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Spatio-Temporal Change Detection of Vegetation Cover in Kalbetta State Forest, Karnataka, India

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Abstract: ***Tropical forests are becoming increasingly fragmented by the widespread and rapid increase in anthropogenic activities affecting the vegetation cover. This is the scenario in almost all the tropical countries and India is no exception. The valuation, assessment and conservation of fragmented forests are critical from the point of Biodiversity conservation. In this context, a study was conducted to observe the vegetation changes over a period of time in Kalbetta state forest which is a fragmented forest patch. Geospatial techniques using multi-temporal satellite datasets are helpful in monitoring changes in the vegetation cover. The change detection of vegetation cover of the study area through RS and GIS technique using multi-temporal Landsat satellite datasets dating 1991, 2000 and 2014 was conducted. Results of the study reveal that there has been a significant positive change in the Vegetation cover in 2014 when compared to 1991. The open forest area (<20% canopy cover) has reduced by 10.95%, moderately open forest (20-40% canopy cover) has reduced by 19.54 % and contrastingly less dense forest (40-60 % canopy cover) has increased by 5.96%, moderately dense forest (60-70% canopy cover) has increased by 17.27% and dense forest block (>70% canopy cover) has increased by 7.25% of the area. The results provide valuable evidence of change in vegetation cover which has helped in the assessment of the extent and direction of changes in the study area. The observations during the study revealed that these changes could be attributed to the management interventions and socio economic changes in the surrounding villages.***

Keywords: Change Detection, Geospatial, Remote Sensing, GIS, Digital image processing

1. Introduction

Forests are important ecosystems and source of subsistence, employment, revenue earnings and raw material to a number of industries apart from many intangible goods which play a vital role in ecological balance, environmental stability, biodiversity conservation and food security [1,2]. Forest ecosystem is a classic example of dynamic system where continuous changes take place in size, shape and structure. Nowadays the decrease in vegetation / tree cover is causing a severe threat reflecting in the depletion of natural resources at the regional, national and global level. The forest resources, in general, have been under mounting pressure owing to increasing human and livestock population. Forest loss is contributed by socioeconomic pressures, industrialization, urbanization, forest fires, over-logging, shifting cultivation, mining, over exploitation of renewable sources such as wood fuels and Non timber forest products. In addition, forest resource loss is also attributed to conversion of forest lands for developmental activities such as multiple usage river valley projects, agriculture, and allocating forested land for rehabilitation of displaced people. Over exploitation without a concern for sustainability is creating forest denudation [3]. This has led to creation of fragmented forests. Evaluation, assessment and conservation of these fragmented forests are critical from the point of biodiversity conservation.

The forest management in the country has followed a scientific method based on the Working Plans for more than a century. The Forest working plan is a document that details the management of forests of a territorial division in all aspects such as, forest protection, conservation, management and resource harvest [4].The prescription in working plan includes silvicultural operations in the forest compartment, timber coupes and bamboo coupes to provide conducive conditions for the growth of the species. These operations include management intervention measures to protect, conserve and develop the forest area. The Forest management in the last few decades has become conservation oriented resulting in the creation of considerable extent of Protected area network in the country. It has also focused on sustainability in addition to scientific and need based extraction of timber and other resources. The ban on green felling in the reserve forests and resorting to the extraction of only dead and fallen timber is a typical example followed in the state of Karnataka. In-spite of this focused management, the growing anthropogenic pressure has resulted in considerable changes in terms of density and structure of the forest.

One way of evaluation and assessment of these changes is through Remote Sensing and Geographical Information Systems (GIS) technologies, whose applications in land and natural resources management are widely recognized. Computer aided Remote Sensing and Geospatial techniques are useful in spatial data integration, data analysis and modeling for suggesting the valuable solutions to mitigate forest degradation problem by identifying the most prominent threats [5,6,7,8]. These technologies are cost effective and relatively accurate in understanding the landscape change dynamics [9]. Satellite imageries are considered as a useful tool to study forest as they provide a digital mosaic of the spatial arrangement of land covers. The process of change detection is premised on the ability to measure temporal changes [10,11]. Use of multi-temporal satellite data helps in observing the changes in the vegetation cover over a period of time. These are effective

modern tools for observing the changes at macro, meso and micro level which could help in the management of critical habitats [12].

