NDVI - Based Assessment of Vegetation Change in Erstwhile Ripu Reserve Forest, Assam

Diganta Kumar Bora, Prasenjit Das

Vegetation change implies ecological imbalances, climate change detection, land use patterns, etc. The analysis of vegetation change is important for sustainable management and planning. The Normalized Difference Vegetation Index (NDVI) is important for the assessment of vegetation change detection. It was analyzed through remote sensing. The study area is a historical place, and it is located in the northwestern most part of Assam. This study analyzes the spatio-temporal changes in vegetation cover within the erstwhile Ripu Reserve Forest using NDVI data from the years 1987, 2005, and 2023. Landsat satellite imagery was utilized to assess vegetation health and density over time. The results indicate a significant decline in NDVI values between 1987 and 2005, suggesting vegetation degradation is likely due to deforestation and other land-use changes. However, the NDVI values show a marked improvement in 2023, with higher vegetation density than in previous years, indicating signs of ecological recovery. This positive shift may be attributed to reforestation efforts, natural regeneration, and improved land management practices. The study highlights the importance of continuous monitoring and sustainable practices to conserve and restore forest ecosystems.

Keywords: *NDVI, Remote Sensing, GIS, Satellite imagery, Vegetation change, Ecological restoration*

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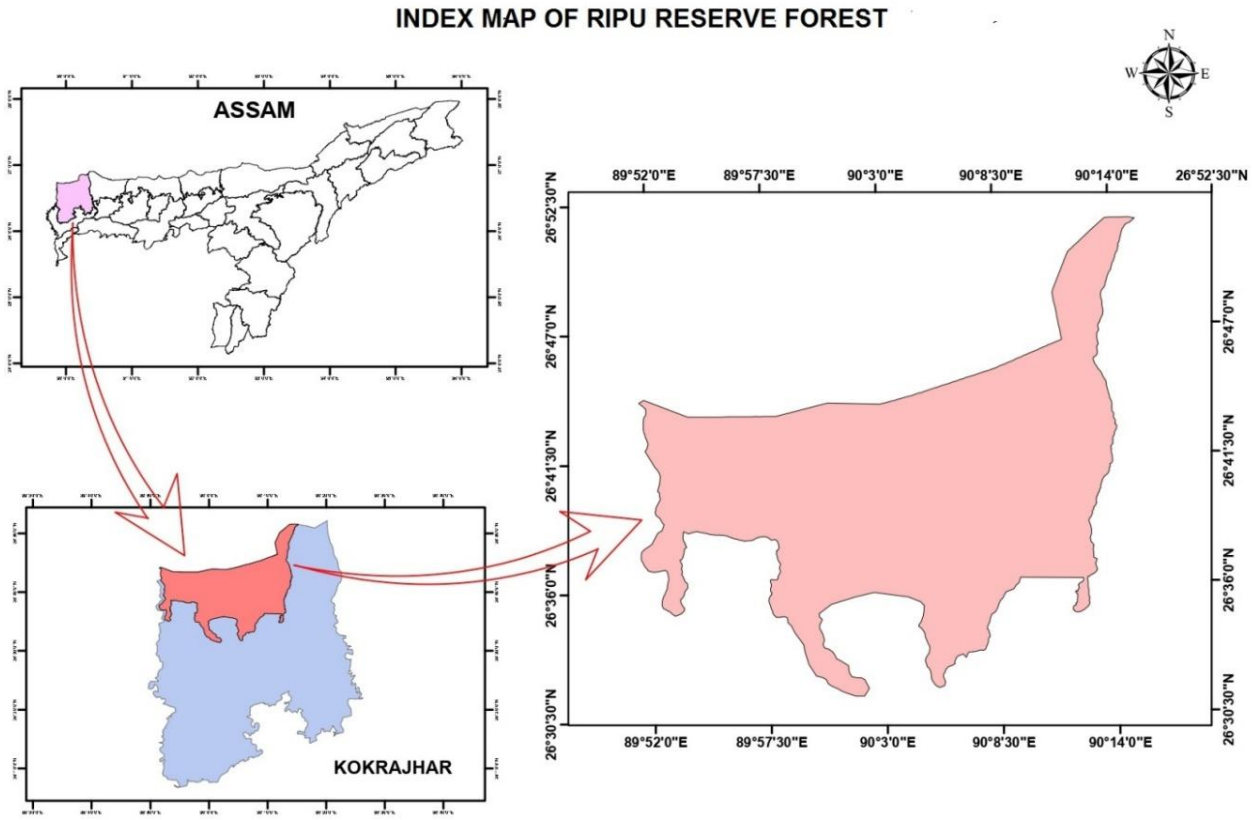
Introduction

Human-induced changes on the Earth's surface are evident everywhere and only a few areas remain in their natural state as 'virgin landscapes.' Most of these are located either at high altitudes, where cold and low oxygen levels deter human habitation, or at high latitudes, where cold temperatures act as natural barriers.

