FOREST COVER CHANGE DETECTION USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSYTEM IN KARBI ANGLONG DISTRICT, ASSAM

THESIS

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IN
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BY

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DECLARATION

I hereby declare that the research work entitled "**FOREST COVER CHANGE DETECTION USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSYTEM IN KARBI ANGLONG DISTRICT, ASSAM**" submitted to the department of environmental science, school of earth sciences, Central University of Rajasthan, Ajmer is a record of an original work carried out by me under the supervision of **Dr. Pramod Kamble, Associate** Professor, CURAJ.

This research is being submitted to fulfil the requirements for the award of the degree of Bachelor of Science in Environmental Science.

The results embodied in this research work have not been submitted to any other university or institution for the award of any degree or diploma.

I certify that all sources of information and data are fully acknowledged in the thesis, and the similarity is within the permissible limit.

Place: CURAJ PADMAPRIYA R
Date:

CERTIFICATE

This is to certify that the thesis entitled "***FOREST COVER CHANGE DETECTION USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSYTEM IN KARBI ANGLONG DISTRICT, ASSAM***" by Ms. Padmapriya R (2020IMSES019) submitted to the Department of Environmental Science, School of Earth Sciences, Central University of Rajasthan.

To the best of my knowledge, the results/findings contained in this thesis have not been submitted in part or full to any other University/Institute for the award of any other Degree/Diploma.

Signature of supervisor
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ABSTRACT

Forests offer a variety of ecosystem services that range from regional, economic and social advantages to worldwide ecological benefits. Therefore, it is necessary to monitor changes in forest cover and determine the factors that contribute to such changes in order to formulate sustainable forest management approaches that facilitate the restoration of forests and ecosystem services. The objective of this study is to use the Normalised Difference Vegetation Index (NDVI) approach to assess how the forest cover has changed in a particular area between the years 2001 and 2021 in Karbi Anglong district of Assam. The data was gathered from both Landsat 5 and Landsat 9 satellites, and ArcGIS 10.8.2 software was utilised to generate the NDVI map, NDVI classified map, and change detection category map. NDVI decreased by 713.22 km^2 throughout the research period. 6.85% of the 10413.12 km^2 research area. 4053.6 km^2 of the studied region experienced some NDVI decreases. This represents 38.931% of the research area. NDVI some increased to 4575.2 km^2. The research area covers 43.94% of this. An area of 1071.1 km^2 increased in NDVI during the investigation. 10.29% of the research area is this. This study shows that anthropogenic activities including jhum cultivation, deforestation, encroachment, etc. have changed the study area's forest cover. Loss of forest cover threatens biodiversity and the community's way of life. The present study is expected to serve as a major step towards attaining Sustainable Development Goal 15, and to preserve and protect the region's forests.

CHAPTER-1: INTRODUCTION, LITERATURE REVIEW, OBJECTIVE OF THE STUDY

1. Introduction

Forest is a sophisticated biological system where trees predominate as the main form of life. The most effective ecosystem in nature is a forest, where a high rate of photosynthesis has an impact on both plant and animal systems in a web of intricate biological interactions. Forests may grow in a variety of environments, and the types of soil, plants, and animals that inhabit them vary depending on the severity of environmental impacts (Britannica, 2023). Forests make up over 31% of the world's land surface and are fundamental to terrestrial ecosystems. The amount of forest cover and changes to that cover have a significant impact on ecosystem services, biodiversity, and stipulate crucial feedbacks to human wellbeing. Moreover, changes in forest cover impact the climate through influencing the energy, water, and carbon cycles. Monitoring forest cover at all scales, from the global to the regional, is becoming more and more essential to global change research as the impact of humans on climate change increases (Jia et al.,2014). The strain on forests and their biodiversity is growing due to an increase in the exploitation of forest resources and the development and intensification of agriculture. Deforestation is regarded as the single biggest danger to biodiversity, and it may have an impact on whole landscapes. (Le Moine 2012). Assessment, appraisal, and protection of these fragmented forests are vital from a biodiversity conservation standpoint (Vinayakumar et al., 2016).

Change detection is the practice of spotting alterations in an object's or phenomenon's condition through repeated observation. There is a growing trend, both nationally and internationally, to use RS and GIS approaches to identify changes. RS provides a unique capability for assessing forest cover, and temporal data enables the identification of changes in land cover over time (Freddy et al.,2014). The Normalized Difference Vegetation Index (NDVI) is a newly simplified picture created by dividing near-infrared (NIR) radiation minus red radiation by near-infrared radiation plus red radiation (Huang et al.,2021). NDVI is based on the principle of red radiation absorption by chlorophyll and other leaf pigments, as well as the significant scattering of near-infrared radiation by foliage (Beck et al., 2006). NDVI serves as an indicator for assessing the health of vegetation. This is because any deterioration in the ecosystem's vegetation or a reduction in its greenery would be manifested in a corresponding decrease in the NDVI value (Meneses-Tovar, 2011). The NDVI method uses remote sensing data to determine the vegetation index, classify land cover, and identify various types of terrain such as water bodies, open areas, scrub areas, hilly areas, agricultural areas, thick forests, and thin forests. This is achieved by analysing different band combinations of the remote sensing data (Borkotoky and Bora, 2018).

