Smart Monitoring of Surface Water Quality using Internet-of-Things at Sembakkam Lake, Chennai, India

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Introduction

- Wetlands offer a multitude of ecosystem services including drought and flood mitigation thereby contributing to climate resilience of cities.
- Monitoring of wetlands plays a crucial role in its conservation and provides valuable insights for restoration approaches.
- Remote Sensing (RS), Earth Observation (EO) satellites, and Internet of Things (IoT) not only pushed the cost of hardware down but also have enabled novel ways for collecting and analyzing data in real-time mode to derive actionable insights for decision making.
- The objective of the current work is to demonstrate the use of remote sensing and earth observation techniques in monitoring the environmental status of an urban wetland, Sembakkam lake.

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Restoration & Monitoring of Sembakkam Lake, Chennai

- The wetland lies between 12.9234°N and 80.1588°E in Chennai, in the east coast of South India.
- The Sembakkam lake is being restored for improvement in water storage, water quality, biodiversity habitat & recreational benefits.
- As a part of long-term restoration approach, the lake is monitored in its pre-and post-restoration phases for various wetland health indicators such as its water spread area and water quality.
- This paper presents the methods and advanced tools adopted in monitoring the water quality of the Sembakkam lake during the pre-restoration period.

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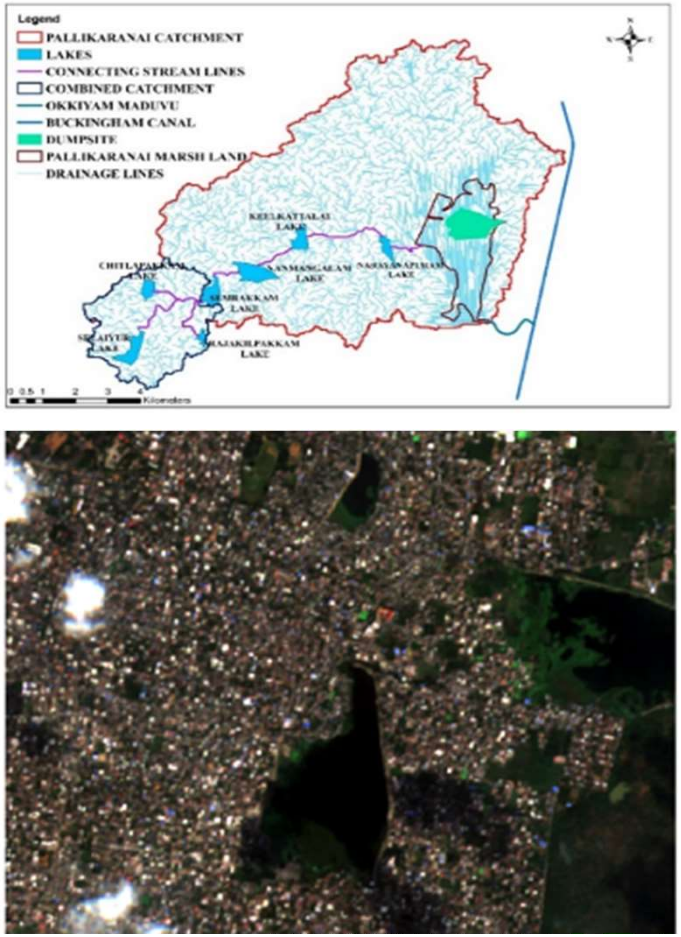
Method and Data

- As a part of baseline survey, the watershed delineation of the Sembakkam Lake was carried out using ArcGIS 10.3 using SRTM DEM obtained from USGS geological survey earth explorer.
- Field surveys and remote sensing using Earth observation optical sensors were used to assess the water quality of the lake.
- Sentienel-2 (S2) is chosen in this study for its superior performance in water quality identification and it has higher spatial resolutions.
- Its optical instrument samples has 13 spectral bands: four bands at 10 m, six bands at 20 m, and three bands at 60 m spatial resolution (Drusch et al. 2012).
- For the duration of July 2018 to February 2021, Sentinel-2 sensor cloud free 73 images (clear sky conditions) were acquired from Copernicus hub (https://scihub.copernicus.eu).



