International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2024.0005
e ISSN: 2584-2854
Volume: 02
Issue: 03 March 2024
Page No: 27-31

Delineation of Water Bodies Using Vegetation and Water Indices

*Arunima Nandy[1], Avinash Kumar[2]
[1]Research Scholar, Department of Agricultural Engineering, Triguna Sen School of Technology, Assam University, Silchar, Assam, India.
[2]Assistant Professor, Department of Agricultural Engineering, Triguna Sen School of Technology, Assam University, Silchar, Assam, India.
Email: arrunimanandy@gmail.com[1], avinashiitkgp86@gmail.com[2]
***Corresponding Author Orcid ID:** 0000-0002-2373-1979*

Abstract
Mapping the water surface is a significant aspect of identifying the extension or shrinkage of any water body. It is a beneficial technique for a region, experiencing gradual river shifting, erosion, or frequent flood events. Climate change often causes excessive rainfall or drought conditions in a riverine region, significantly impacting water over-spilling or shrinkage and sedimentation of a river. The spatio-temporal study of delineation and mapping of water surface area helps to determine the pattern of change of a water body, analyze the trend of shifting of a river course, and estimate the change in the proportion of water surface area. All these kinds of assessments are helpful in analyzing the inundated area of a flood prone region. This study aims to delineate water bodies of Lakhimpur district of Assam using Geographic Information System (GIS) and remote sensing over a temporal scale of twenty years from 2001 to 2021. Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) are used in this study to map and estimate the changes and extension of water bodies of the region. It is observed that there is an increase of 16.75% in water bodies in the district from 2001 to 2021

***Keywords**: Flood, Geographic Information System (GIS), Remote Sensing, Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI).*

1. Introduction
Different forms of surface water, including rivers, streams, lakes, ponds and reservoirs, are an inimitable part of the world's hydrological cycle. Different hydrological processes, spatial distribution of several forms of land surface water and management of those water resources can be assessed by studying the formation, characteristics, distribution, and changes of land surface water bodies [1&2]. Changes in different surface waters have influenced the environment, ecology, agriculture, settlement, health, and food security [3-5]. Hence, monitoring, mapping, and assessing the changes in surface water bodies regarding proper land use and urban planning, environmental monitoring, water resources, and disaster management is essential. Remote sensing technology assists the monitoring and mapping water bodies by providing real-time, high spatial resolution temporal data for large and remote areas, which is more convenient than conventional measurements [6]. The satellite data-derived water indexing method is one of the most suitable and concise water body identification techniques with high precision [7]. The Normalized Difference Vegetation Index (NDVI) is a popular tool for measuring biomass and differentiating vegetation and water bodies over a region [8]. McFeeters introduced the Normalized Difference Water Index

International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2024.0005
e ISSN: 2584-2854
Volume: 02
Issue: 03 March 2024
Page No: 27-31

(NDWI), which can extract open surface water [9] and remove soil and surface vegetation noise [7]. [10] suggested a combinational model of difference between NDVI and NDWI with NIR band and slope for water body mapping using HJ-1A/B. This study intends to delineate open water surfaces of the Lakhimpur district of Assam, with the help of NDVI and NDWI using Landsat images, which will be fruitful in understanding the gradual changes of water bodies over a temporal scale of twenty years.

2. Study Area

Assam is a very flood-prone state in India, as many districts of this region experience severe flood conditions almost every year. Lakhimpur is a populated district of Assam which is fed by the Brahmaputra River and its several tributaries. The district lies in the upper Assam Brahmaputra valley on the northern bank of the river Brahmaputra. The total population of this district is 1,042,137 as per the 2011 Census [11]. In this study, the Lakhimpur district is selected as the study area since this populated region has experienced several flood occurrences, huge river shifting and river erosion. Hence, it is essential to identify and map the extent of water bodies so that the trend of change in the shifting of some parts of the major river Brahmaputra and its tributaries can be identified. This study will be useful in recognizing the captured land and inundated areas by rivers and other water bodies, which will be beneficial to flood management and minimize loss during flood events. The location of the Lakhimpur district is shown in Figure 1.

