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Monitoring of Forest Cover Change in Pranahita Wildlife Sanctuary, Andhra Pradesh, India Using Remote Sensing and GIS

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Abstract: The present study assess spatial change in the land cover over the last decade in Pranahita Wildlife Sanctuary, Adilabad district, Andhra Pradesh, India using Landsat TM and IRS P6 LISS III images. From 1993 to 2004, the forest cover had a severe change and lost about 248.87 ha. There was increase in the scrub cover to about 1637.17 ha, which was quantified to be 172.77 ha. Over all change analysis from 1993 to 2004 with reference to forest cover indicates, negative changes (loss of forest area) accounted for 1229.02 ha (9.04%) area and positive changes (gain of forest) for an area of 980.14 ha (9.04%). The results of the change detection using multi-date satellite imagery suggest that the most of the forest cover has been clearly degrading over the years. The study concluded that underlying causes for the forest cover change are multifarious including illegal logging, grazing, forest fire, expansion of agricultural lands and invasion of exotic species.

Key words: Land cover, forest, change, remote sensing, Pranahita Wildlife Sanctuary, Andhra Pradesh

INTRODUCTION

Land is very important natural resource which provides basis of life to flora and fauna. Land cover and its change is a key to many diverse applications such as environment, forestry, hydrology, agriculture and geology. The land-cover changes occur naturally in a progressive and gradual way, however some times it may be rapid and abrupt due to anthropogenic activities. Land cover change could be regarded as change in biotic diversity, actual and potential productivity, soil quality, run-off and sedimentation rates (Steffen *et al*., 1992).

Remote sensing helps in acquiring multi spectral spatial and temporal data through space borne remote sensors. Image processing techniques helps in analyzing the dynamic changes associated with the earth resources such as land and water using remote sensing data (Giri *et al*, 1998; Hashiba *et al*., 2000). Remote sensing data at different time interval help in analyzing the rate of changes as well as the causal factors or drivers of changes (Louisa and Antonio, 2001). Hence it has a significant role in local/regional/national planning at different spatial and temporal scales. This along with the spatial analysis technologies namely Geographic Information System (GIS) and Global Positioning System (GPS) helps in maintaining up-to-date land-use dynamics information for a sound planning and a cost-effective decision (Ricketts, 1992).

The loss of forest cover in India for the period between 1990 and 2000 is 380.89 km^2, annually as reported by FAO and 1889 km^2 between 1991 and 1999 as reported by Forest Survey of India

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(Shalini *et al*., 2002). Conservation of forests needs an accurate spatial database on the forest resources of the present and the past. There is urgent need of generation of standardized land cover information using the remote sensing data and GIS covering all the protected areas of India.

Keeping the above in view, the present study has been undertaken to prepare the multi-date land use/ land cover maps of Pranahita Wildlife Sanctuary from multi-sensor satellite data and to monitor the changes in various land cover classes using digital image processing techniques and GIS.

MATERIALS AND METHODS

Pranahita Wildlife Sanctuary situated between 18° 51' and 19° 03' N latitudes and between 79° 48' and 79° 57' E longitudes in Adilabad district, Andhra Pradesh, India (Fig. 1). It is spread over 136 km^2 near the banks of river Pranahita, a tributary of the Godavari. The sanctuary is a treasure trove of fossils. It is the home for the endangered Black Buck, Chinkara, Wolf and other animals like Indian Porcupine, Nilgai, Sloth Boar, Tiger, Leopard, Forest Cat, Langur, Rhesus, Palm Civet, Indian Otter, Wild Dogs, Hyena and variety of birds including Brahminy Ducks, Teals, Strokes and Herons. The only one reserved forest is found in the sanctuary i.e., Venchapally RF. The forest in the sanctuary is tropical southern dry deciduous type (Champion and Seth, 1968). The common tree species observed in the forests were *Pterocarpus marsupium*, *Tectona grandis*, *Buchanania lanzan*, *Terminalia alata*, *Terminalia bellirica*, *Diospyros melanoxylon*, *Cleistanthus collinus*, *Holarrhena pubescens*, *Cassia fistula*, *Careya arborea*, *Madhuca indica* etc. The common climber species includes *Acacia pennata*, *Calycopteris floribunda*, *Combretum decandrum*, *Hemidesmus indicus*, *Ichnocarpus frutescens* etc. and the forest ground floor is occupied by *Curculigo orchioides*, *Hemigraphis latebrosa*, *Canscora* sp., *Hybanthus enneaspermus*, *Vernonia cinerea*, *Lindernia* sp., *Blumea* sp., *Sida* sp. etc. The invasion of exotic species, *Hyptis suaveolens* was observed in forests and scrub lands and became part of natural ecosystems and is posing greater threat to indigenous flora.

