

Climate Change Monitoring Using Remote Sensing, Deep Learning, And Computer Vision

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1. Abstract

The precise water bodies extraction from the geospatial image is an important task to monitor climate change. Climate change is amongst the top challenges for mankind as per the UNESCO 2030 survey. Climate change is causing significant changes across agriculture, water bodies, health, coastal areas, and forest amongst others. In this research paper, we wish to study the impact of human actions and climate change on the availability of water in Ballandur lake.

With this study, we introduce a method to monitor natural habitats using Remote sensing, deep learning, and computer vision. The research team has leveraged remote sensing data of the last 20 years for the exercise.

Deep-learning methods use high-dimensional hierarchical picture characteristics to enable precise image recognition. Convolutional neural networks are a type of deep neural network used to evaluate visual information. A convolutional neural network is useful to do image processing tasks such as eliminating image noise and generating high-resolution images from low-resolution images.

The research team also quantified the deterioration of the water body, through benchmarking of available water bodies against the baseline area availability in the year 2002. This study shows that almost 85% of the water body area deterioration in 20 years (2001 - 2020). it also acts as a template for leveraging remote sensing, deep learning, and computer vision as a mechanism for future studies in a cost-effective manner

Keywords: Climate Change; Computer Vision; Remote Sensing; Water Bodies; Deep Learning

2. Introduction

As per the "world in 2030" UNESCO [29] survey response, climate change and biodiversity loss are major concerns amongst most of the respondents. This report offers insights into the challenges that our societies will face in the next 10 years. The report highlights that climate change and loss of biodiversity are expected to be the biggest challenges of the next decade. Respondents were worried about increasing natural disasters and extreme weather. Another area of concern is the loss of biodiversity impacts on oceans and water bodies.

Conservation and restoration of water bodies not only influence the local climate but also revitalize the local habitat. Hence various governments have focused on increasing wetland through their policy and programs aimed at the rejuvenation of wetlands and halting the degradation of such water bodies. Mirroring the global trend, India is facing a huge problem of increasing pressure on natural resources due to the increasing population. This has put pressure on natural resources – both land and water. This has resulted in most of the urban lakes vanishing or are reducing in size due to encroachment and construction activity for urban infrastructure expansion. As per a scientific study by the Centre for Ecological Sciences (CES)[30] from Bangalore at the Indian Institute of science, the water bodies of the metropolitan have reduced from 3.40 percent in 1973 to 1.47 percent in 2005. There have been various overserved adverse effects of such a drastic change.

Through this research, we have proposed an automated method of monitoring environmental assets using remote sensing, deep learning, and computer vision. The team is proposing a solution that uses the images captured over a period, through the satellite to measure the area of water bodies in the lakes. It can also become an automated mechanism to generate alerts for relevant authorities if there is a significant drop monitored in any period. We are introducing an innovative method that leverages satellite imagery to automate the monitoring of natural habitats in general and water bodies in specific. If there are any significant drops in the water content these automated systems can generate an alert. if there is major change around the lake, its biodiversity, or water quality; alerts could be generated to make timely interventions. Google satellite imaginary has been used for the remote sensing application. Google Earth™ includes many images collected by satellites orbiting the planet. These images are combined into a mosaic of images taken over many days, months, and years.

In recent years, **Deep learning** models have introduced a new segment of image segmentation models, with significant performance improvements. Deep Learning-based image segmentation models frequently outperform traditional image

segmentation models on common benchmarks, leading to a paradigm change in the area. Segmentation is one of the most significant procedures in Computer Vision. The objective of image segmentation is to group sections of a picture that belongs to the same object class together. This approach is also known as Pixel-level Classification. **Semantic Image Segmentation** is an important application of computer vision. It is a process of clustering each pixel belonging to a particular label. It's the same for all instances of the same item. For example, if any images contain multiple water bodies, semantic segmentation provides the same label to all the pixels of the water bodies. It is very useful in object detection.

