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Research Paper

Monitoring Of Deforestation and Forest Degradation Using Normalized Difference Vegetation Index (NDVI): A Case Study of Imphal and Its Umland

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ABSTRACT:
A large portion of the carbon dioxide that might otherwise contribute to climate change is absorbed and stored by trees and forests. The atmosphere's temperature and oxygen content are both stabilized by forests. That capability is lost in deforested areas, and more carbon is released. Imphal forest vegetation cover has experienced continuous degradation and defragmentation during the past decades due to the expansion of built-up areas. Together, remote sensing and GIS are complementary technologies that improve the management, monitoring, and mapping of forest resources. This study focuses on the monitoring of forest degradation and deforestation in Imphal city and its Umlandwhere there is city influence. In order to determine a vegetation index for the categorization of vegetation and non-vegetation classes, the Normalized Difference Vegetation Index (NDVI) was used with LISS III data. Three categories of land cover—low vegetation, high vegetation, and non-vegetation areas were the outcome. Planners will be assisted by the knowledge obtained from the results in their future planning for the preservation of vegetation in urban areas.

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I. INTRODUCTION

Forests are vital to life on Earth. They purify the air we breathe, filter the water we drink, prevent erosion, and act as an important buffer against climate change (WWF, 2022). Forests have a significant impact on the availability and, particularly, the quality of water. Forested catchments act as guarantors of valuable drinking and surface water (Carina, 2008). It is well recognized that trees have an influence on the ecosystem's hydrological cycle and the availability and quality of the resulting water (Brown and Binkley, 1994). Numerous international and national policies have been proposed to protect forests in response to deforestation affecting river flow.

In forestry, Remote Sensing and GIS are utilized to quickly and digitally create comprehensive maps. More precise information regarding changes or occurrences that have taken place inside and outside the forest may be obtained from the periodic updates on forest activities. We can foresee or lessen the effects of disasters with the added advantage of monitoring the forests. We can obtain more detailed data regarding forest coverage by combining multispectral satellite and drone image technologies. One of the major applications of remotely sensed data obtained from earth-orbiting satellites is change detection because of the repetitive coverage at short intervals and consistent image quality (Anderson 1977, Ingram et al. 1981, Nelson 1983, Singh 1984). Change detection is one of the primary applications for remotely sensed data from earth-orbiting satellites due to the repeating coverage at frequent intervals and consistent image quality.

The Imphal River's identity is fading, mostly due to variations in rainfall patterns, an ever-increasing amount of deforestation, and pollutants. Large-scale deforestation in the upstream region can be the main reason for the drying up of rivers running across the state and Imphal in particular. This phenomenon also leads to unreliable and unpredictable changes in rainfall patterns, which cause problems in both water availability and quality. High runoff and less infiltration occur due to the felling of trees.

The objectives that were taken into account for this study are listed below:
1. To identify the vegetation cover present and their geographical distribution;
2. To create NDVI and spatiotemporal change maps;

3. To assess how the distribution of vegetation has changed over time.

II. DATA AND METHODOLOGY

2.1 Study Area and Data collection

The present study area covers Imphal, the capital city of Manipur and its surrounding Umland, which is located between 24° 74' and 25° 00' north latitude and 93° 74' and 94° 00' east longitude at a height of about 786 meters above sea level. A sub-tropical or humid sub-tropical climate characterizes this area. Imphal experiences an average maximum temperature of 29.4 °C in June and an average lowest temperature of 4.3 °C in January. The amount of rainfall annually is 1518.36 mm. July is the wettest month, with 253 mm of rainfall. January and February are the driest and least wet months (12.8 mm and 13 mm, respectively). Agricultural land, built-up land, dense and open forest, dense shrubs, barren ground, wetlands, plantations, and water bodies, including reservoirs, lakes, rivers and their tributaries, and numerous ponds, are the main forms of land cover that predominate in the area.

