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Normalized Difference Vegetation Index (NDVI) Based Classification to Assess the Change in Land Use/Land Cover (LULC) in Lower Assam, India

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Abstract The land use activities ultimately affect the land cover spatially and temporarily. The major factor responsible for the change in land use/land cover is to fulfill the growing demands of increasing population through agricultural intensification for food and clearing natural land cover like the forest for settlement and commercial activities. The change in land use and land cover also disturbs the other natural component soil fertility, soil erosion, ecology, biodiversity, air quality and water regime of the disturbed area. The remote sensing and GIS technology has been emerged as a good tool to analyze the change in land use and land cover of the area at spatial and temporal scale. In this study, the NDVI based classification has indicated about significant change in land use land cover between a year 1990 and 2014. The Major change has been found in the forest cover area where about 113 km^2 (2.9%) of forest have been degraded and about 115.4 km^2 area of wetland has been lost between year 1990 and 2014.

Keywords *NDVI; GIS; Landsat; LULC*

1. Introduction

Land cover refers to the physical state of the land surface including cropland, forest, wetland etc. (Di Gregorio & Jansen, 2000); whereas land use refers to biophysical assets used by the human (Cihlar & Jansen, 2001; Campbell, 2002). Land use/land cover analysis is important for agricultural planning, urbanisation and environmental studies (Turner, 1995; Goulding & Blake, 1998; Mahajan et al., 2001, Vitousek, 1994; Nunes et al., 2005; Huang & Siegert, 2006), and this information also helps to understand the relationship between cropland, forest land, settlement etc. In recent time, the modernisation and demographic pressure have increased the land use and simultaneously affected the land cover (Myers, 1984). Remote sensing data and GIS is an appropriate tool for the assessment of the global land use/land cover change and environmental monitoring because of its spatial and temporal coverage capabilities (Anderson et al., 1976; Green et al., 1994; Fraser, 2009; Mukherjee et al., 2010). Normalized difference vegetation index (NDVI) based comparison using multi date satellite data methods proposed for change detection in land use and land cover (Nielson et al., 1998; Stow et al., 1996; Yuan et al., 1999). The change detection and assessment of land use/land cover using geoinformatics allow the user to monitor land cover over the large area and over a period of time. The change in land use and land cover (LULC) varying along regions, in rural areas is attributed due to agriculture expansion, forest fire and illegal tree cutting while in urban areas it is attributed to urbanization and commercialisation. The heterogeneous change in land use and land cover of an area is critically linked to other environmental parameters like groundwater quality and soil health (Rao et al., 1996; Turner, 1995). The normalised difference vegetation index (NDVI) is used for the mapping of changes in land cover (Woodcock et al., 2002; Lunetta et al., 2006). The change in land use/land cover were analysed by studying the difference between images derived by transforming multi-temporal images to digital numbers indicative of the changes (Maselli, 2004). In the present study, analysis of land use/land cover focuses on following 3 aspects Detection of changes in land use & land cover between 1990 and 2014, Identification of nature of changes & Assessment of the pattern of the changes.

2. Study Area

In the present study, lower western Assam area has been selected as the study area (Figure 1) which includes two districts Goalpara and Bongaigaoun. The district Goalpara, situated on the Southern bank of river Brahmaputra, covers an area of 1,842 sq km and is located between 25°53’N & 90°07’E and 26°15’N & 91°05’E. The district Bongaigaoun is situated on the northern bank of river Brahmaputra, adjacent to Goalpara district covering an area about 1725 sq km and is located between 26°30’N and 90°23’E and 26°10’N and 90° 52’E. The study area is occupied by both the hills and plains. The hills in the region occur as isolated inselbergs, areas varying from 1 to 15 sq km (e.g. Inselberg west of Goalpara town), and heights ranging from 60 to 300 m above msl. The hills are veneered by lateritic mantle and are deeply forested with evergreen mixed open jungles (CGWB, 2008). The district Goalpara and Bongaigaoun is a part of the alluvial plains which lies adjacent to the foot-hill ranges. Archaean inliers are present in the central and the eastern part of the district. with a gentle regional slope towards Brahmaputra river.

