Micro Level Land Cover Dynamics: A Study of Land Cover Change within A Planned Developmental Site

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Abstract— Remote Sensing based Land Use land Cover changes are relative vis-à-vis the study period and characterized by elements of uncertainty. The authors compare the results of unsupervised and supervised classification within a defined boundary of 120 acres of planned development space (Technopark), Trivandrum. This provides a classical example to understand hidden uncertainties within land cover studies. The study employed the use of satellite data acquired in 2002 and 2012 respectively by Indian Remote Sensing Satellite (IRS) LISS III sensors. Apart from quantifying the change in vegetated and built up pixels within the study site with and without human intervention for classification, the present study has highlighted that a one to one correspondence was observed in proportion of vegetated and built up pixels in a span of 15 years.

Keywords— Land Use Land Cover, Supervised classification, Unsupervised classification.

I. INTRODUCTION

Land use is a function of complex and dynamic combination of factors: geology, topography, hydrology, soils, microclimates, and communities of plants and animals that are continually interacting under the influence of climate and people's activities. It is the most important natural resource on which all activities are based. According to Food and Agriculture Organization (FAO, 1995), information on the rate and kind of changes in the use of land is essential for proper planning and management of such resources (Phukanet al, 2013). Land cover may be defined as the earth’s surface, which includes the natural vegetation, water bodies, rock/soil, and artificial cover on the land (Ellis & Pontius2006). When focusing on a very pure and strict sense, land-cover consists exclusively in the description of vegetation and man-made features. However land use referred as the use of land by human, usually with emphasis on the functional role of land in economic activities. It is the intended employment and management underlying human exploitation of a land-cover.

There is a link between land-cover and human activities in the environment because most contemporary land-cover is changed by human use (Allen and Barnes, 1985).

Land cover changes are of two types; Conversion and Modification. Land-cover conversion consists of change from one cover type to another while land-cover modification involves alterations of structure or function without a total change from one type to another, which is not necessarily the only change in land cover and it also includes the change in intensity and management (Anil et al., 2011). Land-use change may involve either conversion from one type of use to another i.e. changes in the pattern of land uses in an area or modification of a certain type of land use (Meyer and Turner, 1994). Land-cover/Land-use conversion takes place through many pathways such as deforestation, desertification, agricultural intensification, industrialization, etc. (Vorgelegt, 2007). Local land use and land cover changes are fundamental agents of global climate change at all scales and are significant forces that impact biodiversity, water and radiation budgets, and trace gas emissions.

With the advent of satellite remote sensing techniques, preparing accurate land use land cover maps and monitoring changes at regular intervals of time is relatively simpler. Remote sensing technologies provide an effective and efficient approach to identify changes of a geographical area over time. It has enabled ecologists and natural resources scientists to acquire timely data and observe periodical changes. Change detection is the multi-temporal observation to identify differences in the state of an object or phenomenon at different times (Singh, 1989).

The study site provided a textbook case of planned development to study changes and associated uncertainties in land use land cover classification. Unlike natural or agricultural intrusions into forested lands, the study site had no issues of class mixing. Vegetated land within the site was cleared for construction of IT infrastructure. Hence the study was set to a binary mode of vegetated and non-vegetated pixels for classification.
The study focused on ascertaining the extent of land cover change within the site from 2002 to 2012 and had the sub-objectives of comparison between supervised and unsupervised classification as well to define the land cover change trajectory.

II. METHODOLOGY

A. Study Area

The planned development site was the campus of phase I of Technopark, the first, largest and greenest Information Technology Park in India. The area was notified and IT park was operational since 1990. The site extends between 8.55°86’N latitude and 76.88°14’E in longitude in Thiruvananthapuram district, Kerala, India. The study site was previously a part of the campus of the University of Kerala and was uninhabited hill with perennial vegetation cover.

Thiruvananthapuram has a tropical climate with reported mean maximum temperature 34°C and mean minimum temperature is 21°C. At present the site has 4 million square feet of built-up area, and is home to over 285 IT companies employing over 40,000 professionals. This contrasting scenario within a span of two decades was identified as an opportunity to undertake the present study. The study focused on ascertaining the dynamics of change within the site during the past decade using supervised and unsupervised image classification respectively.