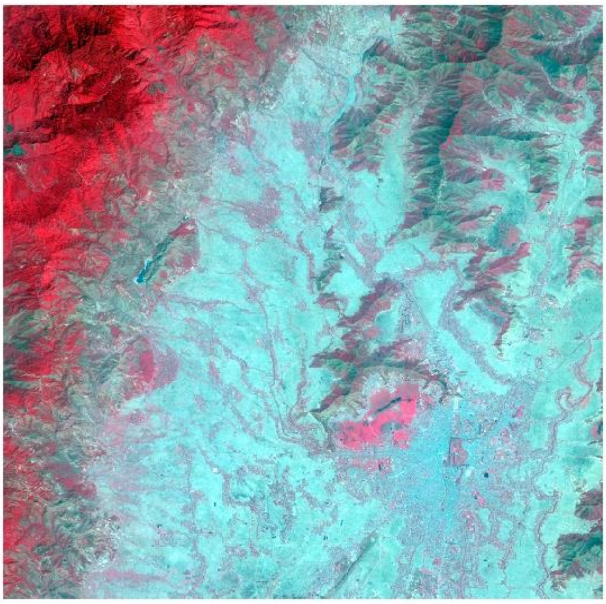

Figure 1. False Colour Composite of Imphal and its umland(Source: Bhuvan**)**

The research was conducted using LISS III satellite data for the years 2008 and 2019 and geometrically corrected products of Resourcesat-1 (IRS-P6) from Bhuvan. Table 1 displays the specifics of the satellite data. The data was originally imported as 4 bands (Band 2, 3, 4, and 5), used floats, and exported into TIFF format as a composite multispectral image.

Particulates	
Satellite	Resourcesat -1(IRS – P6)
Sensor	LISS - III
Temporal Resolution	24 days
Spatial Resolution	24 m
Year	2008 and 2019
Altitude	817 km
Spectralresolution	4 (band 2, 3,4,5) B2 0.52 – 0.59 (microns) B3 0.62 – 0.68 B4 0.77 – 0.86 B5 1.55 – 1.70
Radiometricresolution	8 bits
Swath	141 km

Tab. 1: Details of the satellite image

2.2: *Satellite Image Processing*

The different characteristics shown in the 4-band satellite image of the Imphal area are extracted using the NDVI technique. One of the most significant biophysical indicators of soil erosion is plant cover, which can be assessed using vegetation indices obtained from satellite images. An overview of the methodology is shown in the flowchart, Figure 2. This study can be classified into 4 steps: 1) image pre-processing; 2) NDVI threshold; 3) vegetation reclassification; and 4) image differencing. The satellite imagery was orthorectified imagery from IRS-Resourcesat-2.

Using vegetation indices, we can map out the distribution of vegetation based on the distinctive reflectance patterns of plants. By measuring the difference between near-infrared light, which vegetation strongly reflects, and red light, which vegetation absorbs, the Normalized Difference Vegetation Index (NDVI) measures vegetation

The formula is:

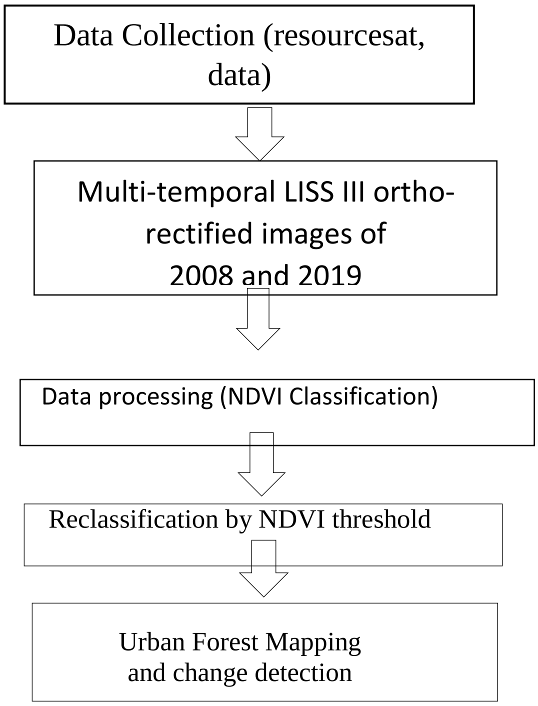

Figure 2. Flowchart of Methodology

where NIR refers to near-infrared reflectance and RED is for visible red reflectance. The red band's wavelength range is 600–700 nm, whereas the NIR band's is 750–1300 nm. NDVI has a scale of -1 to +1. Negative values indicate the presence of water. Likewise, if the NDVI score is near +1, there is a good chance that it is a canopy of dense green leaves. If the NDVI is nearly 0, there are probably no green leaves present, and it may be an urban area.

