A Satellite-based Biodiversity Dynamics Capability in Tropical Forest

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ABSTRACT

Remotely sensed data are widely used in ecological applications because of its great advantages. Increasing availability of remotely sensed images due to the rapid advancement of remote sensing technology expands the horizon of our choices of imagery sources. Remote sensing provides quick, accurate, cost-effective as well as a time effective method for vegetation cover mapping. The present paper focus on the assessment of vegetation in Alwar district (Rajasthan) using forest inventory and geospatial approaches. Vegetation indices among other methods have been reliable in monitoring vegetation change. One of the most widely used indices for vegetation monitoring is the Normalized Difference Vegetation Index because vegetation differential absorbs visible incident solar radiant and reflects much of the infrared. Data on vegetation biophysical characteristics can be derived from visible and NIR and mid-infrared portions of the electromagnetic spectrum. Four forest types, namely *Anogeissus pendula*, *Boswellia serrata*, mixed *Anogeissus butea* and mixed *Acacia zizyphus* are mainly dominant in the forest cover of Alwar district. Satellite data of Awifs (2010) give precise information of vegetation through reflectance value. This paper aimed to develop a model for vegetation at plot level and the associated spectral characteristics. These spectral classes of the imagery are finally translated into the vegetation types in the image.
interpretation process, which is also called image processing. Hence, at the end an overview of how to use remote sensing imagery to classify and map vegetation cover was achieved.

**KEYWORDS:** NDVI; Mapping; Inventory; Density

### INTRODUCTION

Remote sensing provides a useful source of data from which updated land cover information can be extracted for assessing and monitoring vegetation changes. Remote sensing is one of a suite of tools available to land managers that provide up-to-date, detailed information about land condition. Remote sensing uses instruments mounted on satellites or in planes to produce images or 'scenes' of the Earth's surface. Remote sensing satellite data aims for the achieving higher accuracy and more detailed results for classifications [1-5]. Vegetation change may be a terminology of rather comprehensive definitions, which ranges from the in growth of a single tree to the entire deforestation by clear-cut. Whether we can detect and monitor vegetation changes by remote sensing data depends on the spatial and temporal characteristics of the change and the type of remote sensor data to be used. Therefore, it is important for us to understand the nature of vegetation changes prior to analyzing remote sensing data. In the past several decades, air photo interpretation has played an important role in detailed vegetation mapping [6-7].

The basic concepts, available imagery sources and classification techniques of remote sensing imagery related to vegetation mapping were introduced, analyzed and compared. While the high spatial resolution remote sensing imagery provides more information than coarse resolution imagery for detailed observation of vegetation, the increasingly smaller spatial resolution does not necessarily benefit classification performance and accuracy [8-9]. With the increase in spatial resolution, single pixels no longer capture the characteristics of classification targets. The increase in intra-class spectral variability causes a reduction of statistical separability between classes with traditional pixel-based classification approaches. Consequently, classification accuracy is reduced, and the classification results shows individual pixels classified differently from their neighbors. In this study changes in the normalized difference vegetation index was used to assess impact of timber harvesting system [10-11].

However, quantifying the effects of land cover change on forest and above ground biomass density estimates at the regional level over time using optical remote sensing inputs are still in the rudimentary stage. For example, a saturation phenomenon in optical signal obscures biomass density estimates in mature forests [12-14].

### METHODOLOGY

**Experimental Site**

Alwar district is situated in the north-eastern part of Rajasthan and extends between north latitude 27° 03’ to 28° 14’ and east longitude 76° 07’ to 77° 13’ (Figure 1). It covers an area of 8380 sq km and is covered in the Survey of India topo-sheets No. 54A, 54E & 53D. Its length from south to north is about 137 km and width is about 110 km from east to west. From a view point of the succession and the concept of a continuum of vegetation, the large-scale formation types in the area are *Acacia catechu* and *Anogeissus pendula* vegetation types. On the basis of structural attributes two major vegetation types "Tropical Dry Deciduous Forest" and "Tropical
Thorn Forest" [15] are present in the study area. The forest being scattered over a large area on various geological and soil formations vary greatly in composition and quality. Edaphic and biotic factors determine their distribution. Good forest growth occurs in valleys where better soil and moisture conditions exist. The main species of the tree which cover over 42% of the area is Mixed Acacia-Zizyphus. Its associates like Salar (Boswellia serrata Planch.), and Urjan (Linea coromrnrdelica Houtt.) grow on rocks and dry areas. Khair (Acacia catechu Wild.) is common in the valleys and Bamboo (Dendrocalamus strictus Roxb.) grows in extremely limited extent along with well drained reaches of the streams. It is also found in the valley. The trees are generally slow growing and attain poor height. The height of tree varies from 4.5 meters to 7.5 meters. In favorable localities the height up to 12 meters is attained. Imli (Tamarindus indica L.), Aam (Mangifera indica L.), Jamun (Syzygium cumini L.), Tendu (Diospyros melanoxylon Bakh.), Bahera (Terminalia belliric Roxb.), Arjun (Terminalia arjuna L.), Churel (Holoptelia integrifolia Roxb.), Siris (Albizzia lebbek L.) etc. which grow in moist localities and attains large size, both in crown spread and height. Where valleys fan out in open and where they flatten and become wider, Dhok (Butea monosperma Lam.) grows gregariously.

Figure 1: Study area
Data Used

The SOI (Survey of India) topo-sheet at scale of 1,500000 has been used to prepare base map of the study to overview the study area. Here we are using the data of IRS P6 Awifs sensors. Satellite, sensor and acquisition dates for the satellite data used during analysis are given in Table 1.

