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RESEARCH PAPER

Spatial analysis on land use/land cover from IRS-R2 LISS4 FMX data-A case study in Assam University campus, India

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ABSTRACT

Land use land cover (LULC) is a core information layer for scientific study, conservation and administrative tasks. Remote sensing (RS) along with Geographic information system (GIS) can provide such information. Assam university campus is an urban landscape established in a rural background. Spatial based studies help to assess the dynamics of land use in such landscape. The detailed land use land cover components in Assam University Silchar (AUS) using RS and GIS has been studied for the first time. The delineation of AUS campus boundary, spatial analysis and precise mapping of all the different land types of Assam University campus using very high resolution satellite data using visual interpretation techniques has been done. The total area of the campus was estimated to be *ca* 572 acres. A total of 15 different LULC classes was mapped, where the degraded forest area occupied maximum area (34.56 %). The encroached area (2.06 %) within the campus was also mapped. This paper will help the decision makers and researchers working in this area as baseline information for further detailed studies such as management and monitoring, controlling and planning developmental activities in and around the university campus, conservation of the eco-forest area within the campus etc.

KEY WORDS: Land use land cover, Remote Sensing, Geographic Information System, IRS-R2 LISS4 FMX data, Visual Interpretation Technique.

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Introduction

One of the most common applications of satellite images is the extraction of land use/land cover (LULC) information (Lo and Choi, 2004). Satellite images combined with GIS technique has been extensively applied for LULC mapping (Kotoky *et al.*, 2012; Rawat *et al.*, 2013; Dewan and Yamaguchi, 2009; Baldyga *et al.*, 2007; Thakur *et al.*, 2016). LULC mapping using remote sensing and GIS technique is of paramount importance to planners, geographers, environmentalists and policy makers (Abbas *et al.*, 2010). Many studies have demonstrated the effectiveness of land mapping using remotely sensed data as a powerful tool to detect land use pattern for critical environmental areas, vegetation dynamics, urban expansion, and other studies (Yasodharan *et al.*, 2011). A detailed information on urban land use is essential for applications related to urban management and planning (Jensen and Cowen, 1999). The availability of very high-spatial-resolution satellite imagery offers a new avenue to obtain urban information on a very detailed level (Welch, 1982; Donnay *et al.*, 2001). It is an acknowledged fact that urbanisation is an anthropogenic cause of landscape change globally with an estimated 809 km^2 of agricultural land being converted to cities, roads and infrastructure annually (Barnsley and Barr, 1996). Anthropogenic land use and land cover changes are common in developing countries due to increasing population, rapid urbanization and dependence on land based resources for livelihoods (Fox *et al.*, 2006, Slay maker *et al.*, 2009).

Assam University campus is an example of an urban expansion established in a primarily rural background. Assam University came into existence through Assam (Central) University Act, 1989 (Established under an Act of Parliament). It was established in 1994. The campus, situated in Dargakona, about 20 kms from Silchar, consists of hillocks, lakes and intermittent flat areas. The Assam university campus has witnessed rapid changes in its LULC following the establishment of the university at this location. Land use changes and infrastructural developments taking place within such universities set up against a rural backdrop are a beginning point for a progressive large scale urbanisation process. If no sustainable local level land use development policy is in place, proliferation of informal settlements, urban sprawl and encroachment on university lands are the likely

challenges for the university (Kinoti, 2017). Universities are becoming epicenters of human activities leading to urbanisation, local level migrations, land use conversions and micro socio-economic developments in other parts of the globe (Kinoti, 2017). Given the diverse ecological and geomorphological settings in which these institutions occur, it is imperative that spatial based studies be done to assess the dynamics of land uses. A similar study was carried by De *et al*., 2012 using Google earth image of November 2009, where they classified the LULC types broadly into 5 classes. The present study was designed with the objectives of delineation of the boundary of the campus and a detailed mapping of the LULC categories within the campus.