However, in recent times, due to ever-increasing human populations and rapid technological development, even these remote areas are no longer protected and are becoming increasingly vulnerable to anthropogenic activities. In fact, the replacement of natural land cover with human-induced land use categories can be observed in many parts of the world (Geist and Lambin, 2001). Scientific investigation of these changes is essential for effective planning and the sustainable management of natural resources (Verburg et al., 1999; Lambin et al., 2000; Read and Lam, 2002). The advent of remotely sensed satellite observations has fundamentally transformed how scientists study the Earth's surface. Previously, such investigations relied heavily on direct observation or aerial surveys. Today, the potential of remote sensing in vegetation change studies is widely recognized (Hathout, 2002; Lambin et al., 2003). Remote Sensing (RS), when integrated with Geographic Information Systems (GIS), offers a powerful tool for regional analysis, providing timely and cost-effective assessments of natural resources. Ecosystems, dominated by vegetation, support diverse flora and fauna—from microscopic fungi to large mammals. Vegetation plays a vital role in regulating the Earth's climate and providing resources and habitat. Due to both natural and anthropogenic factors, however, these ecosystems are undergoing significant transformations. Anthropogenic changes in LULC are increasingly being recognized as critical drivers of global environmental change (Nagendra et al., 2004). In this study, the Normalized Difference Vegetation Index (NDVI) was used to assess and quantify vegetation density. NDVI, a widely accepted remote sensing index, is especially useful for evaluating vegetation health and density. Its values range from -1 to 1, with higher values indicating healthier vegetation and lower values indicating degraded or sparse vegetation. NDVI is particularly effective for detecting deforestation and forest degradation. Thus, in the present study, an investigation has been undertaken to assess vegetation changes in the erstwhile Ripu Reserve Forest.



Study Area

The area has a deep-rooted mythical and historical significance for the local communities, many of whom have long held traditional ties to the land.

The erstwhile Ripu Reserve Forest originally spanned an area of approximately 615 square kilometers, which is situated in the north-westernmost part of Assam adjacent to West Bengal and in the north the Bhutan international boundary line.

In order to stop the destruction of Ripu Reserve Forest and for its permanent protection, a large part of it (422 square km) was declared as "Raimona National Park" by the Government of Assam via Govt. Notification No. FRW.02/2021/27 dated June 9, 2021 (Islam et al., 2021).

Objectives

To analyze the vegetation change based on NDVI data in the erstwhile Ripu Reserve Forest during 1987 to 2023.

Database and Methodology

The normalized difference vegetation index (NDVI) is a key remote sensing indicator used to assess vegetation health and cover over time. 'The NDVI is used for the mapping of changes in cover' (Woodcock et. al. 2002; Lunetta et. al. 2006). The NDVI is a widely used remote sensing index to quantify vegetation health and density.

The formula of NDVI = (NIR – Red) / (NIR + Red)

Where, NIR = Near Infra-Red

The value of NDVI ranges from -1 to +1. If the value is closer to 1 then it means dense and healthy vegetation and closer to -1 or below 0 means sparse or no vegetation, urban areas, water bodies or bare soil.

This study compares NDVI values across three different years – 1987, 2005 and 2023 to analyze changes in vegetation cover, identify patterns of degradation or recovery and evaluate potential environmental impacts in the study area.