The purpose of this study was to investigate the change in vegetation cover over a period of 23 years in Kalbetta State forest of Karnataka, India using multi-temporal Landsat satellite data. The study involves using of Digital image processing assisted by visual interpretation with adequate ground control points in the study area.

2. Study Area

The study area Kalbetta State Forest is located in Hunsur taluk of Mysuru District, Karnataka, India. It lies between 76°14'13" E 12°19'14" N and 76° 15'16"E 12°17'29"N geographically with an elevation range of 835m – 908 m above MSL (Figure1).

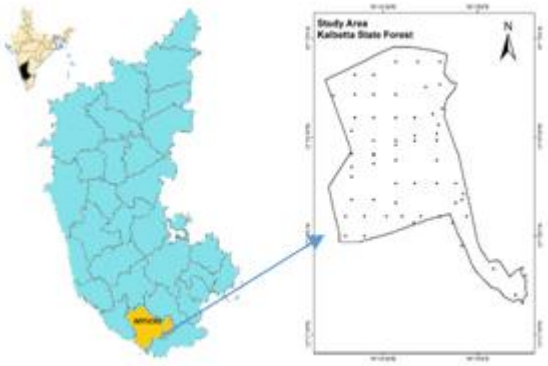

Figure 1: location map of the Study area

This area was declared as the state Forest by the Government of Mysore during the year 1900 as per notification which covers an area of 1412 acres (571 ha). The major vegetation comprises of scrub forest with less than 0.25 densities and scanty natural regeneration interspersed with lot of rocky patches. Rainfall in the region varies between 600 to 900 mm annually. After several land conversions by the Government, the area is now left with only 178.8 ha. In addition to this, the study area also includes adjoining forest lands of 31.2 ha totaling to 210 ha The area is rich in floral biodiversity consisting of trees, shrubs, herbs and climbers with *Santalum album, Boswellia serrata, Cochlospermum religiosum, Gmelina arborea, Abrus precatorious, Diaspyros montana, Canthium dicoccum, Albizia lebbeck, Hemidesmus indicus* and *Ionidium fruticosum* [13].

3. Methodology

Topo-sheet 57D3, 57 D7 on 1: 50,000 scale for Kalbetta State forest was obtained from Survey of India. Available satellite imageries were procured from Landsat Thematic Mapper (TM) and Landsat Enhanced Thematic mapper plus (ETM+) sensors in the path 145 row 51of World Reference System 2 (WRS 2) for the study area. Landsat TM and ETM+ data for 2nd January 1991, 20th December 2000 and 3rd December 2014 were acquired from Global Land Cover Facility (GLCF) with a spatial resolution of 30 meters. The data used in this change detection study is of the same season to maintain uniform spectral reflectance.

Digital image processing comprising of Raster and vector data analysis were conducted using ERDAS Imagine 9.1, Arc GIS 10.1 for processing, analysis and integration of spatial data [14] (Figure2).

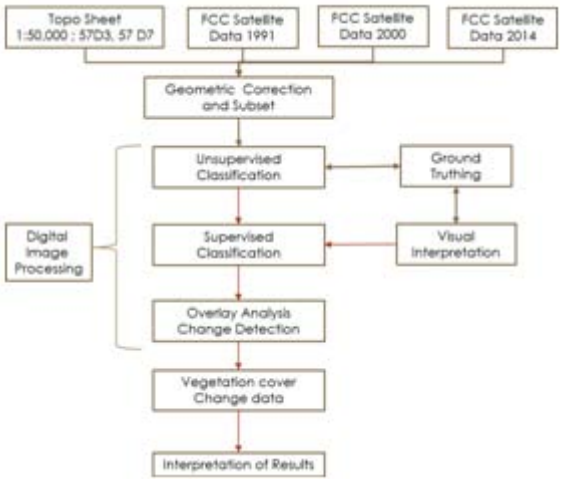

Figure 2: Flow chart of the methodology

False color composite with Bands 2,3,4,5 were generated [15] using layer stack method for each imagery date by replacing with near infrared, red and green bands. Geo-referencing, Edge matching of the topo-sheets and preparation of digital mosaic depicting the study area were done. Digitization of the study area from the topo-sheets were taken up to have a baseline map. The satellite imageries were geocoded and geometrically rectified to 2014 imageries in order to obtain precision among multiple sensors and imagery dates. Digital image enhancement and application of correction models were carried out for making the digital data free from errors and distortions from both radiometry and geometry of the satellite data.

