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Remote Sensing Based Monitoring and Estimation of Lacustrine Chlorophyll-a Concentration in South Tamil Nadu: A Case Study

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Abstract

Lacustrine water bodies are vital for domestic, agricultural, and economic activities, necessitating continuous water quality monitoring for their sustainable management, and the study focuses on inland water bodies from eleven southern districts of Tamil Nadu. Among various water quality parameters, chlorophyll-a (Chl-a) serves as a key indicator of algal biomass and ecosystem productivity, playing a crucial role in assessing eutrophication and water health. Traditional in-situ monitoring methods for Chl-a are often labour-intensive, time-consuming, and expensive. Remote sensing offers an efficient alternative, enabling large-scale and frequent assessments of Chl-a dynamics. This study employs Sentinel-2 satellite imagery to estimate and monitor Chl-a concentration in selected lacustrine environments of South Tamil Nadu. The study aims to improve understanding of spatial and temporal variations in Chl-a levels through the use of remote sensing techniques, allowing for data-driven decision-making for sustainable water resource management. Remote sensing technology is excellent for monitoring water quality.

Keywords: Chlorophyll-a, Remote Sensing, Sentinel-2, Water Quality Monitoring, Sustainable Water Management

1. Introduction

Water bodies are highly vulnerable to ecological changes due to natural processes and human interventions, necessitating continuous monitoring of their water quality. Excessive algal growth, often indicated by elevated Chl-a concentrations, can lead to severe water quality issues such as oxygen depletion, odor, and the formation of harmful algal blooms (HABs), which pose significant threats to aquatic ecosystems and public health ^[1]. Traditional methods for measuring Chl-a concentration rely on in-situ sampling and laboratory analysis, which are often labor-intensive, time-consuming, and expensive ^[2]. These challenges have led to the increased adoption of remote sensing techniques as a viable alternative for large-scale and cost-effective water quality assessment. The availability of high-resolution Sentinel-2 satellite imagery provides an opportunity to monitor Chl-a concentration efficiently, offering extensive spatial and temporal coverage. Remote sensing facilitates the estimation of water quality parameters using spectral reflectance, allowing researchers to track changes in Chl-a dynamics over time ^[3]. Several studies worldwide have demonstrated the potential of remote sensing techniques for monitoring Chl-a concentration and understanding algal bloom dynamics. Research on Lake Winnipeg, North America, analyzed spatial and temporal variability in algal blooms using satellite-derived Chl-a indices, integrating ESA's MERIS mission data from 2002 to 2011 ^[4]. Similarly, studies in Jordan evaluated remote sensing data accuracy for Chl-a estimation, developing predictive models validated with Sentinel-2 surface reflectance data ^[5]. Additional research from China, Europe, and Africa has further highlighted the effectiveness of remote sensing for Chl-a monitoring, emphasizing the importance of integrating satellite-based techniques for long-term water quality assessment ^[3, 6, 7]. In India, studies have focused on using remote sensing for Chl-a monitoring in estuarine and coastal waters. Sachidananda Mishra *et al.* (2019) proposed the Normalized Difference Chlorophyll Index (NDCI) to predict Chl-a concentrations in estuarine and coastal turbid waters using MERIS satellite imagery ^[8]. Govindaraj *et al.* (2020) retrieved Total Suspended Matter (TSM) and Chl-a concentrations in the Velar Estuary, Tamil Nadu, using Sentinel-2 imagery ^[9].

Additionally, research on the Buddha Nala River in Punjab analysed the impact of COVID-19 lockdowns on water quality using remote sensing techniques, revealing significant improvements in water clarity and vegetation growth due to reduced anthropogenic activities^[10]. Despite the growing use of remote sensing for water quality assessment, limited research has focused on the continuous monitoring of Chl-a concentration in lacustrine water bodies of South Tamil Nadu. Most studies have concentrated on estuarine and coastal environments, with fewer investigations into seasonal variations and spatial dynamics of Chl-a in inland freshwater lakes and reservoirs. This study aims to bridge this gap by utilizing Sentinel-2 satellite imagery to monitor Chl-a concentration across eleven districts of South Tamil Nadu. The main objectives are to delineate 33 major lacustrine water bodies across eleven districts in South Tamil Nadu, to monitor seasonal

variations in chlorophyll-a concentrations using Sentinel-2 imagery, and to apply remote sensing indices (NDCI) for estimating Chl-a concentration.

2. Study Area

The study focuses on inland water bodies from eleven southern districts of Tamil Nadu, namely Dindigul, Pudukkottai, Theni, Madurai, Sivagangai, Virudhunagar, Ramanathapuram, Tenkasi, Thoothukkudi, Tirunelveli, and Kanniyakumari, geographically located within the graticules of 77° 08' to 79° 45' E longitudes and 10° 04' to 8° 05' N latitudes. A total of 33 inland water bodies with a surface area greater than 3 square kilometres were identified. This selection provides a comprehensive spatial representation of inland water bodies across South Tamil Nadu, ensuring a robust analysis of chlorophyll-a (Chl-a) dynamics and water quality variations using Sentinel-2 satellite imagery.