2.1. Geological Settings of Study Area

Both the districts of the study area (Goalpara and Bongaigaoun) are situated in foreland depression between the comparatively younger mountains chain of the Himalayas in the north and block Mountains of Shillong plateau in the south. The geological formation in the area are the Archean group of rock comprising Biotite-Hornblend gneiss, granulites, schists which are intruded by granite with pegmatites trending NE-SW with a moderate dip towards NW. The unconsolidated alluvium of quaternary age is divided into older and younger types. The major part of the area is lying under younger alluvial plain which consists of gravel, pebbles, sand, silt and clay while older alluvium is compact and contains limonitic clay, unsorted boulders, pebbles, gravel and sand (GSI, 2009).

3. Materials and Methods

3.1. Image Acquisition

The image of study area has been acquired during the month of November with minimum cloud cover.

Table 1: *Details of the image used in the study*

Image	Path/row	Acquisition Date	Spatial Resolution
Landsat 5	137/43	11/11/1990	30 meter
Landsat 7	137/43	08/11/2014	30 meter

3.2. Image Pre-processing

a) Layer Stacking: The layer stacking of bands was performed on the Erdas Imagine 14 software.
b) Mosaicking the layer stacked image tiles were mosaicked and then clipped with study area shapefile.
c) Image rectification was done to correct distortions resulting from the image acquisition process.
d) Projection: The image downloaded is in Universal Transverse Mercator projection and it is reprojected to Geographic WGS 84, spheroid and datum Everest.

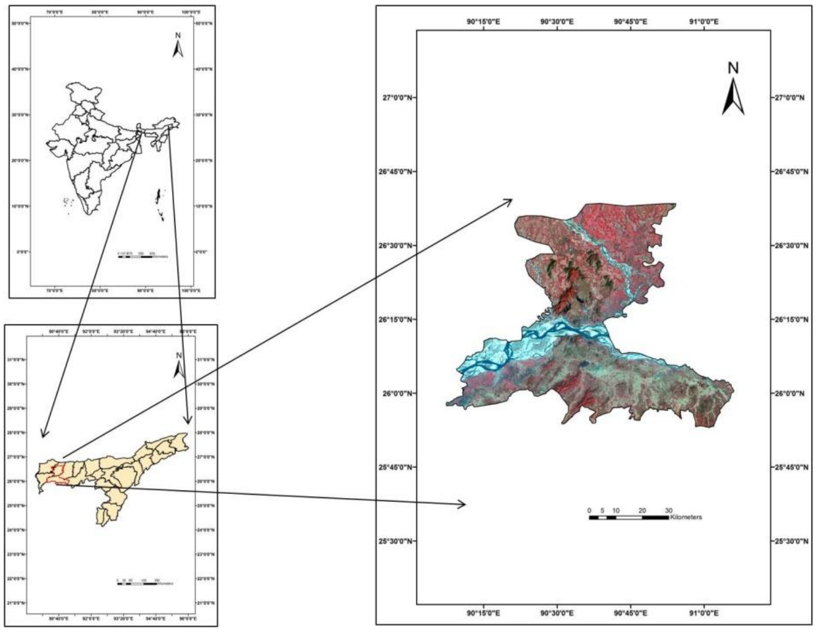

Figure 1: *Study Area*

3.3. Image Classification and Change Detection

Image classification for both years (1990 & 2014) was performed through supervised classification using maximum likelihood classifier, which includes following steps:

a) Selection of signature of different features (training sites) by digitisation of selected area on the image. Selection of signature was based on field knowledge and existing literature and map.
b) Obtained signatures act as an input for digital image classification. On the basis of given signature, the whole study area was classified into four classes.
c) Based on the quality of results, training samples were refined until a satisfactory result was obtained.
d) Classified images were recorded to respective classes (i.e. Forest, wetland vegetation, river, agricultural field)
e) The normalised difference vegetation index was calculated on ERDAS Imagine14.0 for the year 1990 and 2014 of land sat image. The results of both the years were also compared, which show significant changes in land use/land cover over a period of time in the study area.