Study area

The study was conducted in Assam university campus, which lies in the southern part of Assam, India. The campus is situated at Dorgakona adjacent to the Chatla fen area of Cachar district bordering Hailakandi district of Barak valley, Assam. Assam University came into existence through Assam University (Central) Act, 1989 established under an Act of Parliament. The area has numerous low hills ranging from 40 to 60m above sea level bisected with narrow ravines and small streams flowing throw the latter (De *et al*., 2012). A relatively undisturbed forest patch is available within the campus designated as the Eco-forest. The forest of the area is represented by Tropical Semi Evergreen type. The dominant tree species observed includes the *Artocarpus chama* and *Tetrameles nudiflora*. About 16 species of lichens, 12 algal species, fungi and pteridophytes was recorded from this area. The campus vegetation is also a home to many animals ranging from microscopic zooplanktons to some endemic primate species. Several species of herpetofauna have also been reported of which some species were first records in Indian mainland viz. *Microhyla heymonsi* and some extremely rare and endemic (Dutta *et al*., 2008). A total of 14 anuran species belonging to 10 genera and six families have been reported by Jayanta and Dey, 2015. The area also records a total of 38 butterfly species belonging to 30 genera under 5 families (Deb *et al*., 2015).

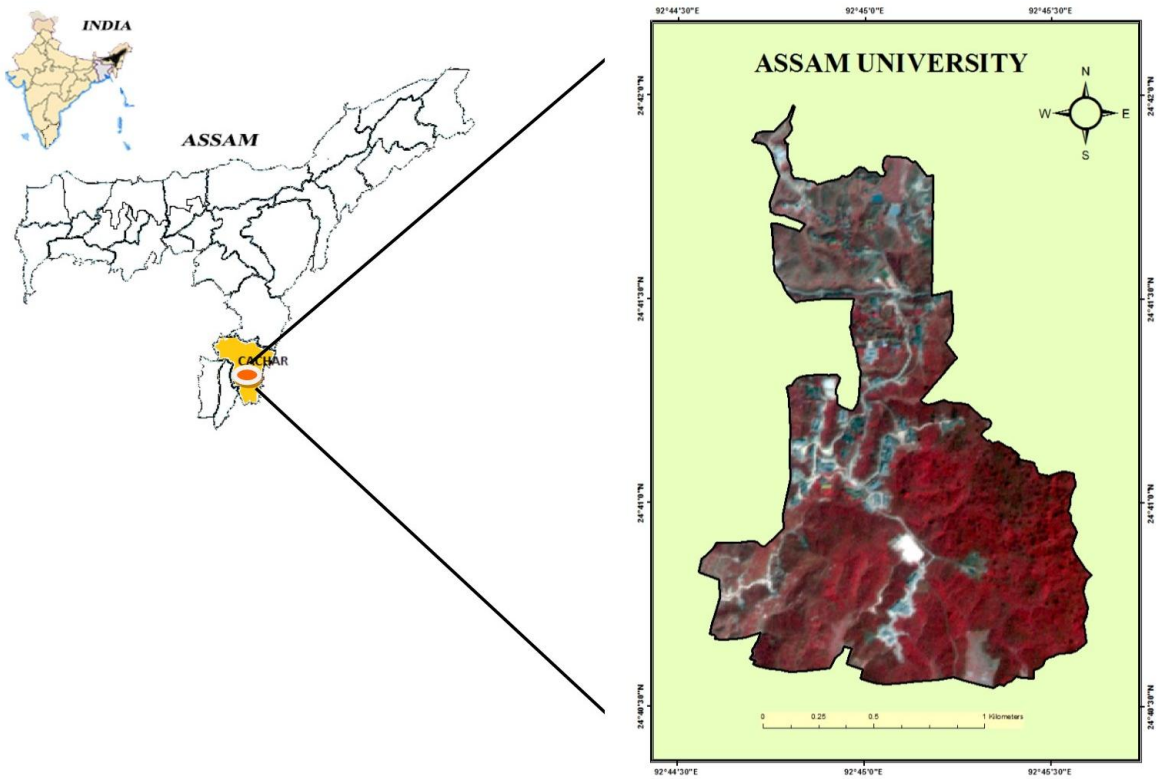

Figure 1. False colour composite of LISS4 FMX showing the study area.

Materials and methods

For precise study and mapping, use of a high resolution satellite data was important. The study area is experiencing various development activities, different levels of disturbances on the natural vegetation. Therefore it exhibits great heterogeneity in the LULC types. To make the study accurate and more precise, a very high satellite data (IRS-R2 LISS-IV FMX) was used. Cloud free data for the desired area of interest (AOI) was procured from National Remote Sensing Centre, Hyderabad. Details of the imagery used for this study in presented in Table 1. LISS4 FMX satellite image consists of three spectral channels, green (0.52-0.59 µm), red (0.62-0.68 µm) and near infra-red (0.77-0.86 µm) with a temporal resolution of 5 days revisit for any given ground area and 70 km swath width.