B. Data Source

Base map of the study site campus was created by digitizing the Google Earth imagery with the help of the web mapping facility available in QGIS 1.8.0. IRS ID and IRS P6 LISS-III satellite data of Path/Row 100/68 acquired on 28 Feb 2002 and 01 Feb 2012 respectively were used for the present study. Spatial analysis was carried out with Quantum GIS 1.8.0 and IGIS 1.1 was used for displaying, processing, image enhancement and extracting the area of interest (AOI) and subsequently for the preparation of land use land cover maps.

C. Data Preparation

Ortho-rectified IRS P6 image was used as the master image to geocode the IRS 1D LISS III image. Since the satellite images used were from identical sensor and comparable season/time almost similar view and sun angles were presumed for further analysis. Preliminary radiometric correction was carried out using the dark object subtraction method. This involved a global subtraction of the minimum digital number estimated over water body within the study area from all pixels.

D. Image Classification and Change detection

Classification was performed on sub image comprising the study site that was extracted from the full scene. Independent, multi date supervised classification using the Maximum Likelihood method and ISODATA algorithm for unsupervised classification were respectively used. Numbers of classes were restricted to vegetation, which includes all types of vegetated pixels, water body and built up area. Table 1 describes Land use land cover classes used for the study.

Numerical analysis was done on the output statistics of individual classified images to ascertain the change in classes across the time period.
Table 1
Description of the Land use Land Cover Change

<table>
<thead>
<tr>
<th>Class</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vegetation</td>
<td>Dense and sparse trees, avenue trees, etc.</td>
</tr>
<tr>
<td>2</td>
<td>Built up</td>
<td>Commercial and Industrial areas, transportation, communications and utilities</td>
</tr>
<tr>
<td>3</td>
<td>Water</td>
<td>Lakes, streams, canals</td>
</tr>
</tbody>
</table>

III. RESULTS AND DISCUSSION

Land use maps of the study site for 2002 and 2012 are shown in Figure 3. Overall classification accuracy for supervised classification of 0.86 and 0.88 (Kappa values) for 2002 and 2012 respectively were accepted. Land use dynamics in the study region over the study period is indicated in Table 2.

Table 2
Land use details of Techno Park in 2002 & 2012

<table>
<thead>
<tr>
<th>No</th>
<th>Land use</th>
<th>Area in Hectares</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>supervised</td>
</tr>
<tr>
<td>1</td>
<td>Vegetation</td>
<td>34.75</td>
</tr>
<tr>
<td>2</td>
<td>Built-up</td>
<td>12.91</td>
</tr>
<tr>
<td>3</td>
<td>Water</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>

Figure 5, Land cover comparison from 2002 and 2012 in Technopark campus

Either due to the size of the study area or due to the binary approach of classification into either predominantly vegetation or built up area, the outputs of supervised and unsupervised classification were comparable for the two years. Built-up area has come at the cost of vegetated pixel. During 2002 the total build up area was only 26.8%, while in 2012 it has increased to 46.6%. Figure 5 depicts the inter class changes graphically.

The uniqueness of the site with planned developmental activity helped generate a class trajectory curve for the site. It may be noted that the time period was stretched to 1990 and indicated as 0% built-up area and 100% vegetation. A curve drawn over the three points (Figure 6) for both classes (vegetation and built up) intersects at year 2006 and then runs almost parallel to the X axis.

Figure 6, Land cover trajectory for vegetation and built-up area with the study site.
IV. CONCLUSION

The information on land use / land cover is essential for the selection, planning and implementation of land use and can be used to meet the increasing demands for basic human needs and welfare. Change detection analysis on the multi temporal classified data revealed high amount of change in vegetative cover in the study site. The land cover class trajectory, with added data points will help explain uncertainties in classification. The change analysis focused on the dynamics of vegetation to built-up area switch over. It was estimated that 27.2 % of the total vegetated land conversion attributed for change to built-up area. i.e., more than half of the total vegetation conversion was to serve built up purposes. With a couple of years of additional years data, it would qualify as a site to have a land cover change model.

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REFERENCES