For both years 2008 and 2019, an NDVI image was created using the sub-scene bands 3 and 4, and the images were then differentiated to look for changes. The software's (ArcGIS Desktop 10.8)raster calculator was used to create NDVI image applying its formula as float(band 4-band 3)/(band 4+band 3)to generate values between -1.0 and 1.0. The resultant image was then reclassified based on the standard value into 3 vegetation groups as in Tab.2.(Hashim, Hussam&AbdLatif, Zulkiflee& Adnan, Nor.,2019).

$$\text{NDVI} = \frac{(\text{NIR - Red})}{(\text{NIR + Red})}$$

Vegetation Classes	Description	NDVI Range
NonVegetation	Barren areas, build up area, road network, water	-1 to 0.199
Low Vegetation	Shrub and grassland	0.2 to 0.5
High Vegetation	Temperate and Tropical forest	0.501 to 1.0

Tab. 2: vegetation classes and NDVI value

The categorization outcome was then compared with the ground truth data for purposes of verification.
Finally, in the 4th step, the NDVI-classified image was differentiated using the image differencing tool in the software for change detection. In order to differentiate, an image calculator built into the software was used to subtract the 2019 NDVI picture from the 2008 NDVI image.

III. RESULT AND DISCUSSION

Depending on their characteristics, various surfaces will reflect, transmit, and absorb a proportionate quantity of radiation. The index makes use of the differences between red and NIR band features, specifically the red band's absorption of chlorophyll pigment and the NIR band's high reflection of plants. Red light is reflected more by bare surfaces and water than by thick green foliage, which reflects far less red light. The NDVI readings for bare soil are often near 0.

Using remote sensing and GIS, three different types of land cover in the research region were retrieved and categorized. Figure 2 displays the outcomes of NDVI threshold-based urban vegetation mapping, with dark green denoting high vegetation, yellow denoting low vegetation, and red denoting non-vegetation areas. The changes can be clearly seen in the Figure 2 NDVI maps.

Between 2008 and 2019, there was a significant loss of forest cover, which fell by 507 sq. km over an 11-year period. This figure is clearly shown in Table 2. Equivalent to a reduction of 19.17% from the prior year.