<table>
<thead>
<tr>
<th>Particulates</th>
<th></th>
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<tbody>
<tr>
<td>Satellite</td>
<td>IRS P6</td>
</tr>
<tr>
<td>Sensor</td>
<td>Awifs</td>
</tr>
<tr>
<td>Band combination</td>
<td>3,2,1</td>
</tr>
<tr>
<td>Swath</td>
<td>740 km.</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>56 m. IFOV</td>
</tr>
<tr>
<td>Year</td>
<td>2010</td>
</tr>
</tbody>
</table>

Data Collection

The precision of the sample estimate of the population depends not only upon the size of sample, but also on the variability in the population which is very high. Sampling variance can be reduced by dividing the population into the number of homogeneous groups and then selecting a random sampling from these groups of population independently. The homogenous group in which the population is divided is called strata and the procedure of sample selection is called stratified random sampling. The use of stratification is possible only when the complete frame for all strata and size are variable. In the present study, stratified random sampling was carried out.

In the grid center a square plot of 0.1 ha is laid out. Measurement of various parameters like DBH, species name, crown-diameter etc. for all trees above 10 cm DBH is carried out. For litter, humus and soil carbon, two sub plots of 1 sq.m. are laid out on opposite corners of the inventory plot (0.1 ha). Samples of litter, humus and soil are then collected from all the sub-plots.

Data Analysis

Digital image analysis was carried out using ERDAS-9.3 and ArcGIS 9.1 software package. The approach used for forest inventory method is based on remote sensing and GIS. Based on the preliminary keys, the forest was eco floristically classified through the preliminary interpretation of the satellite imageries. All the spatial data in the form of map were scanned using a scanner and transformed into computer readable digital maps. This digital map is imported into PCI Geomatica and liner enhancement processes were performed which is then imported into ERDAS IMAGINE for rectification process [16-18]. The rectified digital map was consequently imported into ARC GIS in order to digitize and generate various thematic layers via; forest cover map, forest density map etc.
RESULT AND DISCUSSION

Land-Use/Land-Cover Density Classification

Land is the most important natural resource endowment on which all human activities are based. Therefore, knowledge of different type of land use as well as its spatial distribution in the form of map and statistical data is vital for spatial planning and management of land and its optimal use. Land use/land cover classification was done on the basis of spectral signatures along with field verification and ground truthing. Six main classes were identified for land-use/cover-types as elaborated in Figure 2. Forest cover is concentrated in Sariska Tiger Reserve and its surroundings area.

![Landuse / Landcover Map](image)

The Forest cover type has been categorized into six classes (Figure 3). Mixed *Acacia-Zizyphus* occupied the maximum area (542.955 km²) followed by mixed forest (461.19 km²), *Anogeissus pendula* (213.801 km²), *Butea monosperma* (3.019 km²) and minimum area occupied by mixed riverine forest (0.82 km²) as shown in Table 2. On the basis of NDVI values, visual interpretation and supported ground truth information, four forest density classes viz., <10%, 10-40%, 40-70% and >70% has been differentiated in the study area. Maximum area fall within the 10-40% density classes (581.313 km²) followed by > 70% density classes (38.030 km²), 40-70%
density classes (364.726 km$^2$) and < 10% density classes (323.087 km$^2$) shown in Figure 4 and Table 3.

**Table 2: Area under major forest cover types**

<table>
<thead>
<tr>
<th>Species Name</th>
<th>Area (km$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anogeissus pendula</td>
<td>213.801</td>
</tr>
<tr>
<td>Boswellia serrata</td>
<td>103.368</td>
</tr>
<tr>
<td>Butea monosperma</td>
<td>3.019</td>
</tr>
<tr>
<td>Mixed Acacia-Zizyphus</td>
<td>542.955</td>
</tr>
<tr>
<td>Mixed forest</td>
<td>461.19</td>
</tr>
</tbody>
</table>

![Forest Cover Type Map](image)

**Figure 3:** Forest cover type map of study area

**Table 3: Area with corresponding density class**

<table>
<thead>
<tr>
<th>Density Class</th>
<th>Area (km$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 70%</td>
<td>38.030</td>
</tr>
<tr>
<td>40 – 70%</td>
<td>364.726</td>
</tr>
<tr>
<td>10 – 40%</td>
<td>581.313</td>
</tr>
<tr>
<td>&lt; 10%</td>
<td>323.087</td>
</tr>
</tbody>
</table>
Figure 4: Forest density map of study area

Forest NDVI Classification

The NDVI approach is based on the fact that healthy vegetation has low reflectance in the visible portion of the EMS due to chlorophyll and other pigment absorption and has high reflectance in the NIR because of the internal reflectance by the mesophyll spongy tissue of green leaf [2]. NDVI can be calculated as a ratio of red and the NIR bands of a sensor system. NDVI values range from -1 to +1, because of high reflectance in the NIR portion of the EMS, healthy vegetation is represented by high NDVI values between 0.1 and 1. Conversely, non-vegetated surfaces such as water bodies yield negative values of NDVI because of the electromagnetic absorption quality of water. The obtained value of NDVI image of the study area ranges from -1 to +1 shown in Figure 5. Maximum NDVI values fall within the range of 0.50-0.73 and minimum 0.09-023.
CONCLUSION

It is well established that infra-red bands has been found to be very useful discriminating vegetation cover in conjunction with other bands in the optical range. Red band and infra-red band, particularly ratio images have been widely used for vegetation discrimination. Middle infra-red has been found useful in vegetation discrimination of tropical forest where infra-red reflection was not useful (Figure 6).
REFERENCES


