Eco. Env. & Cons. 30 (October Suppl. Issue) : 2024; pp. (S179-S183)
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ISSN 0971–765X

DOI No. http://doi.org/10.53550/EEC.2024.v30i06s.026

Study on NDVI and NDWI change detection of Gai river basin, NEI using GIS and remote sensing

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(Received 25 March, 2024; Accepted 15 May, 2024)

ABSTRACT

This paper is a study on the change detection of the Gai River basin. Researchers considered Normalised difference vegetation index and Normalised difference water index techniques for the detection of changes in vegetation and water bodies. Landsat 7 and 8/9 satellite imagery are utilised in ArcGIS, a raster calculator tool, to evaluate the ratio difference. The vegetation index ratios are -0.23 (low), 0.55 (high), -0.12 (low), and 0.52 (high) between 2003 and 2024. Moreover, the NDWI ratio value varies from -0.44 low to 0.28 (high) in 2003 and -0.46 (low) and 0.16 (high) in 2024. The difference in ratio values indicates the change detection areas. The prepared map of the NDVI and NDWI has shown the changes. Vegetation and water are crucial natural resources, but the changes in these resources impact our environment. So, maintenance and sustainable utilisation are needed to conserve those resources.

Key words: *NDVI, NDWI, Change detection, GIS, Remote sensing*

Introduction

Northeast India is comprised of eight states. These states are rich in biodiversity. India State of Forest Report 2021, reported by the top five states forest cover percentage are Mizoram 84.53%, Arunachal Pradesh 79.33%, Meghalaya 76%, Manipur 74.34% and Nagaland 73.90% NEI has taken several initiatives and policies for the conservation of forest resources. The primary reasons for the changes in vegetation cover in northeast India are shifting cultivation, increasing population, mining and development activities. These are causes of the degradation of forest resources. Traditionally, the northeast states practice Jhum cultivation in hilly areas, a significant human activity. Deforestation is one of the reasons for the change in vegetation cover (Chakraborty, 2009). NDVI indices are highly applied in detecting changes, i.e. land, water and forest resources. These indices correlated with the rainfall and temperature (Saikia, 2009). Resources are limited on our earth's surface. Changing resources widely impacts the ecosystem (Hu *et al*., 2023).

The imagery is the best and most reliable source of earth surface data in various contexts like topography, biodiversity, land use, cultural aspects, etc. Vegetation indices, i.e., Normalised Difference Vegetation Index, is an emerging technique from remote sensing and GIS technology to detect spatio-temporal changes in vegetation cover on the earth's surface. The analysis of change in vegetation cover is of great significance to understanding the overall nature of biodiversity in response to recent climatic change (Agone and Bhamare, 2012). Both techniques are currently efficient in analysing, interpreting and monitoring the vegetation change in any particular area on the earth's surface. The normalised difference water index ratio method also considers the measures of the water bodies. It effectively distinguishes the water and land variation (Laonamsai *et*

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al., 2023). Water is a vital resource for sustaining the whole ecosystem. Detecting water bodies using the NDWI method based on the Landsat image is useful (Ozelkan, 2019).

Remote sensing techniques provide an outstanding possibility to analyse the environmental processes locally or globally. Satellite images provide a wide range of possibilities for monitoring the environment quickly, especially in areas unavailable for a field survey due to the topography, dense vegetation, or other local factors (Szabo *et al*., 2016). Change detection is the process of distinguishing differences in the phenomena by observing them in different periods, including the ability to determine temporal effects using a multi-temporal data set (Ahmed, 2023). Satellite data helps analyse change information in different periods (Forkel *et al*., 2013).

Many researchers were using satellite-based multi-spectral remote sensing data and NDVI and NDWI methods to apply GIS software in estimating changes in surface features (Singh *et al*., 2022; Huete *et al*., 2002; Meera Gandhi *et al*., 2015; Krishna-Prasad *et al*., 2008). Nowadays, LU/LU changes estimates based on the NDVI value. Change detection of land cover is a current topic for monitoring ecological balance and management of natural resources. This paper aims to detect the changes based on NDVI. Analysis of change in NDVI is crucial because we know the causes, which areas, and how many are changed. The result of this paper will help identify the changes in natural resources such as water, forest and soil resources to protect, conserve and manage those resources as well as our environment. Government programmes and policies are applied to maintain the resources for achieving sustainable development.

