Role of Geospatial Techniques in Forest Resource Management of Sariska Tiger Reserve (Rajasthan), India

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Abstract: Forests have played a vital role in the economics and civilizing development of the India. Forest Management of forest cover, forest types, deforestation rate etc. is essential data for forest management. These data are now being secured applying on GIS and Remote Sensing. The present study focus on the forest management plane of Sariska Tiger Reserve using forest inventory method and geospatial techniques. Forests have the potential to be managed to reduce atmospheric concentration of CO_2 and thus mitigate climate change. Four forest species types, namely *Anogeissus pendula, Boswellia serrata*, mixed *Anogeissus butea* and mixed *Acacia zizyphus* mainly dominant in the forest cover of Sariska Tiger Reserve. The multistage statistical technique with incorporated the satellite data of LANDSAT ETM+ (2006) gives a precise information of vegetation. Satellite remote sensing has played a pivotal role in generating information about forest cover, vegetation type and Landuse changes.

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1.0 Introduction

Forests currently cover approximately 30 percent of the land area of the planet (Foody, Lucas *et al*., 1997). Forest resources are the natural resources available on forest lands or associated there of (Akpan and Ofiong, 2007).Estimates suggests that deforestation is occurring at a rate of between 15-17 million ha per year, predominantly because of human-induced land-use changes. Over 45 per cent of the Earth's original forests have been cleared during the past century (United Nations, 1992). These human-induced changes in forest extent and condition impact biodiversity, climate, biochemical cycles and economic development (Malingreau Achard *et al*., 1995). Forest biomass is an important component for studying the carbon cycle dynamics and is one of key indicators of forest health (Heath and Birdsey, 1993; Dixon *et al*., 1994; Houghton, 1995; Schimel, 1995; Sannier *et al*., 2002; Zheng *et al*., 2004; Bechtold and Patterson, 2005).Goals of forest management can focus on one or more outcome, output or benefit. Benefits include conservation of soil, water, vegetation, wildlife, carbon and nutrient resources. Forest management can enhance levels of carbon stocks. Remote sensing has been widely used in the study of forested environments (Boyd & Danson, in press; Franklin, 2003). A study made by the Forest Survey of India reveals that 51% of the forest area in Assam and Gujarat, 93% in Arunachal Pradesh, 67% in Bihar, 69% in H. P., 46% in J & K, 45% in Karnataka, 76% in M. P., 94% in Meghalaya and Orissa, 87% in Nagaland, 58% in U. P. and 33% in West Bengal is subject to repeated annual fires (Lal, 1989).

Satellite based methods are conventional remote sensing method and biophysical response modeling. Different conventional remote sensing method such as slicing, image arithmetic, segmentation and multispectral image classification are prepared by different authors.

Many applications of forestry require accurate analysis. Changing conditions due to urban sprawl, as well as increasing forest fragmentation, make land cover and change analysis an extremely important consideration for management, planning and inventory mapping. This includes ecosystem and species diversity, forest productivity, reforestation, forest health, conservation of soil, water resources, and nutrient cycling. Geospatial techniques play a fundamental role in determining, enhancing and monitoring the overall carrying capacity. The repetitive satellite remote sensing over various spatial and temporal scales offers the most financial means of assessing the environmental parameters and impact of the developmental processes. The anthropogenic interference in the natural forest reduces the number of trees per unit area and canopy closure.

Remote sensing data combined with GIS technique facilitates to analyze the data to obtain information and to bring out subsequent scenarios and changes after over laying and data base modeling for decision making for various forest related objectives. Fire hazards are disastrous not only for environment but also are disastrous for precious human life, animal kingdom and the insect world. With the use of modern techniques like GIS and RS these hazards can be detected and neutralized effectively using various applications like: fire risk / probability assessment, post fire assessment and monitoring and fire management.

2.0 Materials and methods

2.1 Experimental site

Sariska Tiger Reserve and its whole adjoining areas, both together constitute the tiger reserve. Its lies between 27º13' to 27º31' N latitude and 76º15' to 76º33' E longitude (Figure 1). The reserve holy lies in the civil district of Alwar of Rajasthan and located in the oldest hill ranges of the Aravalli spreading over the tract starting from Mount Abu and culminating at the Delhi ridge. The area was declared a reserve in 1955 and became a national park in 1971. The climate of the area is subtropical, characterized by distinct winter, summer, and monsoon and spring seasons. Temperature ranges from 0°C in winter to 41.5°C in summer. The average annual rainfall is 650 mm. The bulk of the precipitation being from south-east monsoon is July, August and September. The winter (January-February) rain showers are few. The average numbers of primary of rainy days in a year are 30.

