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A Study on Water Security for Bengaluru-A Predictive Analytics using Sentinel data

Rajashri Padaki
Dept. of Electronics
Seshadripuram First Grade College
Bangalore City University, Bangalore
Karnataka, India
rajashri@sfgc.ac.in

Dr. Veena C S
Dept. of Electronics & Communication
Engineering College, Presidency University
Karnataka, India
veena.cs@presidencyuniversity.in

ABSTRACT

Water is the lifeline of living beings. It is one of the most essential fundamental element to sustain the life. Bengaluru-"The City of Gardens", "The city of Thousand Lakes" or "Necklace of Lakes" has now become like a once upon a time story because of heavy exploitation of the resources and uprooting of the trees in the name of Urbanization. Bengaluru was said to have around 1000 lakes earlier and now because of real estate revolution many lakes are dried up and sky scraping buildings are seen everywhere. It is said that now around 100 odd lakes only are there and no lake is Potable. Almost all the lakes in Bengaluru fall in D or E category. We need to safeguard our lakes, recharge, maintain our wells, and enhance the utilization of our groundwater aquifers effectively [1 May 7 2024, Avinash Murthy]. It is important to study and understand the declination of the areas of existing potable water lakes. Sentinel data, which is supplied by the Copernicus Program of the European Space Agency, is essential for tracking changes in urban areas, aquatic bodies, and land usage. Data from Sentinel-1 (SAR) and Sentinel-2 (optical) are very pertinent. In order to analyse satellite data and develop prediction models, geospatial approaches are essential. This involves the use of remote sensing tools and Geographic Information Systems (GIS). Using the sentinel images [2] of 4 lakes of Bengaluru North, the diameter of the water body is obtained from previous records and the primary data of 2025 is gathered in our work. Further using the Image processing technique, we would attempt to do Predictive Analysis using Artificial Intelligence to build an algorithm that will give suggestions for water security in Bengaluru in the coming days. This research work is dedicated to sensitize the importance of Water bodies to the mankind in general and Bengaluru City in particular, which helps in conservation and recharging of the water bodies and resilience to the underlying aquifers.

KEYWORDS: ***Water Security, Aquifers, Sentinel data, Image Processing, Artificial Intelligence, Algorithm, Predictive Analytics, Remote Sensing, Urbanization.***

Introduction:

Society benefits from urbanization because it makes it easier for people to live more ordered lives. However, if not properly planned and managed, it can also be detrimental [1]. (Rimba et al. 2021). Mohan et al. (2011). The population of Bengaluru has increased historically in just 25years due to the city being technological hub. The garden city is now popularly called as Silicon city. Majority of influx is from rural side of the state and from other state seeking for Jobs. Urbanization happening quickly [2] has drastically changed the region's natural resources, impacting both the ecosystem and society (Sun et al. 2013, 2016; Bharath et al. 2021). (Bhat et al. 2017; Mundia and Aniya 2006; Berling-Wolff and Wu 2004). The rapid growth of cities and industries has raised interest in learning more about the environmental effects of these developments. Data on water levels must be gathered in order to manage water bodies effectively. It is a key component that reflects the changes in lake's water status. The European Space Agency (ESA)'s Sentinel-2 mission, which is a component of the Copernicus Program, offers multispectral, high spatial resolution pictures of the Earth's surface. Sentinel-2 finds its applications in ; Assessing the quality of water, keeping an eye on factors including turbidity, collared dissolved organic matter, Algal bloom detection is the process of locating and keeping an eye on dangerous algal blooms. Monitoring shifts in the size of lakes, rivers, and reservoirs is known as "water body mapping." Mapping flooded areas both during and after floods is known as flood monitoring. In our study we have used sentinel-2 images for its high resolution and accuracy in providing the accurate coordinates of the lake for the study of our topic.

The idea behind applying deep learning neural networks to water level analysis is comparable to the conventional approach of taking pictures of water gauges [17–19] or water level lines [20–26] in order to measure water levels. Nonetheless, the two methods differ greatly from one another. The location of the water gauge and the water level line must be manually set up in order to perform classic image analysis of water levels. When a result, when additional conditions are taken into account, the program structure grows larger and more intricate.