3. Literature study

[1] proposed a detection method to help locate abnormal changes around the lake and reservoir caused by human activities. There are separate studies focused on and around Bangalore city, including Bellandur lake. [2] found that in the 1960s, the number of tanks and lakes was 280. This number dropped to less than 80 in 1993 in Bangalore. [3] reviewed the technical aspects of oil spills through remote sensing. Similarly, [4] shared a series of remote sensing models mainly such as the crop growth model, vegetation evapotranspiration model. There are many other applications of the same technology in other areas as well. [5] proposed a ship detection method based on dark channel priority haze removal and Faster RCNN using the remote sensing data. [6] leveraged optical remote sensing techniques for potential application in detecting and monitoring forest fire. [7] introduce the principle of agricultural drought monitoring based on remote sensing technology and review the current remote sensing approaches in drought monitoring. Similarly, [8] provides a critical and comprehensive review of the characteristics of remote sensing systems, and in particular the trade-offs between various system parameters. [9] shares experiences of applying remote sensing for forensics, where remote sensing can provide valuable inputs to various judicial authorities, who are engaged in the investigation of crimes against the environment and the territory. [10] proposed an automatic procedure for individual fruit tree identification using GeoEye-1 sensor data. an automatic procedure for individual fruit tree identification using GeoEye-1 sensor data. [11] propose a deep learning-based framework for oil palm tree detection and counting using high-resolution remote sensing images for Malaysia. [12] proposed a novel detection method to help locate abnormal changes around the lake and reservoir caused by human activities. [13] illustrated how optical images from MODIS sensors, that are cheaply available, despite their reduced geometric resolution, proved to effectively support the investigation of climate change effects onto crops in the medium term. [14] presented an approach to counting mango fruit from daytime images of individual trees for a machine vision-based estimation of mango crop yield. proposed an end-to-end framework for road detection in satellite imagery with convolutional neural networks (CNNs). [15] proposed an end-to-end framework for road detection in satellite imagery with convolutional neural networks (CNNs). [16]

proposed a super-resolution mapping of trees pixel swapping method in Madurai city for urban forest monitoring. [17] shared an effective method for marine sewage detection from remote-sensing images. [18] shared a data-intensive computing methodology based on the combined use of Sentinel remote sensing data and a water leak pathways model to detect water leak detection. [19] proposed a method to protect the lives and property safety of people in mountainous areas using the data of satellite remote sensing images combined with various factors inducing landslides and transforming them into landslide influence factors. [20] used geological data to provide information about the geological background of the area and landslide vulnerability. [7] introduced the principle of agricultural drought monitoring based on remote sensing technology and reviews the current remote sensing approaches in drought monitoring. The paper [21] lists out various modeling techniques and their accuracies used in land use classification using UC Merced data. Apart from using the aerial imagery for land use classification, with the availability of a large number of satellite images publicly, the researchers have applied the machine learning models to remote sensing data obtained from satellites like Sentinel II by [22], [23], [24–26]. While the availability of large remote sensing data has opened a lot of possibilities, one of the major challenges that remain with training models using such data is the data labeling with the ground truth. Researchers have been exploring the possibilities to create labeled datasets [26th] most efficiently so that more complex models can be trained for accurate land use classification.

4. Methodology

Computer vision is very useful in creating digital systems that can process, analyze, and make sense of visual data. It is very useful to extract information from images. In this study, we find a method to monitor Climate change from High-Resolution Remote-Sensing Imagery using Deep Learning and Computer Vision. This research paper is mainly focused on to analysis of the water spread area of Bellandur Lake in the different periods (2001 - 2020).

4.1. Data collection

The research team has collected the relevant historical images from Google Earth using the geolocation coordinates of Ballandur Lake. The team included the 20 years (2001-2020) Image data for the analysis.



Figure 1. Bellandur Lake image of 2002



Figure 2. Bellandur Lake image of 2020

4.2. Image Analysis

To perform the analysis of water bodies, the following steps are performed.

4.2.1. Image preprocessing

In this process, we have used some filters to enhance the image quality for better results. For example, brightness enhancement, noise deletion, morphological operation, etc.

4.2.2. Image trimming

Since we are analyzing the area within the lake. Therefore, we have converted all the pixels into white pixels that belong outside the lake.



Figure 3. Bellandur Lake trimmed image of 2001

1.1.1. Water body pixel detection

Since all the pixels within the lake do not belong to water bodies. Many pixels represent vegetations, dry land, etc. Therefore, we used HSV (Hue, Saturation, Value) color space range to detect the water body pixels using the OpenCV library.



Figure 4. Detection of a water body using HSV color space range

1.1.2. Calculations:

We have performed the water body percentage in the following steps.

Step1: Calculate the number of pixels within the lake

Since we are analyzing only water body area within the lake. Therefore, to get the total pixels within the lake, we must calculate the non-white pixels from the trimmed image (figure 3)

Total pixels of lake = non-white pixels of the trimmed image

Step2: Calculate the number of pixels that represents the water body

Since all pixels within the lake do not represent the water body. Therefore, we must calculate the water body pixels using the HSV color space range. The water body pixels should always be less than the total pixels of the lake

Total water body pixels = Detect water body pixels using HSV color space range

Step3: Calculate the water body percentage concerning the year 2001.