Watershed map around the studied lake and RGB image from S2 on January 16, 2020

Lake Water Quality Parameters Derived from ESA Sentinel-2

- **Chlorophyll a (Chl a)** is the photosynthetic pigment that causes the green color in algae and plants. The concentration of chlorophyll a present in the water is directly related to the quantity of algae present in the water and computed using S2 band B1 & B3.
- **Cyanobacteria (Cya),** also called blue-green algae, are microscopic organisms found naturally in all types of water and computed using S2 composition of bands B2, B3 & B4.
- **Turbidity (Turb)** is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates and computed using S2 band B01 & B03.
- **Colored dissolved organic matter (CDOM)** is the optically measurable component of dissolved organic matter in water and computed using S2 as: CDOM = a $*$ e^{bR}, R=ratio (B3/B4), a= 537, b= -2.93.
- **Dissolved organic carbon (DOC)** is the most relevant parameter for the global determination of organic pollution of water and wastewater and computed using S2 as: DOC = a $*$ e^{bR}, R=ratio (B3/B4), a= 432, b= -2.24.
- **Water color** is usually a routinely analyzed water quality parameter in limnological studies, and also in water treatment plants, since it can be measured easily and at minimal cost.
- **Water color** was computed using Sentinel-2 as: Water color = a $*$ e^{bR}, R=ratio (B3/B4), a= 25366, b= -4.53. Generally, the coefficients should be calibrated based upon in situ observations (IoT setup is on-going). However, in this study, water quality parameters empirical coefficients are adopted based on the available literature.

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Field observation of Wetland Details

The morphometric details of Sembakkam lake as assessed on ground are as follows,

- Water spread area (acres): 88.10,
- Land area (acres): 9.69,
- Total tank area (acres) 103.00 and storage capacity (Million Litres): 286.
- The water quality results observed by field analysis showed the pH range between 7 to 8.5.
- The other selected water quality indicators namely biological oxygen demand, dissolved oxygen and free ammonia in the lake was observed to be 40-150 mg/L, < 0.2 mg/L & < 6 mg/L respectively.