By creating a system for determining the location of the water gauge and the water level line during training, deep learning networks for water level analysis overcome this difficulty. As a result, the bar for starting a program is lowered. Finding the water level line is the first step in performing semantic segmentation for water level analysis. The location of the water level is then represented by the dividing line between the two parts of the image, which are the water body area and the non-water body area. [20]

Predictive analysis for water security of lakes in Bengaluru involves using historical and real-time data, statistical modeling, and machine learning techniques to forecast future conditions and identify potential risks to the lakes' water quantity and quality. The methodology involves Data acquisition and preprocessing, the historical data can be obtained from **Government Agencies such as, Karnataka Lake Board Authority,** Bangalore Water Supply and Sewerage Board (BWSSB). Sentinel-2 data from remote sensing satellites, in-situ sensors and monitoring stations. Further the predictive modeling techniques and machine learning models and AI tools are used to develop an algorithm, validation of the algorithm is done by providing different data sets. Once the algorithm meets the required standards, the trained and validated models with the latest available data to forecast future water quantity and quality indicators over different time horizons is used (e.g., short-term: days/weeks, medium-term: months, long-term: seasons/years). The summary reports are generated for predictions; the predictive tools are integrated into a user friendly platform for regular forecasting.

Literature Survey

Water level measurement technologies can be categorized as contact and non-contact sensors. Contact sensors such as floating sensors and pressure sensors are low-cost and easy to use. However, they are prone to inaccurately measured data and instrument damage due to bed sediment interference [3]. Radar and ultrasonic instruments must be positioned directly above the river surface, typically on bridges. However, they are vulnerable to bridge vibration, and ultrasonic instruments are also susceptible to wind speed interference during typhoon events. Alternatively, imaging instruments offer a different solution, and there are two ways to measure water level using this technology. The first method involves utilizing satellite images to calculate the coordinates of water body boundaries [11–13]. While this approach is not always feasible, it is useful in defining the boundary between the river and land areas [14] and examining long-term changes in the river area [15, 16]. The conventional approach of taking pictures of water gauges [17–19] or water level lines [20–26] is comparable to using deep learning neural networks for water level analysis. The location of the water gauge and the water level line must be manually set up in order to do a significant traditional image analysis of water levels. Consequently, when more conditions are taken into account, the program structure grows larger and more intricate. By creating a system for determining the location of the water gauge and the water level line during training, deep learning networks for water level analysis overcome this difficulty. As a result, the bar for starting a program is lowered [3].

Bengaluru has seen a population increase from 394,794 persons in 1901 to 9,621,551 in 2011 as per the Census of India. With increase in population, urbanization also increases. Urbanization, which is an output of population increase in cities, which overloads the cities natural resources includes land and water through activities such as building of more residential areas, industrialization and commercialization. This urbanization impacts not only the drainage network, which is often broken due to encroachment, but also the quality of run off and thus the quality of water stored in the lakes. Atmosphere of urban areas adds to the pollution load in the lakes too (Lazaro, 1979). Thus, quality of lake water has to be periodically monitored and communicated to authorities and public as they are the main stakeholders in preserving their environment and the benefits also go to them [6]. Sentinel-2, in effective turbidity management for dynamic urban coastal

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environments such as Los Angeles. Remote sensing allows for improved spatial–temporal monitoring that could capture seasonal and storm-related variations in turbidity, which might be difficult for traditional monitoring methods to catch. Incorporating machine learning models, such as random forests, with variables like precipitation, tides, and human activity may further enhance turbidity prediction and support proactive management strategies to protect coastal ecosystems and public health. Satellite data can also help storm water management by identifying turbidity hotspots from a broader spatial aspect to guide interventions like sediment control and public health advisories [9].