Materials and Methods

Study area

The study area is situated in the Dhemaji districts (Assam) and West Siang districts (Arunachal Pradesh). Geographically, it is extended between 27° 26′0" to 27° 48' 0" N latitude and 94° 28' 0" to 94°45' 0" E longitude. Gai river basin covers 471 sq. km. of areas. The research area's Physiography is divided into hilly and plain areas. The geology of this area belongs to three groups- Lower Gondwana, Siwalik unclassified and undifferentiated fluvial sediments,

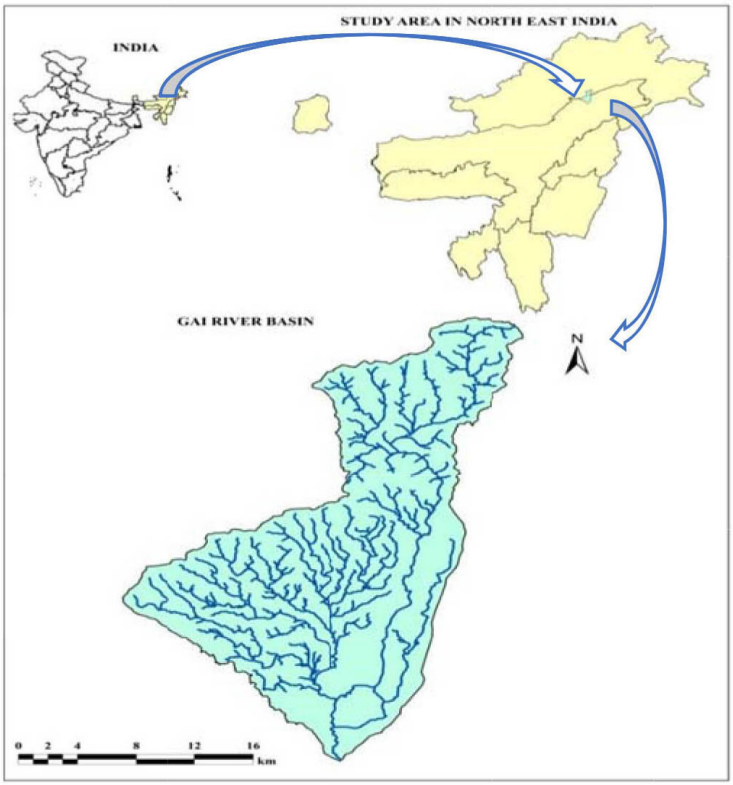

Fig. 1. Location map of the study area

and Geomorphology of the Gai River Basin come into the eight classes, i.e., Alluvial plain, Flood plain, Highly Dissected Hills and Valleys, Mass wasting products, Moderately dissected hills and valleys, Piedmont slope,Waterbodies-Otherand Waterbody (river). The present study area elevation varies from 21 to 1410 m, and the slope varies from 0 to 70.34 degrees.

Study method

The delineation of basin boundary was using Cartosat DEM, Bhuvan 2D and Google Earth Pro, Survey of India Toposheet no 83I/6, 9, 10, 11, and Landsat imagery- 7(10-05-2003) &8/9 (11-03-2024). The calculation of NDVI and NDWI of the research area has implemented Landsat satellite imagery to detect the changes in landform features. In Landsat 7, NDVI is derived using bands four and three, while Landsat 8/9 uses bands 5 and 4. NDVI value is from -1 to +1. The calculated formula is -

Landsat 7, NDVI = (band 4- band 3) / (band 4+ band 3).

Landsat 8/9, NDVI = (band 5 – band 4) / (band 5 + band 4).

Landsat 7, NDWI = (band 2- band 4)/ (band 2+ band 4).

Landsat 8/9, NDWI = (band 3 – band 5) / (band 3 + band 5).

The processing of satellite data in 2003 and 2024 computes ArcGIS software and raster calculator tools to obtain the NDVI and NDWI.