Since we have collected the historical image from 2001. Therefore, we have analyzed the water body concerning the year 2001.

$$\text{Water body percentage} = \frac{\text{Total water body pixels in the given year}}{\text{Total water body pixels in 2001}}$$

2. Results

We have analyzed the water body of Ballandur Lake since 2002 to 2020 using computer vision. The results are as follows:

Image Year	Water Body Pixels	Decrement Percentage
2001	286,177	Base
2002	286,073	0%
2003	286,107	0%
2004	286,117	0%
2005	286,102	0%
2006	286,109	0%
2007	286,098	0%
2008	286,124	0%
2009	286,134	0%
2010	281,916	1%
2011	263,121	8%
2012	276,021	4%
2013	268,389	6%
2014	174,497	39%
2015	190,698	33%
2016	67,637	76%
2017	151,979	47%
2018	148,956	48%
2019	99,120	65%
2020	49,804	83%

Table 1. Water body pixels from 2002 to 2020

The lake understudy has lost 83% of its water body in the last 20 years. The worst year for the lake was in the year 2013-14 when almost 32% of the lake water There were seeming attempts in the year 2017-18 to revive the lake, which unfortunately

gave only temporary improvement to the water body and eventually resulted in shrinking by almost 83% in the year 2020.

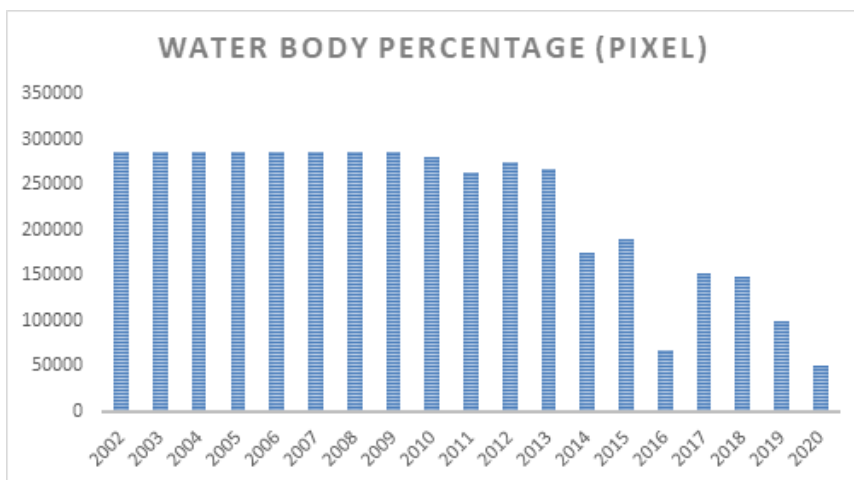


Figure 5. Number of water body pixels across different year

3. Conclusions

Bangalore is a metropolitan city having a Moderate Climate condition due to which is often referred to as the City of Lake and recently "Silicon Valley of India". Bangalore's lakes have contributed to the city's pleasant weather through the years. In 1960, there were a total of 280 lakes and tanks. After 30 years, the total number of water bodies was less than 80. In today's city, there are just 17 lakes.

The studies conducted on the lake revealed that there has been a considerable decrease in water body level in Ballandur lake for the past 20 years and a potential threat of groundwater body shortage. This study is an alarming situation for lake existence in Bangalore. The studies also suggest that it is possible to monitor the lake waterbody using remote sensing, computer vision, and deep learning technology. One interesting policy implication of current work is that if any lake where such a dramatic water loss is estimated, can be a topic of immediate attention from the government authorities. Such automated systems can bring efficiency in the monitoring, managing, and protecting the assets, which are a concern for local governments as well as federal governments across the globe.

This research paper simplifies lake and water body monitoring by using high-resolution remote-sensing Imagery and computer vision. Automation of such a process for all the lakes and other environmental assets will revolutionize the way the lakes and other water bodies can be monitored. Application of computer vision in the form of color extraction of static images can help in lakes conservation. Loaded with insights from such studies, relevant organizations can prioritize their

engagement and initiatives.

Furthermore, other areas could be further studied like impact due to increasing urbanization and illegal lake encroachment that has taken a significant toll on these diminishing waterbodies. To save the dying lakes across Bangalore City, a comprehensive urban-level lake restoration plan combining technology (automation) must be devised

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