) were selected. These spectral bands were processed using the Normalized Difference Water Index (NDWI), which effectively highlights water bodies by enhancing the contrast between water and other land features. The NDWI maps generated from these datasets helped visualize and compare the surface water extent captured by each satellite. The analysis revealed that SENTINEL-2A, owing to its higher spatial resolution of 10 meters, offered more detailed and accurate results compared to the 30-meter resolution of LANDSAT 8. It allowed for the identification of finer water channels, fragmented patches, and more defined lake boundaries, making it more suitable for precise surface water studies. In contrast, LANDSAT 8 still proved useful for broader-scale assessments but lacked the level of detail seen in SENTINEL-2A imagery. This study demonstrates the value of remote sensing tools in environmental monitoring, particularly in arid and semi-arid regions like Rajasthan, where water resource management is vital. The findings support the use of high-resolution satellite data for continuous observation of dynamic water bodies and contribute to improved decision-making in hydrological planning and ecological conservation. Overall, the research highlights the importance of selecting appropriate satellite data based on the objective and scale of analysis in surface water mapping.

***Keywords**: LANDSAT-8, SENTINEL-2A, NDWI, Water Mapping, Decision-Making.*

Introduction

Wetlands are essential ecosystems in maintaining ecological balance, supporting biodiversity, and providing various ecosystem services crucial for human survival. These wetlands are protected under various national laws, including the Indian Forest Act (1927), the Forest (Conservation) Act (1980), and the Indian Wildlife (Protection) Act (1972).

Since 1990, there has been an unprecedented loss of wetlands. More than half of the world's wetlands have been converted into agricultural land or industrial and urban areas. Waste discharge from industries has also affected wetlands. (‘(PDF) Spatiotemporal analysis of encroachment on wetlands: a case of Nakivubo wetland in Kampala, Uganda’, 2024)

The Ramsar Convention on Wetlands is an international treaty established in 1971, which provides a framework for the conservation and sustainable use of wetlands around the world. This paper explores the Ramsar Site of Rajasthan – Sambhar Lake and emphasizes the sustainable management of these wetlands for both human and environmental health. With a growing emphasis on sustainability, India has significantly expanded its network of Ramsar Sites to 85 (as of August 14, 2024), making it the country with the largest number of such sites in South Asia.(*Ministry of Environment, Forest and Climate Change*, no date)

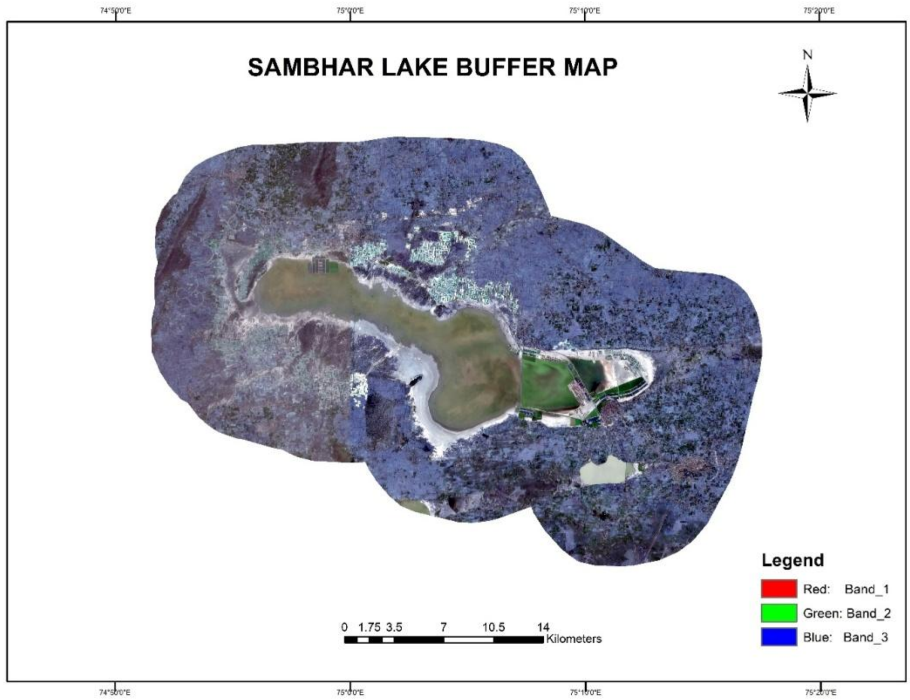
India has added three new Ramsar sites to its network, totaling 85 Ramsar sites across the country. The total area under these sites now stands at an impressive 1,358,068 hectares.The new additions include two sites in Tamil Nadu viz Nanjarayan Bird Sanctuary (125. 865 Hectares) and Kazhuveli Bird Sanctuary (5151.6 Hectares), both of which are vital for bird conservation and biodiversity. Additionally, Madhya Pradesh has joined the ranks with the inclusion of Tawa Reservoir (20050 Hectares), a crucial wetland for supporting local wildlife.

