Spatiotemporal Assessment of Water Bodies Using GIS and Remote Sensing

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ABSTRACT - India is rich in man-made and natural water, which plays a vital role in the domestic and water system. This study demonstrates a variety of field application techniques and recognized lake characteristics and models to improve processes for developing remote models to detect green growth and use. As satellite and airborne sensors evolve and their information becomes more readily available, the use of models to measure water quality using a remote sensor seems to be more effective in designing water facilities. The remote sensor has the amazing ability to detect and detect water bodies in very wide areas in a powerful and productive way. Accurately surveying untouched water sources is an important and fundamental process in remote recovery. The Normalized Difference Water Index (NDWI) is another strategy created to highlight highlights of open water and to enhance its presence in digital sensitive images.

Keywords: Landsat, NDVI, NDWI, Platforms Sensors, Remote sensing, Water Body Mapping.

I. INTRODUCTION

The surface of the groundwater fluctuates continuously over time. These differences are closely related to anthropogenic factors and climate change processes. Understanding the distribution of space and the variability of runoff immersion is essential for the broad and necessary applications of water resources managers, policy makers, and climate change scientist's regions as fluctuations will cause droughts or floods. Remote sensing systems for water monitoring have greatly improved with an exaggerated amount of free high-resolution data, such as Landsat satellites. Therefore, this data is widely used to map the watersheds further by historical and time analysis. Remote sensors can provide better information about spatial and temporal fluids compared to normal field monitoring due to synoptic coverage in large areas, sensitivity to remote and inaccessible areas and access to historical data.

1.1 Evolution of Remote Sensing

A few other studies have been evaluated using Landsat image for annual or seasonal collections. The process of selecting the appropriate time of year or season of water representation is challenging due to the uncertainty of both the seasonal and mid-season water variables, as well as the availability of free cloud detection. Therefore, it is important to use all available images. This method is very satisfactory, especially in regions with free cloud data.

1.2 Emerging Era of Landsat's

Landsat scenes are well-suited to the area, spectral, and radiometric forces for water monitoring and have been used successfully to map and monitor runoff and its changes in global and regional scales. The TM, the ETM + and the OLI sensors on the Landsat board are particularly well suited to generating time-tested information for water resources (Yun Du, n.d.). Landsat reports on the world's most widespread land surveillance since the launch of Landsat 5 in 1984.

Landsat 5

- Developed by National Aeronautics and Space Administration (NASA),
- launched from Vandenberg Air Force Base in CA on March 1, 1984,
- Carries the MSS and also the TM sensors (Spider, n.d.),
- It sets a Guinness World Record for 'Longest operating Earth Observation Satellite', before being decommissioned on June 5, 2013 (Spider, n.d.), &
- This satellite outlived it's 3 yrs. design.

Landsat 7

- Launched at Vandenberg Air Force Base in CA on April 15, 1999,
- Carries ETM and ETM + sensors (USGS, usgs, n.d.),
- Adopts a panchromatic band with 15m spatial adjustment, &
- Since June 2003, the sensor has acquired and delivered information with information gaps caused by the Scan Line Corrector (SLC) failure.

Landsat 8 Launch

- Launched on Feb 11, 2013 from Vandenberg Air Force Base, CA,
- Carries the OLI & the TIRS sensors,
- OLI sensors measure Visible, NIR and SWIR parts of the spectrum,

 DOI : 10.35291/2454-9150.2022.0178

- TIRS sensors measures land surface temperature in 2 thermal bands to detect heat, &
- Landsat 8 pictures have 15-meter panchromatic and 30-meter multi-spectral spatial resolutions.

Landsat 9

- Launched on Sep 27, 2021 from Vandenberg Air Force Base, CA,
- Carries the OLI – 2 & the TIRS – 2 sensors,
- OLI – 2 captures Earth's visual acuity in near infrared, visible and shortwave-infrared bands(USGS, United States GS, n.d.),
- TIRS-2 sensors measure the infrared radiation, or heat, emitted by the earth's surface (USGS, United States GS, n.d.), &
- The OLI and the TIRS sensors have a lifespan of 5 years of design.