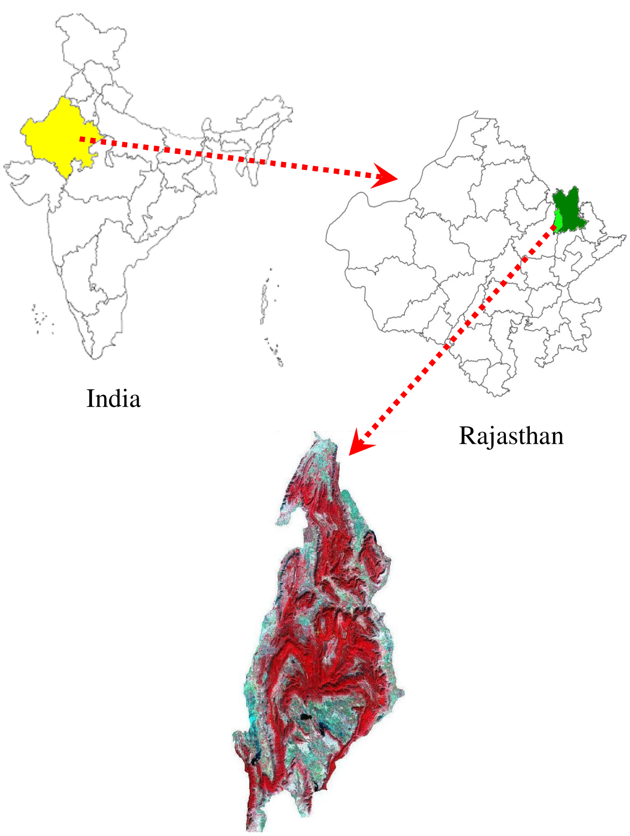

Figure 1. Location map of experimental site

2.2 Flora of experimental site

Under broad category the forest is "Dry Tropical Forest". According to the classification of forest types of India by H.G. champion and S.K.Seth (1968). The forest met within the tract falls under group 5 "Tropical Dry Deciduous Forest" and group 6 "Tropical Thorn Forest". The forest being scattered over a large are on various geological and soil formation, vary greatly in composition and quality. The main species of the tree which cover over 90% of the area is Dhok (*Anogeissus pendula* Edgew.) (Figure 2). Its associates like Salar (*Boswellia serrata* Planch.), and Urjan (*Linnea corommrndelica* Houtt.) grow on rocks and dry areas. Khair (*Acacia catechu* Willd.) is common in valleys and Bamboo (*Dendrocalamus strictus* Roxb.) grows in extremely limited extent along with well drained reaches of the streams. It is also found in 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(*Terninalia arjuna* L.), Churel (*Holoptelia integrifolia* Roxb.), Siris (*Albizzia lebbek* L.) etc. which grow in moist localities attain large size, both in crown spread and height. Where valleys fan out in open and where they flatten and become wide, Dhak (*Butea monosperma* Lam.) grows gregariously.

These forests have been classified on the basis of their composition as follows;

1. Dhok Forest;
2. Salar Forest;
3. Khair Forest;
4. Miscellaneous forest (Chhila Forest; Forest along Nalas; Scrub Forest; and Bamboo Forest.

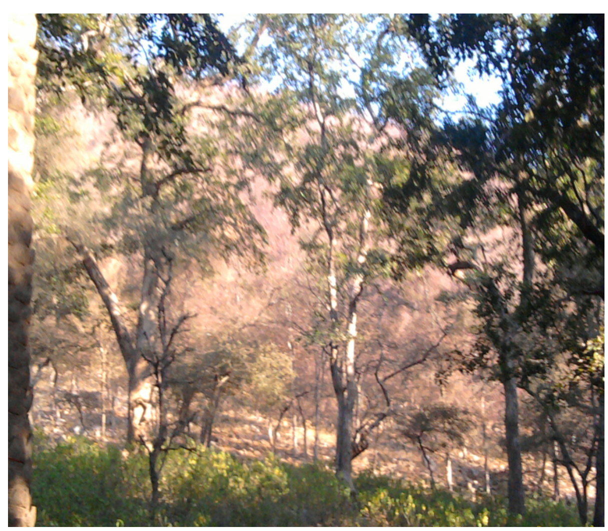

Figure 2. Location map of experimental site

2.3 Data used

Satellite, sensor and acquisition dates for the data used during analysis are given in Table 1.