Methodology

This study utilizes satellite imagery from Landsat 8 and Sentinel-2A for two specific years, 2015 and 2025, to monitor changes in the surface area of Sambhar Lake. The satellite data were processed using GIS tools to quantify the lake's area in both years. The Landsat 8 and Sentinel-2A datasets were chosen for their high spatial resolution and long-term availability. The images were pre-processed for atmospheric correction, georeferencing, and cloud masking before the area of the lake was extracted using the Normalized Difference Water Index (NDWI). The area of the lake in 2015 and 2025 was then calculated for both satellite platforms, and a comparative analysis was conducted to determine the extent of expansion over the decade.

Study Area

Sambhar Lake located about 80 kilometers southwest of Jaipur, Rajasthan lies between latitude 26°57'18.36"N and longitude 75° 3'5.67"E. It is a unique feature in India's natural landscape, known for its high salinity and the diverse flora and fauna that thrive in extreme conditions. It has garnered attention for its remarkable hydrological characteristics and ecological significance. As India's largest inland saltwater lake, Sambhar Lake covers an area of approximately 152.26 km², based on the maximum water spread recorded in 1996. However, the lake often dries up during the dry season, leaving behind a white salt crust.(Sen, 2024)



Data Products

The Normalized Difference Water Index (NDWI) is used to monitor changes in the water content of water bodies. Since water strongly absorbs light in the visible-to-infrared electromagnetic spectrum, NDWI utilizes green and near-infrared bands to highlight water bodies effectively. However, it is sensitive to urban development and may lead to overestimating water bodies. The index was proposed by McFeeters in 1996, and values greater than 0.5 typically indicate the presence of water bodies.

NDWI McFeeters = (Green – NIR) / (Green + NIR

Eq. 1 represent the formula where:

- Green = Green band
- NIR = Near-Infrared band

This formula is particularly effective for mapping open water bodies and is less sensitive to built-up land than the original NDWI.(farmonaut, 2024)

Landsat 8

Landsat 8 orbits Earth in a sun-synchronous, near-polar orbit at an altitude of 705 km (438 mi), inclined at 98.2 degrees, and completes one Earth orbit every 99 minutes. The satellite has a 16-day repeat cycle with an equatorial crossing time of 10:00 a.m. +/- 15 minutes. It is the most recently launched Landsat satellite and carries the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) instruments both the OLI and TIRS are push broom sensors with focal planes aligning long arrays of detectors across-track providing 30m resolution images. (Roy *et al.*, 2014)

NDWI for LANDSAT 8 is calculated using bands 3& 5, corresponding to Green and NIR reflectance (wavelengths) respectively.

NDWI = (B3 – B5) / (B3 + B5)---------------------(2)

Eq. 2 represents the formula where:

- B3 = Band 3 for green reflectance
- B5 = Band 5 for NIR reflectance

Sentinel-2

The Copernicus Sentinel-2 mission comprises two polar-orbiting satellites placed in the same sun-synchronous orbit, phased at 180° to each other. It aims at monitoring variability in land surface conditions, and its wide swath width (290 km) and high revisit time (10 days at the equator with one satellite, and 5 days with 2 satellites under cloud-free conditions which results in 2-3 days at mid-latitudes) support monitoring of Earth's surface changes. The satellite carries a wide swath high-resolution multispectral imager with 13 spectral bands.

Sentinel-2A and Sentinel-2B satellite image data at 10 m spatial resolution is resampled to 3 meter resolution.

It can provide information for agriculture and forestry, among others allowing for the prediction of crop yields.

NDWI for SENTINEL 2A is calculated using bands 3& 8, which correspond to Green and NIR reflectance (wavelengths) respectively.