II. STUDY AREA AND DATA SOURCES

2.1. Study Site

The Ghaziabad region on the western edge of Uttar Pradesh, is located between the Ganges and Yamuna, the 2 main rivers of the country, and between 770 to 780, the length of the East and 280 to 290 North latitudes. Due to contact with people from the city centre, the main highway into the province, Ghaziabad is suspected to be the U.P. The local area of Ghaziabad district is 777.9 sq. Km. km. Physiographic parameters acquired in an improved environment play an important role in the distribution of development resources.

2.2. Data

Remote sensor provides flexible data sets that cover large areas with high location details and high frequency frequencies. Beginning in the 1960s, the remote sensor may provide information of a fixed time series. due to the lack of temporary data sets and distinct regions, many high-resolution satellite images (CORONA, SPIN, and IKONOS) to moderate correction (LANDSAT MSS and TM) were analysed to detect temporary changes. in geographical patterns since the 1960s. High resolution images are only provided in limited areas within the valley; therefore, great attention was given to the images of LANDSAT MSS and TM.

III. METHODOLOGY

3.1. Spectral Water Index

3.1.1. NDVI

Surveillance of surface biomass and primary production was created by the researcher using an indicator called the 'Normalized distinction Vegetation Index' (NDVI) (Townshend and Justice 1986, Tucker and Sellers 1986) (McFEETERS, 1996). The presence of options with a bright coefficient near high infrared and a low red-light coefficient of reflection (e.g., ground vegetation) increases, while those with a low red-light coefficient and a very low NIR light coefficient (e.g., water) are suppressed or perhaps eliminated (McFEETERS, 1996). The reference will be based on information equipped from ground, airborne, or satellite platforms with sensory recorders such as light red mirrors and near infrared radiation. The NDVI index is calculated as follows:

$$\frac{[NIR - RED]}{[NIR + RED]}$$

The index results will vary from to -1 to +1. Vegetation tends to have good conditions, clean soil can be zero, and selective open water with poor standards.

3.1.2. NDWI

If the variables within the maximum value were reversed, and as a result the green band was used instead of the red band, the stated goal of only improving water options would be achieved. NDWI is organized in a practical way to achieve this goal (McFEETERS, 1996). NDWI was named using the same principles that were used to diagnose NDVI. The NDWI is calculated as follows:

$$\frac{[GREEN - NIR]}{[GREEN + NIR]}$$

where GREEN is a band that incorporates the green light shown and the NIR represents the reflected NIR rays.

The selection of those waves was made to:

i. enhances the normal reflection of water features through the use of green light waves

ii. reduce low NIR exposure by water features

iii. use high NIR exposure for terrestrial vegetation and soil characteristics.

When the above figure is used to use satellite imagery many water features with good values; whereas soil elements and vegetation have zero or negative values. Image processing software will automatically be configured to remove invalid values. NDWI domain ranges from zero to at least one. Multiplication of a number by a repeating element (e.g., 255) enhances the image as a result of visual interpretation.