Table 1: Specifics of the images used in the study area

Number of Image	Type	Year	Row	Path	Band
2	Landsat 5	1987-08-12	041	138	4,3
			042	138	
2	Landsat 5	2005-04-13	041	138	4,3
			042	138	
1	Landsat 9	2023-04-07	041	138	5,4

Source: Remote Sensing Data

The procedure of methodology is outlined in the diagram below

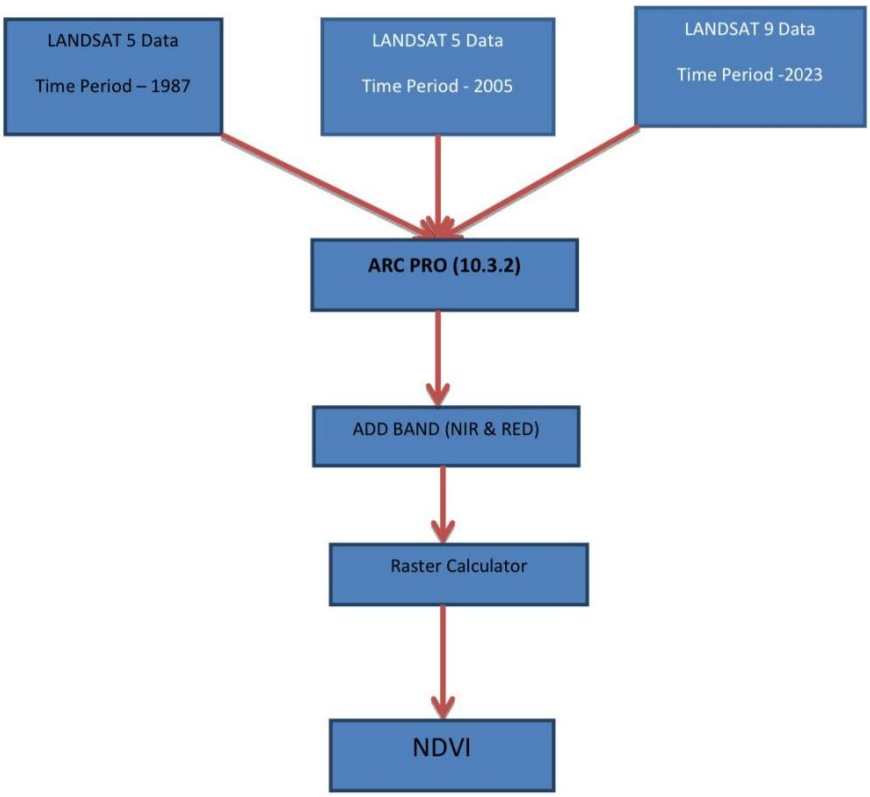


Figure 1. An Outline Diagram of NDVI Methodology

Results and Discussion

NDVI of 1987

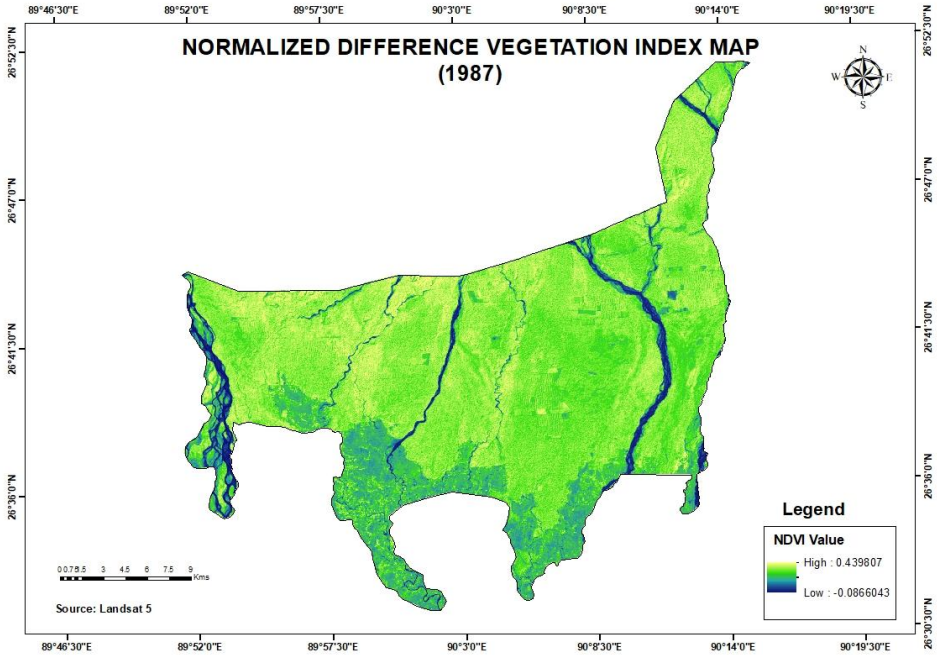


Figure 2. NDVI map of Ripu Reserve Forest - 1987

This NDVI (Normalized Difference Vegetation Index) map from 1987 provides a spatial representation of vegetation health and density in the erstwhile Ripu Reserve Forest. In the Figure 2, the satellite used Landsat 5 and the data acquisition date was 12th August, 1987. In this map the high NDVI value (0.439807) represents healthy and dense vegetation and low NDVI (-0.0866043) indicates water bodies or areas with little to no vegetation.