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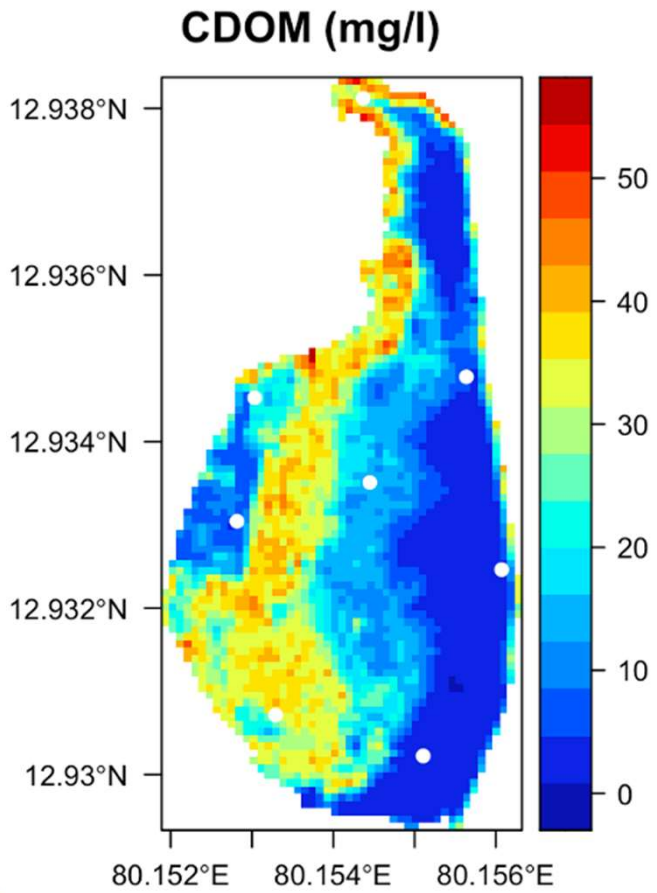
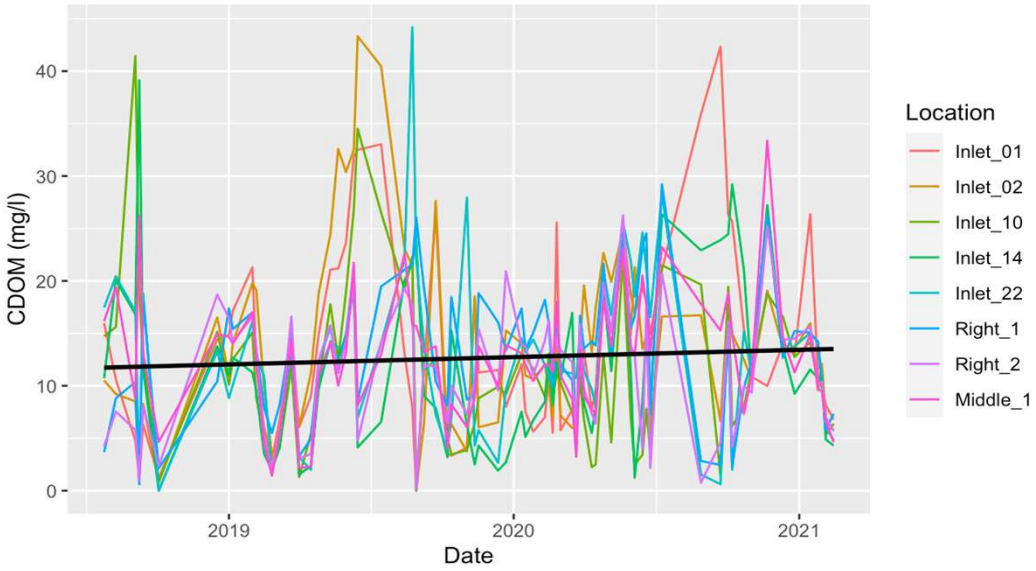
CDOM Spatial Map

The CDOM spatial map across the lake is shown below
It was observed that higher CDOM concentrations were prevalent in the area around wastewater inlets.



Seasonal Variation of Pollutants at Sembakkam Lake



- Moreover, seasonal pattern on CDOM concentration is clear and the annual mean trend line (black line in Figure) shows relatively similar CDOM concentrations starting from mid-2018 to February 2021.
- Similar pattern was observed for other water quality parameters.
- Observations on water quality using remote sensing techniques and the field analysis allude to high pollution of the lake around inlet 16, 17 and 18 which are the entry points of major wastewater quantity from the surrounding areas.

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Summary of Results

- Results of water quality at the Sembakkam lake both by field measurements and remote sensing data revealed that the lake is highly polluted with incoming wastewater.
- The quality of the lake water does not meet the drinking water criteria nor the wildlife and fisheries propagation standards as prescribed by surface water quality standards of the Central pollution control board (https://cpcb.nic.in/wqm).
- The water storage capacity of the lake was also compromised due to accumulation of silt from incoming wastewater.
- Based on the above observations, the restoration project aimed at improving the water quality suitable for wildlife and fisheries, water storage capacity and groundwater recharge which offers enhanced drought and flood mitigation benefits to the surrounding areas while offering a better habitat for biodiversity.

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Conclusion

- The integrated use of remote sensing, earth observation data, and IoT based solutions will help in regular monitoring and measurement of water quality in Sembakkam lake in real time.
- Utilizing a cloud-based platform with integrated sensor feeds and satellite image analysis will provide actionable insights for the health of the lake.
- The scalable nature of the platform enables future addition of more sensors for finer resolution in data feeds as well as greater geographic coverage by onboarding additional water bodies.
- This innovation will enable consistent impact analysis and data-based decision-making in designing, implementing, and optimizing science-based wetland restoration plans.
- This study is a contribution for ongoing and future scalable and explainable model building work of water quality mapping in space and time with IoT data along with supplementary data from various sources.
- This study will eventually help in building a digital twin of the waterbody, which will provide novel ways to manage health of the waterbody.

