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Change in vegetation using geospatial technology: A case study of Shillong city of Meghalaya, India

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Abstract
The present study focuses on Normalized Difference Vegetation Index (NDVI) change detection techniques to carry out the change in vegetation using Remote sensing data. The study area used in this study is Shillong City and surroundings of Meghalaya, state India. Two Landsat scenes recorded on 28th Oct 1989 and 21st Nov 2015were downloaded from USGS. Images were geometrically and radiometrically corrected and the NDVI change analysis were performed using different threshold values. Change map obtained from NDVI change detection were visually interpreted. In order to determine the accuracy map, random points were generated using systematic sampling. For each random point, change/no change was separately evaluated by using high resolution data (Google Earth data) and a confusion matrix method. The study revealed two important changes increase and change decrease. Change (Increase) explain vegetation area has been clear-cut whereas “Change (Decrease) indicate area either with regrowth or secondary succession.

Keywords: NDVI, change, remote sensing data

1. Introduction
Vegetation changes in tropical country over the last few decades of the 20th century is one of the biggest issues. The spatial and temporal change in vegetation is mainly caused by to land utilization by human activities (Singh *et al*., 2016; Kumar *et al*., 2018; Pyngrope *et al*., 2021) [14, 6, 11]. Due to anthropogenic activities, the Earth surface is being significantly altered in some manner and man’s presence on the Earth and his use of land has had a profound effect upon the natural environment (Ahmed *et al*., 2020) [1].
Assessing the change in vegetation in spatial and temporal domain is a difficult task by conventional methods. Observing the Earth from space is now crucial to the understanding of the influence of man’s activities on his natural resource base over time. A rapid and unrecorded land use change observations of the earth from space provide objective information of human utilization of the landscape. After the launch of Landsat satellite, mapping of earth surface and managing natural resources and studying environmental change become easy and faithful. Today geospatial technologies can greatly facilitate an excellent capacity for data collection and analysis of natural resources at low cost and timely manner (Burai *et al*., 2015; Gabril *et al* 2019) [2, 3].
The present study focuses on the Shillong City and surroundings of Meghalaya, state India to quantify the process of vegetation changes using multi-temporal remotely sensing data and GIS. The aim of this study is to quantify the change in vegetation dynamics using Landsat imageries because of its synoptic view, historical archive and continuous data sets. This quantification was made possible through NDVI change detection techniques. Multi data classification using NDVI are reported more straightforward to detect changes in tropical forest (Lyon *et al*., 1998; Hayes and Sader, 2001; Lunetta *et al*., 2002; G. Meera Gandhi *et al*.2015) [9, 5, 8, 4].

2. Material and Method
2.1 Study area
Shillong is the capital and hill station of Meghalaya, also known as "The Abode of Clouds", one of the smallest states in India. It is situated at an average altitude of 4,908 ft (1,496 m) above sea level, the capital city of Meghalaya is located at 25° 56' N latitude and 91° 88' E longitude (Figure1) occupying a valley called Shillong valley of about 45 sq. km in area. The city features a subtropical highland climate. Its summers are cool and very rainy; the temperature varies from 4 °C to 23 °C.

As of 2011 India census, Shillong City population is 354,325; of which 176,591 are males and 177,734 are females. The soils in Shillong are derived from gneissic complex parent materials; they are dark brown to dark reddish brown in color, varying in depth from 50-200 cm. The texture of the soils varies from loamy to fine loamy. They are rich in organic carbon. The reactions of the soils vary from acidic (pH 5.0 to 6.0) to strongly acidic (pH 4.5 to 5.0).