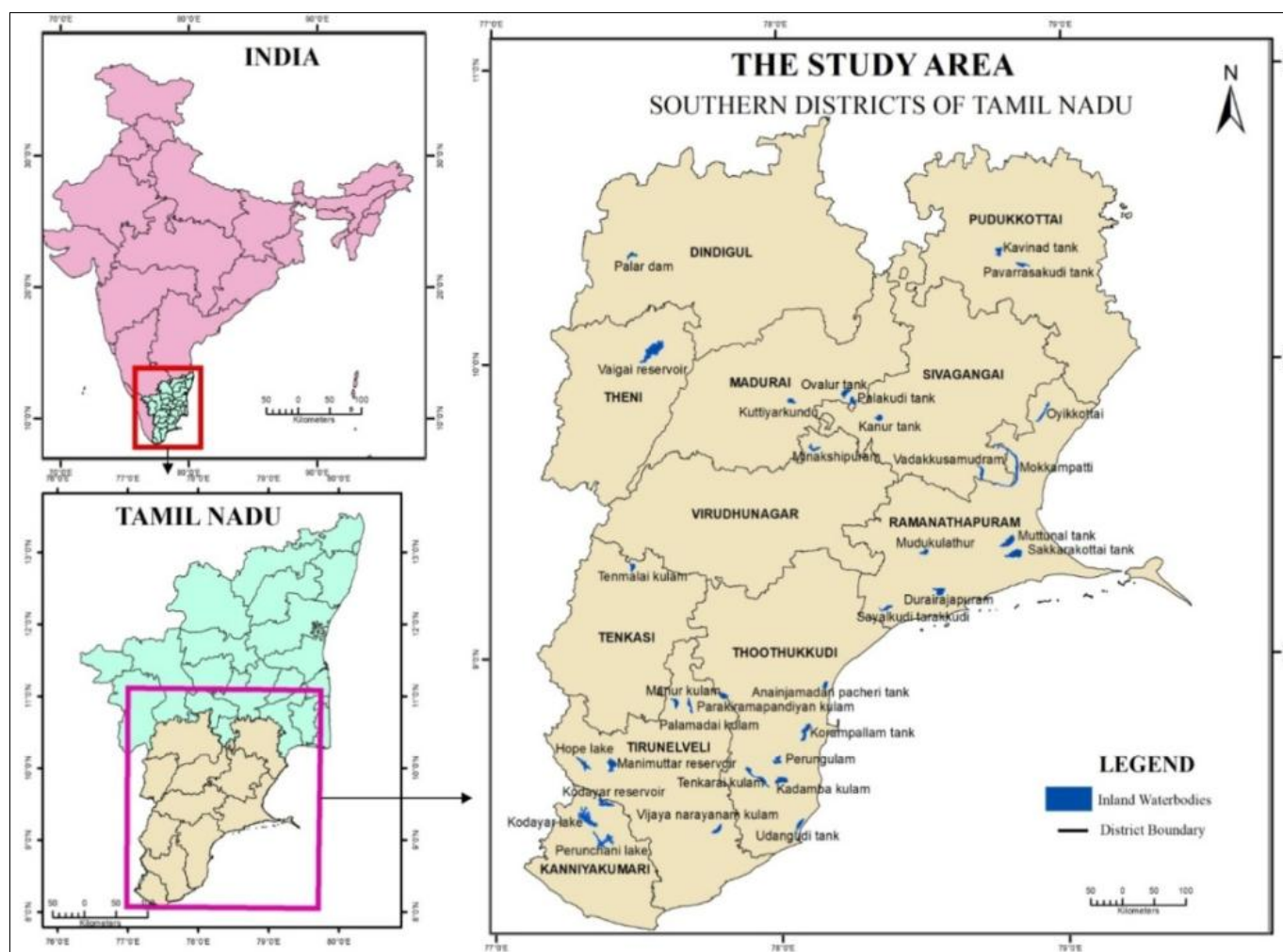


Fig 1: Locations of lakes in this study

3. Methodology

3.1 Satellite Data

Sentinel-2 satellite imagery was utilized in this study to estimate the concentration of chlorophyll-a (Chl-a).

Sentinel-2 carries an advanced Multi-Spectral Instrument (MSI) with 12-bit radiometric digitization, making it particularly useful for analyzing low-radiance aquatic environments.

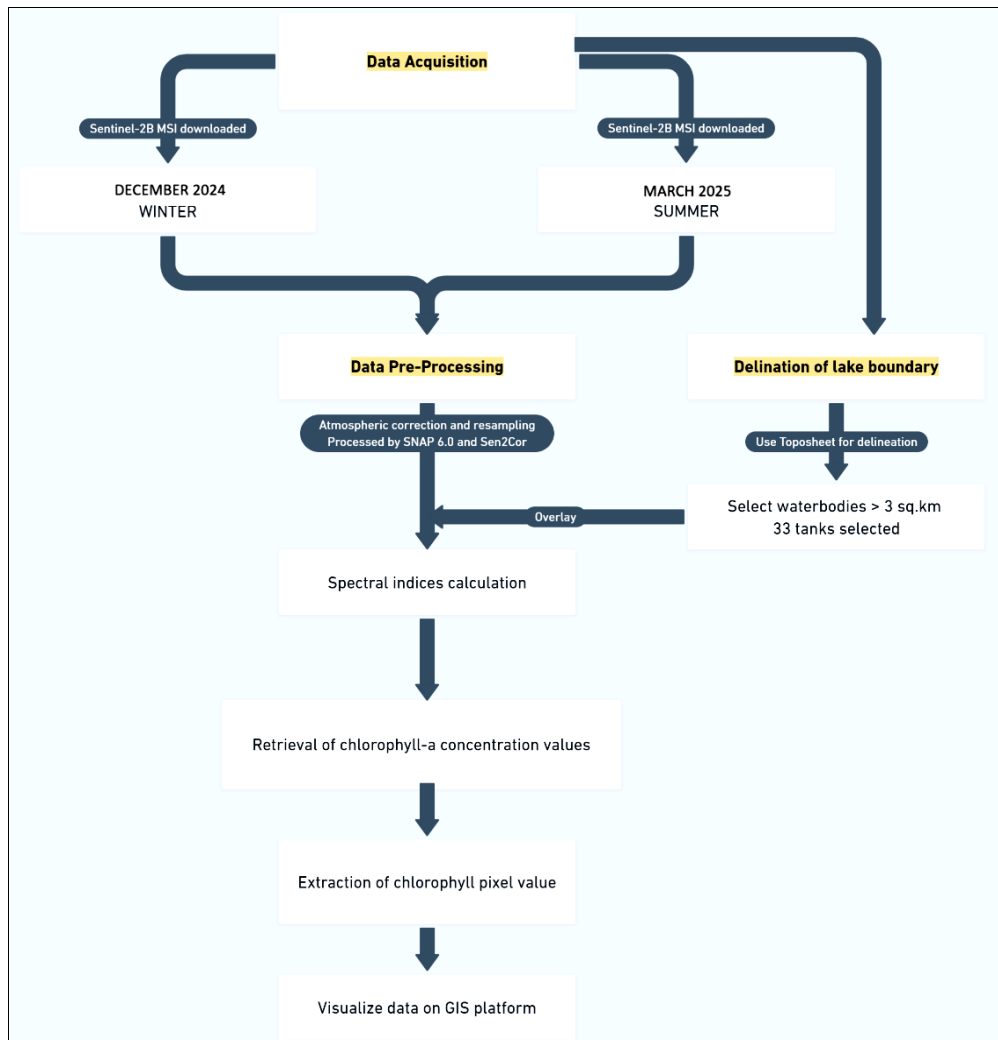


Fig 2: Methodology flowchart

3.2 Data Acquisition

For seasonal analysis, Sentinel-2B MSI data were downloaded from the Copernicus Open Access Hub (sentinels.copernicus.eu) for the months of December 2024 representing winter and March 2025 representing summer. These datasets provide spectral information on water bodies, capturing variations in Chl-a concentration and phytoplankton distribution.

3.3 Delineation of Lake Boundaries

The boundaries of the selected inland water bodies were digitized using Survey of India toposheets at a 1:50,000 scale. Water bodies with a surface area greater than 3 square kilometres were included in the study, resulting in the selection of 33 lakes and reservoirs.

3.4 Data Pre-Processing and Processing

Pre-processing of satellite imagery was conducted using the Sentinel Application Platform (SNAP 6.0). Atmospheric correction was performed using the Sen2Cor algorithm, followed by image resampling. Chlorophyll pixel values were then extracted using GIS-based analysis with ArcGIS Model Builder.