1.1 Literature Review

In order to quantify natural forest expansion in Basilicata, southern Italy, research was carried out utilising Landsat TM data and NDVI differencing to identify vegetation change. The paper suggests an assessment of vegetation change due to natural forest expansion for the Basilicata area of southern Italy from 1984 to 2010 based on the NDVI differencing approach. The goal of the study is to identify a threshold for the detection of vegetation change, develop a method for pre-processing Landsat TM imagery, and identify a procedure for NDVI differencing. It also aims to identify the main patterns of the natural expansion of forests in Mediterranean environments (Mancino et al.,2014). Research has been done on the use of NDVI techniques to determine how the forest cover has changed in a portion of the Bandarban Hill Tracts. The study shows that this region's forest cover has altered significantly as a result of both natural and anthropogenic activity (Nath, 2014). In North-East India, a study has been done on analysing deforestation rates, spatial forest cover changes, and identifying crucial locations of forest cover changes. The land use methods include actions for harvesting timber, permanent agriculture, shifting cultivation, mining, etc. The main factor contributing to forest fragmentation has been identified as the practice of shifting cultivation, or jhum. It causes the conversion of dense forests into open forests as well as non-forest activities like shifting cultivation. With the use of a geographic information system, the purpose of this paper is to illustrate the processes of forest cover change occurring in North-East India (Lele and Joshi, 2009). In Lower Assam, India, research has been carried out to evaluate the change in land use and land cover (LULC). This study's NDVI-based categorization revealed considerable changes in land use and cover between 1990 and 2014. The area with the most forest cover is where the massive change was discovered. The development of agriculture and human invasion were the major causes of the changes (Singh et al.,2016).

1.2 Objectives

The objectives of the study involve

- Detecting the forest cover change using geospatial methods, specifically by using NDVI in the study area
- Generate NDVI map of the study area during 2001-2021
- Generate NDVI derived classified map of the study area during 2001-2021
- Generate image difference and spatio temporal change detection map

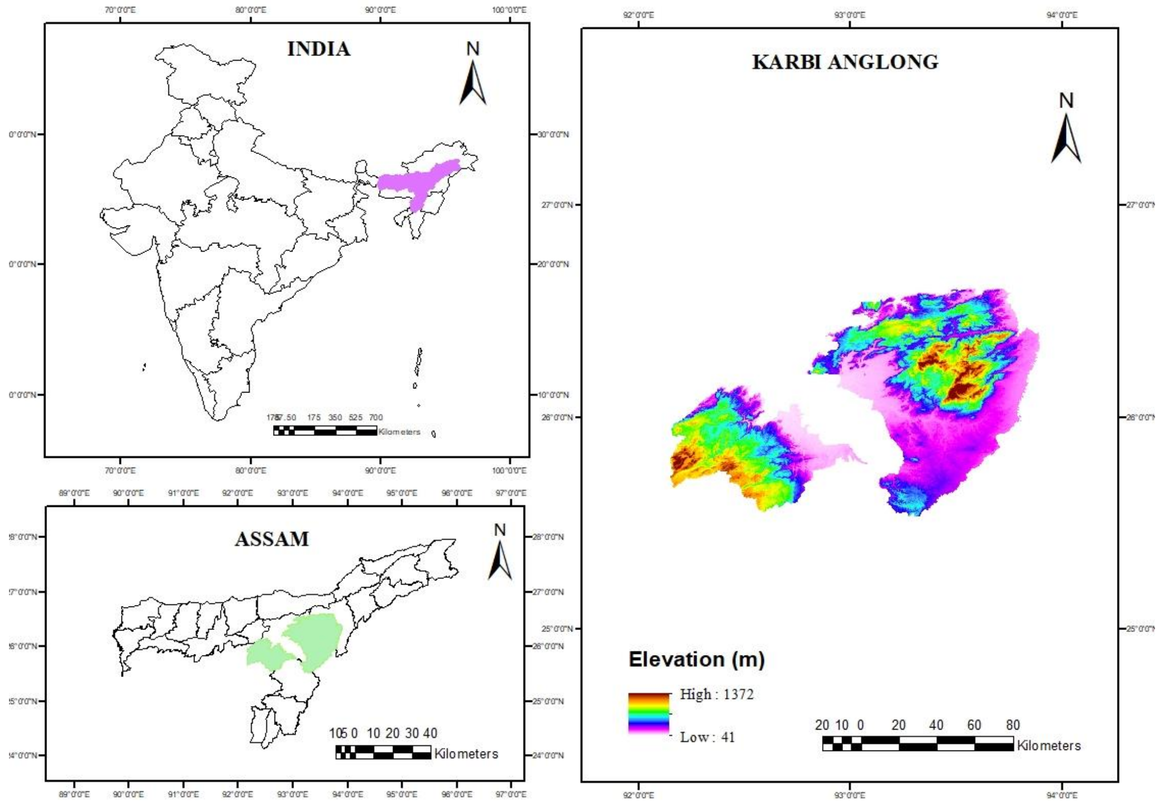

Figure 2.1 Location map of study area

2. Introduction

The location of Karbi Anglong in terms of latitude and longitude is between 25° 33′ and 26° 35′ north and 92° 10′ and 93° 50′ east, respectively (Fig. 2.1). It is situated in the central part of Assam, and the district is made up of both plains and hills. Two areas of the Karbi Anglong region are divided from one another by the constricting Kopili alluvial plain and its rivers. Golaghat District borders the district on the east and north, Meghalaya State and Morigaon District border it on the west, and Nagaon and Dima Hasao Districts and Nagaland State border it on the south.