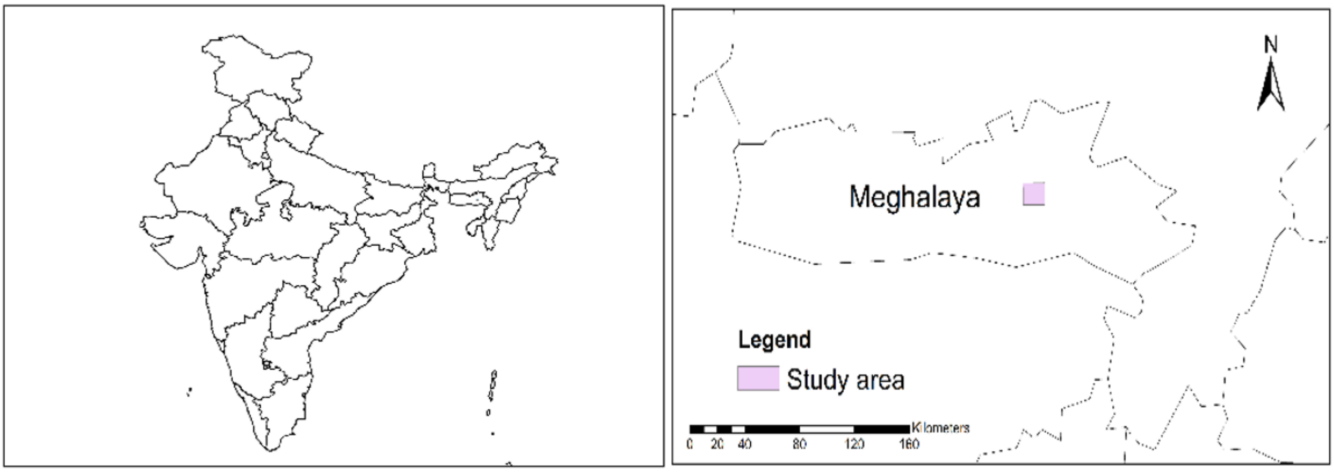

Fig 1: Geological location of study area

2.2 Satellite data acquisition and processing

The Geometrically corrected Landsat images of two different years were downloaded from United States Geological Survey (USGS) portal (http:// www.usgs.gov/in) and details are given in Table 1.

Table 1: Satellite data used for this study

Images required	Path/Row	Date of acquisition	Source
Landsat TM	136-42	28.Oct.1989	http:// www.usgs.gov/in
Landsat ETM	136-42	21.Nov.2015	http:// www.usgs.gov/in

In this work, band to band histogram matching was performed using multi-temporal images taken at different times (Yasuoka 1988) [15]. A lookup table is created which converts the histogram of one image, so that it resembles the histogram of another image, called the reference image. In this case, the satellite image of 1989 was used as input and the 2015 image was chosen as reference image.

2.3. Vegetative index differencing (NDVI)

One of the most commonly used band combination techniques involves the calculation of vegetation indices is NDVI. The Normalized Difference Vegetation Index (NDVI) is a band ratio calculated using the given formula (Rouse *et al*. 1973)

$$NDVI = \frac{NIR - R}{NIR + R}$$

NDVI is normalized difference vegetation index, NIR is near-infra red band response for band 4 and R is the red response for band 2 in a given pixel for TM/ETM sensor.

2.4 Change analysis using NDVI image differencing

Change detection is the process of identifying differences in the state of an object or phenomena by observing it at different times (Singh, 1989; Kumar and Kumar 2011) [13, 7]. NDVI image differencing is one of the most frequently used method, when changes are sought for in vegetate and non-vegetated areas. NDVI image differencing was successfully carried out by (Nelson, 1983; Singh 1986; Lunetta *et al.*, 2002) [10, 12, 8]. In this method NDVI was calculated for both dates and then subtracted (Nelson 1983; Singh 1986) [10, 12]. In the present study, NDVI was calculated for 1989 and 2015 images. Mathematical image differing was carried out to find out the difference in the NDVI values of two images.

$$D_{NDVI} = NDVI_{t2} - NDVI_{t1}$$

Where,

$NDVI_{t2}$ is NDVI image of time 2 and

$NDVI_{t1}$ is NDVI image of time 1.

All this process was carried out in ERDAS IMAGING software. A number of threshold values (in%) were tested in upper and lower tail of the distributing representing change pixel value (DN value). Thresholding (in%) used in this study for find the change is shown in table 2.

Table 2: Different tested Thresholding (in%)

Threshold (%)	Increase	Decrease
	7,12,15,17,21	11,,13,15,17,22

2.5 Accuracy Assessment

In order to determine the accuracy of the change images (which were obtained from image differencing and NDVI differencing), a random sample of 60 points was selected. For each sample point, changes were separately assessed and two levels of information were determined: the first level involved only ‘change/no change’ binary information and the second level described the nature of change (from-to information). This information was compared with the change detection results using confusion matrices

3. Result and Discussion
3.1 Radiometric Normalization
The radiometric variation of the images procured at different dates is a key parameter while interpreting the occurred changes (Kumar and Kumar 2011) [7]. The band-to-band histogram matching of images procured in 1986 and 2002 was performed. After radiometric normalization, statistics of the 1989 image were come closer to the 2015 image (Tab. 3).

Table 3: Statistics of the images before and after radiometric normalization.