3.5 Estimation of Chlorophyll-a Concentration

The Normalized Difference Chlorophyll Index (NDCI) was

applied using the band ratio method to estimate Chl-a concentration:

$$NDCI = \frac{B5 - B4}{B5 + B4} = \frac{(705nm - 665nm)}{(705nm + 665nm)}$$

The derived NDCI raster values were used to compute Chl-a concentrations (mg/m^3) using the regression equation proposed by Mishra and Mishra (2012):

$$C = 14.039 + 86.115x + 194.325x^2$$

3.6 Mapping of Chlorophyll-a Concentration

The Chl-a concentration values were classified into seven equal interval classes; to facilitate interpretation and a color-coded scheme was applied to generate thematic maps for visual representation of spatial distribution patterns.

4. Results and Discussion

The Chl-a concentration is calculated and the values in the resultant images range from $4.5 mg/m^3$ to $193.34 mg/m^3$ overall for all the selected periods - Winter (December 2024), Summer (March 2025) Table 2 shows the calculated Chl-a concentration values of the selected water bodies.

Table 2: Chlorophyll -a concentration values

Chlorophyll-a Concentration mg/m3					
SL.NO	Name of the Inland Water body/District	Winter December 2024		SUMMER March 2025	
		LOW	HIGH	LOW	HIGH
	Madurai				
1	Kuttiyarkundu Tank(T1)	12.54	82.77	15	38.487
2	Ovalur Tank(T2)	12.95	114.52	15.21	37.625
3	Palakudi(T3)	11.36	125.608	13.38	42.763
	Theni				
4	Vaigai Reservoir(T4)	10.098	80.965	12.54	54.897
	Dindigul				
5	Palar Dam(T5)	13.74	105.17	12.54	36.32
	Pudukkottai				
6	Kavinad(T6)	6.67	116.373	10.02	44.477
7	Puvarasakudi(T7)	15.92	121.78	14.49	52.771
	Sivagangai				
8	Kanur Tank(T8)	21.48	165.58	16.183	58.996
9	Vadakkusamudram(T9)	15.81	167.7	13.63	52.777
	Ramanathapuram				
10	Oyikkottai(T10)	9.77	110.79	14.63	33.729
11	Mokkampatti(T11)	12.74	132.72	13.94	36.099
12	Muttunal Tank(T12)	11.58	140.75	16.047	41.761
13	Mudukulathur(T13)	11.586	140.75	14.05	48.807
14	Sakkarrakottai Tank(T14)	12.38	105.59	14.88	36.127
15	Durairajapuram Tank(T15)	12.98	124.5	15.6	34.632
16	Sayalkuditarakkudi Tank (T16)	12.8	154.07	11.813	44.024
	Virudhunagar				
17	Minakshipuram (T17)	15.39	125.34	16.18	46.667
	Tenkasi				
18	Temmalai Kulam (T18)	18.09	73.186	16.54	40.847
	Thoothukkudi				
19	AnainjamadanPacheri tank (T19)	13.57	111.25	12.47	47.659
20	Korampallam Tank (T20)	11.655	94.97	11.86	52.536
21	Perungalam Tank (T21)	16.31	76.038	13.15	47.636
22	Kadamba Kulam(T22)	13.45	91.101	12.75	77.671
23	Tenkarai Kulam (T23)	15.51	69.284	12.97	56.871
24	Udangudi Kulam (T24)	10.79	85.76	12.43	54.88
	Tirunelveli				
25	Parakiramapandiyan Kulam (T25)	16.149	52.698	15.24	39.069
26	Palamadai Kulam (T26)	14.784	48.65	13.28	36.209
27	Manur Kulam (T27)	15.035	58.34	16.22	42.342
28	Manimuttar Reservoir (T28)	9.939	70.858	10.56	37.869
29	Hope Lake(T29)	8.93	84.411	10.43	37.063
30	Vijaya Narayana Kulam(T30)	11.438	54.223	12.23	38.62
	Kanniyakumari				
31	Kodayar Reservoir (T31)	4.49	193.34	4.5	54.09
32	Kodayar Tank(T32)	5.239	103.099	10.23	47.02
33	Perinchani Lake (T33)	8.164	92.091	12.6	51.915

4.1 Chl-a concentration - The spatial pattern in Madurai, Theni, Dindigul, Pudukkottai, Virudhunagar, Tenkasi districts

The above mentioned six districts contain nine water bodies namely Palakudi tank, Ovalur tank, Kuttiyarkundu tank, Vaigai reservoir, Palar dam, Kavinad tank, Puvarasakudi tank, Minakshipuram, Tenmalaikulam in Madurai (3), Theni (1), Dindigul (1), Pudukkottai (2), Virudhunagar (1), Tenkasi (1) respectively. The fig 3(a)(i) shows the Winter - December 2024 results from which it can be observed that there is extremely high, very high, moderate, and low Chl-a concentration in the Palakudi tank, Ovalur tank, Puvarasakudi tank, Kavinad, Minakshipuram,

Tenmalaikulam water bodies. The extremely high concentration in these nine tanks ranges up to 125.60 mg/m³. The rest of the water bodies i.e., Vaigai Reservoir, Palar Dam, Kuttiyarkundu Tank have low and very low Chl-a concentration. The fig 3(a)(ii) shows the Summer - March 2025 results from which it can be observed that there is moderate and low Chl-a concentration in the Palakudi tank, Ovalur tank, Puvarasakudi tank, Kavinad tank, Minakshipuram, Tenmalaikulam, and Kuttiyarkundu tank. The rest of the water bodies i.e., Vaigai reservoir, Palar dam, and Kavinad tank have low and very low Chl-a concentration.