Field Survey

Field survey was carried out in the study area during January to February 2006 to study the vegetation and other land cover. False colour composite satellite images and Survey of India topographical maps were used to collect ground information. Ground truth data was collected using GPS, at various locations before the image classification.

Remote Sensing Techniques

Data Used

The study was carried out using temporal satellite images of Landsat TM (path/ row: 143/47; date: 25th November, 1993) and IRS P6 LISS III (path/ row: 101/59; date: 7th January, 2004). The orthorectified Landsat data was downloaded from GLCF website (http://glcf.umiacs.umd.edu/). The images were processed using the ERDAS Imagine 9.1 software. The IRS P6 LISS III image data was geometrically corrected in relation to the Landsat TM. By using sanctuary boundary, study area has been extracted from Landsat TM and IRS P6 LISS-III scenes (Fig. 2).

Based on the field survey of the ground details and signatures, an interpretation key has been developed to enable information extraction from the image to prepare training sites for supervised classification. The colour key shows a significant change of land use from the forest cover to large scale scrub lands and agricultural fields. The forests are in dark red to light red tone. The richness of the red indicates the vigour of the leaves and their sizes. Patches of light red mottled tones represent scrub vegetation (Table 1).

Table 1: Image interpretation key for vegetation and other land cover mapping

Land cover class	Tone	Texture	Shape	Pattern	Description
Dense forest	Dark red	Medium	Varying	Rough	Tree cover (forest crown density more than 40%)
Open forest	Light red	Medium to low	Varying	Rough	Tree cover (forest crown density 10-40%)
Scrub	Light red mottled	Coarse	Varying	Rough	Bushy vegetation with shrubs or scattered trees/shrubs with exposed ground surface (Low vegetation crown density less than 10%)
Barren land	Greyish/ whitish	Fine	Irregular/ regular	Smooth	Sparse or no vegetation cover; in case of sand generally along streams and dried up river beds
Agriculture (incl. fallow)	Pinkish or light green or light blue	Smooth	Regular	Smooth	Crops/ current fallow lands
Water bodies	Blue or black	Smooth	Irregular	Scattered	Rivers and tanks

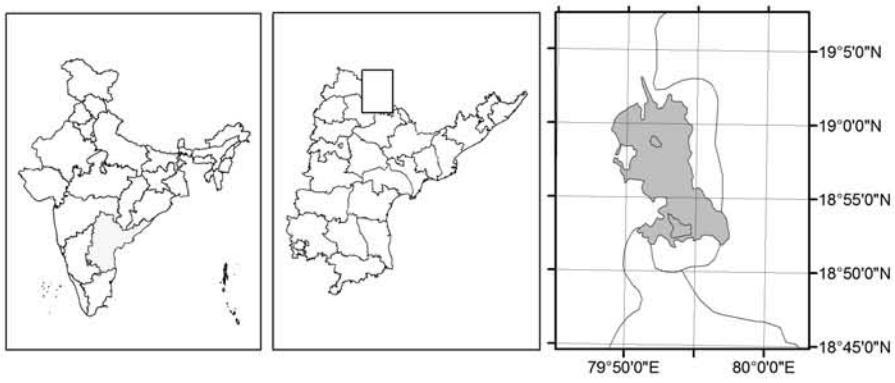

Fig. 1: Location map of Pranahita Wildlife Sanctuary, Andhra Pradesh, India

Classification

Supervised digital classification method is used for mapping of vegetation and land cover of the study area. This has been the most frequent method for remotely sensed data classification. In supervised classification the samples of known identity were used to classify pixels of unknown identity. Training sites in the images are generated to represent the typical spectral information of the land cover classes (dense forest, open forest, scrub, agricultural land, barren land and water bodies). After the selection of training sites, the classification was run on the images using Maximum likelihood classifier in ERDAS Imagine 9.1 software. Prior to the classification, signature separability analysis was carried out on the training signatures for better classification.

To determine the accuracy of the thematic maps obtained using the supervised classification, an accuracy assessment was carried out using the GCPs recorded during the field survey. Overall accuracy was calculated, based on error matrix method (Congalton, 1994; Cihlar, 2000) that included all the land cover classes, as the percentage of agreement between GCP reference points and the classification results.

Change Detection

After the independent classification of images of the two time periods (T1 and T2), the post classification change detection method was applied to determine the changes and to observe the nature of changes. The change in the spatial extent of forest and other land cover types detected were analysed. From the change map the change area matrix table was generated for the result and discussion.