As per the result, the majority of the area appears green, indicating healthy vegetation cover. Some patches are slightly lighter green, possibly representing agricultural lands or less dense forests. Dark blue areas along river channels represent water bodies. The southwestern and eastern parts have prominent river networks with adjacent lower NDVI values, suggesting wetland areas or sparser vegetation near the water. Certain regions show a mix of green and yellowish patches, which indicate agricultural lands or deforested areas. Thus, different land-use practices indicating elevation and soil moisture differences.

Comparison of NDVI (1987-2005)

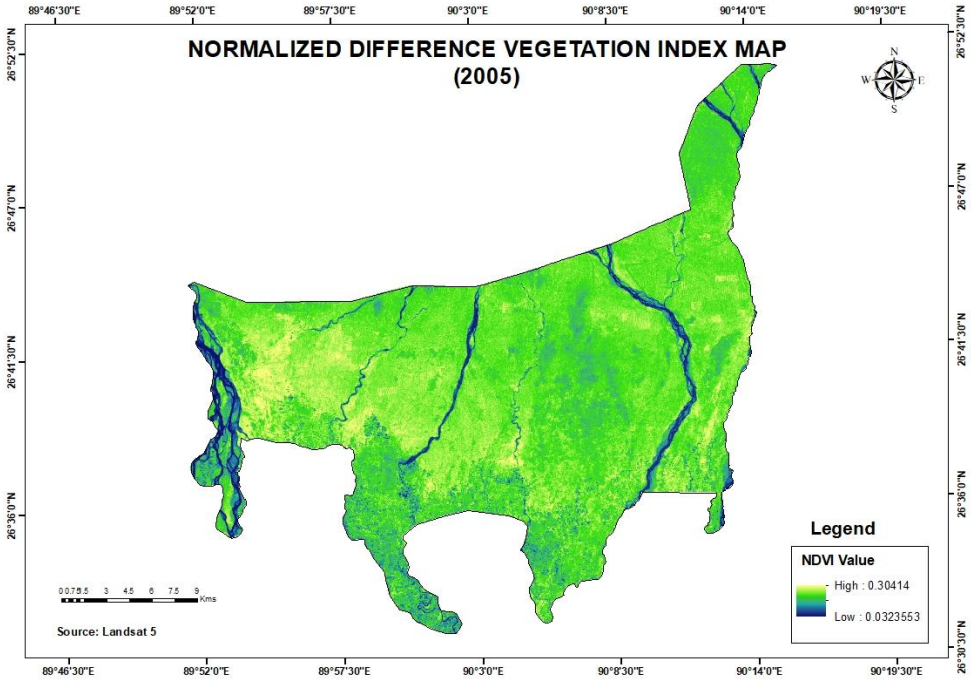


Figure 3. NDVI map of Ripu Reserve Forest – 2005

Table 2. Data Overview

Features	NDVI Map 1987	NDVI Map 2005
Satellite	Landsat 5 (12-08-1987)	Landsat 5 (13-04-2005)
NDVI Range	-0.0866043 to 0.439807	0.0323553 to 0.30414

Source: Remote Sensing Data

The maximum NDVI value in 1987 was 0.439807, whereas in 2005 it dropped to 0.30414. This suggests a decline in healthy vegetation, potentially due to deforestation, land-use changes or climate variations. The areas with lighter green shades in 2005 indicate lower vegetation density compared to 1987.

The dark blue areas, which represent water bodies or non-vegetated areas, appear to have increased in 2005. This could be due to river erosion, flooding or human activities such as sand mining or urbanization. In 1987, vegetation was more uniformly spread, while in 2005, there are more patches of low NDVI. This suggests potential land clearing for agriculture, settlements or infrastructure development.