2.1 Climate

Many portions of this hill region endure diverse climates as a result of the topographic diversity. Temperatures range from 6 to 12 °C in the winter and 23 to 32 °C in the summer. Around 2416 millimetres of precipitation are averaged annually. The soil pH varies from 4.1 to 6.2 in different areas. The variety of meteorological elements such as heavy rainfall, warm temperatures, humidity, and the weather have led to the formation of abundant woods.

2.2 Physical features

Almost 85 percent of the entire land area of 10,434 square kilometres is comprised of undulating hills. It is a wildlife refuge and a biodiversity hotspot inside the Himalaya biodiversity hotspot. It is home to several rare, unique, and endangered species of flora and fauna, as well as a gene bank containing the wild stock of numerous cultivated crops. Around 7,983 square kilometres, or 76.5% of the land surface, is covered by forest, which is comprised of very dense forests covering 586 square kilometres (7.3%), moderately dense forests covering 3,801 square kilometres (47.6%), and open forests covering 3,596 square kilometres (45.1%).Moist semi-evergreen forests, Moist Mixed Deciduous forests, Riverain Type, and Various Type with scattered pure or mixed patches of bamboos, are the significant forest types found in Karbi Anglong District. Rural residents make up the majority of the district's population, which totals 9,56 ,313 people, of which 8,43,347 (88.2%) live in rural regions and 1,12,966 (11.8%) live in urban areas. Agriculture is the primary source of income for the population together with Horticulture, Livestock, Plantation, Weaving and Sericulture (Wikipedia).

CHAPTER-3 METHODOLOGY

3.1 Data

The major objective of this research is to provide a quantitative evaluation of changes in forest cover in the Karbi Anglong district of Assam using Normalized Difference Vegetation Index (NDVI). We obtained the data from USGS Earth Explorer by selecting cloud-free, 30 m-resolution, Landsat 5 and Landsat 9 satellite images during November and December 2001 and 2021, when vegetation is at its verdant best and bare soil is most distinct. Remote sensing and GIS software, ArcGIS 10.8.2 were used for digital image processing.

3.2 Methodology

The Normalised Difference Vegetation Index (NDVI), one of the most commonly used indices for vegetation monitoring. NDVI maps are produced by combining the red and NIR bands. NDVI is computed as a ratio between the red (R) and near infrared (NIR) values:

$$NDVI = \frac{(NIR - R)}{(NIR + R)} \dots\dots\dots\dots\dots\dots\dots.(1)$$

The values of the NDVI ranges from -1.0 to +1.0. When the NDVI index has a negative value, it indicates that there is a presence of water, snow and cloud. Furthermore, a number of zero denotes the presence of barren land and rocks, while a value in the positive range indicates the presence of a variety of various types of vegetation. The Natural Breaks (Jenks) approach is used to classify the NDVI map and generate the NDVI derived classified maps, and this is categorized into five categories: very low, low, moderate, high, and very high, based on the NDVI values obtained. With the goal of determining if forest cover changes have had a positive or negative impact, an image difference map between 2001 and 2021 is created using NDVI maps and a change detection category map have also been made which was further classified as NDVI decreased, some decreased, some increased, increased.

The same approach that is natural breaks is used in this classification also. Figure 3.1 illustrates the methodology adopted in this study.