3.1.3. Working Methodology

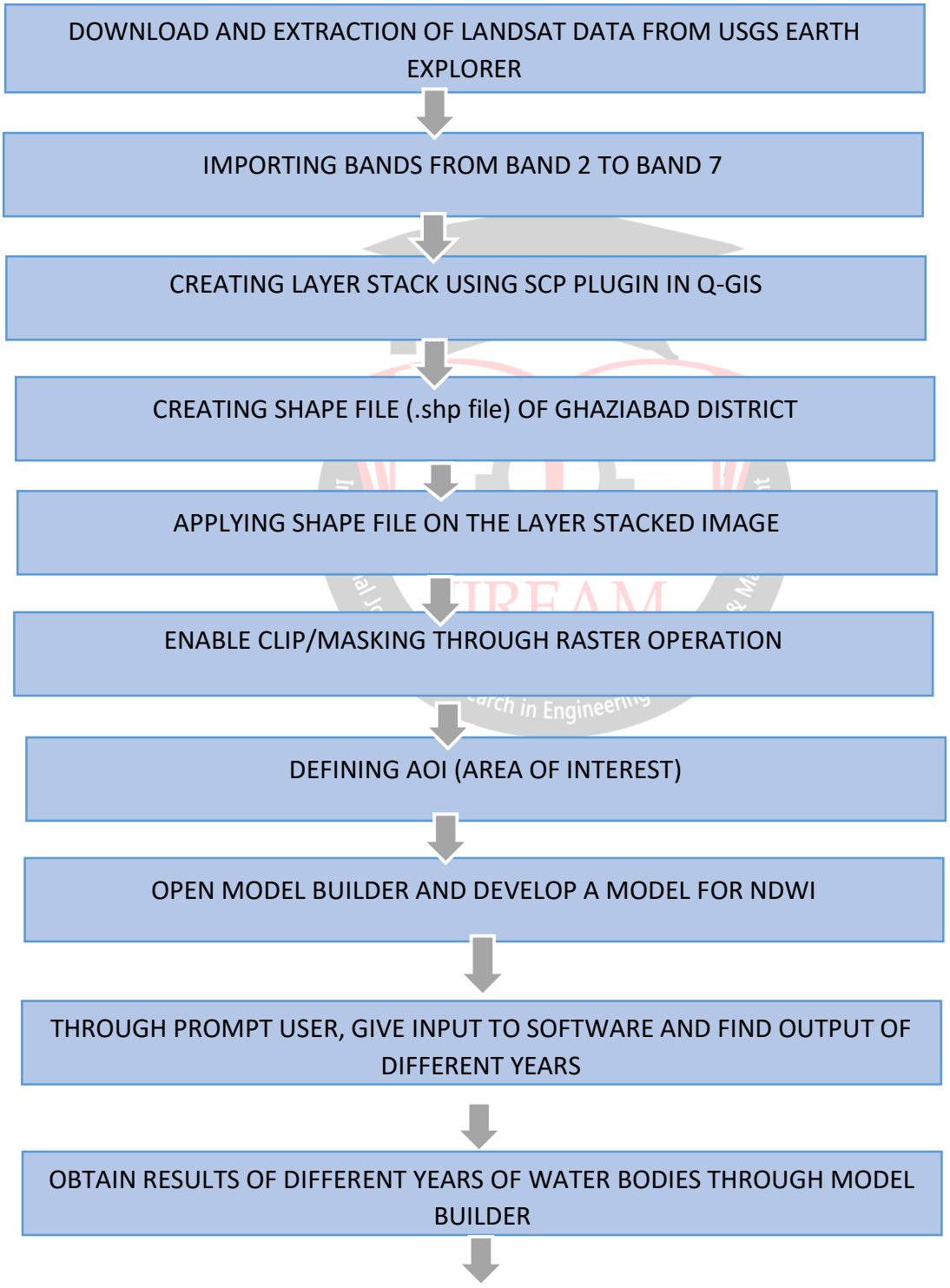
ERDAS IMAGINE is a best and finest software used for the working on the satellite data. With the help of this software, we can easily demonstrate relationships between different geospatial and other imagery data representation. It is an easy-to-use user-friendly software in which the geo-spatial imagery is processed and result is being carried out through the various ways.