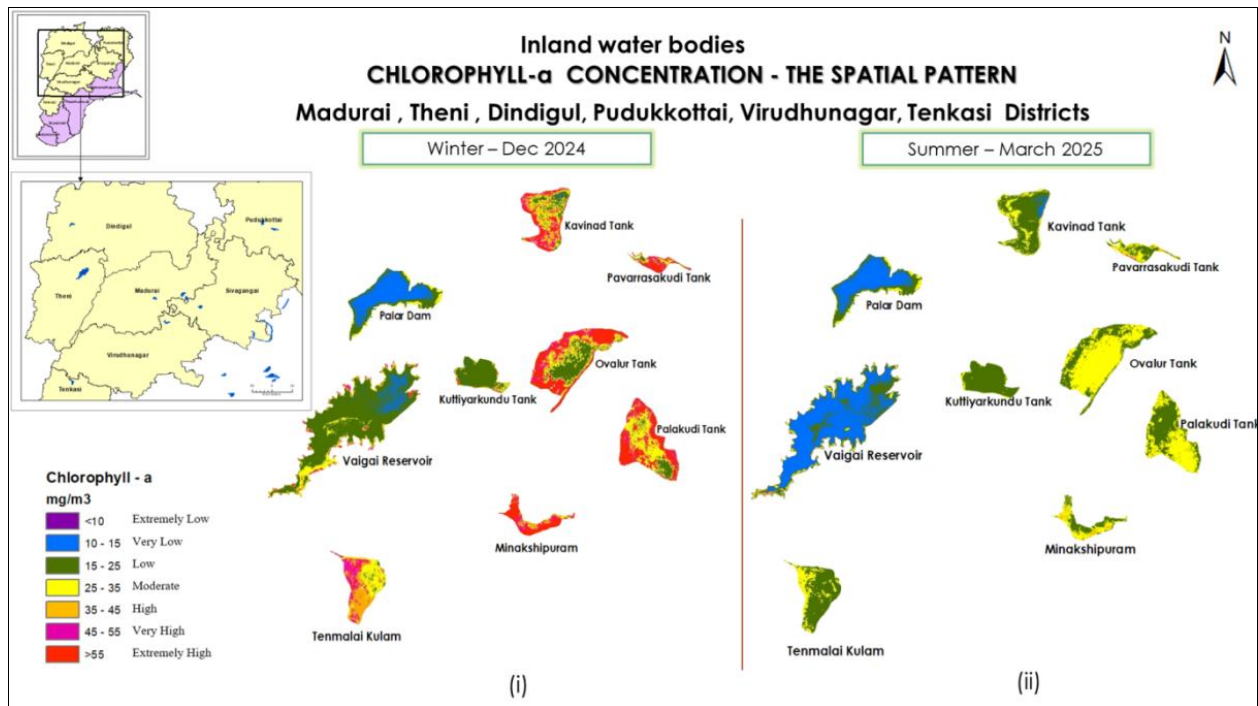


Fig 3 (a): Spatial pattern of chlorophyll -a concentration of Madurai, Theni, Dindigul, Pudukkottai, Virudhunagar, Tenkasi districts

4.2 Chl-a concentration - The spatial pattern in Sivangai, Ramanathapuram districts

The above-mentioned two districts contain ten water bodies namely Kanur tank, Vadakusamudram, Oyikkottai, Mokkampatti, Muttun tank, Sakkarakottai tank, Durairajapuram, Mudukulathur, SayalkudiTaraikkudi in Sivangai (2), Ramanathapuram (7) respectively. The fig 3(b)(i) shows the Winter - December 2021 results from which it can be observed that there is extremely high, very high, moderate and low Chl-a concentration in the Kanur Tank, Vadakusamudram, Oyikkottai, Mokkampatti, Muttun tank, Durairajapuram, Mudukulathur, SayalkudiTaraikkudi water bodies. Sakkarakottai tank

shows moderate and low-level Chl-a concentration. The extremely high concentration in these nine tanks ranges up to 167.07 mg/m³. The fig 3(b)(ii) shows the Summer - March 2025 results from which it can be observed that there is moderate and low Chl-a concentration in the Oyikkottai, Mokkampatti, Muttun tank, Sakkarakottai, Durairajapuram, Sayalkudi Taraikkudi. whereas very high and moderate as well as low Chl-a concentration can be observed in the Mudukulathur, Vadakusamudram and Kanurtanks. In Kanur tank, it is observed that more area is covered with vegetation and so extremely high concentration of Chl-a is seen.

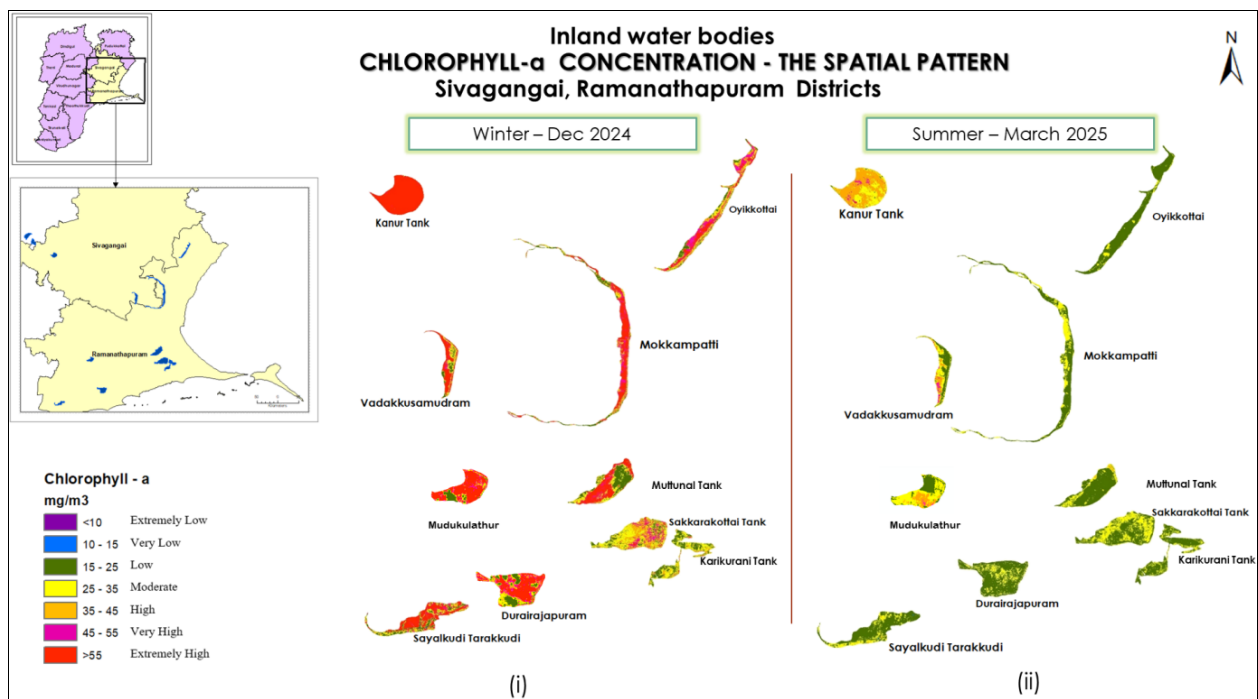


Fig 3: (b): Spatial pattern of chlorophyll -a concentration of Sivangai and Ramanathapuram districts

4.3 Chl-a concentration - The spatial pattern in Thoothukudi and Tirunelveli districts

The above-mentioned two districts contain nine water bodies namely Anainjamadanpacheri tank, Parakiramapandiyankulam in Thoothukkudi (6), Tirunelveli (3) respectively. The fig 3(c)(i) shows the Winter -