Results and Discussion

Normalised difference vegetation index, 2003 and 2024

Normalised difference vegetation index is a universally used method for detecting changes in the surface features. This index is popular in detecting vegetation health. NDVI threshold value from -1 to +1, -1 represents no vegetation, and +1 indicates dense or healthy vegetation. This paper estimates the changes in NDVI and NDWI threshold Values. In these 21 years, changes have been detected because we know that the hilly areas are more prone to soil erosion and shifting cultivation or deforestation.

Table 1. Descriptive statistics of NDVI and NDWI

Parameters	NDVI		NDWI	
	2003	2024	2003	2024
Min	-0.23	-0.12	-0.44	-0.46
Max	0.55	0.52	0.28	0.16
Mean	0.21	0.27	-0.17	-0.23
Std. deviation	0.13	0.07	0.09	0.06

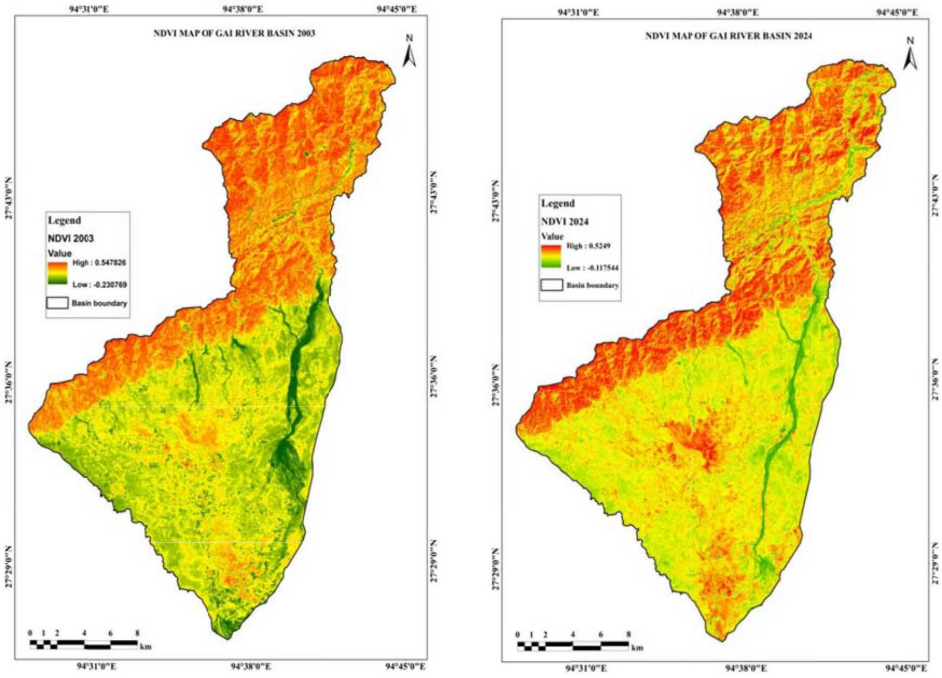

Fig. 2. Map showing NDVI 2003 and 2024

On the other hand, in the plain areas, there is an increasing population and flood-prone areas, decreasing the vegetation cover. Proper planning and management are needed to protect natural resources for sustainable development. In 2003, minimum (-0.23) and maximum (0.55) NDVI values were found to be negative values representing water bodies, and maximum positive values denote dense or healthy vegetation. Maximum (0.52) and minimum (-0.12) values have changed in 2024. The value difference proved the change of LU/LC in the Gai River Basin.

Normalised difference water index 2003 & 2024

Normalised difference water index ratios determine the greenness of the earth's surface. The processing of green and near-infrared bands obtains this ratio. This technique is applied in Landsat imagery to distinguish open water features. The value varies from -1 to +1. A positive value plus one means the area is humid, and minus one denotes the area lacks humidity. The variation of the NDWI has decreased compared to 2003, and the maximum value changes in 2024 as well. A high positive value indicates a dark blue colour and a negative value indicates a red colour. The result of changes in threshold value estimates is that the natural resources are decreasing gradually, and the environment has also degraded.