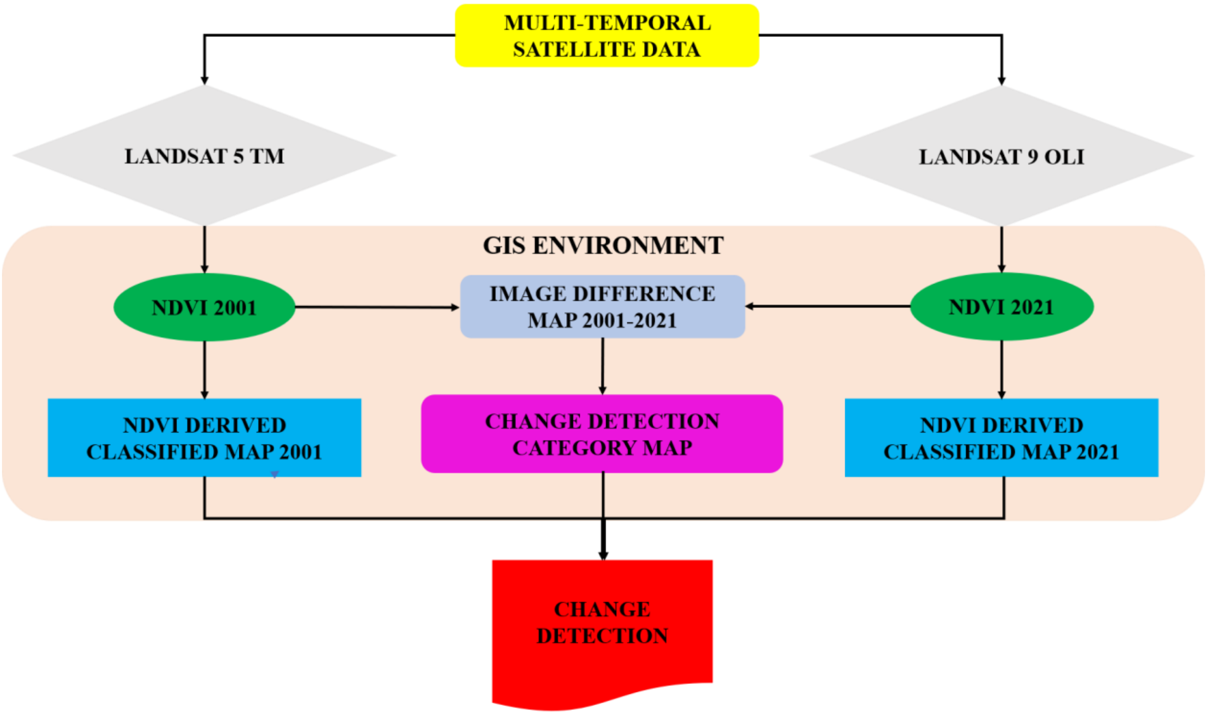

Figure 3.1 Methodology Flowchart

4. Introduction

Satellite-based remote sensing offers a synoptic method for monitoring land use and land cover aspects across time, and it is playing an essential role in determining the extent to which forest cover is changing (Anand et al.,2018). The normalized difference vegetation index is an indicator that was established for the purpose of assessing the cover of vegetation based on reflective bands of satellite data. NDVI pictures that were generated could be used to determine the pattern of shifts that had taken place between two distinct times (Sahebjalal and Dashtekian, 2013). The NDVI method is used to evaluate the loss of forests (Bid, 2016). NDVI is notably useful for forest cover change detection due to its ability to cover extensive areas and provide a consistent, continuous record of vegetation cover over time. This allows for the large-scale detection and monitoring of forest cover changes over time. As a result of their greater verdant biomass, forest areas tend to have higher NDVI values (Forkuo and Frimpong, 2012). A drop in NDVI values over time could be a sign of deforestation or forest cover deterioration. On the other hand, a rise in NDVI values may signal reforestation or a rise in forest density.

In this study,

$$NDVI = \frac{(Band\ 4 - Band\ 3)}{(Band\ 4 + Band\ 3)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.(2)$$

is the formula used for Landsat 5 image which was taken in the year 2001.

$$NDVI = \frac{(Band\ 5 - Band\ 4)}{(Band\ 5 + Band\ 4)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.(3)$$

is the applied equation for the 2021 Landsat 9 data set.

4.1 NDVI calculations using Landsat data

From the satellite images, we could gather data on the vegetation. The NDVI spectral index can be used to do this. NIR and Red bands are used to calculate NDVI. In 2001 Band 4 is considered to be NIR and Band 3 is red band. In 2021 Band 5 is the NIR band and Band 4 is the red band. Created the NDVI map by applying the required formula. Analyse the NDVI map to find changes in forest cover. Low NDVI values imply sparse or non-vegetated environments, whereas high NDVI values indicate abundant vegetation. We can observe the changes in forest cover and track the health of the forest by comparing the NDVI map across the 20-year period between 2001 and 2021 (Fig.4.1a,4.1b). In 2001, 0.557989 was the highest NDVI value, while -0.367064 was the lowest. In 2021, the highest NDVI value was 0.959927 and the lowest value was -0.22767. There is a high amount of NIR reflectance in the year 2021 which indicates the presence of healthy vegetation.