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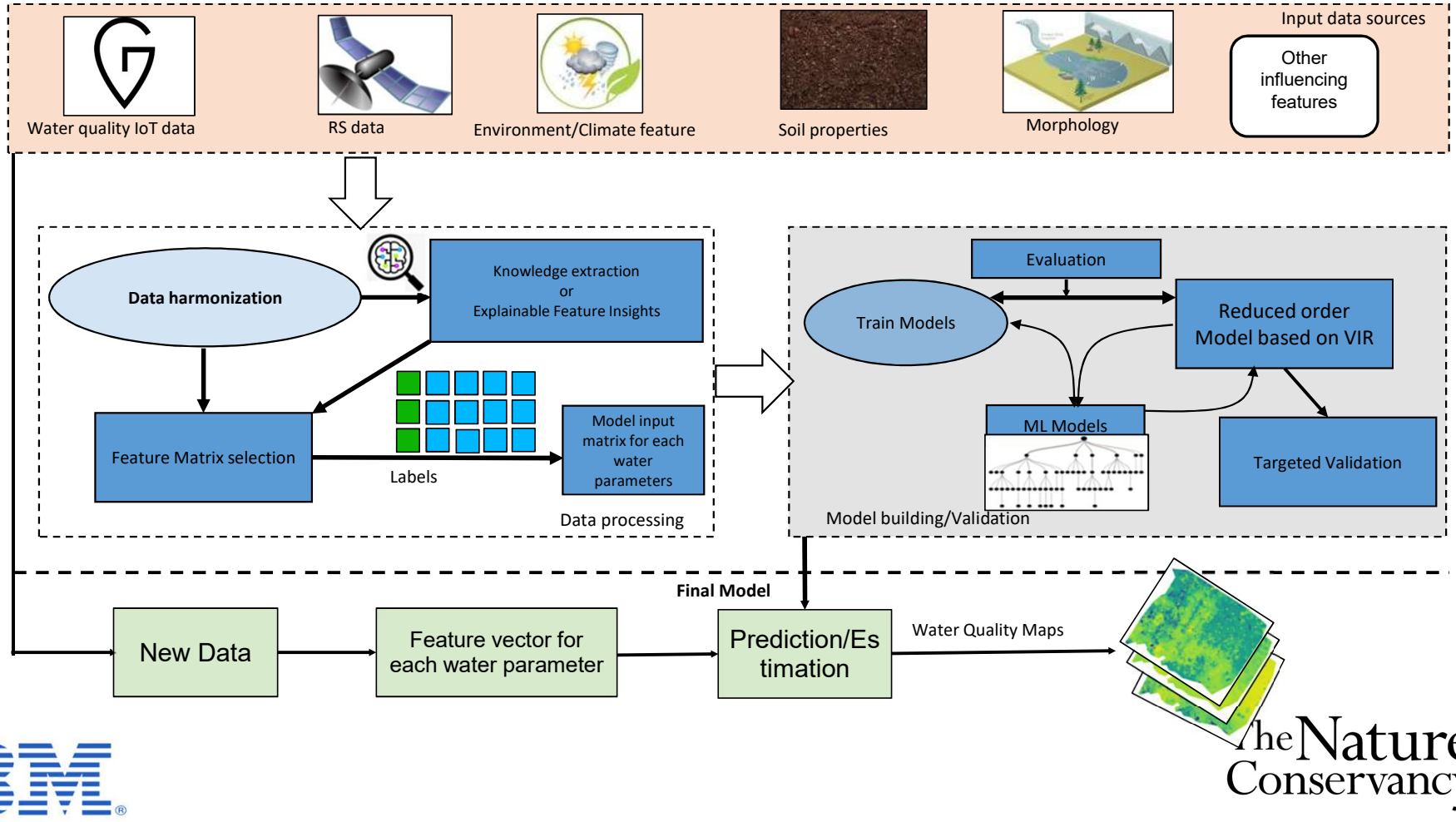
Future work: Scalable and Explainable Lake Water Quality Monitoring



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