 DOI : 10.35291/2454-9150.2022.0178

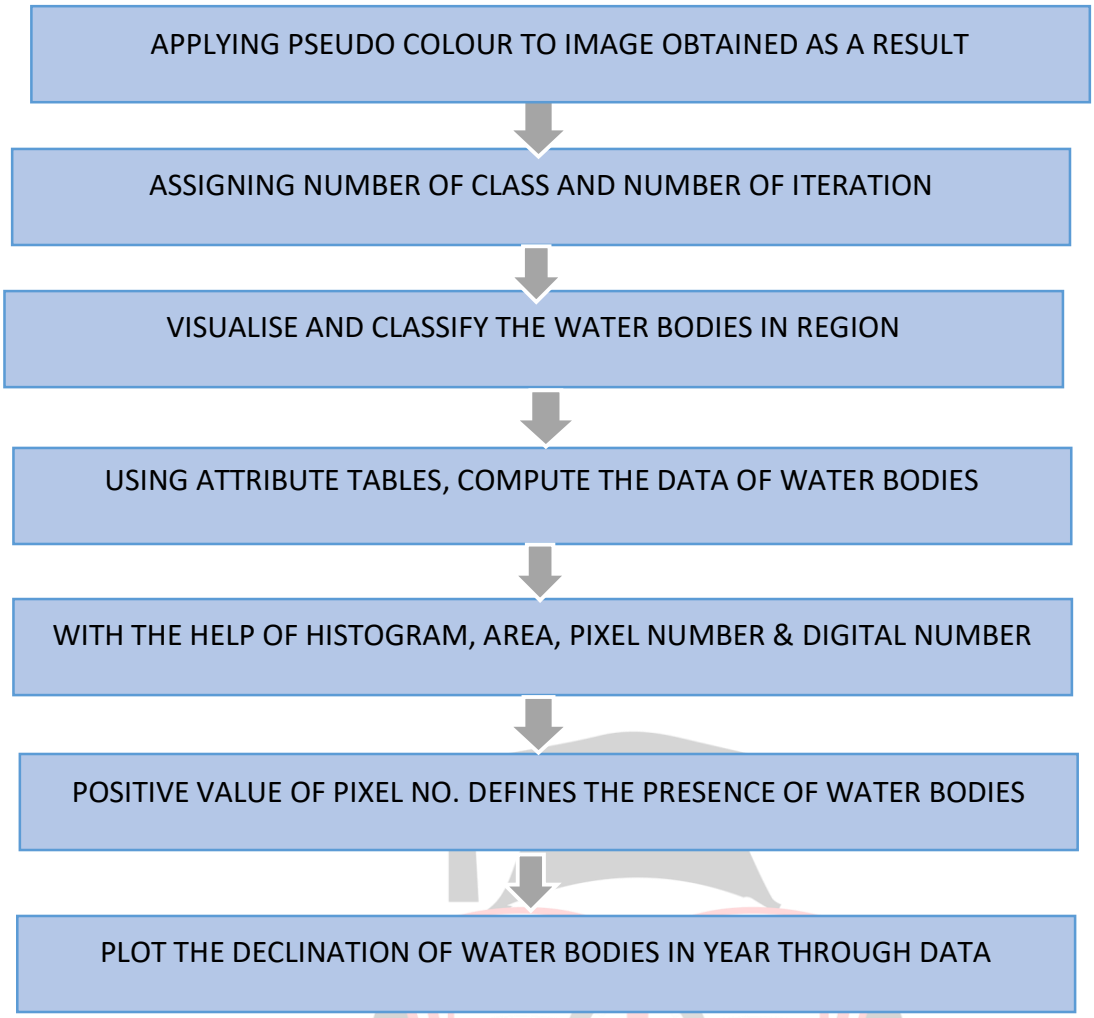
Although, it is a raster-based software but it also works as well as processes the vector data. It also processes the hyper spectral imagery received from the different sensors accordingly. This software can also be utilised for extracting the information from the images.

There were several steps involved in the working methodology, some of which are as given below:

- Downloading and extracting the data from the USGS Earth Explorer.
- Creating a new file and importing the bands from Band 2 to Band 7.
- Creating layer stack i.e., combining the bands collected from our extracted file.
- Creating FCC (False Colour Composite)
- Creating shapefile (.shp file) of Ghaziabad District and applying it over the layer stacked image.
- Defining AOI (Area of Interest) i.e., the area in which we are analysing.
- Performing the clipping/masking operation and extracting the required imagery of Ghaziabad region.
- Opening the Model Builder and performing the various mathematical operations in it.



 DOI : 10.35291/2454-9150.2022.0178



3.2 Waterbodies Assessment

The main rivers that flow through the Ghaziabad district area unit Hindon, Ganga and Yamuna. for the duration of the year these 3 rivers stay full with water. Besides these main rivers, there are many alternative little rivers, the foremost outstanding among them is that the watercourse, Kali. it's primarily a rain-fed watercourse. accessorial to the present, the district uses water from the Ganga Canal for the aim of irrigation.

However, the Hindon river, tributary of the Yamuna River, may be a river in India from the centre of the Saharanpur region, from Shakumbhari Devi varies with the high Sivaliks in Uttar Pradesh. The waterway is completely wet and has a drainage hole of approximately 7,083 sq. Km. kilometres (2,735 sq. mi).

3.2.1 Present State of Water Bodies

In Aug 2015, according to the Ghaziabad regional development official, only 31 of the 590 inland lakes were selected under Jal Bachao Yojana by the prime minister to restore them to their original condition. this means that the region has plans to restore only 5% of its water resources. The department maintains lakes and water resources within the municipal boundaries.