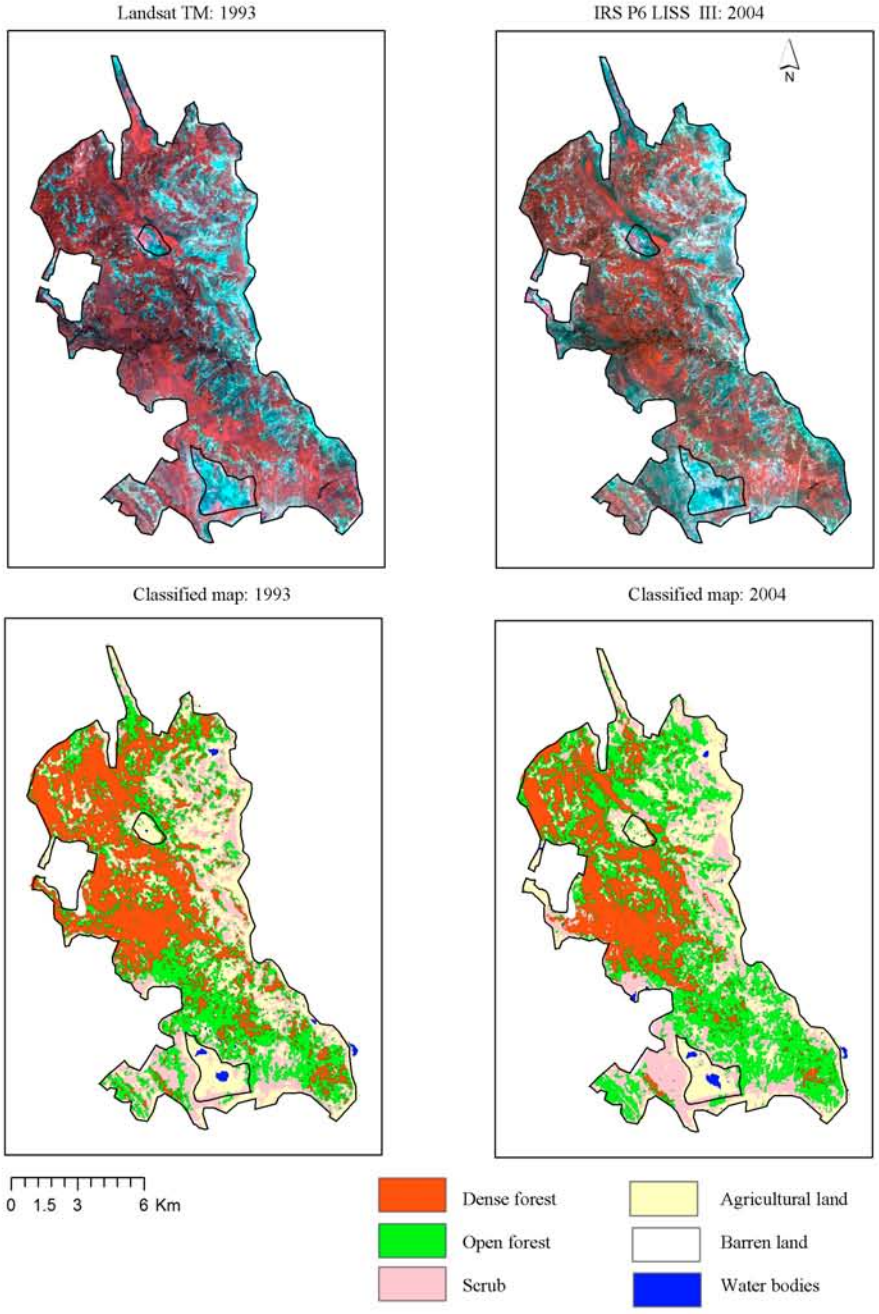

Fig. 2: False Colour Composite images and Classified Vegetation and Land cover maps of Pranahita Wildlife Sanctuary, Andhra Pradesh, India

RESULTS AND DISCUSSION

Six major land cover types were delineated using satellite data viz: dense forest, open forest, plantation, agricultural land, sand and water bodies (Table 2). The change analysis map shows that the major changes were taking place in the proximity of agricultural lands due to high anthropogenic pressure. It was ascertained through time series analysis that there has been a significant land use cover change, particularly the conversion of forest to scrub and agricultural land as shown in Table 3.