Table 1. Description of data

Particulates	
Satellite	LANDSAT
Sensor	ETM+
Scale	1:50000
Band combination	4, 3, 2
Year	2006

3.0 Role of geospatial techniques in forestry

A variety of approaches and data sources have been used to estimate forest above ground biomass .A comprehensive review of remote sensing based estimates of AGB has been completed, categorized by data source: (i) field measurement; (ii) remotely sensed data; or (iii) ancillary data used in GIS based modeling (Lu *et al*., 2006). Estimation from field measurements may entail destructive sampling (Miksys *et al*., 2007; Jia *et al*, 2005) or direct measurement (Liddell *et al*., 2007) and the application of allometric equations Above ground biomass is necessary for studying productivity, carbon cycles, nutrient allocation and fuel accumulation in terrestrial ecosystems (Alban *et al*., 1978; Brown *et al*., 1999; Crow, 1978; Ryu *et al*., 2004).

4.0 Forest inventory and sampling

4.1 Planning for field data collection

Planning is most important before reaching to the field. This is important to optimize on effort to reach the sample locations. This needs to be done using Survey of India toposheet and latest road map.

4.1.1 Pre Field preparation

List of the items required for field survey is given in Table 2. Please check items as per the list before leaving for field. Please carry enough number of consumables like field forms, pencil/pens and batteries for GPS and torch etc.

Table 2. List of the items for field work

Items	Remarks
FCC/Google earth printout	For TOF location and finding the tonal characteristics of the plots.
SOI Sheets preferable on 1:50K	Find out the route to reach the sample sites; location.
Field form	Please carry enough number of sets.
Good quality writing pads with clamp(Plastic)	2-3, as the work progresses more people can be involved in taking observation.
GPS with 8 extra Duracell batteries	Feed all site location before going to field and also note down the location street or place/vehicle before entering the forest.
Hypsometer with strip	This is useful for measuring height and slope.
Polythene bags of 5 kg capacity x 1 kg good quality	For keeping the harvested biomass from 1x1m herbaceous ground flora and also for keeping ultimate twigs.
12 Secateurs-good quality	To cut the ultimate branch.
Pen/pencil/shar-pener and eraser	To write the information of field work.
Blades	For small purpose.
Field bag/ruck sack	Rucksack should have several pockets.

4.2 Preparation for primary data collection

The primary data such as forest types, forest density, species composition, number of storey, stand height, girth at breast height(GBH) are essential to estimate growing stock, especially these information are much more important when the study is carried out through the stratified random sampling. For a satisfactory output from any project, pre field work is the most importance as it is the first step of the study. The working plan enumeration inputs are based on field surveys across the forests on a systematic way. The conventional way of systematic sampling suffer due to accounting various strata and burdened with intense field work & expensive procedures. The stratified sampling procedures provide a reliable quantification of forest resources depending on the objective set during the inventory.

4.3 Determination of sample size

The precision of sample estimate of population depends not only upon the size of sample, but also on the variability in the population is very high, sampling variance can be reduced by dividing the population into the number of homogeneous groups and then selecting random sampling from these groups of population independently (Chako, 1980).The homogenous group in which the population is divided are 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. Effectiveness of stratification can be investigated by the analysis of variance. The variance of total population is made up off the variance within individual strata and of variance within the strata.

In the present study, stratified random sampling was carried out. The number of sampling units was calculated by following formula.

$$N = \frac{t_2\,(CV\,\%)^2}{E^2}$$

Where n = number of sample required for allowable error (E %)
t = value of t-static's at 95% level significance: 1.96
CV = co-efficient of variation ± 33.5

Assuming the E% equal to 10% the required number of sample unit comes out to be 30. These sample plots were allotted to different strata of homogeneous vegetation according to stratified random sampling method. In this study, the sizes of the samples were taken as 26 due to inaccessibility and severe cold.

4.3.1 Layout design of sample plot

Laying of plots need lot of precautions. After reaching the site consider the following points Firstly, on hills chooses any aspect and all the plots need to be same aspect; Secondly, avoid any major stream inside the plot, the plot can be adjusted to that plot is laid on one side of the stream within the frame of 31.62*31.62 m; Thirdly, we need to fix the direction/side of plot, *i.e.* left or right side of the direction, which can be followed uniformly; Fourth precaution is to keep the all the baggage outside the proposed plot (Figure 3). This is important to avoid trampling of the herbaceous flora of that corner. The actual laying of plots begins by identifying the corner tree and marking. A red flag can be put on the stream at appropriate height so that it is visible from distance. Working plan of the forest division office or range office or range office can be consulted for this. More knowledge can be from local flora/books.