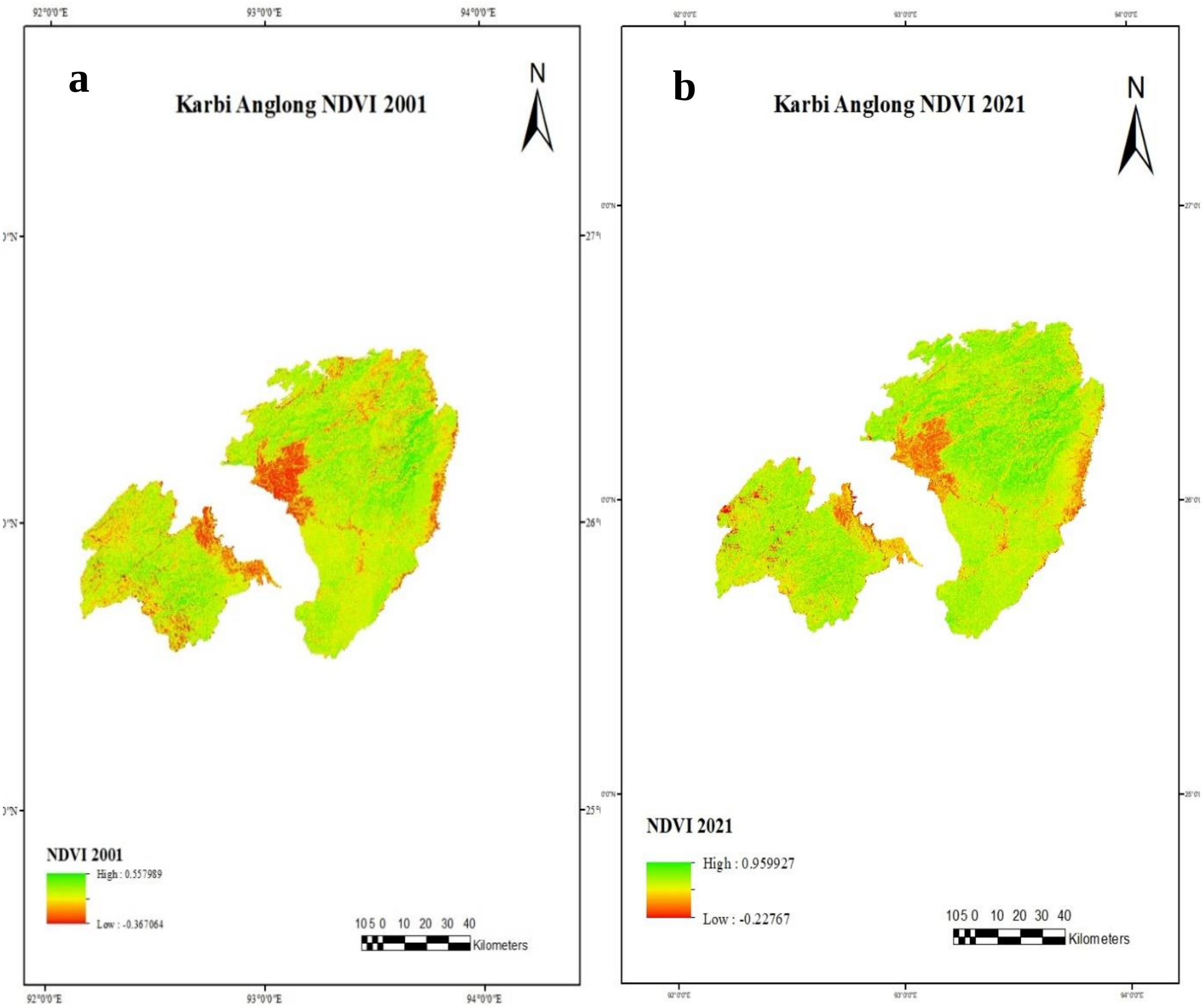

Figure 4.1 NDVI map of Karbi Anglong (a) 2001, (b) 2021

The NDVI-derived classified maps (Fig. 4.2a,4.2b) shows several degrees of vegetation density or greenness in the region of interest, which have been classified as very low, low, moderate, high, and very high NDVI. The classified map of NDVI exhibits an identifiable alteration over a period of two decades, specifically between 2001 and 2021. Very low NDVI locations are devoid of vegetation, such as bare soil or water. Low NDVI values could be a sign of sparse vegetation, such as grassland or shrubland. Moderate NDVI values indicate a more dense plant cover, such as in a forest or agricultural area. High NDVI values often indicate highly dense vegetation, such as tropical rainforests. Very high NDVI values may be seen in regions with substantial plant cover, such as dense tropical forests. Categorised maps can offer insights into the patterns and density of local vegetation when utilised for various purposes, including monitoring changes in land use, assessing crop health, and looking into the effects of climate change on vegetation.