NDWI = (B3 – B8) / (B3 + B8)---------------------(3)

Eq. 3 represents the formula where:

- B3 = Band 3 for green reflectance
- B8 = Band 8 for NIR reflectance

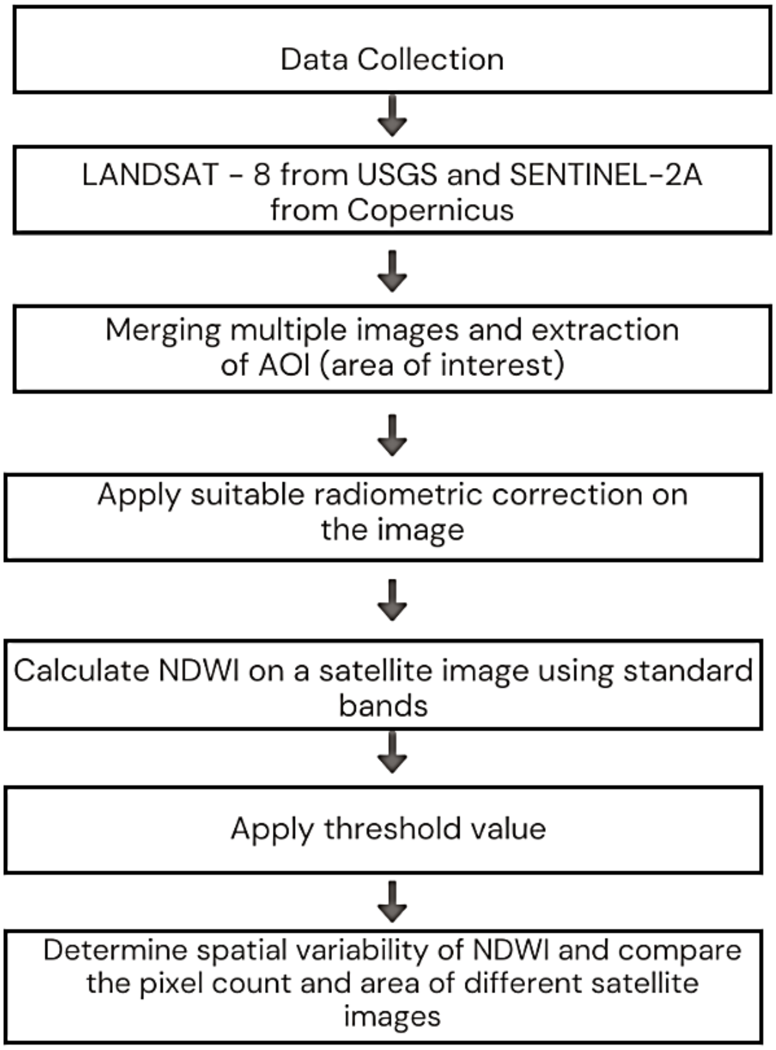
Methodology

This study involved a systematic approach to analyzing the spatial distribution of surface water in Sambhar Lake using satellite imagery. The initial step was data collection, wherein satellite images were obtained from two key sources: LANDSAT-8 (sourced from the USGS Earth Explorer) and SENTINEL-2A (acquired through the Copernicus Open Access Hub). These images were selected based on clarity, resolution, and temporal relevance

Following data acquisition, multiple satellite images were merged, and the area of interest (AOI) — specifically, Sambhar Lake — was extracted for focused analysis. To ensure the accuracy and consistency of the data, radiometric corrections were applied to the images to remove atmospheric distortions and sensor-based irregularities. These corrections were crucial for enhancing the quality and reliability of the satellite data used in the analysis.

Subsequently, the Normalized Difference Water Index (NDWI) was calculated using specific spectral bands—Band 3 and Band 5 for LANDSAT-8, and Band 3 and Band 8 for SENTINEL-2A. This index is effective in distinguishing water bodies from other surface features based on the reflectance of green and near-infrared light. After calculating the NDWI values, an appropriate threshold was applied to delineate water features from non-water features more accurately.

Finally, the study focused on assessing the spatial variability of the NDWI outputs. This involved comparing the pixel count and surface area derived from both satellite datasets to evaluate the effectiveness and resolution quality of each. The comparison enabled an in-depth understanding of how sensor resolution impacts the detection and mapping of surface water, ultimately aiding in determining the most suitable dataset for detailed hydrological and environmental analysis.