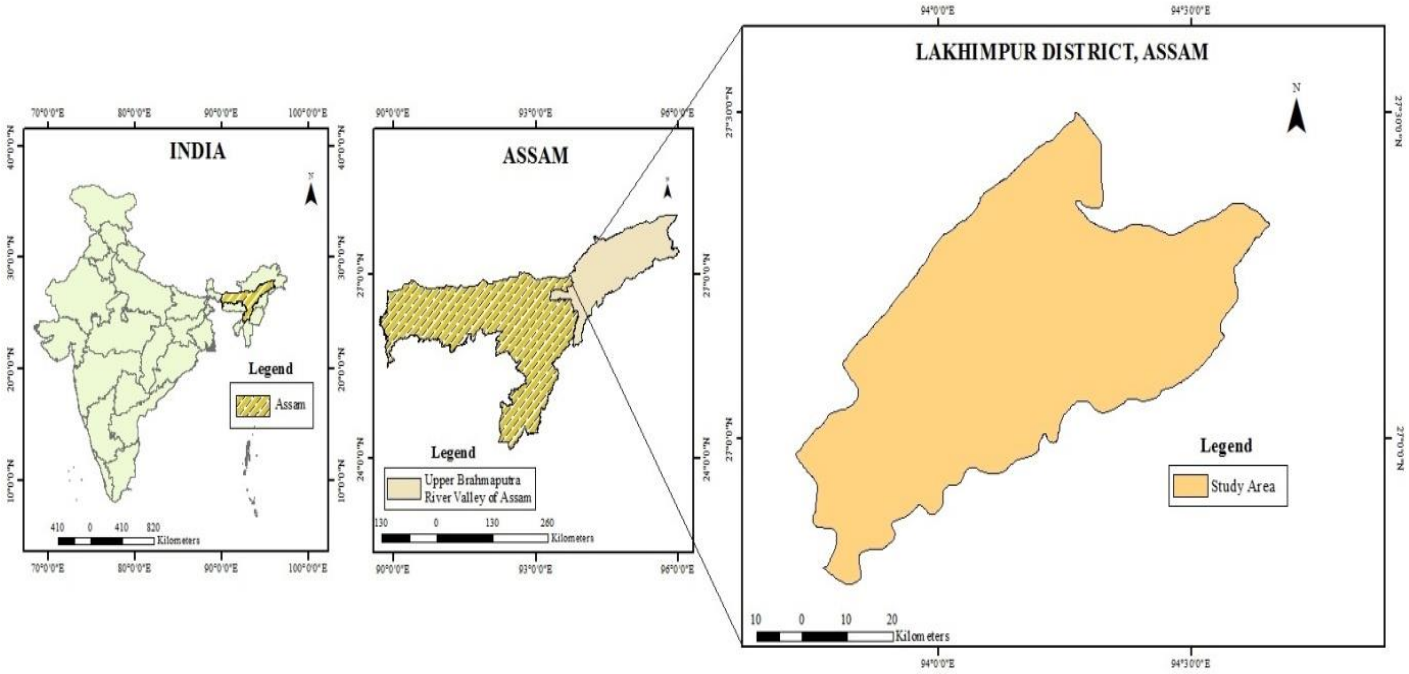

Figure 1 Location Map of Lakhimpur District of Assam

3. Database and Methodology

The state map of Assam has been collected from the Survey of India, Guwahati, to prepare the location map of the state and the Lakhimpur district. Landsat data are collected from USGS for remote sensing analysis in this study. The Landsat 5 TM satellite image of 2001 and the Landsat 8 OLI satellite image of 2021 are used to understand the changes in the extension of water bodies over a temporal scale of twenty years. The post-monsoon season is selected for analysis as after monsoon, all the rivers and their tributaries are filled with water and have not dried up. The spatio-temporal

International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2024.0005
e ISSN: 2584-2854
Volume: 02
Issue: 03 March 2024
Page No: 27-31

Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) have been analyzed for the Lakhimpur district for 2001 and 2021. Delineation and mapping of surface water bodies are prepared for two years from the difference of the NDWI from the NDVI map. The resulting map shows the spatio-temporal changes in surface water bodies of the district. The framework of the methodology is shown in Figure 2.

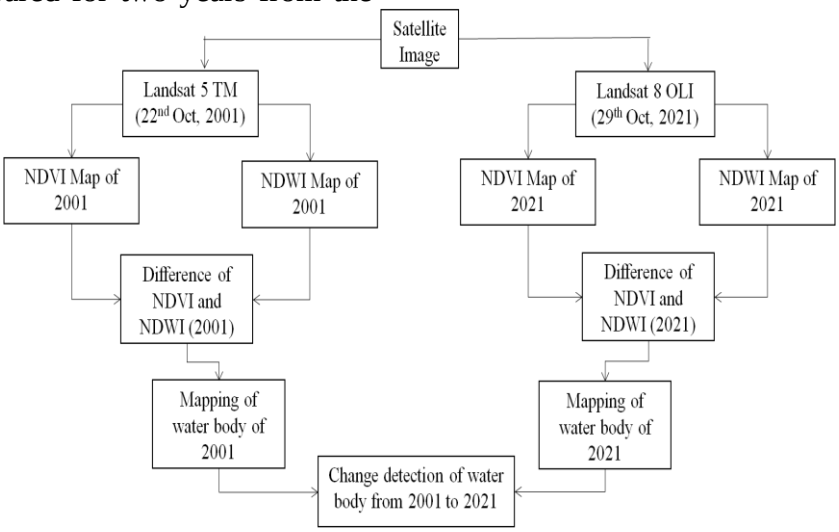

Figure 2 Framework of The Methodology

4. Analysis

Spatio-temporal changes of any phenomena depict the gradual alteration of the particular phenomena within the specified period. In this study, the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) are analyzed for 2001 and 2021 to understand the distribution of vegetation and water and spatio-temporal changes over twenty years.