December 2024 results from which it can be observed that there is extremely high, very high, moderate, and low chlorophyll - a concentration in the AnainjamadanPacheri tank, Korampallam tank, Perungulam, Kadamba kulam, Tenkaraikulam water bodies. In Parakiramapandiyankulam, Palamadai Kulam, Manur Kulam,

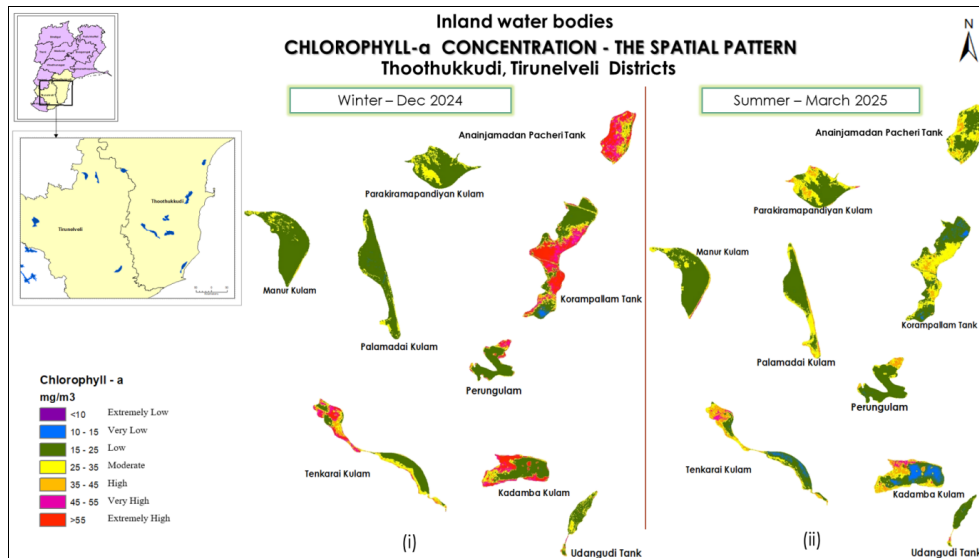


Fig 3(c): Spatial pattern of chlorophyll -a concentration of Thoothukudi and Tirunelveli districts

Udangudi tank moderate and low-level Chl-a concentrations can be observed. The extremely high concentration in these nine tanks ranges up to 111.25 mg/m³. The fig 3(c)(ii) shows the Summer - March 2025 results from which it can be observed that there is high, moderate, and low chlorophyll - a concentration in the AnainjamadanPacheri tank, Korampallam tank, Perungulam, Palamadaikulam, Manurkulam, Udangudi tank. In Kadamba kulam, Tenkaraikulam there is a presence of very high in the northern region of the tanks, high, moderate, low, very low, and extremely low Chl-a concentrations spanning over the water bodies.

4.4 Chl-a concentration - The spatial pattern in Tirunelveli and Kanniyakumari districts

The above mentioned two districts contain six water bodies

namely Manimuttar reservoir, Vijaya narayanamkulam, Hope Lake, Kodayar reservoir, Kodayar lake, Perunchani lake in Tirunelveli (3), Kanniyakumari (3) respectively. The fig 3(d)(i) shows the Winter - December 2024 results from which it can be observed that there is extremely high, low, and very low Chl-a concentration in Hope Lake. The extremely high concentration is observed over the boundaries of the lake and low and very low spanning to the centre of the lake. Similarly, there is an extremely high concentration in small areas over the boundaries of the Manimuttar reservoir, with low and very low concentrations spanning to the centre of the reservoir. In Vijaya narayanamkulam, there is presence of moderate, low and very low Chl-a concentration spreading from the boundary to the centre.

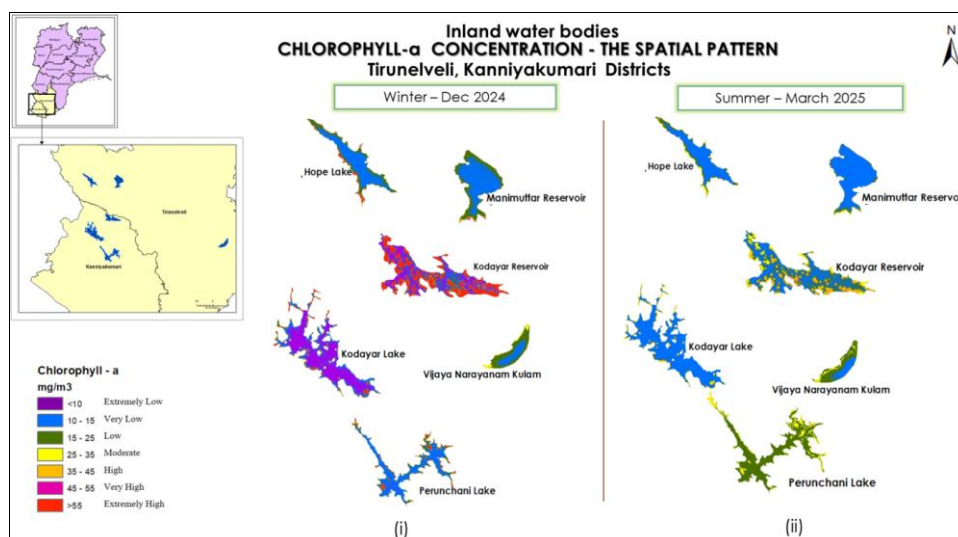


Fig 3(d): Spatial pattern of chlorophyll -a concentration of Tirunelveli and Kanniyakumari districts

In Kodayar lake and Kodayar reservoir, there is a presence of extremely high over the boundaries as well as extremely low spanning over to the center. In Perunchani lake we can observe the extremely high concentration over the edges at some locations and low, very low concentration spread over the rest of the lake. The extremely high concentration in these six tanks ranges up to 193.34 mg/m³. The fig 3(d)(ii) shows the Summer - March 2025 results from which it can be observed that there is moderate, low, and very low Chl-a concentration in Hope Lake spreading from the boundaries to the central part of the lake in order of moderate to very low Chl-a concentration. There is a presence of low Chl-

a concentration at small areas over the southern lower part of Manimuttar reservoir, very low concentration spanning to the center of the reservoir. In Vijaya narayanamkulam, there is presence of moderate, low, and very low Chl-a concentration spreading from the boundary to the centre. In Kodayar lake and Kodayar reservoir there is presence of high and moderate Chl-a concentration over the boundaries as well as very low spanning over to the centre. In Perunchani lake we can observe there is high concentration over the edges at some locations and moderate and low Chl-a concentration spread over the rest of the lake.