4. Results and Discussion

The pressure of increasing population and unplanned land use practices has great impact over natural land cover. The large vegetation cover has been converted into crop land, settlement and the natural wetlands are under the threat of dryness. The concern about the change in LULC has got attention after realizing the impact of change on climate and ecosystem of the area. In present study, two images (1990 and 2014) have been classified on the basis of normalised difference vegetation index (NDVI), a vegetation index calculated by

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}}$$

NDVI is an index based on spectral reflectance of the ground surface feature. Each feature has its own characteristic reflectance varying according to the wavelength. NDVI value ranges between -1 to +1. A Higher value of NDVI infers the presence of healthy vegetation in the area while its lower value is the indicator of sparse vegetation. NDVI has been used for analysis of change detection in many studies (Huang and Siegert, 2006; Ahl et al., 2006; de Boer, 2000). The NDVI value calculated from Landsat satellite image of the year 1990 ranges from 0.85 to -0.02. The higher value of NDVI was found in the upper part of the district Bongaigaoun and in the periphery of Goalpara district in south of Brahmaputra river (Figure 2). The upper part of the area having higher NDVI value belongs to the Manas reserve forest. The lower values of NDVI were found in the rivers and wetland regions of the study area.

In comparison to the year 1990, the NDVI values of the year 2014 show a significant change across the whole region and its value ranges from 0.83 to -0.37 (Figure 2). Higher NDVI was found in scattered patches. The decrease in NDVI value indicates the change in land use of the area mainly due to the loss of forest area because of agricultural expansion and human encroachment.

4.1. Change in Land Use/Land Cover

Change in land use/land cover between 1990 and 2014 were evaluated using satellite images in the area. The whole area was classified under 4 classes by supervised classification (maximum likelihood method) using image processing software on Erdas 2014. The classes are as follows: Forest (2) River (3) Wetland (4) Agricultural field and sand. The classified satellite image of the year 1990 and 2014 shows a significant change in land use/land cover in the study area. The classified image of the year 1990 (Figure 3) shows that about 78% of the area is under agricultural field; while 10% of the area is drained by the rivers (Table 2). A dense forest has been observed in the north of the area lying near Manas forest reserve and along the hilly area of Bongaigaoun (north of Brahmaputra) and Goalpara district (South of Brahmaputra) (Figure 3). The classified image of the year 2014 (Figure 4) shows a significant change in the land use and land cover. A major change has been found in the forest cover area where about 113 km2 (2.9%) of forest have been degraded between the year 1990 and 2014. The changes occur mainly due to the human encroachment and agricultural intensification.