Table 1. Details of satellite data used.

Satellite ID	Sensor	Path	Row	Scene date	Resolution
IRS-R2	LISS-4 FMX	111	54	10-Mar-13	5.8m

In this study, Image pre-processing was done using the Earth Resources Data Analysis System (ERDAS Imagine) 2013 and the digitization of the different land classes and final map composition was done using the ArcGIS 10.1 software. Other ancillary information such as GPS point collection and Google Earth Pro were used for the proper identification and delineation of the different land types within the study area. Prior knowledge of class occurrence was used to increase classification accuracy significantly. The study uses the visual interpretation classification technique for the delineation of all the different land types because of its relatively small area. Visual interpretation of high spatial resolution data is not automated, but requires the systematic search, identification, and the delineation of all the target features by the analysts (Galeon, 2008).
The following steps were involved in the processing of image and final map composition:

1. Procuring of IRS-R2 LISS4 FMX data.
2. Geo-rectification of different bands/layers (The projection and datum used were the Universal Transverse Mercator (UTM) and WGS84 respectively).
3. Layer stacking and data enhancement.
4. Preparation of False colour composite (FCC) image.
5. Maximum possible ground point collection for creation of study area boundary.
6. AOI creation and subset of study area.
7. Visual interpretation classification based on interpretation keys.
8. Ground data collection of unknown features and their delineation.
9. Vegetation characterization based on the canopy cover using spherical crown densitometer.

*Calculation: # of squares covered / # of squares not covered x 100 = % canopy cover.

Where;

Good forest = >40% of the sky is obstructed by the tree canopies.

Moderate forest = 15 to 39% of the sky is obstructed by the tree canopies.

Degraded forest = <14% of the sky is obstructed by the tree canopies.

10. Final ground validation using GPS for accuracy checking.
11. Final map composition.
12. Area estimation of all the land use land cover classes.

Result and Discussion

The study has successfully mapped a new boundary of Assam University campus. The present study revealed the study area statistics to be *ca* 572 acres. The study adopted the visual interpretation technique and the land use land cover map of Assam University campus was classified precisely into 15 different classes; AUS gate, Gorge, Good forest, Moderate forest, Degraded forest, Built-up land (Buildings), Water body, Acacia plantation area, Playground, Roadways, Helipad, Bare land, Encroached land, Wasteland and Park (Fig. 2). The study revealed the degraded forest land (197.71 acres i.e., 34.56% of the total area) occupied the maximum area in the campus, thus indicating the high level of degradation in the landscape. The area statistics of the different land classes is presented in Table 2. From this study, we could delineate and map the encroachment (*ca* 11.81 acres) taking place inside the campus by the local people residing around the campus. It was observed during field survey that the local people were engaged in seasonal paddy cultivation, establishment of small fisheries and collection of some forest products from the fringes of the campus. This sort of activities need to be checked immediately to avoid such illegal practices.

Plantation area which covered an area of 2.58 acres mainly consists of *Acacia auriculiformis*. As compared to the previous study carried out by De *et al.*, 2012, the total area under these plantation was 2.3 acres. This increase in the area under plantation in a span of four years is indicative of the good regeneration health of these plantations.