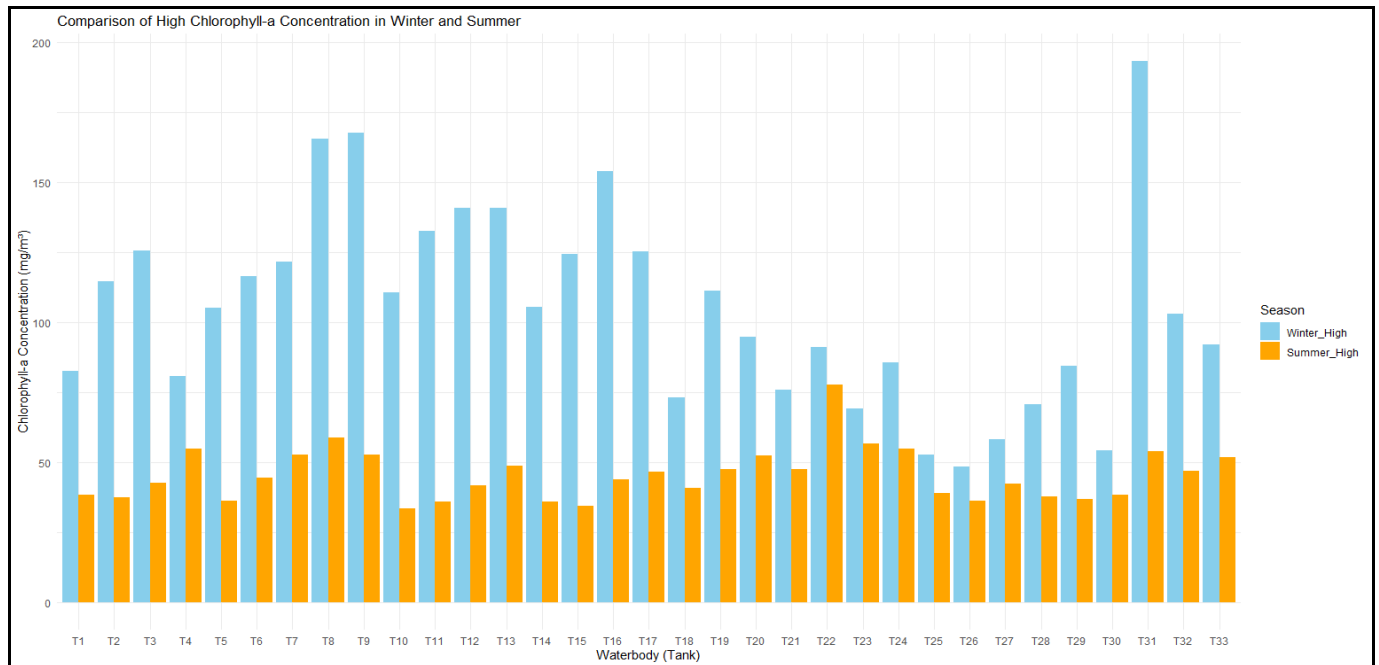


Fig 4: Graphical comparison of high Chl-a concentrations of the waterbodies

Figure 4 depicts a graphical comparison of Chl-a concentrations in the study area water bodies between the high Chl-a concentration of winter and summer months. For optimal clarity, each water body is assigned a unique identifier (T1, T2, T3, etc.). Upon analyzing the data, distinct patterns emerge across different bodies of water. For example, certain bodies of water have higher Chl-a concentrations in the winter than others do in the summer. These differences could be linked to seasonal changes in environmental parameters as sunlight, temperature, availability, and nutrient inputs. The comparison emphasizes on the temporal variability of Chl-a concentration within each water body, which offers valuable insights into seasonal dynamics and probable environmental factors. Effective monitoring and management of water resources, particularly in lacustrine environments where Chl-a is a critical indication of algal abundance and water quality, depend on an understanding of these fluctuations. Overall, the graphical representation emphasizes the need of constant monitoring of Chl-a concentrations with remote sensing technology, enabling accurate evaluations of temporal and spatial fluctuations in water quality. This proactive approach is critical for informed decision-making and long-term management of lacustrine settings, ultimately

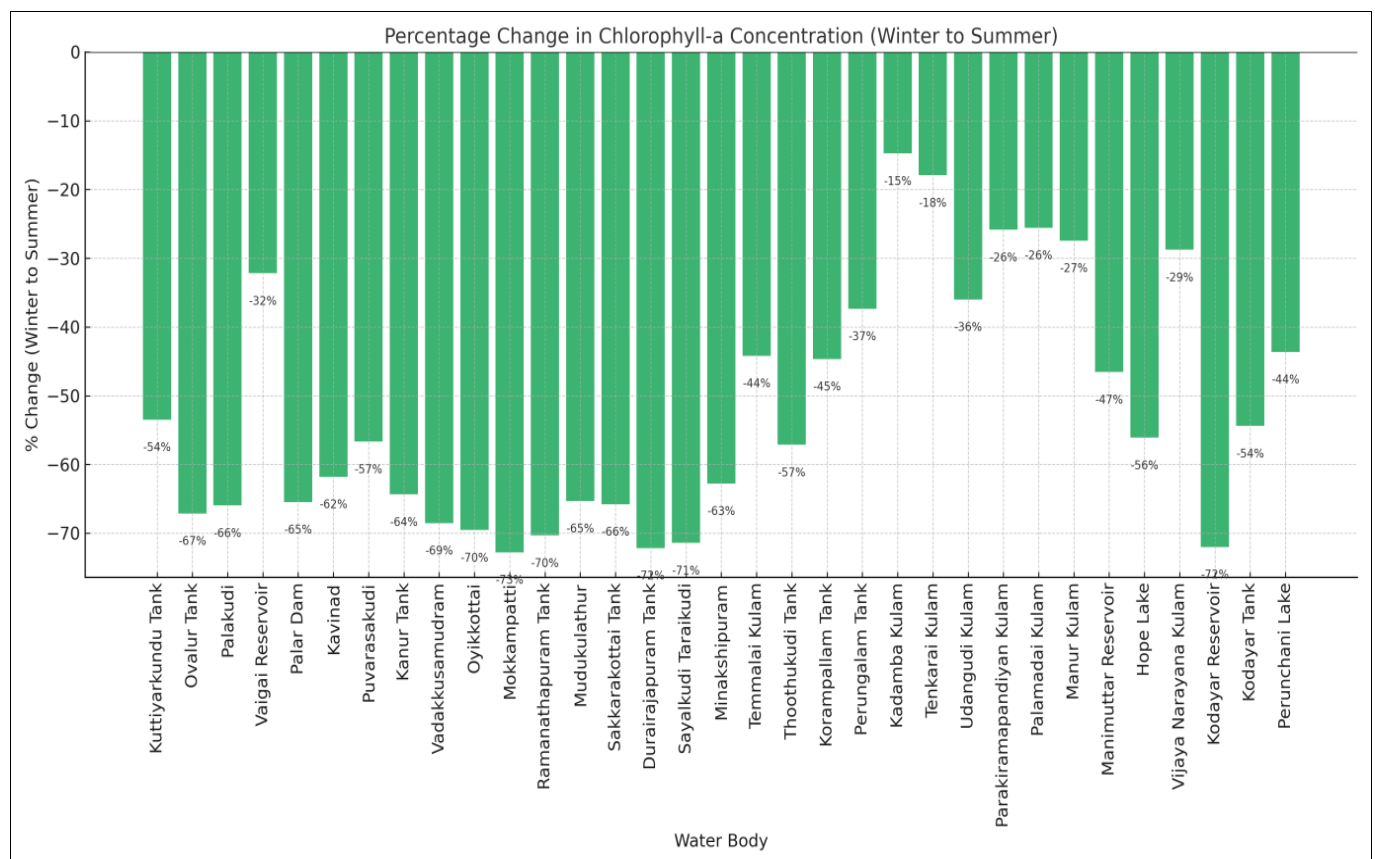
helping to preserve and conserve these key aquatic ecosystems.