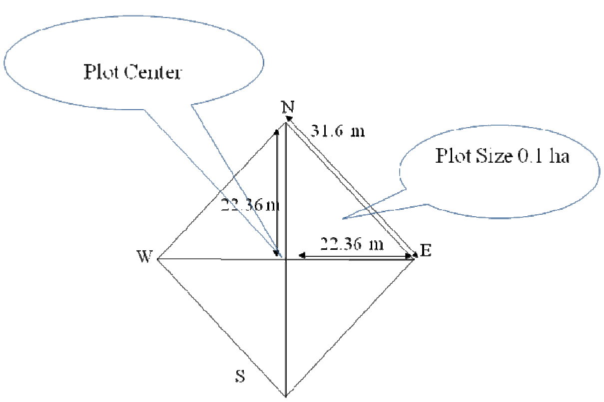

Figure 3. Layout design of sample plot

4.4 Field work

4.4.1 Reconnaissance survey

The reconnaissance survey has been carried out at the beginning of field in order to be familiar with the study area and for ground truth observations needed for preparing the interpretation keys which are essential in forest cover type and forest density classification.

4.4.2 Preliminary visual interpretation on satellite data

Based on the preliminary keys, the forest was eco floristically classified through the preliminary interpretation on the satellite imageries. During field work, it was observed that some of the mixed Dhok dominant trees had thick under storey growth and these are coppicing in nature. Finally the forest was classified into four classes in terms of forest density as Table 3.

Table 3. Classification of forest canopy density

Sl.No.	Class	Description
1	Class I	Very Dense 70% and above
2	Class II	Moderate 40-70%
3	Class III	Open 10-40%
4	Class IV	Scrub <10%

5.0 Results and discussions

5.1 Forest land use and cover type classification

Land use/ land cover classification was done on the basis of spectral signatures, along with field verification and ground truth. The classified land use/cover map of the study area is shown in Figure 4. There are three types of forest categories *i.e.* Dense Forest, Degraded Forest and Open Forest which is shown in Figure 5.

5.2 Forest canopy density classification

The obtained value of NDVI image of the study area ranges from -1 to +1. On the basis of NDVI values, visual interpretation and supported ground truth information, Forest cover types have been categorized in to six classes. Maximum NDVI shows that area cover by dense forest and minimum NDVI shows that area cover by open forest because reflectance of NIR are maximum in dense forest. Mixed *Acacia-Zizyphus* has the maximum area occupied, followed by mixed forest, *Boswellia serrata*, *Anogeissus pendula*, *Butea monosperma* and mixed riverine forest (Figure 6). The information regarding vegetation density has been extracted through different approaches. In present study the different spatial and bidirectional properties of various vegetation indices were developed. The principle behind vegetation indices were that they should be sensitive to the amount or density of foliage and insensitive to other environmental variable such as soil, atmosphere attenuation etc.