Result

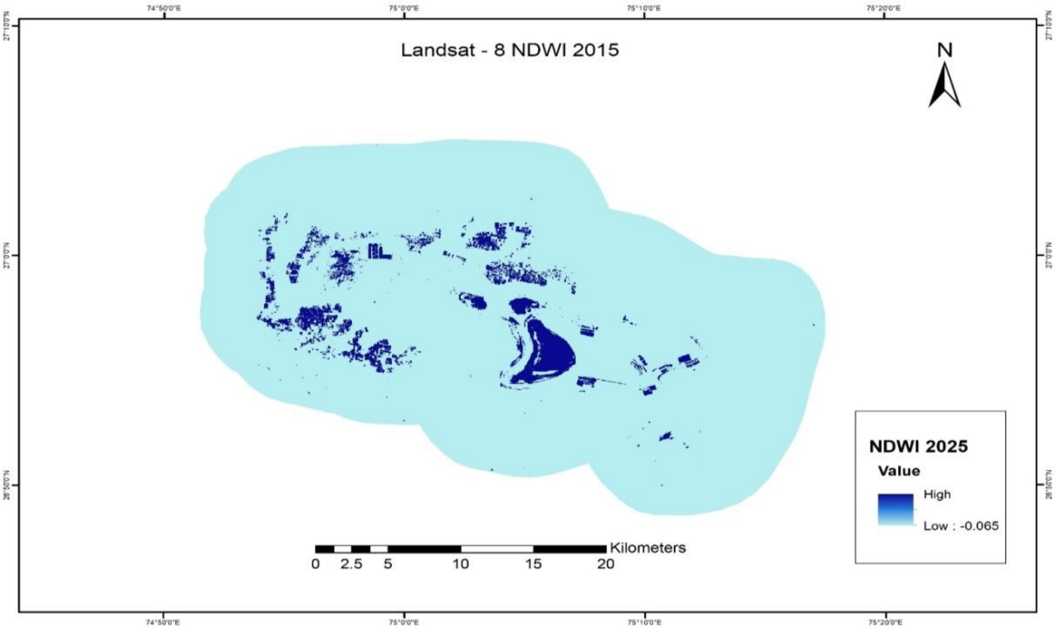
- **NDWI Maps**

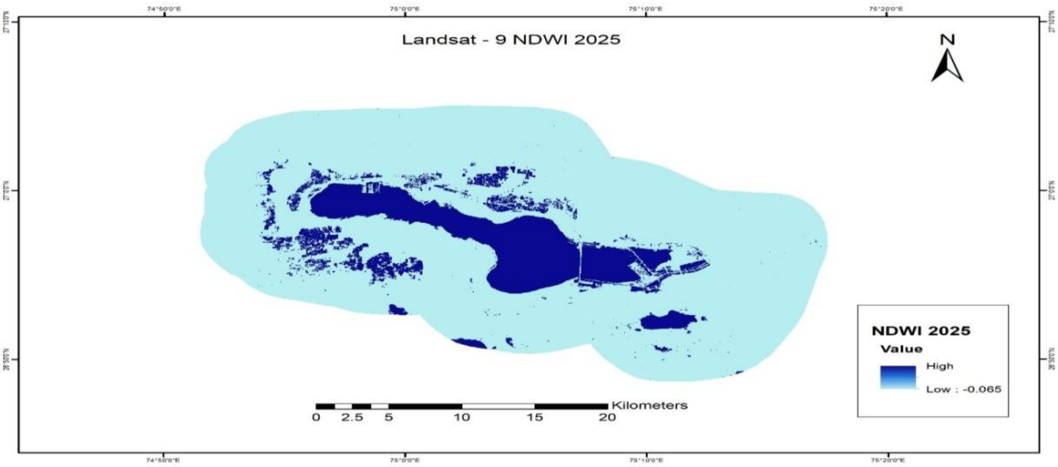
Using the NDWI approach and methodology, we generate NDWI maps for the selected study area, classifying them into two categories based on a specified threshold for 2015 and 2025. These maps are then analyzed for their spatial variability, potential applications, and relevant uses.

- **Landsat8**

The NDWI with LANDSAT 8's band combination ranges from -0.448088to 0.222143, representing various shades of grey indicating no/low surface water and high surface water regions, respectively. To make the data more informative and easier to interpret, a threshold value of -0.065 was applied—both years which showed an increase in the surface water spread area.