An unsupervised classification of satellite imagery was done to produce different classes in 2014 imagery as a baseline study. Visual interpretation was carried out by having a reconnaissance survey of the entire study area to correlate image characteristics and ground features. The imagery was visually interpreted and spectral signatures were collected using six basic photo elements viz., tone, texture, shape, size, pattern and association together with 52 Ground Control Points (GCPs). Supervised classification for all the imageries was performed using the GCPs by adopting Maximum likelihood classification technique. Based on Feature extraction and selection of signatures, each imagery was classified into five major vegetation cover classes namely Open, Moderately Open, Less Dense, Moderately Dense and Dense forest blocks. Based on the crown cover Open block with <20% cover, Moderately Open block with 20-40% cover, Less Dense block with 40-60% cover, Moderately Dense block with 60-70% cover and Dense forest blocks with >70% cover were classified.

Change detection was performed by overlaying all the temporal data to compare change in each of the vegetation classes. Raster to vector data conversion was performed for digitizing each classes to calculate the area. Thematic maps

were generated using Arc map software by digitization of topo maps and ancillary maps. The maps provided basic features like roads, topography, water-bodies, settlements etc. Layout of GCPs based on unsupervised classification, over lay and change detection with area calculation were carried for finalization using GIS technique. Map Composition was done depicting the changes in vegetation cover with temporal data.

4. Results

The results indicated a positive change in vegetation cover during the comparison of the temporal data of 1991, 2000 and 2014. (Figure 3, 4 & 5) and (Table 1). Kalbetta once classified as scrub forest with less than 0.25 densities, with scanty natural regeneration and lot of rocky patches has changed positively with reference to vegetation cover.
The details of the results are as follows:

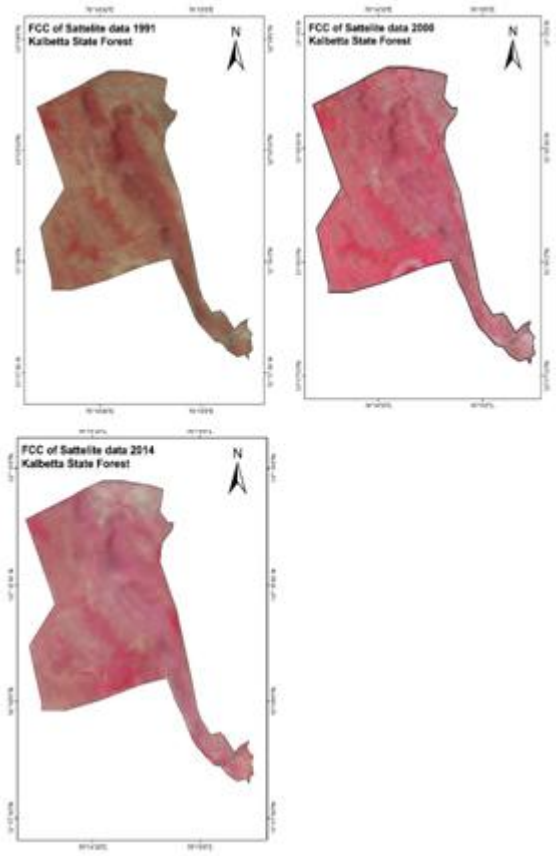

Figure 3: FCC of Satellite data for vegetation mapping of Kalbetta State Forest

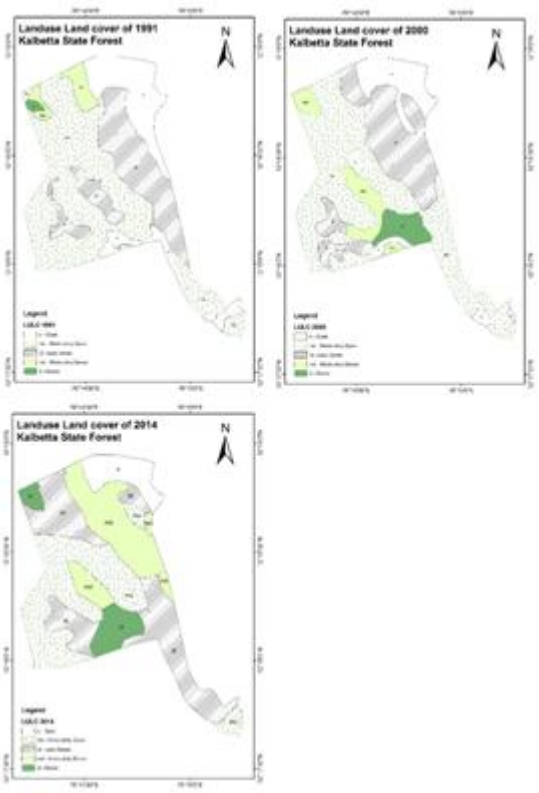

Figure 4: Land use/ Land cover change detection map of Kalbetta State Forest

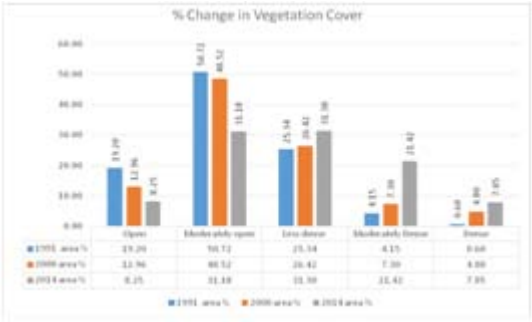

Figure 5: Graphical representation of Change in Vegetation cover

Table 1: Comparison of change in vegetation cover class during 1991, 2000 and 2014

Sl. No.	Category of vegetation cover	1991 area (Ha)	1991 area %	2000 area (Ha)	2000 area %	2014 area (Ha)	2014 area %	Total % Change
1	Open	40.31	19.20	27.22	12.96	17.33	8.25	-10.95
2	Moderately open	106.50	50.72	101.90	48.52	65.48	31.18	-19.54
3	Less dense	53.21	25.34	55.48	26.42	65.74	31.30	5.96
4	Moderately Dense	8.72	4.15	15.32	7.30	44.98	21.42	17.27
5	Dense	1.26	0.60	10.08	4.80	16.48	7.85	7.25
	TOTAL	210.00	100.00	210.00	100.00	210.00	100.00	

Open Forest Block - As per the results, during 1991, the extent of open area block accounted for 19.20% (40.31 ha) of the total area. In 2000, the area accounted for 12.96% (27.22 ha) and in 2014, the extent of the area is 8.25% (17.33 ha). There is an overall reduction of 10.95% of area when compared from 1991 to 2014. The reasons for this reduction could be attributed to some of the management

decisions. A major portion of this open area block was once used as a timber depot. It was used to store huge quantities of timber, firewood and poles. Subsequent change in the policy of the Government to ban green felling in the natural forests has resulted in the decrease of extraction of timber, firewood etc. leading to the reduced inflow of timber into the depot. Later the forest department raised the plantations in the unused vacant area of the depot and eventually the natural vegetation increased thereby resulting in positive change in open area block. The area mainly comprises of *Tectona grandis, Cassia siamea, Acacia auriculiformis, Albizia amara, Delonix regia, Pongamia pinnata. Ficus* sp., and *Eucalyptus* sp.

Moderately Open Block - During 1991, the moderately open area block accounted for 50.72% (106.5 ha) of the total area. However in 2000, the area has decreased marginally by 2.19% accounting for 48.52% (101.9 ha) of the area. Whereas in 2014, the area was reduced to 31.18% (65.48 ha) resulting in overall decrease of 19.54% (41.03 ha) when compared to 1991 data. This decreased area was converted into moderately dense, less dense and dense categories. This change could be attributed to consistent management interventions. The area comprises mainly of *Erythroxylon monogynum, Ixora arborea, Chomelia asiatica, Canthium dicoccum, Dodonaea viscosa* and *Randia spinosa*.