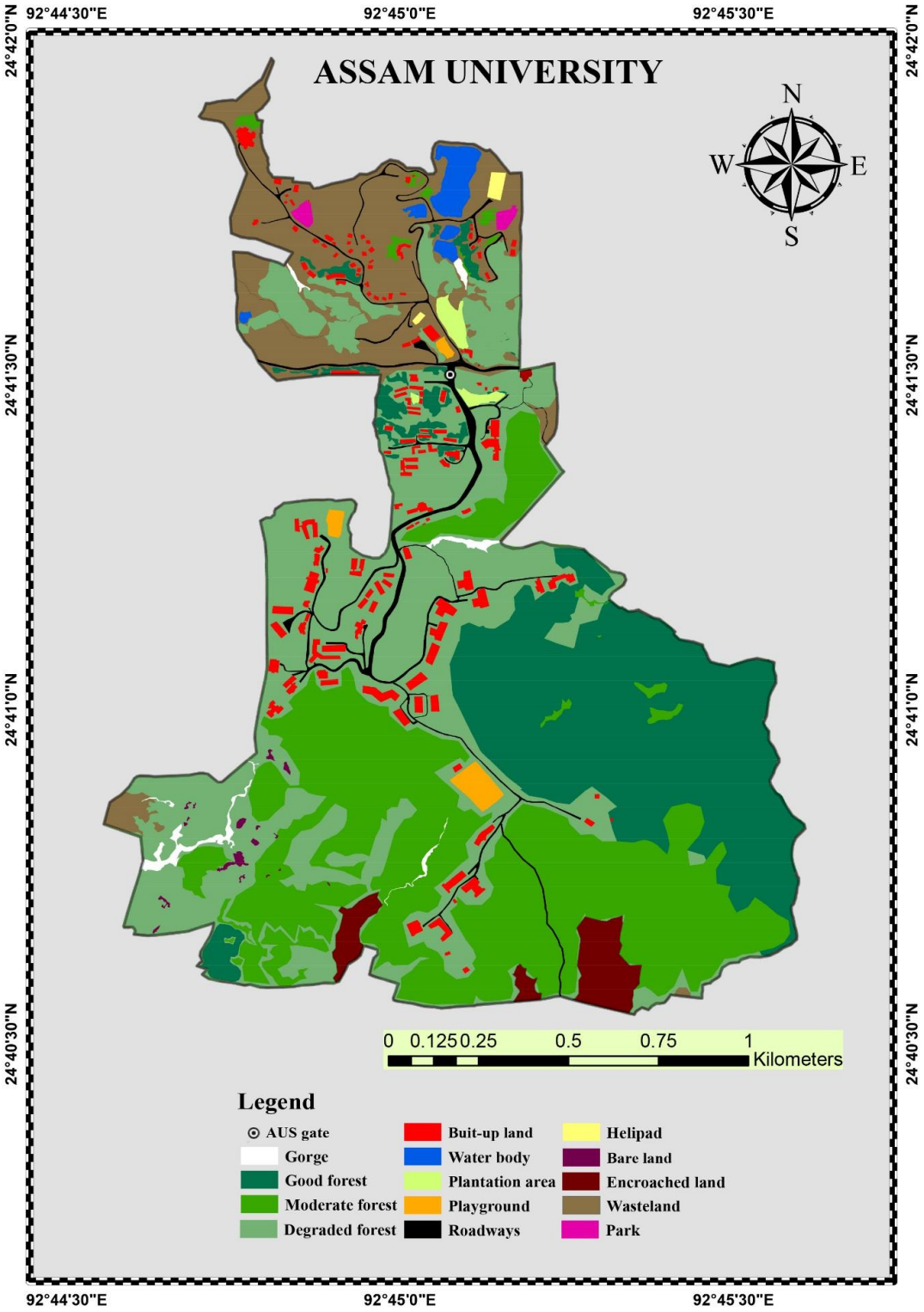

Figure 2. Detail LULC components of AUS campus, Assam India

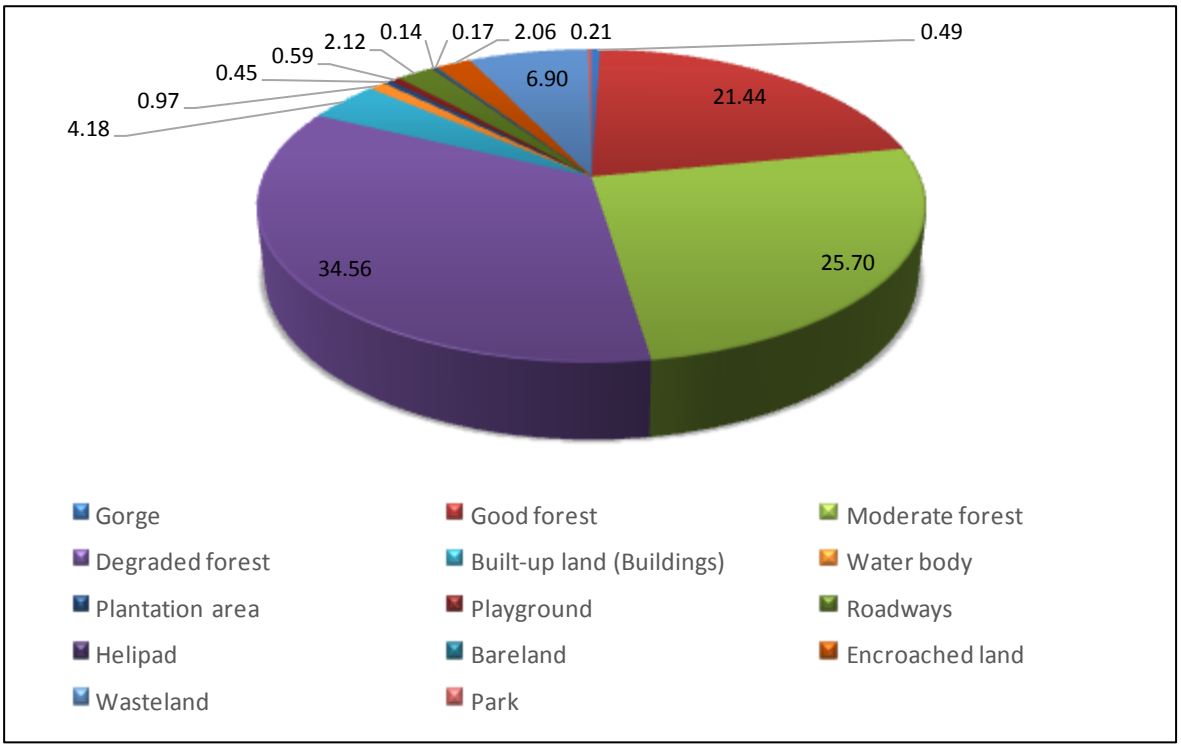

Figure 3. Percentage distribution of LULC clases.

From the vegetation characterization, it was observed that the good forest (i.e., the ecoforest) covers an area of 122.61 acres as against 171 acres indicated by De *et al.*, 2012. This means a significant loss of vegetation and increased degradation or disturbance is taking place, particularly in the eco-forest region. During the field survey, early succession of invasive species was observed, indicating the high disturbance on natural vegetation. Also the local people were found to be extracting several bamboo species and other species from this region. The need of the hour therefore is to stop all kinds of encroachment and illegal entry into the eco-forest region by the local people, as this area not only serves as a repository of plant species, it is also an important habitat for the many rare animals such as the Phayre's Leaf Monkey (*Trachypithecus phayrei*) (Dutta *et al.*, 2008). While carrying out the study, several tree species and small plants were encountered in the field. Some of these include, *Gmelina arborea*, *Erythrina variegata, Bombax ceiba, Artocarpus chama, Azadirachta indica, Tectona grandis, Tetrameles nudiflora, Schizostachyum dullooa, Terminalia bellerica, Sterculia villosa, Melastoma malabathricum, Eupatorium odoratum, Mimosa himalayana, Lantana camara, Licuala peltata* etc. Degraded forest types occupied the highest area (197.71 acres). Such areas may be managed or utilized for plantation or care should be taken so as to conserve the tree species that are located very sparsely.