Total forest area 2008 (sq. km)	Total forest area 2019 (sq. km)
2644	**2137**

Table 2. Total forest area

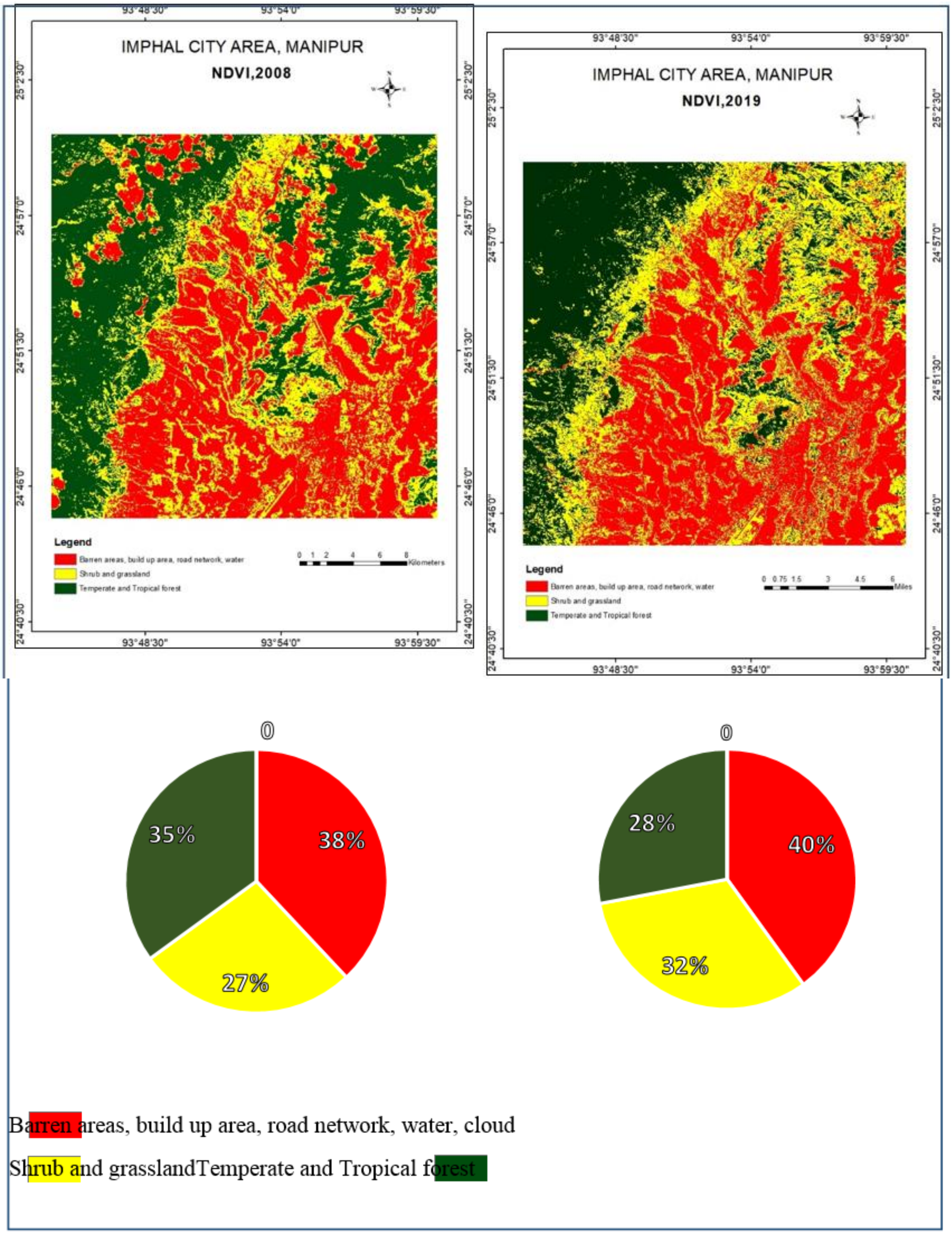

Fig. 2: NDVI threshold classification map of the 2008 and 2019

The image differencing result of the post image from the pre image is shown in Figure 3, where light shades indicate high changes while darker shades are less changed areas.

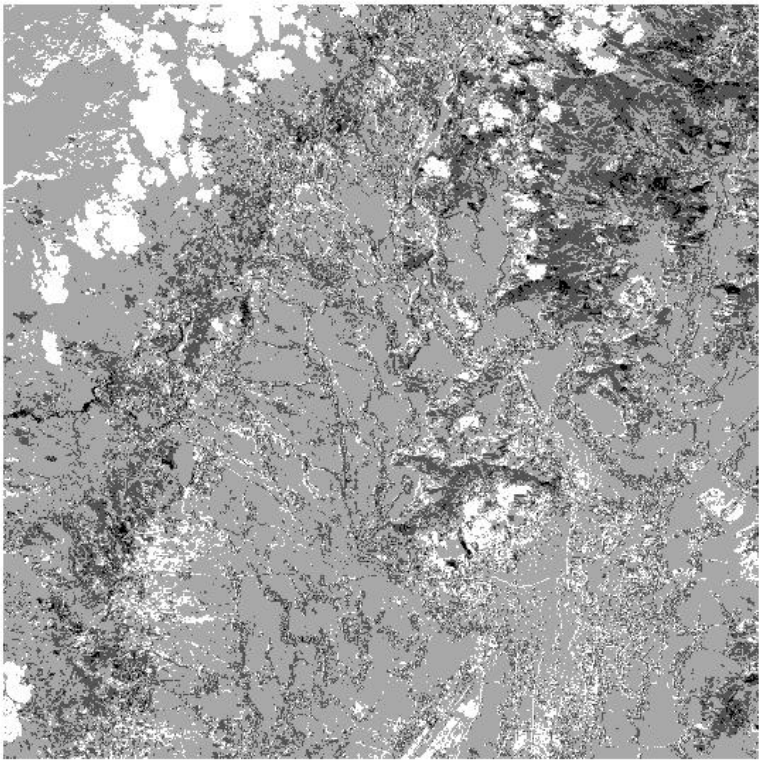

Fig. 3: NDVI Image differencing result of 2008 and 2019

IV. CONCLUSION

Due to issues like population expansion, urbanization, climate change, and public needs and expectations, forest land management is becoming increasingly difficult nowadays. The use of technology-based tools like GIS and remote sensing, however, has greatly aided forest management in balancing these difficulties and maintaining the forest for a sustainable future. In this study, resourcesat LISS III image of 24m spatial resolution was used to detect changes in forest cover over an 11-year period. After detection of forest cover, the NDVI image, whose value ranged between -1.0 and 1.0, was reclassified into three categories by thresholding NDVI values and assigning each generated group to a vegetation type. Nonvegetation, Low Vegetation, and High Vegetation are the three groups having threshold ranges of (-1 to 0.199), (0.2 to 0.5), and (0.501 to 1.0), respectively. The resultant NDVI image was then mapped for both the years 2008 and 2019 to detect the changes. It was found that a reduction of 507 square kilometers in forest area is a great loss for the city area.

Future forest conservation plans in the urban area can use this vegetation mapping. The various sensor characteristics would, however, have an effect on the results of categorization. The study's findings indicate that the NDVI threshold technique can significantly detect vegetation in urban areas.

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