Conclusion

Above the index (NDVI and NDWI) is the most effective method for measuring vegetation health, condition, and water body or humidity. Vegetation and water are crucial natural resources, but the changes or decreases of those resources on the earth's surface impact the ecosystem. Decreasing of natural resources in the future causes the loss of a healthy environment. Without water resources, no one is living on the earth's surface. All biotic and abiotic components are entirely dependent on the water body. NDVI refers to the health of vegetation or forest cover. Defence between these 21 years results found that the forest cover has changed. This two-year prepared map variation of colour change difference was shown. Vegetation value ratio differ-

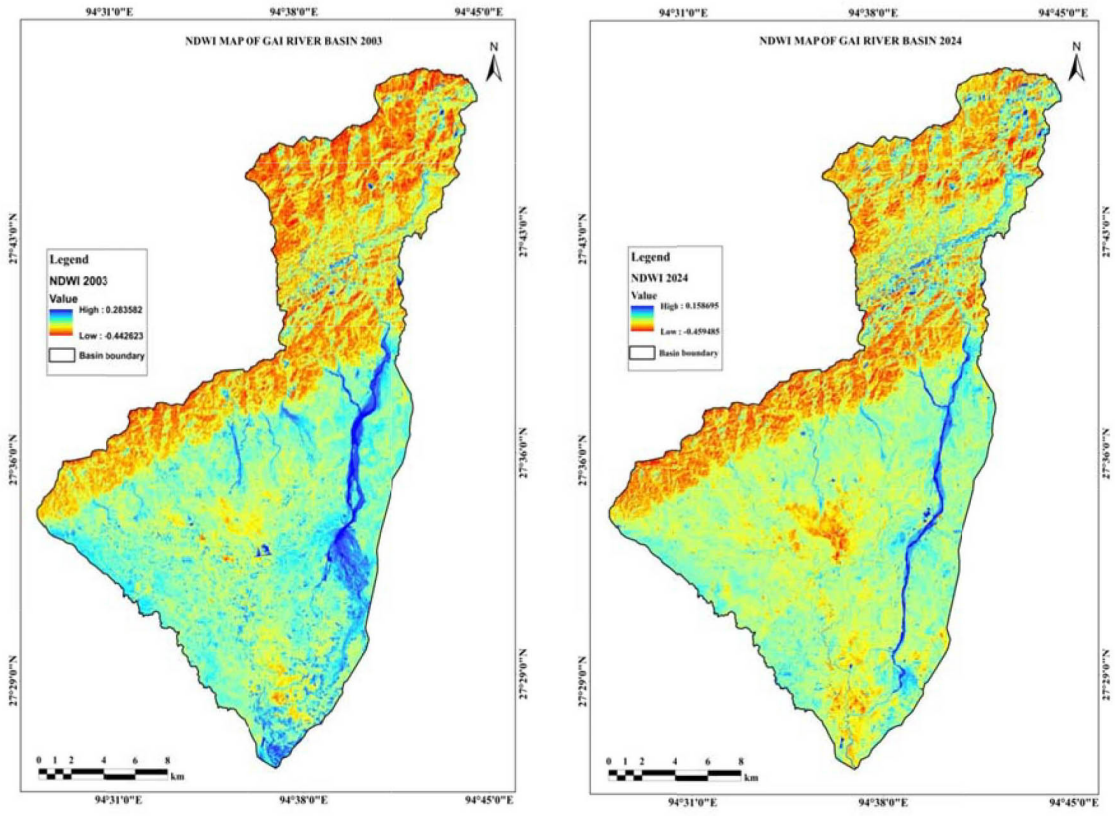

Fig. 3. Map showing NDWI 2003 and 2024

ences range from -0.23 (min) and 0.55 (max) in 2003 and -0.12 (min) and 0.52 (max) in 2024. Normalised difference water index ratio considers the moisture or water available area. A positive value denotes water available area, and a negative value denotes low moisture or dry area. NDWI minimum and maximum variation are -0.44 and 0.28 (2003) and -0.46 and 0.16 (2024). Certainly, the result of the value difference concluded that the study area water body has decreased compared to 2003. Some areas are going to declining water bodies. Climate change, soil erosion, soil, station, and deforestation impact the resources of this study area because of the possibility of these factors. Proper conservation and management planning is essential to protect and conserve these resources and sustainable utilisation.

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