After thorough ground validation and GPS point collection, a total 149 built-ups were successfully digitized. This includes houses and buildings within the study area, including the small canteens, ATMs, etc. The total area under this land use class is 23.93 acres. This indicates that only ca 4% of the total land is currently under the built up category. This is because the area has many hillocks and gorges that is unfit for building purposes. Such areas may be converted into zones of eco restoration and help in ameliorating the environment through sequestration of carbon. Wasteland of the area covers an area of 39.48 acres. The present authors suggest these area being suitable for further construction projects if any in the future, since the areas are not suitable for cultivation due to the rugged topography.

The university therefore needs to develop and incorporate land use and development plans into their strategic plans and extend these policy plans to their neighbourhoods. It is the right time to adopt GIS based approaches in the management of land related data. Integrating land use with geophysical and community interests will promote land

development practices congruent to the local contexts. The study recommends further research on the possibility of developing University Land Use Spatial Data Base (ULUSDB) to inform sustainable land use planning and resource developments.

.Table 2. Area Statistics of the different LULC classes.

LULC class	Area (acre)	Percentage (%)
Gorge	2.81	0.49
Good forest	122.61	21.44
Moderate forest	147	25.70
Degraded forest	197.71	34.56
Built-up land (Buildings)	23.93	4.18
Water body	5.53	0.97
Plantation area	2.58	0.45
Playground	3.4	0.59
Roadways	12.13	2.12
Helipad	0.8	0.14
Bare land	1	0.17
Encroached land	11.81	2.06
Wasteland	39.48	6.90
Park	1.21	0.21
Total	**572**	**100**

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