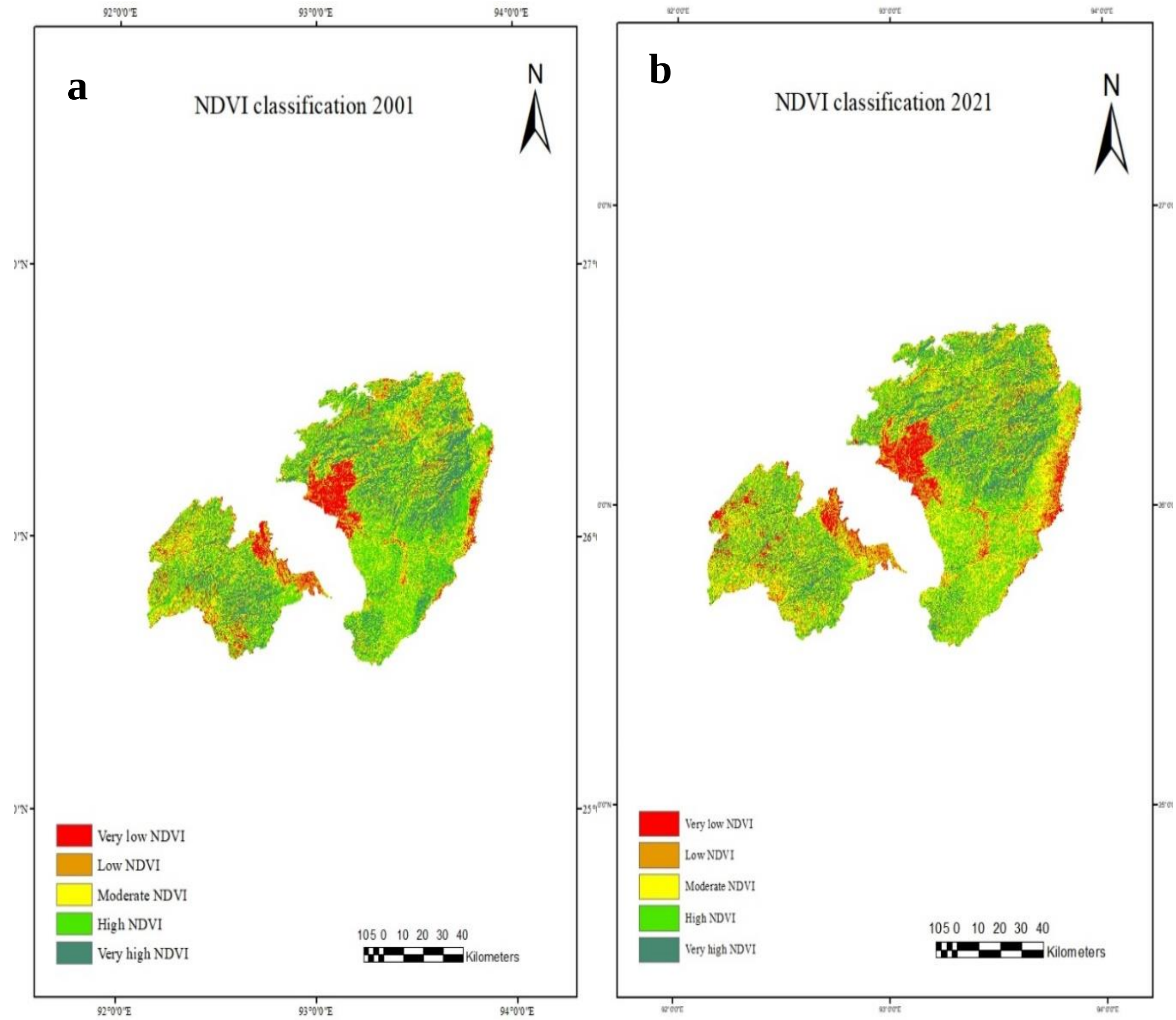

Figure 4.2 NDVI Derived classified map of Karbi Anglong (a) 2001 (b) 2021

Table 4.1 NDVI derived changes of Karbi Anglong during 2001 - 2021

Class	Area (km^2)		%		Change (km^2)	Change (%)
	2001	2021	2001	2021		
Very low NDVI	739.0044	745.9083	7.09298	7.1591811	6.9039	0.066200636
Low NDVI	1190.227	1565.094	11.42382	15.021674	374.867	3.597849205
Moderate NDVI	2505.42	2910.029	24.04708	27.930276	404.609	3.883199713
High NDVI	3662.985	3236.696	35.15741	31.065605	-426.289	-4.091805208
Very high NDVI	2321.177	1961.178	22.27871	18.823264	-359.999	-3.455444346

The empirical evidences (Table 4.1) indicates that alterations have occurred in the extent of land occupied by each classification of the Normalised Difference Vegetation Index (NDVI) over the period that extends from 2001 to 2021, whereby certain categories have undergone expansion while others have undergone a decrease. The low NDVI category has experienced a 3.5978% increase in area, equivalent to 374.867 km^2, while the moderate NDVI category has also shown a significant increase in area, by 3.8832%, or 404.609 km^2. Conversely, the High NDVI category has experienced a notable decrease in area, by -4.0918%, or 426.289 km^2. The areas corresponding to the categories of very low NDVI and very high NDVI have exhibited a decrease of 7.09298 km^2 (0.0662%) and 359.999 km^2 (-3.4554%), respectively. The alterations observed in the NDVI classifications indicate that there have been modifications in the vegetation coverage within the examined region from 2001 to 2021. The observed expansion of low and moderate NDVI categories may suggest a corresponding increase in vegetation density and health, whereas the observed decrease of high, very low, and very high NDVI categories implies a reduction in vegetation density and health. Figure 4.3 graphically represents the variations in the NDVI in Karbi Anglong.

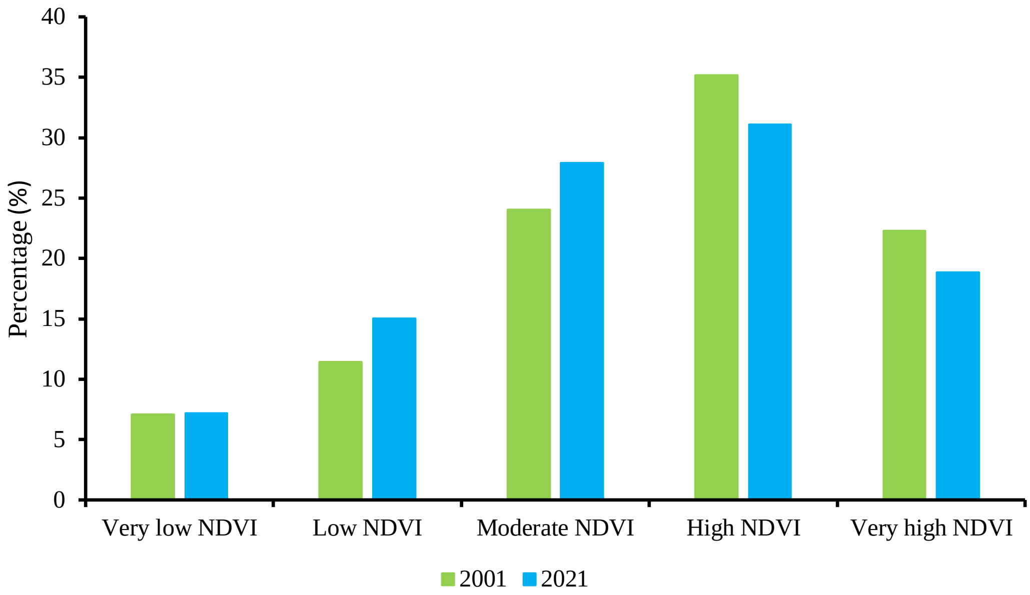

Figure 4.3 Graphical representation of changes in NDVI during 2001 – 2021

4.2 Spatio-temporal change detection

After creating an NDVI derived classified map, the researcher concentrated on the general change in forest cover in the study region that was shown by an image difference map created using images from 2001 and 2021(Fig. 4.4a), two separate years of study. Identification of changes is a useful indication for describing and comprehending changes that take place during the research period. The pixels with low values are located in the region where the NDVI has decreased, whereas the portion where the NDVI has increased is characterised by high pixel values (Nath 2014, Nath and Acharjee, 2013) NDVI values were classified as decreased, some decreased, increased, some increased. ArcGIS 10.8.2 software was used for change detection and value-based classification map generation (Fig. 4.4b).