The pixel count of the Landsat image was 2015: -0.367277 to 0.115702 and 2025: -0.448088to0.222143 before threshold.

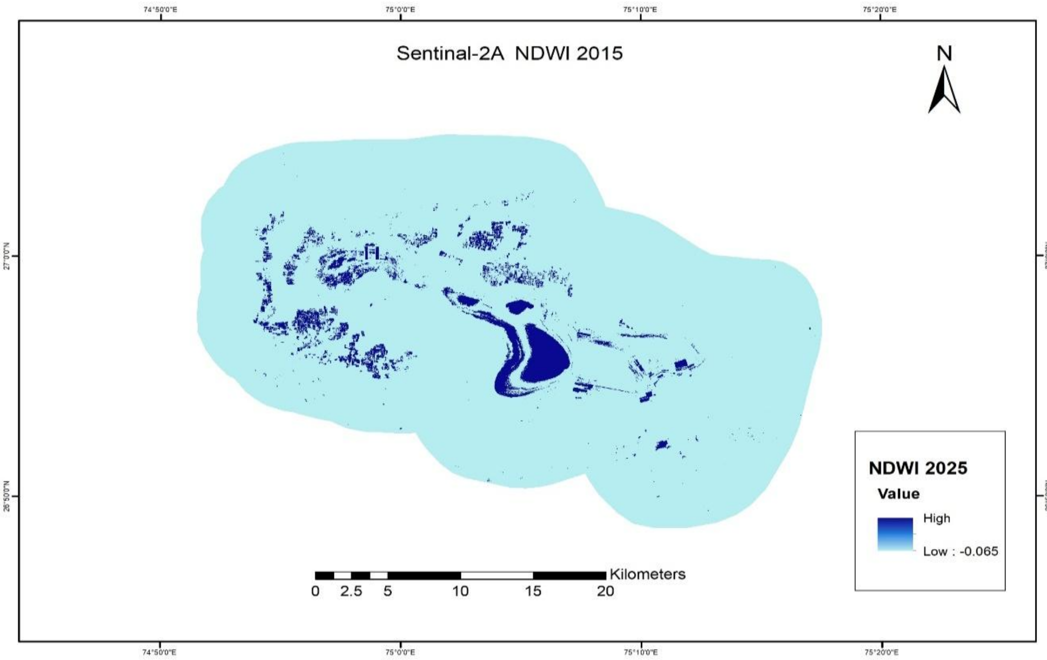


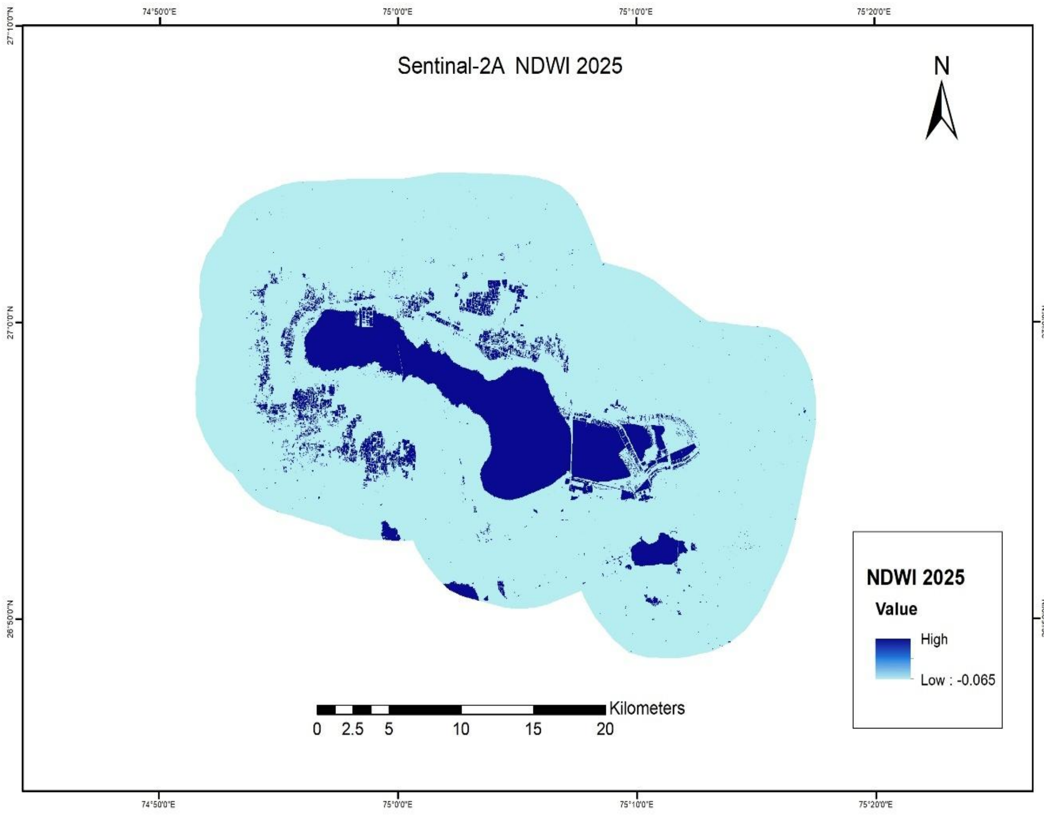


- **Sentinal 2A**

The NDWI with Sentinal 2A band combination ranges from -0.663978 to 0.401491, representing various shades of grey indicating no/low surface water and high surface water regions, respectively. To make the data more informative and easier to interpret, a threshold value of -0.065 was applied—both years which showed an increase in the surface water spread area.

The pixel count of the Sentinal 2A image was 2015: - 0.615433 to 0.283993 and 2025: -0.663978to0.401491before threshold.