Comparison of NDVI (1987-2005-2023)

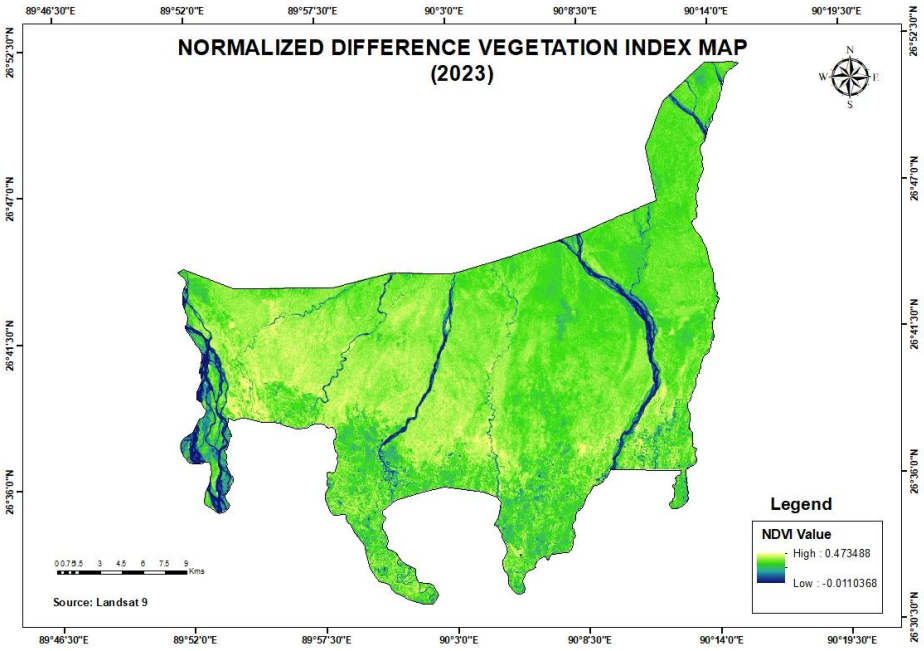


Figure 4. NDVI map of Ripu Reserve Forest – 2023

Table 3. NDVI Comparison

Year	NDVI Range (Low-High)	Source	Key Observations
1987	-0.0866 to 0.4398	Landsat 5 (12-08-1987)	High NDVI, dense vegetation
2005	0.0323 to 0.3041	Landsat 5 (13-04-1987)	Vegetation decline, more barren land
2023	-0.0110 to 0.4734	Landsat 9 (07-04-2023)	NDVI improvement

Source: Remote Sensing Data

There has been a significant decrease in NDVI values from 1987 to 2005. Adverse factors like deforestation, urbanization, or agricultural expansion may have contributed towards such unhealthy changes. The last part of the 20th century was a period of political instability in the study area due to Bodoland agitation which affected the normal works of forest department. According to Nath and Mwchahary, 2012, political instability and insurgency was responsible for large-scale destruction in Ripu Reserve Forest as forest areas were converted into agricultural land and settlement.

In the NDVI Map of 2005, more patchy vegetation can be observed resulting in lower maximum NDVI value of 0.3041 as compared to NDVI value of 0.4398 in 1987. Fortunately, NDVI value has substantially increased in 2023 (0.4734) which is way better than NDVI value of both 1987 and 2005. Possible reforestation efforts, natural recovery, or better agricultural practices may have contributed towards such positive changes.

The fact that a large part of erstwhile Ripu Reserve Forest was declared as Raimona National Park by Government of Assam in the year 2021 resulting in better conservation and protection efforts may have contributed towards such positive changes.

Conclusion

The analysis of NDVI data from 1987, 2005, and 2023 clearly reflects the dynamic changes in vegetation cover in the erstwhile Ripu Reserve Forest over the past three decades. Between 1987 and 2005, there was a noticeable decline in vegetation health, as indicated by a significant drop in NDVI values and increased barren or low-vegetation areas. This degradation can likely be attributed to deforestation, agricultural expansion, and other anthropogenic pressures.

However, the NDVI data from 2023 show a positive trend, with values surpassing even those from 1987. This indicates an overall improvement in vegetation health and density, potentially resulting from natural regeneration, reforestation initiatives, or improved land-use management. The resurgence of green cover, particularly around riverine areas, suggests efforts toward ecological restoration are yielding positive results.

Overall, the NDVI trend from 1987 to 2023 reflects a period of degradation followed by gradual recovery, highlighting both the vulnerability and resilience of forest ecosystems when subjected to human and environmental influences.

Conflict of Interest Statement

The authors declare that we have no conflicts of interest related to the publication of this manuscript.

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