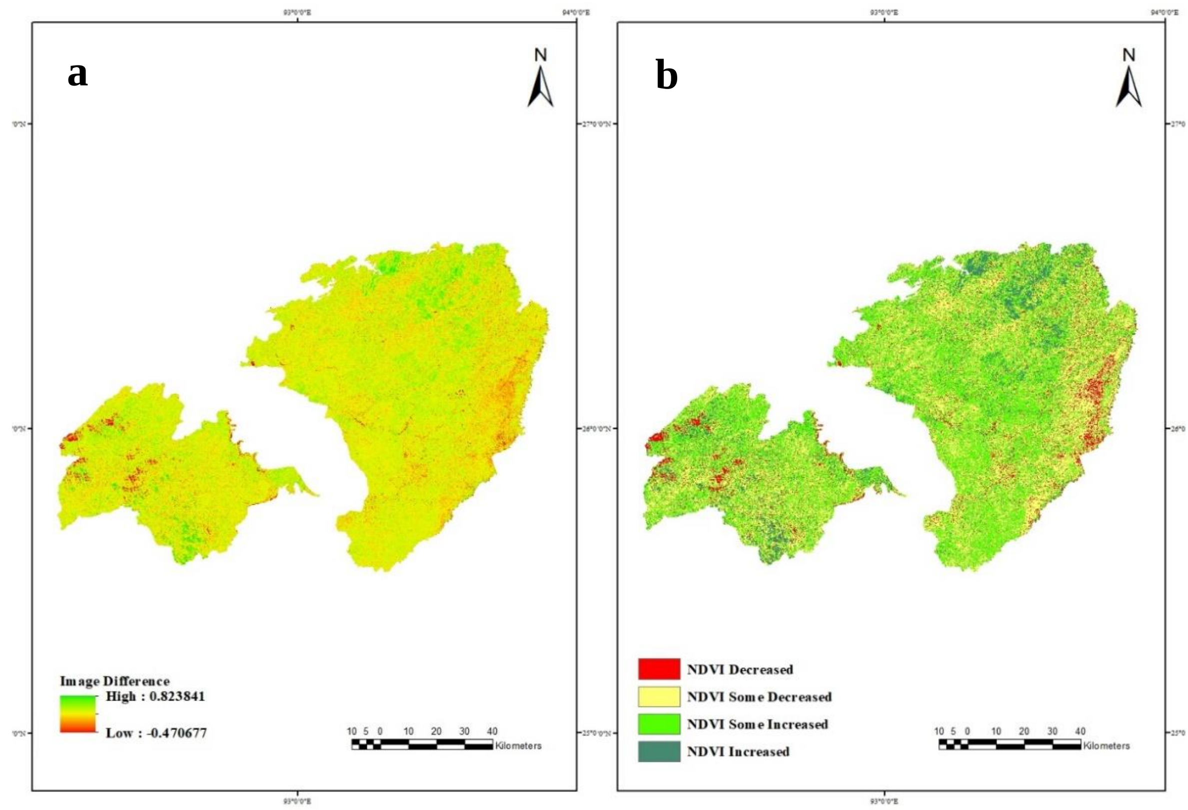

Figure 4.4 (a) Image difference map based on NDVI during 2001 – 2021 and **(b)** Change detection category map based on NDVI during 2001 – 2021.

In accordance with the change in NDVI, the data is categorised into four categories (Table 4.2 & Fig. 4.4b):

i. NDVI Decreased: During the research period, an area of 713.22 km^2 showed a reduction in NDVI. This is equivalent to 6.85% of the 10413.12 km^2 research area.

ii. NDVI some Decreased: Within the course of the study period, an area of 4053.6 km^2 had some NDVI decline. This accounts for 38.931% of the entire research area.

iii. NDVI Some Increased: The NDVI increased in a 4575.2 km^2 region. This is equivalent to 43.94% of the entire research area.

iv. NDVI increased: Over the course of the research, an area of 1071.1 km^2 showed an increase in NDVI. 10.29% of the whole research area is represented by this.

The results indicate that between 2001 and 2021, there was a mixed change in the health and density of the vegetation in the study region. A wider area witnessed some decrease, some increase, or an increase in NDVI whereas a very small area saw a decrease. It's important to note that the change's intensity varied, with some regions seeing more significant alterations than others.

Table 4.2 NDVI Change detection of Karbi Anglong during 2001 - 2021

NDVI Change Category (2001-2021)	Area(km^2)	% Change
NDVI Decreased	713.22	6.849244031
NDVI Some Decreased	4053.6	38.92781414
NDVI Some Increased	4575.2	43.93687963
NDVI Increased	1071.1	10.2860622