In 1993, the forest cover accounted for about 8268.30 ha (58.30%) of the total study area of 13,600 ha. Within a period of one decade, by 2004, it was reduced to 8019.43 ha (56.72% of the area). There was a drastic increase in the scrub cover to 3165.83 ha, which was quantified to 395.48 ha. The agricultural area of 1993 is decreased from 2464.81 ha (21.49%) to 2294.80 ha (20.29%) in 2004. Change of an area of agricultural land to scrub is assessed as 647.28 ha, infer the protection activities in parts of sanctuary. Open forest area of 557.93 ha was converted to dense forest, mainly due to natural growth of vegetation cover and protection.

At the same time, Dense forest cover accounting to 1725.95 ha is converted to other land cover categories Indicates high anthropogenic pressure in the sanctuary. Similarly open forest area of 910.37 ha was converted to scrub and agricultural fields. Over all change analysis from 1993 to 2004 with reference to forest cover indicates, negative changes (loss of forest area) accounted for 1229.02 ha (9.04%) area and positive changes (gain of forest) for an area of 980.14 ha (9.04%).

Earlier, few studies were conducted in India, related to changes in forest cover of protected areas. A study conducted in Kameng and Sonitpur Elephant Reserves (KSER) during 1994-2002, reported a forest loss of 344 km^2 area (Kushwaha and Hazarika, 2004). Recent study in Bhitarkanika Wildlife Sanctuary also shows forest loss of 15.34 km^2 during 1973 to 2004 (Reddy *et al*., 2007). The present also noticed forest cover loss during 1993 to 2004. There is an urgent need to monitor vegetation and land use in Protected Areas in India.

Accuracy assessment is carried out to express the quality of thematic maps derived from remotely sensed data in a meaningful way. Overall classification accuracy is 95.5% in 2004 data (Table 4).

Table 2: Areal extent of vegetation and other land cover in Pranahita Wildlife Sanctuary

	1993		2004	
Class	Area (ha)	Area (%)	Area (ha)	Area (%)
Dense forest	4369.82	30.81	3201.81	22.90
Open forest	3898.48	27.49	4817.62	33.82
Sub total	8268.30	58.30	8019.43	56.72
Scrub	2795.03	19.71	3190.52	22.32
Agricultural land	2464.81	21.49	2294.80	20.29
Barren land	10.05	0.07	25.89	0.18
Water bodies	61.81	0.44	69.37	0.49
Grand total	13600.00	100.00	13600.00	100.00

Table 3: Change area matrix of vegetation and other land cover in Pranahita Wildlife Sanctuary

Class: 1993/2004	Dense forest	Open forest	Scrub	Agricultural land	Barren land	Water bodies	Grand Total
Dense forest	2643.87	1407.30	242.70	75.95	0.00	0.00	4369.82
Open forest	557.93	2430.17	767.17	143.20	0.00	0.00	3898.48
Scrub	0.00	755.72	1533.37	501.81	0.00	4.14	2795.03
Agricultural land	0.00	224.42	647.28	1557.93	11.94	23.23	2464.81
Barren land	0.00	0.00	0.00	0.00	10.05	0.00	10.05
Water bodies	0.00	0.00	0.00	15.92	3.90	41.99	61.81
Grand total	3201.81	4817.62	3190.52	2294.80	25.89	69.37	13600.00

Table 4: Accuracy assessment of classification

	1993		2004	
Classified data	UA*	PA**	UA*	PA**
Dense forest	88.9	92.2	89.4	91.7
Open forest	90.1	91.2	94.9	92.4
Scrub	89.6	91.1	94.8	95.8
Agriculture	96.2	92.3	97.5	95.6
Barren land	98.4	99.3	99.2	100.0
Water bodies	100.0	100.0	100.0	100.0
Overall accuracy	92.3%		95.5%	
Kappa statistics	0.90		0.93	

*UA: User's accuracy (%); **PA : Producer's accuracy (%)

CONCLUSIONS

In the present study, an integrated approach of remote sensing, GIS and statistics was used for land cover change detection. Results revealed significant changes in the study area. The land cover change could be attributed to degradation of forest into a lesser form of vegetation (i.e., scrubland) along the hills and to agricultural fields in the plains.

The study has demonstrated the utility of multi-temporal satellite data and GIS to monitor changes in the forest cover. The results of the change detection using multi-date satellite imagery would suggest that the most of the forest cover has been clearly degrading over the years. The underlying causes for the forest cover change are multifarious including illegal logging, grazing, forest fire, expansion of agricultural land due to intense population pressure, invasion of exotic species etc.

So, reasonable measures are needed in this Protected Area to keep harmonious relationship between human activities and environment.

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