4.1 Normalized Difference Vegetation Index

Normalized Difference Vegetation Index (NDVI) represents vegetation's health and distribution by separating water bodies and wetlands. It is estimated as a ratio between measured reflectivity in the near-infrared and red portions of the electromagnetic spectrum as the maximum portion of the NIR spectrum is absorbed by vegetation due to the presence of chlorophyll content. NDVI is calculated by Equation 1 [12]:

$$NDVI=\{(NIR-R)/(NIR+R)\} \quad (1)$$

Where NIR is the Near Infrared band and R is the red band of the electromagnetic spectrum. NDVI analysis has been done in this study, as shown in Figure 3, using Landsat 5 TM and Landsat 8 OLI satellite images for 2001 and 2021, respectively. NDVI values range from +1.0 to -1.0. In the study area, dense vegetation represents values greater than 0.4. Areas with sparse vegetation, such as shrubs, grasslands, and crops, have moderate NDVI values, approximately 0.2 to 0.4. Barren land and settlement areas have values from 0.2 to 0.1, and surface water, including rivers, represents NDVI values less than 0.1.

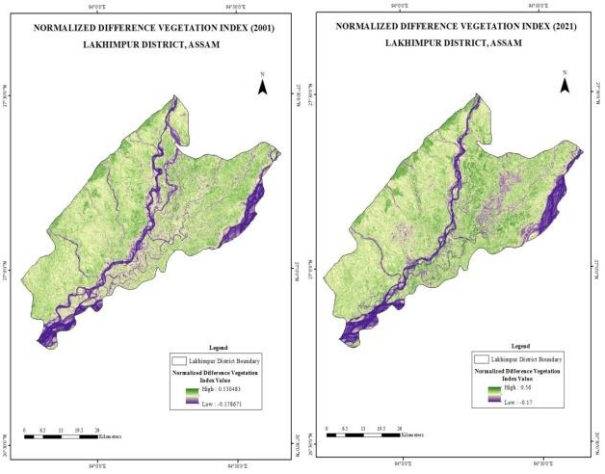

Figure 3 Normalized Difference Vegetation Index of Lakhimpur District of 2001 and 2021

International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2024.0005
e ISSN: 2584-2854
Volume: 02
Issue: 03 March 2024
Page No: 27-31

4.2 Normalized Difference Water Index

The Normalized Difference Water Index (NDWI) facilitates identifying and mapping open water features. It is a satellite data-derived index from the Near-Infrared (NIR) and Green channels of the electromagnetic spectrum [9].

NDWI=(Green-NIR)/(Green+NIR) (2)

According to McFeeters, NDWI values greater than zero are assumed to represent water surfaces, and non-water surfaces possess values less than or equal to zero [9]. This paper analyzed NDWI using Landsat 5 TM and Landsat 8 OLI satellite images for 2001 and 2021, respectively (represented in Figure 4.), to study the distribution of water and their gradual areal changes over the specified temporal scale. It is observed that the NDWI value has decreased in 2021 from 2001.

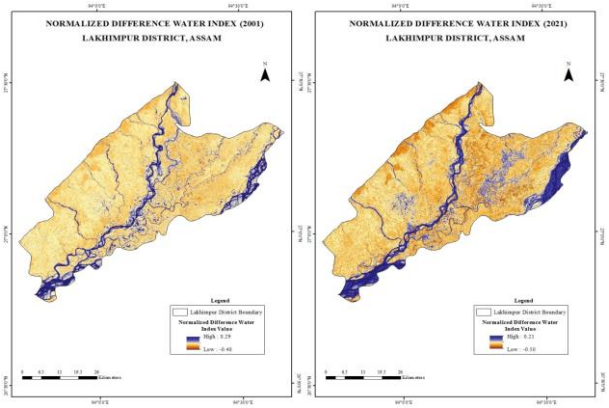

Figure 4 Normalized Difference Water Index of Lakhimpur District of 2001 and 2021

5. Results and Discussions

NDVI maps of the district represent the temporal distribution of vegetation, while NDWI depicts the region's dynamic changes in water bodies. This research subtracted the NDWI map from the NDVI map to delineate the surface water bodies. Subtracted map enhances only the surface water features, identical to extracting and mapping the water bodies of the whole district, including rivers, tributaries, streams, lakes, ponds, and wetlands, suppressing all other surface features. Figure 5 represents the identification and mapping of water bodies in the district for 2001 and 2021. It is observed that the total proportion of water bodies has increased from 460.92 sq. km. in 2001 to 538.11 sq. km. in 2021 at a rate of 16.75%. Such an increase in the proportion of water bodies depicts the probability of a high rate of inundation and land captured by water.