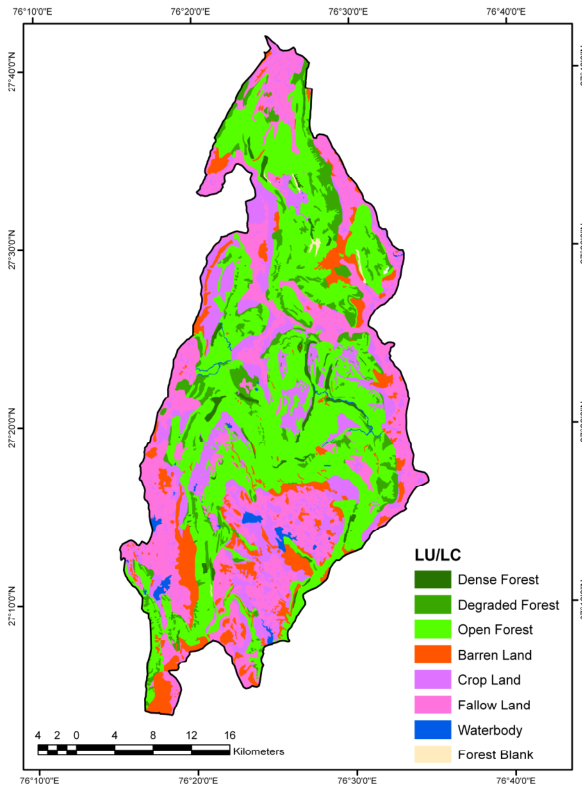

Figure 4. Landuse / Landcover map

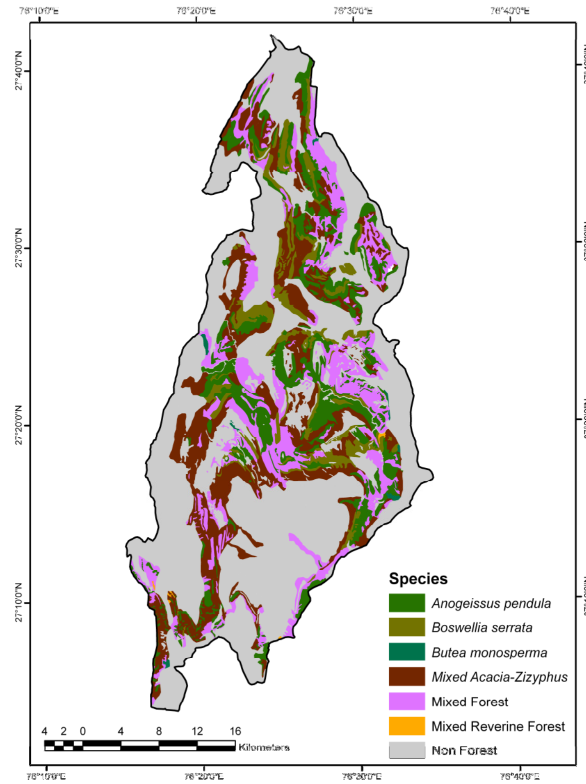

Figure 6. Forest species map

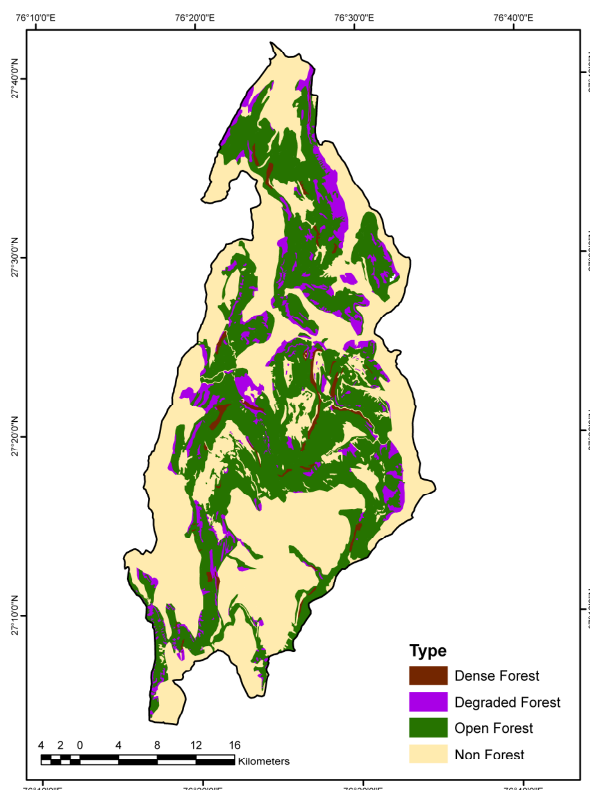

Figure 5. Forest cover type map

5.4 Discussion

It is well established that infra-red bands has been found to be very useful to discriminate vegetation cover in conjunction with other bands in 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 when infra-red reflection was not useful (Kumar *et al*., 2011) which is shown in Figure 7.

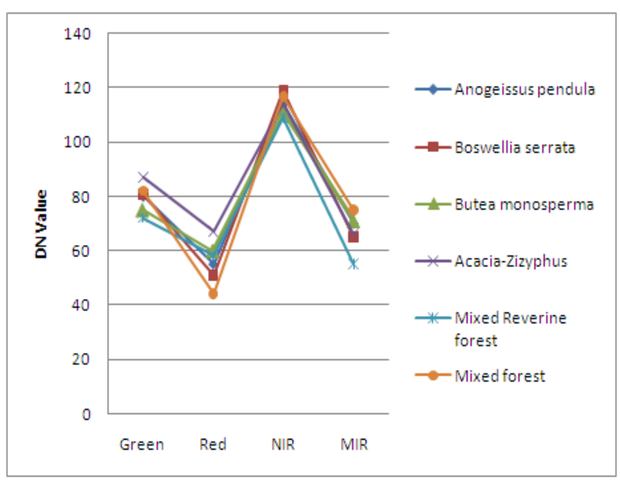

Figure 7. Spectral signature of vegetation

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