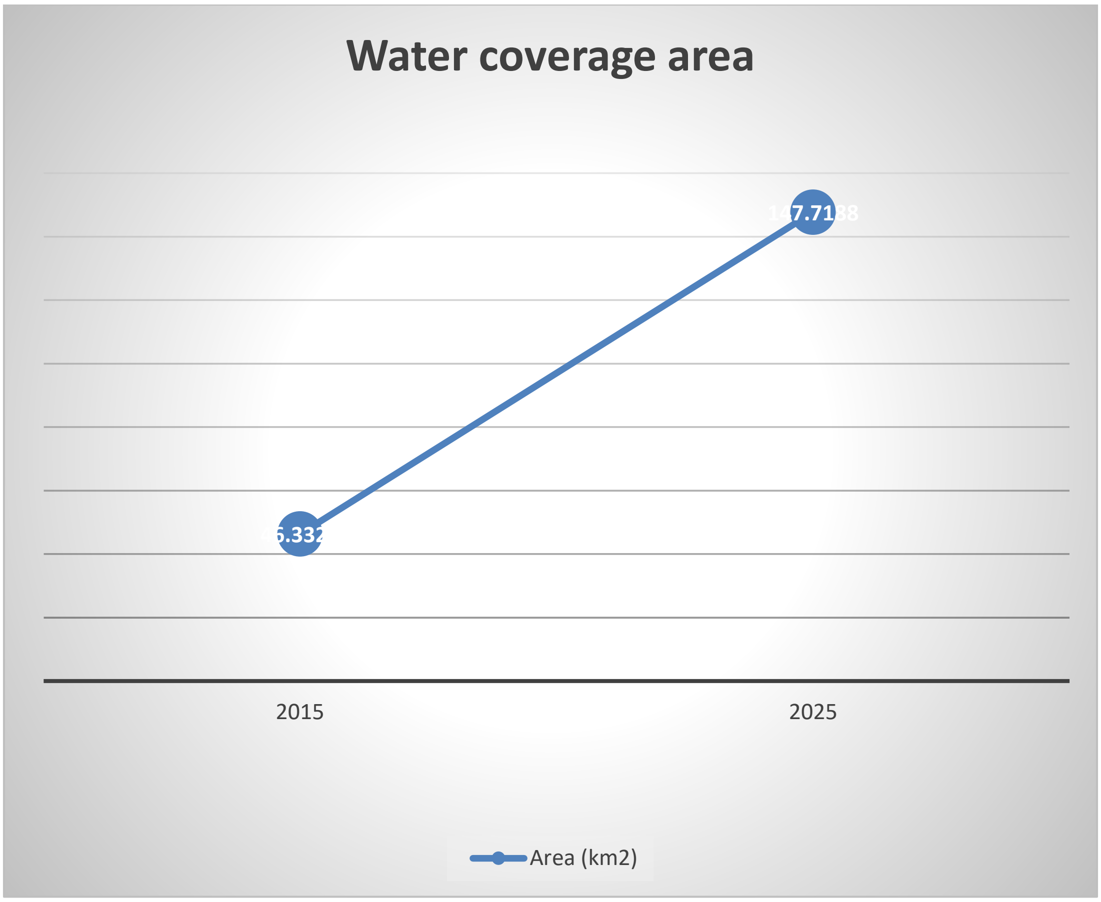

Sentinal-2A NDWI 2015
N
NDWI 2025
Value
High
Low : -0.065
0 2.5 5 10 15 20 Kilometers
74°50'0"E
75°0'0"E
75°10'0"E
75°20'0"E
27°0'0"N
26°50'0"N


Sentinal-2A NDWI 2025
N
NDWI 2025
Value
High
Low : -0.065
0 2.5 5 10 15 20 Kilometers
74°50'0"E
75°0'0"E
75°10'0"E
75°20'0"E
27°10'0"N
27°0'0"N
26°50'0"N

- **Comparison Table**

2015		
Parameters	**Landsat -8**	**Sentinal -2A**
No. of Pixels	51481	52570
Area of water (km2)	46.3329	47.313

2025		
Parameters	Landsat -8	Sentinal -2A
No. of Pixels	164132	1335743
Area of water (km2)	147.7188	133.5743



Conclusion

Ecologically, Sambhar Lake is vital as it serves as an important habitat for a variety of bird species, including both resident and migratory birds. It is recognized as a Ramsar site, highlighting its international significance for wetland conservation and biodiversity. Additionally, the lake has served as a traditional source of salt production in the region for centuries.

The significant expansion of Sambhar Lake was observed from 2015 to 2025, with an increase in surface area from 46.33 sq km (2015 Landsat 8) to 147.72 sq km (2025 Landsat 8) and from 47.31 sq km (2015 Sentinel-2A) to 133.57 sq km (2025 Sentinel-2A), suggests important hydrological shifts as well as due to increase in number of borewells which pulls the groundwater over the surface for enhancing salt production.

The pixel count of the Landsat image – 51481 and 164132 for the respective years and the pixel count of the Sentinal 2A image – 52570 and 1335743for the respective years. This shows that the more the pixel count more information the image stores.