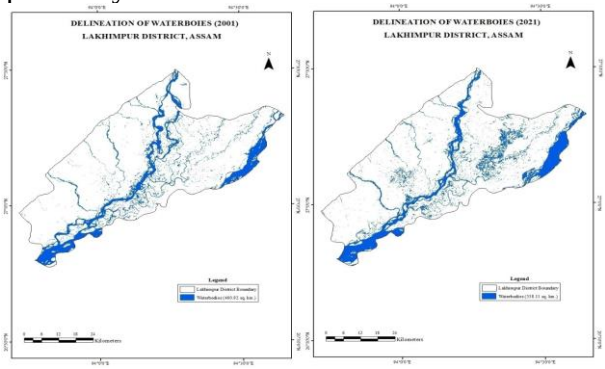

Figure 5 Delineation of water bodies of Lakhimpur district from 2001 to 2021

In future, applying more advanced indexing like the Modified Normalized Difference Water Index (MNDWI), high spatial resolution satellite images, and comparative study of NDVI and NDWI and landuse/landcover assessment will be more in-depth assessment of this work.

Conclusion

The study delineates the open surface water and eliminates other features as non-water features from the difference between NDVI and NDWI. It was found from the NDWI map that values have decreased in 2021 from 2001. Meanwhile, the result from the difference between NDVI and NDWI reveals that the proportion of surface water bodies has increased by 16.75% in these twenty years, and the output result eliminates the soil and vegetative water. This study will benefit fundamental research on monitoring and mapping water bodies, identifying inundated areas, spatio-temporal change detection of surface water, and managing water resources.

References

[1]. Jakovljević, G., Govedarica, M., & Álvarez-Taboada, F. “Waterbody mapping: A comparison of remotely sensed and GIS open data sources”. International Journal of Remote Sensing, 40(8), 2936-2964, 2019.

International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2024.0005
e ISSN: 2584-2854
Volume: 02
Issue: 03 March 2024
Page No: 27-31

[2]. Tomar, P., Singh, S. K., Kanga, S., & Pattanaik, A. (2023). Water Bodies mapping and monitoring using high-resolution satellite images. Sustainability, Agri, Food and Environmental Research, 11.
[3]. Lacaux, J. P., Tourre, Y. M., Vignolles, C., Ndione, J. A., & Lafaye, M. "Classification of ponds from high-spatial resolution remote sensing: Application to Rift Valley Fever epidemics in Senegal". Remote sensing of environment, 106(1), 66-74, 2007.
[4]. Misra, A. K. "Climate change and challenges of water and food security". International Journal of Sustainable Built Environment, 3(1), pp. 153-165, 2014.
[5]. Viala, E. "Water for food, water for life a comprehensive assessment of water management in agriculture". Irrigation and Drainage Systems, 22, pp. 127–129, 2008.
[6]. Jensen JR. "Introductory Digital Image Processing: A Remote Sensing Perspective". Prentice Hall, Upper Saddle River, New Jersey, pp. 316, 1996.
[7]. Xu, H. "Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery". International Journal of Remote Sensing, 27(14), pp. 3025-3033, 2006.
[8]. Rouse, J. W., Haas, R. H., Schell, J. A., & Deering, D. W. "Monitoring vegetation systems in the Great Plains with ERTS". Third 80 ERTS Symposium, NASA SP-351(1), pp. 309-317, 1974.
[9]. McFeeters, S. K. "The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features". International Journal of Remote Sensing, 17(7), pp. 1425-1432, 1996.
[10]. Lu, S., Wu, B., Yan, N., & Wang, H. "Water body mapping method with HJ-1A/B satellite imagery". International Journal of Applied Earth Observation and Geoinformation, 13(3), pp. 428-434, 2011.
[11]. https://www.censusindia.co.in/district/lakhimpur-district-assam-307, accessed on 16.12.2023.
[12]. Orhan, O. and Yakar, M. "Investigating land surface temperature changes using Landsat data in Konya, Turkey". The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 41, pp. 285-289, 2016.