4.5 Comparative Analysis of Seasonal Chlorophyll-a Variations

The chlorophyll-a concentrations observed across the 33 lacustrine water bodies in South Tamil Nadu demonstrate a clear seasonal pattern. As shown in Table 3, nearly all water bodies displayed a substantial deterioration in maximum Chl-a values from winter to summer. For instance, Ovalur Tank and Palakudi Tank showed reductions of over 65%, while reservoirs such as Vaigai and Kodayar displayed more moderate decreases (~30-40%). These patterns suggest that nutrient availability and environmental conditions favour algal growth during the post-monsoon winter season. The consistently high winter concentrations in smaller tanks near populated or agricultural zones may reflect runoff-induced eutrophication. Contrariwise, larger reservoirs with greater depth and inflow capacity, like Vaigai and Manimuttar, showed lower seasonal fluctuation, signifying possible dilution effects or better self-regulation. These insights underscore the importance of seasonal remote sensing in identifying at-risk water bodies and inform prioritization for water quality management interventions.

Table 3: Chlorophyll -a percentage change table

Water Body	Winter High (mg/m ³)	Summer High (mg/m ³)	% Change
Kuttiyarkundu Tank	82.77	38.49	-53.50%
Ovalur Tank	114.52	37.63	-67.14%
Palakudi	125.61	42.76	-65.96%
Vaigai Reservoir	80.97	54.90	-32.20%
Palar Dam	105.17	36.32	-65.47%
Kavinad	116.37	44.48	-61.78%
Puvarasakudi	121.78	52.77	-56.67%
Kanur Tank	165.58	58.99	-64.37%
Vadakkusamudram	167.70	52.78	-68.53%
Oyikkottai	110.79	33.73	-69.56%
Mokkampatti	132.72	36.10	-72.80%
Ramanathapuram Tank	140.75	41.76	-70.33%
Mudukulathur	140.75	48.81	-65.32%
Sakkarakottai Tank	105.59	36.13	-65.78%
Durairajapuram Tank	124.50	34.63	-72.18%
Sayalkudi/Taraikudi	154.07	44.02	-71.43%
Minakshipuram	125.34	46.67	-62.77%
Temmalai Kulam	73.19	40.85	-44.19%
Thoothukudi Tank	111.25	47.66	-57.16%
Korampallam Tank	94.97	52.54	-44.68%
Perungalam Tank	76.04	47.64	-37.35%
Kadamba Kulam	91.10	77.67	-14.74%
Tenkarai Kulam	69.28	56.87	-17.91%
Udangudi Kulam	85.76	54.88	-36.01%
Parakiramapandiyan Kulam	52.70	39.07	-25.86%
Palamadai Kulam	48.65	36.21	-25.57%
Manur Kulam	58.34	42.34	-27.43%
Manimuttar Reservoir	70.86	37.87	-46.56%
Hope Lake	84.41	37.06	-56.10%
Vijaya Narayana Kulam	54.22	38.62	-28.77%
Kodayar Reservoir	193.34	54.09	-72.02%
Kodayar Tank	103.10	47.02	-54.39%
Perunchani Lake	92.09	51.92	-43.62%

**Fig 5:** Graphical comparison of Percentage change

The percentage change graph (Fig 5) reveals a clear pattern of seasonal reduction in chlorophyll-a concentrations across nearly all 33 lacustrine water bodies. The majority of sites exhibit a 30%-70% decrease in Chl-a from winter to summer. Notably, tanks such as Ovalur, Palakudi, and Palar Dam show the most significant declines (over 65%), which may indicate strong post-monsoon algal blooms followed by nutrient depletion or climatic stress in the summer months. A few reservoirs such as Vaigai, Kodayar, and Hope Lake display more modest reductions (~30-40%), possibly due to their larger water volume, better mixing, or lower nutrient influx compared to smaller urban or agricultural tanks. This seasonal contrast underscores the influence of climatic drivers, including reduced runoff and increased evaporation in summer, and suggests the role of anthropogenic nutrient loading in winter months. The high winter Chl-a concentrations in smaller, shallow, or urban-proximate lakes likely result from runoff containing fertilizers, sewage, and organic matter. These results reinforce the importance of temporal monitoring and targeted management. Water bodies with consistently high Chl-a and large seasonal swings should be prioritized for mitigation strategies such as catchment treatment, aeration, or phytoremediation.

4.5.1 Rainfall Influence on Chl-a Variation

To investigate potential hydrological drivers of seasonal Chl-a dynamics, rainfall data for December 2024 and March 2025 were extracted for all 33 lakes using CHIRPS satellite rainfall estimates in Google Earth Engine. Between the percentage change in Chl-a from winter to summer and the rainfall in December, a Pearson correlation was computed. The findings showed a very weak and statistically insignificant correlation ($r = -0.06$, $p = 0.808$), indicating that rainfall alone does not linearly influence Chl-a variability across the study region. This implies that nutrient

inflow and algal productivity are not solely controlled by seasonal precipitation but are likely influenced by localized catchment characteristics such as land use, human activity, and lake morphology. As such, a deeper spatial analysis incorporating land cover patterns was undertaken in the following section.

4.5.2 Land Use and Land Cover Influence on Chl-a Dynamics

ESA World Cover data was used to analyse land use and land cover (LULC) around the 33 lakes to improve seasonal Chl-a interpretation. Google Earth Engine was used to apply a 1-kilometer buffer around each lake to extract the percentage of prominent LULC classifications such as tree cover, farmland, built-up area, grassland, and wetlands. Pearson correlation analysis was performed between LULC types and the percentage change in Chl-a from winter to summer (Fig 6). Notably, wetlands ($r = +0.583$) and grasslands ($r = +0.554$) exhibited moderate positive correlations with Chl-a increase, showing that lakes near such landscapes may experience nutrient inflow from organic-rich catchments. On the contrary, tree-covered catchments had a moderate negative correlation ($r = -0.489$) with Chl-a change, suggesting a buffering role against nutrient loading. Cropland showed weak positive correlation ($r = +0.253$), while built-up areas had a weak negative relationship ($r = -0.234$). These findings show that land use in the immediate vicinity of lakes is crucial in determining Chl-a fluctuation, potentially more so than rainfall. Wetlands and grasslands may increase production, although forests appear to reduce nutrient-driven eutrophication. Integrating LULC variables improves our understanding of the anthropogenic and biological determinants of water quality.