Predictive modelling techniques, particularly machine learning algorithms, are increasingly being used in conjunction with Sentinel-2 data to forecast various water-related parameters. Studies have demonstrated the potential of using machine learning models like Artificial Neural Networks (ANN), Support Vector Machines (SVM), Random Forest, XG Boost, and Partial Least Squares Regression (PLSR) to predict water quality parameters such as turbidity, chlorophyll-a, and other indicators based on Sentinel-2 spectral data. These models often show good performance, with reported R^2 values and Root Mean Square Errors (RMSE) indicating a strong relationship between Sentinel-2 data and water quality measurements. The choice of the specific machine learning model often depends on the water quality parameter being predicted and the specific characteristics of the water body under study. Beyond water quality, Sentinel-2 data is also being used for forecasting surface water extent and hydrological events. While the optical nature of Sentinel-2 limits its ability to directly monitor floods in real-time due to cloud cover, it proves valuable for post-flood assessment and for integration with hydrological models and climate data to improve forecasting of water availability and drought conditions. Studies have also focused on predicting water scarcity and water stress conditions using Sentinel-2 data. This often involves using water indices derived from Sentinel-2, such as NDWI, or monitoring changes in surface water extent and vegetation health, particularly in agricultural contexts for assessing crop water stress [13].

Objectives:

- Data Acquisition from Google Search Engine of Sentinel-2
- Data Preprocessing using appropriate software

[13] (Sandeep Gupta et al.)Data preprocessing involves three steps; Data cleaning, Data Transformation and Data Reduction using various software's viz. Python, R, Jupyter Notebook

- Data Mapping

Data Mapping is an integral part of Data Management, Data Mapping if not done appropriately can cause the data corruption or data loss by the time it reaches the destination. It is the important tool to get data out of Data cleaning, Data transformation and Data reduction

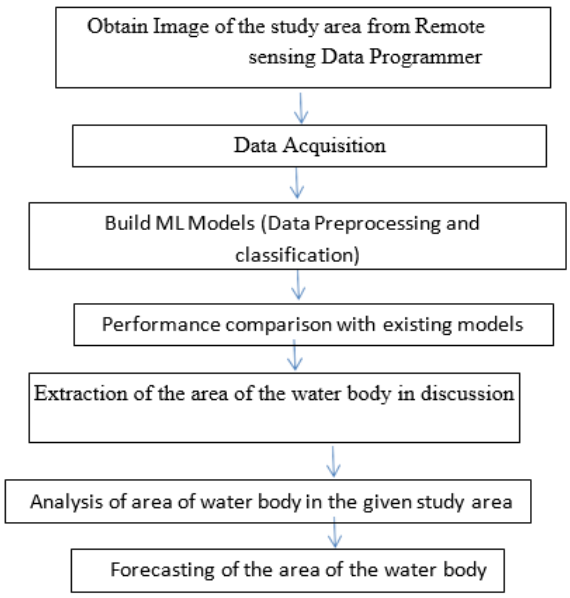
- Data Validation

Proposing the best band combination of sentinel image and efficient deep neural network architecture. Results were evaluated with various sentinel band combinations namely, Near Infrared, Red, Green and Blue. Deep neural network and Deep Convolutional Neural Network architectures were customized and hyper parameters were fine tuned to improve the classification results.

Methodology

The study is supervised using various data sets to analyze the cultivated crops using the temporal data in the area. To effectively manage this region's growth, it is imperative to comprehend the dynamic phenomena of urban sprawl. Jupyter Notebook and MATLAB 18 are the two software tools used in this investigation.

1.1 Proposed flowchart



Discussion

To effectively design methods to measure the water body, it is imperative to obtain a full understanding of the fluctuations in the area at regular intervals and seasons. The complexity of the procedure makes classifying and mapping the land cover pattern extremely difficult. The same operation may now be carried out on satellite photos thanks to the growing variety of image processing techniques and algorithms. After downloading the 2001 and 2021 satellite photos from the USGS, MATLAB 18 software is used to classify the images using a supervised image classification method.

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This paper is guided by my coauthor and guide Dr. Veena C S who also has contributed key points and pointers in writing this paper. Around more than 30 papers are referred and understood before writing the paper.

My Orcid ID: https://orcid.org/0000-0001-7613-5591

My Guide Dr. Veena C S Orcid ID: http://orcid.org/0000-0002-7609-673

Conclusion:

After the completion of this work the changes in the area of The water body is tabulated and changes in the water body in The future will be understood and forecasted.

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