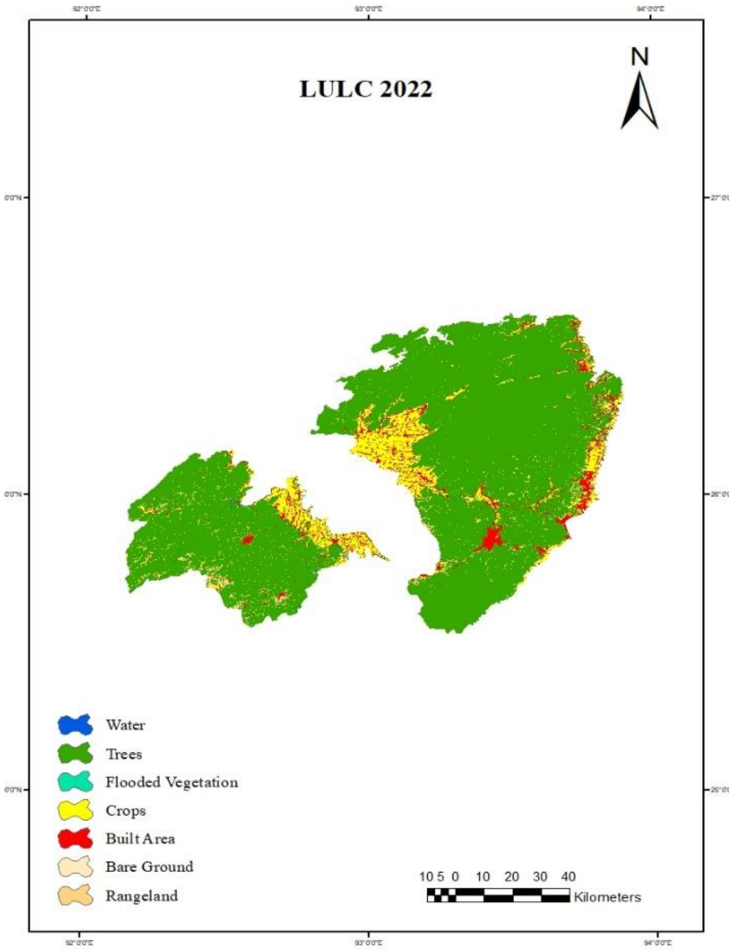

Figure 4.5. Land use /land cover map of the Karbi Anglong district (Esri 2022 land cover)

Fig 4.5 shows the major land use/land cover types in the study area. The overall evaluation of this study has made it clearly evident that the study area's forest cover is changing. Deforestation, encroachment, and inappropriate land use are the primary causes of this loss in forest cover. The illegal harvesting of timber, mining, and clearing of land for agricultural and infrastructure development are other significant factors in the alteration of the forest cover. The region's biodiversity and the way of life of the inhabitants that depend on the forests have serious consequences when there is a loss of forest cover. Thus, the study area's changing forest cover is a cause for concern. To maintain the preservation and sustainable management of the region's forests, sustained efforts are required.

4.3 Recommendations

i. Encourage the use of sustainable forestry techniques, including planting new trees, agroforestry, and selective logging. This can support economic growth while also preserving the health of the forest environment.

ii. Enhance forest management and law enforcement: Ensure that the study area's forests are properly managed and that the country's strict anti-poaching and illicit logging laws are upheld.

iii. This study's findings on forest cover pattern can serve as a valuable foundation for conducting a more in-depth examination of the spatial and temporal trends of vegetation changes in areas that have been degraded.

iv. Engage local communities in forest conservation in conservation efforts and provide them incentives to support the protection of the forest. This can include initiatives that support ecotourism and instruct participants in sustainable forestry techniques.

v. Increase public understanding of the value of forests: Educate the people on the value of forests for maintaining biodiversity, regulating the climate, and sustaining local economies. This may be accomplished through a variety of strategies, including media campaigns, public outreach initiatives, and educational initiatives in schools.

vi. Further research is necessary to investigate the vegetation potential in order to preserve the ecological balance of these areas.

CHAPTER-5 SUMMARY AND CONCLUSION

5.1 Summary

The NDVI approach has proven to be an effective tool for analysing the dynamics and health of vegetation. The technique involves quantifying vegetation cover and health by measuring the difference in reflectance between near-infrared and visible light. The objective of the research was to identify a change in the forest canopy over a period of time, with particular emphasis on the reduction in the forested region observed at the conclusion of the study in the year 2021.

On the basis of the data, it can be inferred that in the year 2001, the region with the greatest expanse of vegetation exhibiting a high NDVI value was measured at 3662.985 km^2. This was subsequently followed by an area of 2321.177 km^2, which exhibited a very high NDVI value. The vegetation exhibiting a very low NDVI had the smallest coverage area, measuring 739.0044 km^2.In the year 2021, there was a reduction in the extent of vegetation cover with a high and very high Normalised Difference Vegetation Index (NDVI), measuring 3236.696 km^2 and 1961.178 km^2, respectively. Conversely, there was an increase in the extent of vegetated regions exhibiting low and moderate NDVI, measuring 1565.094 km^2 and 2910.029 km^2, respectively. There was a slight increase in the extent of vegetation with a very low NDVI, which covered an area of 745.9083 km^2.

5.2 Conclusion

The research findings suggest that the use of NDVI analysis can be regarded as an effective mechanism for observing alterations in forest coverage over a period of time. The NDVI maps have revealed a general reduction in forest coverage within the Karbi Anglong district of Assam during the period ranging from 2001 to 2021. The trend of a notable decrease in forest cover is supported by the image difference map. The adverse effects of this situation on the regional ecosystem and biodiversity, as well as on the sustenance of the local population, which is dependent on the forest for their livelihoods, are notable. The study's results emphasise the necessity of implementing efficient conservation and management plans to safeguard forest resources in the Karbi Anglong district and other regions encountering comparable circumstances.

The results of the research could potentially make a valuable contribution to the continuous endeavours aimed at the sustainable monitoring and management of forest resources. In order to address the negative impacts of a change in forest cover, it is essential to implement suitable policies and strategies that facilitate the conservation, restoration, and sustainable use of forests. Moreover, additional investigation and monitoring are important to acquire a greater understanding of the factors accelerating changes in forest cover within the studied region and to determine the most efficient management measures.

5.3 Shortcomings of The Study

One potential limitation of the study refers to the absence of ground-truthing or validation of the NDVI outcomes. The absence of empirical data obtained from fieldwork may pose challenges in ascertaining the accuracy of the outcomes or in identifying the specific factors that underlie changes in forest cover within the studied area.

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