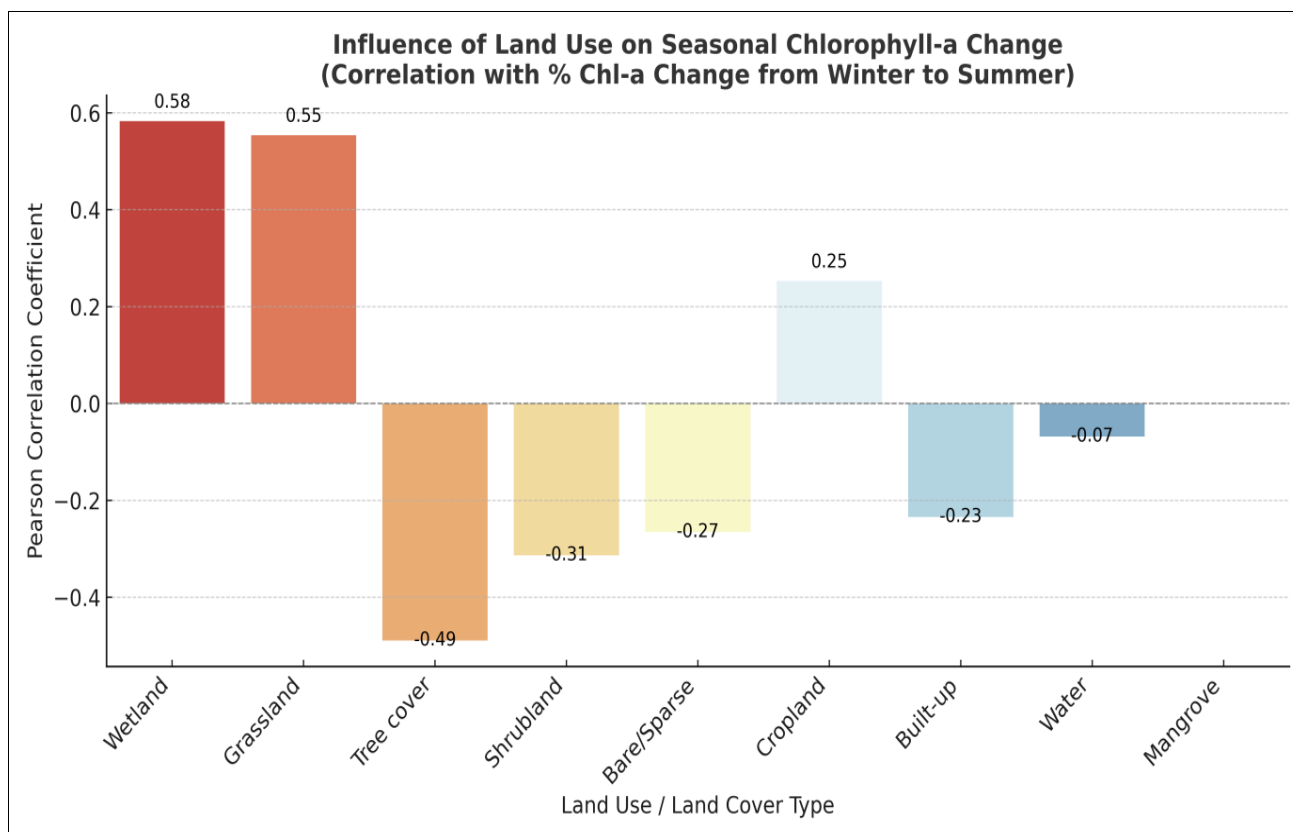


Fig 6: Correlation between land use classes and percentage change in chlorophyll-a concentration.

5. Conclusion

The pivotal role of geospatial technology in advancing the understanding and management of lacustrine water quality. The insights generated provide a foundation for sustainable water governance and the conservation of ecologically and socio-economically vital freshwater resources in South Tamil Nadu. Although rainfall was initially hypothesized as a contributing factor, statistical analysis showed no significant correlation with seasonal Chl-a variations, redirecting focus toward landscape-level variables such as land use. Furthermore, this study demonstrates that land use patterns in lake catchments significantly influence seasonal Chl-a dynamics. The positive correlation of wetlands and grasslands with elevated Chl-a levels, coupled with the mitigating effect of forest cover, underscores the importance of incorporating land use and land cover (LULC) data into remote sensing-based water quality assessments.

6. Acknowledgement

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Declarations

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical Approval: Ethical approval not required.

Human or Animal rights

This article does not contain any studies with human participants or animals performed by any of the authors, since only the secondary data collected at various search engines are used in the study.

7. References

1. Paerl HW, Otten TG. Harmful cyanobacterial blooms: causes, consequences, and controls. *Microbial Ecology*. 2013;65(4):995-1010.
2. Wang M, *et al.* Remote sensing of chlorophyll-a in coastal and inland waters: current status and future perspectives. *Remote Sensing of Environment*. 2020;240.
3. Odermatt D, *et al.* Review of water quality retrieval from remote sensing data. *Remote Sensing of Environment*. 2012;118:116-126.
4. Hussein H, *et al.* Remote sensing of algal blooms in Lake Winnipeg using MERIS data. *Journal of Great Lakes Research*. 2011;1-10.
5. Hussein H, *et al.* Chlorophyll-a estimation using Sentinel-2 data: a case study in Jordan. *Remote Sensing Applications: Society and Environment*. 2019;13:53-63.
6. Hu C, *et al.* Remote sensing of water quality in inland waters: advances and challenges. *Remote Sensing of Environment*. 2019;231.
7. Matthews MW. A current review of empirical procedures of remote sensing in inland and near-coastal transitional waters. *International Journal of Remote Sensing*. 2014;35(21):6855-6899.
8. Mishra S, *et al.* Normalized difference chlorophyll index: a novel model for estimating chlorophyll-a in turbid waters. *Remote Sensing Letters*. 2019;10(8):803-812.
9. Govindaraj K, *et al.* Retrieval of chlorophyll-a and total suspended matter using Sentinel-2 data in Velar

estuary, Tamil Nadu. *Environmental Monitoring and Assessment*. 2020;192.

10. Kumar P, *et al.* Impact of COVID-19 lockdown on water quality of Buddha Nala River using remote sensing. *Science of the Total Environment*. 2021;764.