While an increase in water area might initially seem beneficial for waterbird populations by providing more foraging and nesting habitats, the overall decrease in surrounding wetland areas could have a detrimental impact. Wetlands play a crucial role in supporting a wide variety of waterbird species, particularly during migration periods, by offering critical feeding and breeding grounds. The loss of these wetland habitats could lead to reduced biodiversity, disrupt breeding cycles, and hinder the ability of waterbirds to find suitable resources, ultimately affecting their population dynamics. These changes highlight the need for balanced water management practices that consider both the expansion of water bodies and the preservation of adjacent wetlands, ensuring long-term ecological sustainability for waterbird species in the region

References

1. farmonaut (2024) 'Understanding NDWI: From Basics to Advanced Applications in Remote Sensing and Water Management -', 24 September. Available at: https://farmonaut.com/remote-sensing/understanding-ndwi-from-basics-to-advanced-applications-in-remote-sensing-and-water-management/ (Accessed: 30 January 2025).
2. *Ministry of Environment, Forest and Climate Change* (no date). Available at: http://pib.gov.in/PressNoteDetails.aspx?NoteId=152029 (Accessed: 10 January 2025).
3. '(PDF) Spatiotemporal analysis of encroachment on wetlands: a case of Nakivubo wetland in Kampala, Uganda' (2024) *ResearchGate* [Preprint]. Available at: https://doi.org/10.1007/s10661-016-5207-5.
4. Roy, D.P. *et al.* (2014) 'Landsat-8: Science and product vision for terrestrial global change research', *Remote Sensing of Environment*, 145, pp. 154–172. Available at:

   https://doi.org/10.1016/j.rse.2014.02.001.
5. Sen, M. (2024) 'Hydrology Report of Sambhar Lake: A Safe Haven Past Disaster Recovery', *Advances in Hydrology & Meteorology*, 2(1). Available at:

   https://doi.org/10.33552/AHM.2024.02.000526.