However, in October 2020, the work in the Ghaziabad district on October 28 concluded that 251 lakes / water areas were identified under the municipal organization (146) and 3 tehsils of Loni (2), Sadar (44) and Modinagar (59) . Collectively they indicated that 49 lakes were of no benefit and the other 19 were barren. About 183 lakes, or about 72.9% of Ghaziabad water resources, are inadequate or contaminated. The Ghaziabad municipal corporation has completed the rejuvenation work of 10 bodies beneath its jurisdiction space and plans to revive 28 a lot of before the appearance of the monsoon season. officers aforesaid that they're additionally considering the linking of water bodies to water treatment plants so drinkable supply can even be increased within the town.

In Feb 2022, the ten water bodies that were revived embrace those at Rispur, Sadarpur, Makanpur and Dundahera. per the officers, solely 38 of the 41 water bodies that are known is rejuvenated, whereas the remainder are encroached upon for the past many decades. The corporation has additionally known 14 of 41 known waterbodies whose water quality is taken into account “good.” These include waterbodies at Morta, Noor Nagar, Duhai, Dundahera, Byana and Makanpur, among others.

 DOI : 10.35291/2454-9150.2022.0178

3.2.2 Causes of declination of water bodies

Despite the fact that, there are a few many reasons or foundations for the declination of the water bodies. These causes are as per the following:

1. The waterbodies are evaporating to widespread unlawful extraction for business, development and modern purposes.
2. Rapid urbanization has likewise been faulted for the circumstance of consumption of the water bodies.
3. Conflicts among utilizations and clients are probably going to develop. The fundamental worries are:

a. Irrigation versus homegrown use.

b. Irrigation versus hydro-power, and water use versus ecologic streams.

4. Water freedoms of people and gathering of people need better outline through a legitimized course of portions and survey of distributions. This framework needs to cover returned waters, water quality, and satisfying need through water of a quality fitting to the interest.
5. Fluvial groundwater additionally should be brought under the allotment situation, and the restrictive freedoms of landowner over groundwater need to stop.
6. Water administration for hydrologic units like bowls/sub-bowls necessities to include partners. For homogenous regions with just water system use, WUA's could be the vehicle for the executives. For heterogeneous purposes, partner advisory groups would need to be framed and enabled to deal with the asset, inside allotments and monetary manageability.

3.2.3 Issues in water management

1. Dealing with old water system frameworks

i. Structural Problems Requiring Replacement

ii. Considering new data with respect to plan

iii. Meeting expanding requests

iv. Catering towards Improved Management

- a. Reducing water misfortunes
- b. Providing control structures
- c. Provision of field and trunk channels
- d. Installation of conjunctive use part
- e. Provision of better dissemination organization

v. Lack of support & maintenance

3.2.4 Measures taken to improve the issue of water declination of water bodies

i. Appropriate improvements in overall water resource management through stakeholder participation and power allocation.

ii. Save water quality by establishing norms and procedures.

iii. Surface and groundwater management as one integrated resource management resource.

iv. Ensure equity between users in resource allocation and management. However, drinking water is kept a priority.

v. Establish a legal framework for the management and control of water resources.

vi. To promote awareness, research and training in the field of water resources.

vii. Effective and efficient water management options require the integration of both the Structural and Non-Structural measures which include water conservation, the expansion of this natural resource (especially groundwater resources through recycling strategies).

viii. The construction and implementation of large-scale recycling in groundwater is an important solution to this problem.

ix. In order to prevent degradation and improve groundwater quality and improve groundwater quality, the roof rainwater harvesting and the proper method of replenishing it should be welcomed especially in urban areas.

x. In rural areas, the demolition of old tanks and the development of a drainage system, direct and indirect methods of automatic recycling i.e., water flowing through a side canal and drainage pattern in a small flood area.

IV. RESULTS & DISCUSSIONS

From studying, observing and analysing the NDWI's images of years 1994, 2002, 2014 and 2020, we came into the different conclusion for the different images. As we can interpret from the same that a sudden decline can be seen till the year 2014.