	Band1	Band2	Band3	Band4
Before Radiometric Correction				
Mean 1989	54.20	21.82	23.34	58.87
Mean 2015	14.17	17.52	14.20	60.12
SD 1989	6.20	5.11	7.10	14.86
SD 2015	11.25	14.01	14.47	39.34
After Radiometric Correction				
Mean 1989	14.10	18.67	16.33	62.09
SD 1989	12.01	13.74	13.95	38.32

3.2 Change detected by NDVI image differencing
The Landsat band (Blue, Green, Red and NIR) were used in NDVI image differencing. In the case of the NDVI image differencing, NDVI was calculated for both dates (Figure2). Image differencing is performed by subtracting the pixel value of 1989 image data for a given band from the pixel value of the same area for the same band of the 2015 image data. After that the NDVI image of 2002 was subtracted from the NDVI image of 1989 and a change image was obtained (Figure3). The pixel values were categorized the same way as in image differencing. The pixel values were categorized into the “No Change”, “Change (Increase)” and Change (Decrease). Change increase and decrease in area has been shown in Table 4. The accuracy assessment of NDVI difference maps, generated from satellite images, indicates 93.65% overall accuracy with Kappa coefficient 0.89. The class “No Change” indicate no changes in vegetation cover; Change (Increase)” explain vegetation area has been clear-cut whereas, “Change (Decrease)” indicate area either with weeds, regrowth or secondary succession.