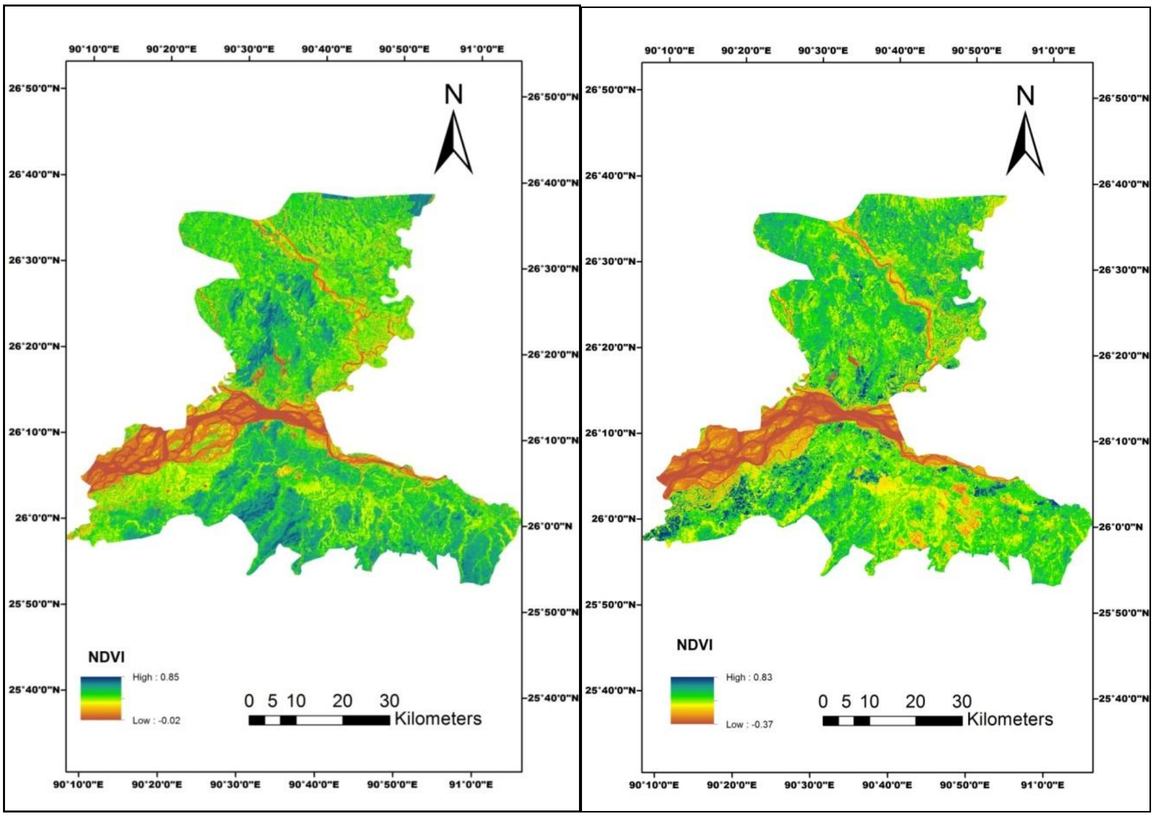

Figure 2: *NDVI variation in the study area in 1990 (a) and 2014 (b)*

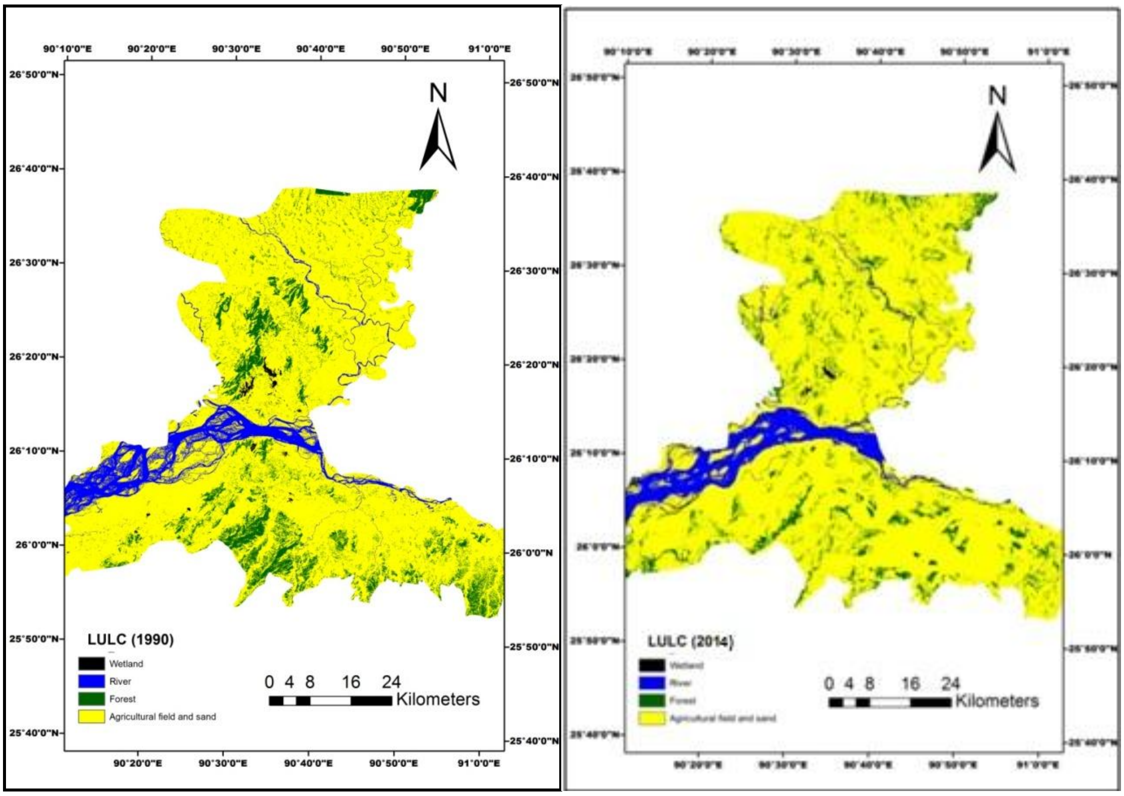

Figure 3: *Change in Landuse and Landcover of the area in the year 1990(a) and 2014(b)*