After working on ERDAS IMAGINE with year 1994's data, we came to the inference having this NDWI image as shown below in Figure1:

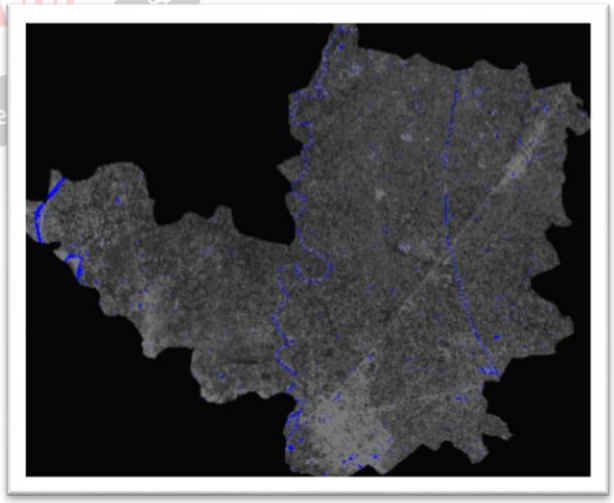


FIGURE 1 : NDWI OF LANDSAT 5 (1994)

With the 2002's data, we came to the inference having this following NDWI image as shown below which shows a particular greater decline in water bodies over a certain period of time.

As we can clearly see that the above image (of year 1994) has the greater area (or number) of water bodies as

 DOI : 10.35291/2454-9150.2022.0178

compared to that of in future i.e., in the year 2002, which can be seen below in the Figure 2:

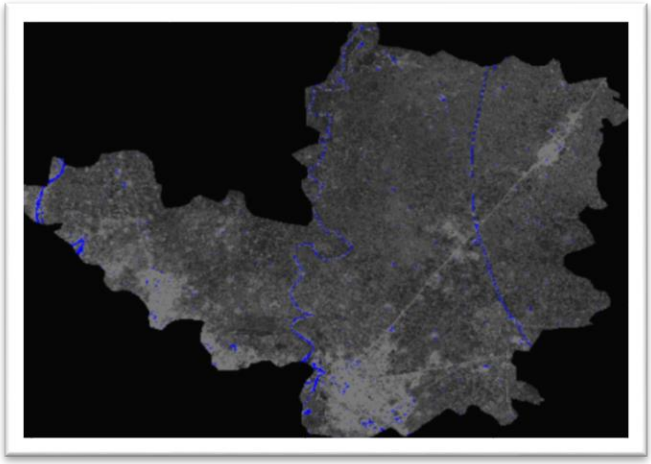


FIGURE 2: NDWI OF LANDSAT 7(2002)

Following the data of year 2004, after interpreting the data of year 2014, we came to the following result having this NDWI image as shown below in Figure 3:

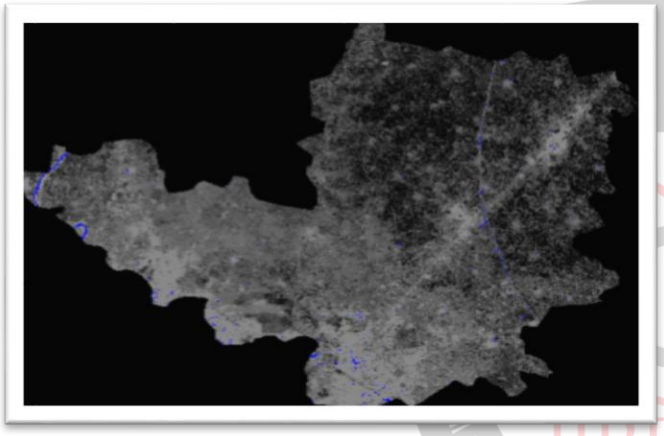


FIGURE 3: NDWI OF LANDSAT 8 (2014)

In the year 2020, we may can say that the bodies have been certainly increased a bit as some work has been done upon it after having the downfall of waterbodies in the account, as the below NDWI's image for the same year shows a glimpse of growth in the water bodies in Figure4:

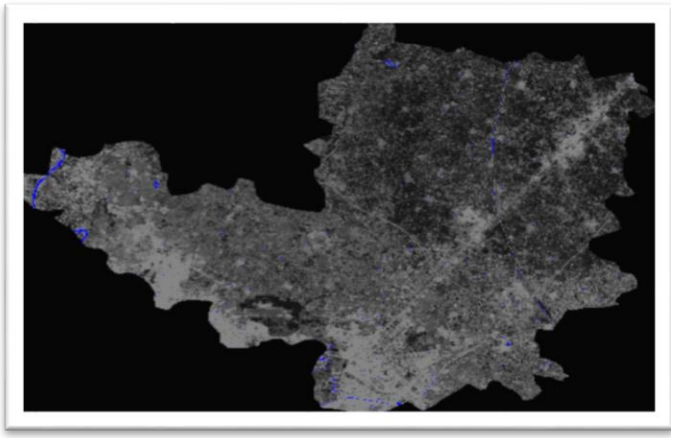


FIGURE 4 NDWI OF LANDSAT 8 (2020)

This chart shows the graphical analysis of water bodies over a certain period of time as follows:

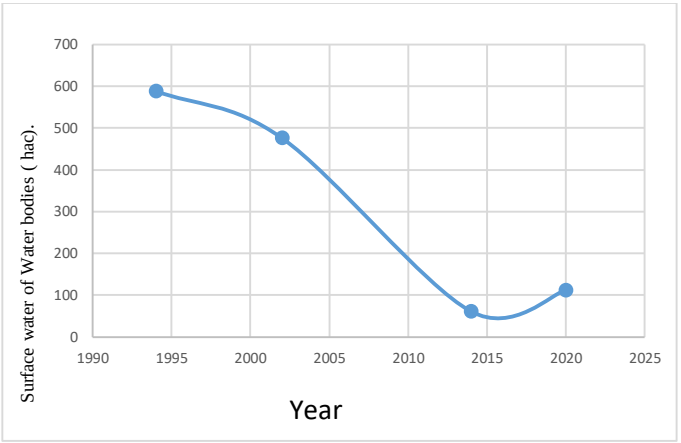


FIGURE 5 GRAPH SHOWING THE CHANGE IN NDWI

Year	Surface area of water bodies (hac)
1994	588.06
2002	475.55
2014	60.39
2020	110.88

TABULAR REPRESENTATION OF VARIATION IN WATER BODIES OVER YEARS

The indices for the delineation of the region extent of water bodies like, NDWI and MNDWI once applied on Landsat pictures through ArcGIS and ERDAS Imagine software package give reliable spatiotemporal data. The NDWI is utilised for interpretation of the region extent of water bodies in a wide selection of imageries. MNDWI square measure restricted to be used solely in pictures that have the MIR band. MNDWI provides for a sophisticated and refined estimation of the extent of surface water bodies among the CMA compared to NDWI (Figures one, 2, 3 & 4). this is often significantly evident for the flood affected years 1994 - 2020. The extracted pictures are utilised by designing authorities so as to know the inundated areas among the CMA, analyse the causes for identical, and take appropriate selections for the bar of such occurrences within the future.

V. CONCLUSION

The adjustment of the NDWI utilizing a MIR band rather than a NIR band can extensively work on the improvement of untamed water highlights. It can rapidly and precisely segregate water from non-water highlights. The MNDWI is more appropriate for improvement of water with many developed land regions behind the scenes than the NDWI in light of the fact that it can productively lessen and try and eliminate developed land commotion. Quick and effective assessment of vast water surface region in such advanced symbolism can then be made utilizing picture handling programming. Also, the NDWI might end up being a

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helpful apparatus in the investigation of water quality issues, especially with respect to turbidity assessments. Further exploration is expected to research the utility of this file in the evaluation of water assets both concerning the amount and furthermore the nature of such assets.

From the Attribute table of various different year results of water bodies, a conclusion has been derived that from digital no. varying from 0-255 (a total of 256 digital number in image of 30*30 m resolution), a positive value of pixel number represents the presence of water bodies with respect of the histogram values which are showing number of iterations of water bodies which helps us in computation of surface area of water bodies in Ghaziabad region (in hectares).

Here we used time series of Landsat TM and OLI images for estimate distribution of surface and seasonal variations, from the year 1994 to the year 2020. Lakes and water sources across the country need immediate attention. There's seen to be the continuous decline in water bodies from the 1994 till the year 2014. But after a certain particular period of time i.e., after 2014, we have clearly observed that the water bodies have increased that till now i.e., in year 2020 water bodies replenishment have started. These water bodies are being rejuvenated and recharged as well by various ways to maintain the ground water level and in order to maintain balance between both of them.

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