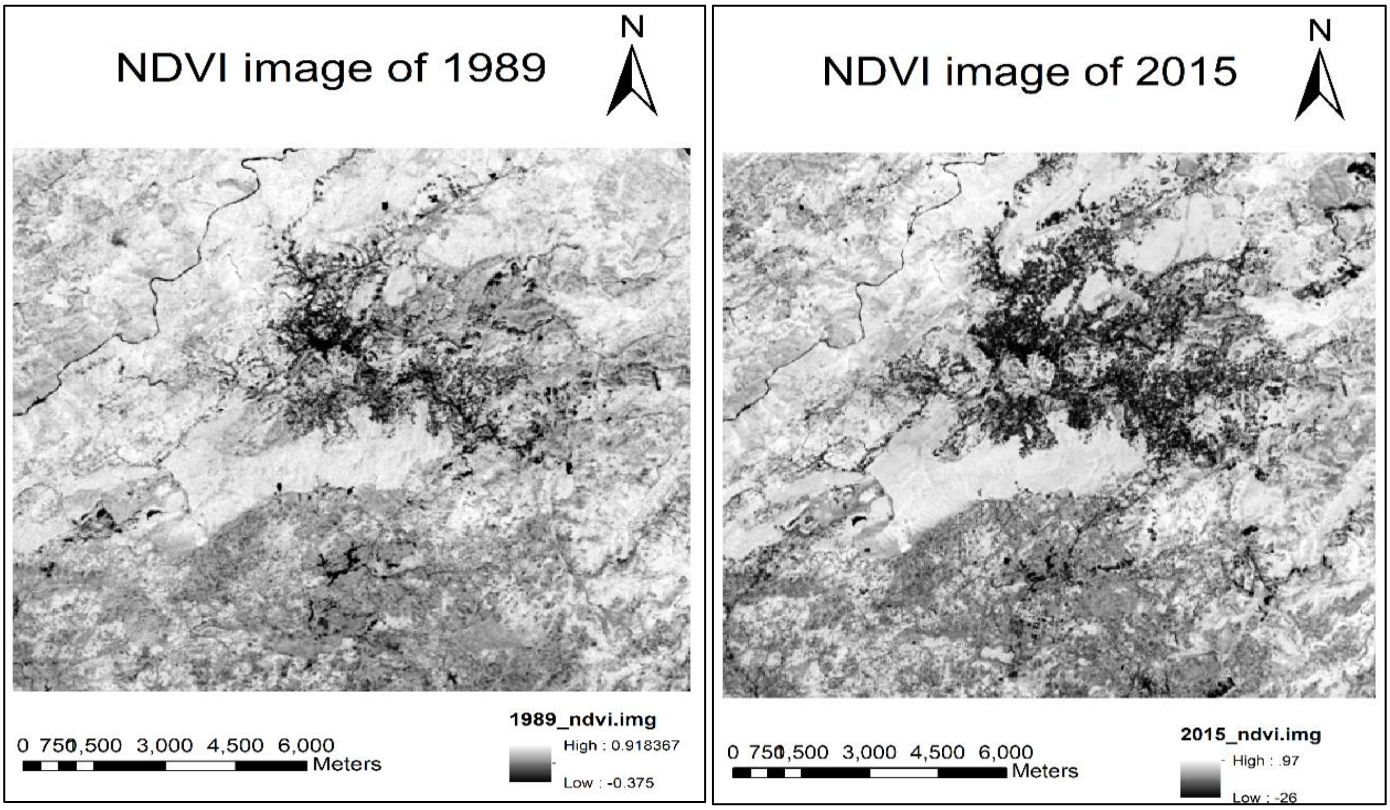

Fig 2: NDVI image of 1989 and 2015

Table 4: Change detected by NDVI image differencing

Changes	Area(ha)	Percentage
Increase	1352.53	6.52
Decrease	929.82	4.48
No change	18449.62	88.99

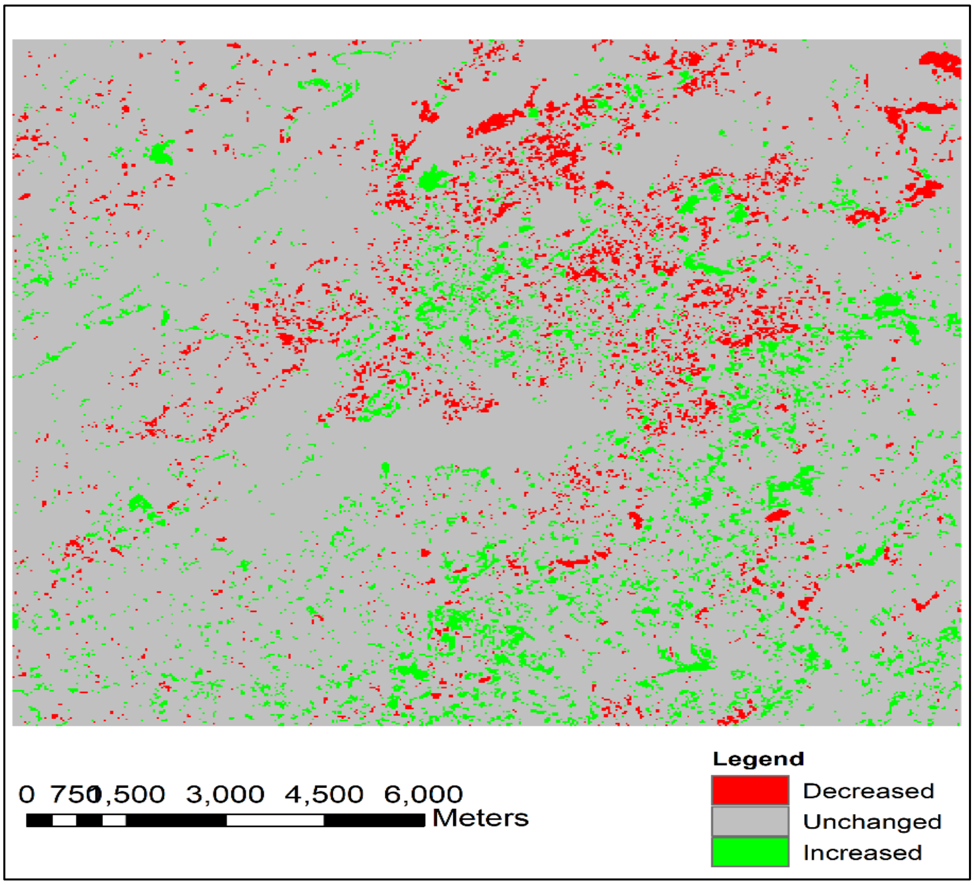

Fig 3: NDVI difference image using threshold.

4. Conclusion

This study reveals the spatial and temporal vegetation changes of Shillong City and surroundings of Meghalaya, state India during period of 1989 to 2015. This research was done to capture change in vegetation cover as accurate as possible using three land use and land cover classes, namely; increase in change, decrease in change and no change; using geo spatial techniques. Analyses of the result exhibit that NDVI differencing provide satisfactory and fast result in case of vegetation changes. However, NDVI image differencing cannot provide detailed information. It can only give the information of increase or decrease of the NDVI value.

The study area is forest dominated area however, development of city and its surrounding is also growing in fast rate. It is therefore, very essential that planners and policy makers evaluate and monitor the vegetation cover changes from time to time to ensure that the transition does not harm the society, economy and the environment of the area. Concerted efforts should be taken to prevent further unplanned and uncoordinated expansion.

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