The increasing population has changed the land cover pattern through overexploitation of land resources for their livelihood because the population residing near forest depends on upon valuable timbers of forest and agriculture (Sharma, 2003; Bhattacharjee and Nayak, 2003). The agricultural expansion (mainly paddy crops) and settlement have become a threat for forest cover. The area of the agricultural field has increased in the year 2014 about 225 km^2 which is 5.8 % more than the year 1990 (Figure 4). The demographic pressure and illegal natural resource exploitation have not only affected the forest cover but also the wetland area. The wetlands, locally known as “Bils”, developed during geomorphic transformation and tectonic activities, are also the conspicuous features of flood plains in Brahmaputra river basin. In 1990, the wetland area was about 146.3 km^2 (3.75 %) of the total area while in the year 2014 it was found that about 115.4 km^2 area of wetland has been lost. In comparison to the year 1990, only 30.9 km^2 areas are covered by wetland which is about 0.79 % of total area (Table 2). Although there is no significant change in the area of river between 1990 and 2014, but the course of river Ai, and river Manas the northern flowing tributaries of Brahmaputra has changed which is clearly visible in Figure 3.

Table 2: *Change in Land use/Land cover of the study area*

LULC category	Area(km^2)		Percentage of total area		Change	
Total area =3903.2 km^2	1990	2014	1990	2014	km^2	Percentage
Forest	408.2	294.6	10.46	7.55	-113.6	-2.91
River	283.5	287.3	7.26	7.36	3.8	0.1
Agricultural field	3065.2	3290.4	78.53	84.30	225.2	5.8
Wetland	146.3	30.9	3.75	0.79	-115.4	-2.96

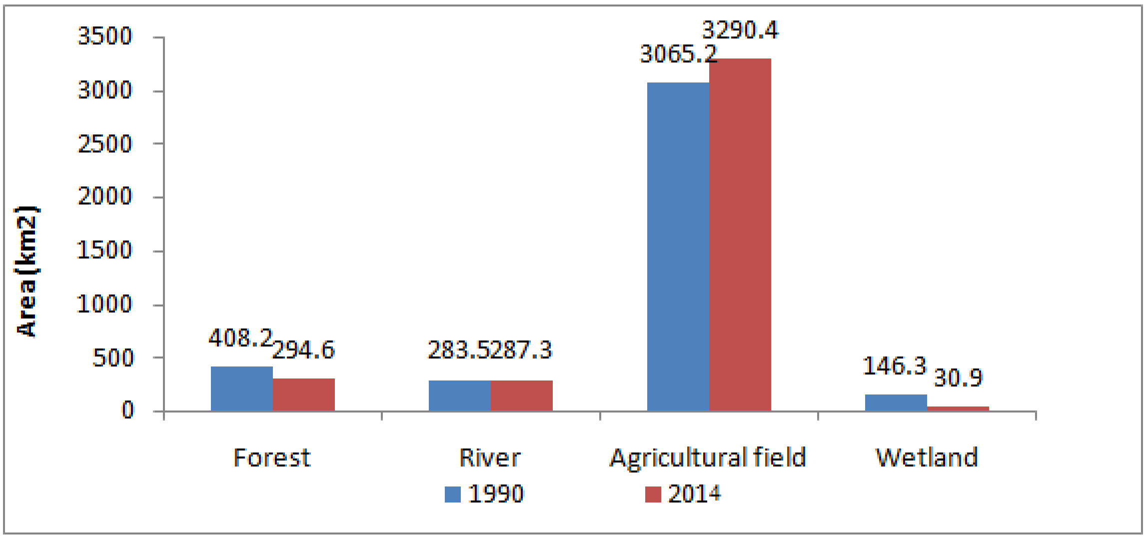

Figure 4: *Graphical presentation of change in Landuse/Landcover of study area*

5. Conclusions

In comparison to the 1990 and 2014 show a significant change in land use and land cover. In recent time the modernisation, increasing demographic pressure, and over-exploitation of natural resources have become a major threat for degradation of forest cover and loss of wetland in the study area. The total 113 km^2 of forest cover and 115.4 km^2 wetland has been lost between the year 1990 and 2014 due agricultural intensification and human encroachment. This alarming condition is required a scientific management of land use for sustainable development in the area.

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