Less Dense Block – This particular block occupied the next higher extent after moderately open area during 1991 with an extent of 25.34% (53.21 ha) of the total area. In 2000, there is a marginal increase of 26.42% (55.48 ha) of the total area. Subsequently in 2014, there is a further increase of 31.30% (65.74 ha) of the total area. Overall, there is an increase of 5.96% (12.53 ha). This gain is mainly from Open and moderately open blocks over a period of time. The change could be attributed to natural regeneration and plantation activity. The area comprises of *Erythroxylon monogynum*, *Diospyros montana*, *Chloroxylon swietenia, Boswellia serrata* and *Eucalyptus* sp.

Moderately Dense Block - During 1991, moderately dense block accounted for 4.15% (8.72 ha) of the total area. In 2000, there is a marginal increase of 7.30% (15.32 ha). However during 2014, there is a remarkable increase to the extent of 21.42% (44.98 ha) and an overall increase of 17.27% (36.26 ha). This significant increase was gained from moderately open and less dense categories over a period of time. The change could be attributed to increase in plantation activities along with natural growth. Major species found in these area were *Anogeissus latifolia, Acacia chundra, Chloroxylon swietenia Acacia auriculiformis, Bamboo arundinacea*, *Eucalyptus* sp., *Cassia siamea, Morinda tinctoria, Stereospermum chelonoides* and *Diospyros montana.*

Dense Block - During 1991, this block accounted for 0.60% (1.26 ha). In 2000, the area increased to 4.80% (10.08 ha). During 2014, it increased to 7.85% (16.48 ha) of the total area. The overall increase was 7.25% (15.22 ha). This increase was gained from the moderately open, less dense and moderately dense categories which could be attributed to increased plantation activity along with natural regeneration and protection measures. The area comprises mainly of *Acacia auriculiformis, Tectona grandis, Acacia chundra, Ziziphus mauritiana, Santalum album, Cassia fistula, Anogeissus latifolia, Cassia siamea, Erythroxylon monogynum, Phyllanthus emblica, Bamboo* sp., *Cactus* sp., *Canthium dicocum* and *Casuarina equisetifolia.*

Overall there is a positive increase in the vegetation cover to an extent of 30.48% amounting to 64.01 ha which is a good indicator of the health of this ecosystem. It shows the positive growth trend. The positive changes could be attributed to several factors such as policy decisions, management interventions like afforestation, soil and moisture conservation measures, protection in the form of excavation of cattle proof trenches, fire protection measures, involvement of people in the management of forests and socioeconomic changes in the nearby villages etc. The present study only looks into the overall interventions based on secondary data and primary field observations but doesn't go into assessment of the impact of each of these factors. That would be an interesting study to be taken up in future.

5. Conclusion

The present study on change detection using temporal remote sensing data for the period 1991, 2000 and 2014 provide detailed information for detecting and assessing the vegetation cover of the study area. The Change detection analysis showed an overall increasing trend in the vegetation cover of the study area to an extent of 30.48 %. This positive change could be attributed to various factors viz., rigid protection measures, afforestation and adopting of soil moisture conservation measures, Participatory management, Socio-economic changes in lifestyle of the stakeholders leading to less dependence on forest areas and also due to climatic and edaphic factors. The study indicates the overall conservation measures could lead to the recuperation of natural vegetation providing congenial atmosphere for the natural succession. The detailed assessment of each of these factors relating to their impact if taken up in future could show an accurate assessment of their contribution for this positive change.

6. Future Scope

The present study provides wider scope for further scientific research on the management of this forest. The various studies that could be taken up are - contributing factors for the positive change, Biodiversity assessment and conservation, mapping of all management activities, JFPM activities and Socio economic change in the neighboring villages. The data obtained from these studies would help in generating the Habitat suitability models to indication the health status of this forest.

7. Acknowledgement

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