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Assessment of forest land degradation by remote Sensing and GIS: A case study of Jaisamand Wildlife Sanctuary, Udaipur (Rajasthan)

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ABSTRACT

Assessment of the degradation of forest cover by Remote Sensing and GIS (Geographical Information System) technique of the Jaisamand Wildlife Sanctuary is the main aim of the present investigation. Anthropogenic activities in the study area are so intense that forest cover is degrading at an alarming rate. Supervised classification methodology has been employed using maximum likelihood technique in ERDAS Imagine 14.0. The images of the maps were classified into Forestland, scrubland, water and barren land. Although the forests cover in the study area is of open forest type. The statistical analysis indicates change in land use pattern from the year 2001 to 2005 and till 2015. And this change in land use pattern is of great concern for environmentalists and this leading to the habitat loss to the endemic flora and fauna species. This scientific venture gives a vivid picture of the forest degradation due to human activities which has to be checked immediately to save the forest land and the sanctuary as well.

Key words : *Forest cover, Change detection, Forest degradation, Remote sensing, LULC.*

Introduction

The forests themselves are dynamic in nature and are undergoing constant changes due to both natural and anthropogenic forces. (Giri Chandra *et al.*, 2007). The forest is under threat from both the forces leading to forest degradation, primarily due to human interference and over-exploitation of forest resources (Denise and Richard, 1997). The land-cover changes occur naturally in a progressive and gradual way, however sometimes it may be rapid and abrupt due to anthropogenic interventions (Giriraj *et al.*, 2008). Remote sensing data at different time intervals help in analyzing the rate of changes as well as the responsible causal factors or drivers of changes (Louisa and Antonio, 2001). Map generalization can improve the integration of data for change detection purpose (Petit and Lambin, 2001). Forests have important and vital global ecological as well as socio-economic resources and they require a sustainable management (Muhammad Asim Rizwan, 2011). Anthropogenic forested landscapes throughout the tropics provide socially and economically important subsistence and market goods to rural households (Chazdon and Coe, 1999; Bray *et al.*, 2003). The analysis of satellite imagery allowed us to test the relative impact of population and remittances on forest cover (Susanna and Sassan, 2007). Satellite data have become a major application in forest change detection because of the repetitive coverage of the satellites at short intervals (Mas, 1999). Forest cover today is altered primarily by direct human use and any conception of global change must include the pervasive influence of human action on land surface conditions and processes (Yang and Lo, 2002). Mapping LULC is now the standard way to monitor changes and in order to monitor land use change and development, a change detection analysis was performed to determine the nature; extent and rate of land cover change over time and space (Eric and Adubofour, 2012). The International Union of Forest Research Organizations (IUFRO) defines forest monitoring as 'the periodic measurement or observation of selected physical, chemical and biological parameters (of forests) for establishing baseline data for detecting and quantifying changes over time' (Paivinen 1994). Monitoring the locations and distributions of land-cover changes is important for establishing links between policy decisions, regulatory actions and subsequent land-use activities. Past studies incorporating two-date change detection using Landsat data have tended to be performance limited for applications in biologically complex systems (Ross, 2006). Forest is an important Natural Resource which should be conserved on priority basis for sustainable environmental management (Panigrahy *et al.*, 2010). A pixel-based comparison was used to produce change information on pixel basis and thus, interpret the changes more efficiently taking the advantage of ''-from, -to'' information (Rawat and Manish Kumar, 2015).

In this paper we employ a simple yet accurate time-series satellite change detection method to monitor forest change in the Jaisamand Wildlife Century. The overall objective of this study is to map out and analyze the structural changes of forest cover using Landsat imageries of the area under investigation.

Study Area

Situated in most fragile ecosystem of Aravalli's "Jaisamand Wild Life Sanctuary" is 50 Kms in south of Lake City "Udaipur". The world famous Jaisamand Lake constitutes an integral part of the Sanctuary. From this famous lake the Sanctuary has derived its name as "Jaisamand Wild Life Sanctuary". The tract of the sanctuary is highly undulating with broken ranges of hills of height ranging from 25 to 200 Mts. from surrounding countryside. Most of the hilly tract has moderate to high slopes. The hills and hillocks form a network leading to the nallahas. The floral constituents of the Jaisamand Wild Life Sanctuary are mostly edapho-climax type forests

As per the Champion and Seth's classification (1968) the forests of The Udaipur district fall under the II category of Tropical Dry Deciduous forests, which can be sub-classified as:

(i) 5 A Southern Tropical Dry deciduous 2C1, 2C2 types,

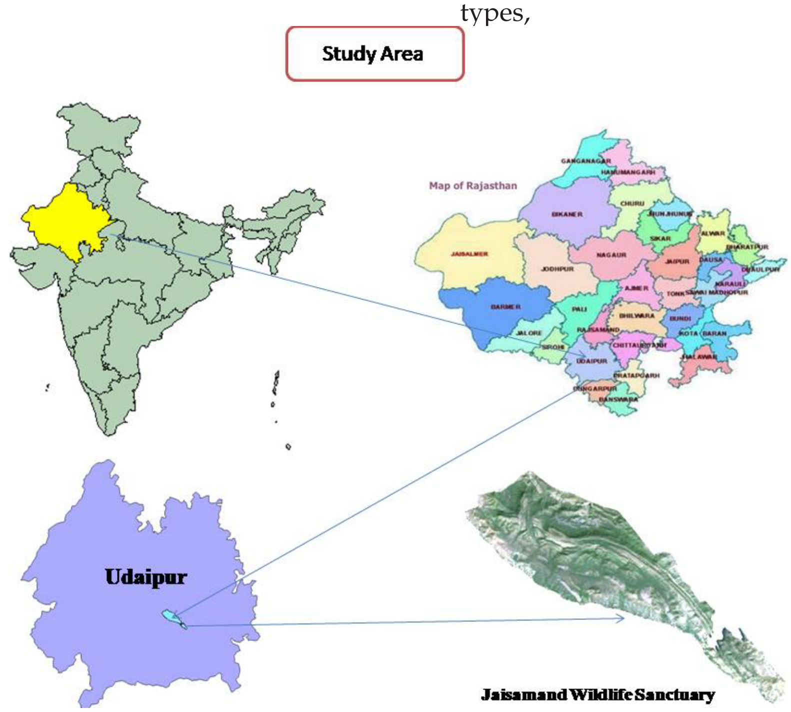

Fig. 1. Study area map

(ii) 5 B Northern Tropical Dry deciduous 2C2, Tropical Dry mixed deciduous (DS-1, DS-3) and Dry Edaphic types E-1, E/Ds-1 types.

The forest is 'Salar' (*Boswellia serrata*) mixed forest type, vegetation mainly comprised of trees like *B. serrata, Butea monosperma, Tectona grandis, Anogeissus pendula,* on Slopes faily dense vegetation mainly dominated by *Xanthium strumarium, Calotropis procera, Ziziphus nummularia, Cassia tora,* and grasses like *Cymbophogon matrini, Apluda mutica, sorghum helpense, arsitida hystrix* and *Erianthus spotaneum.* (Source-Environmental Management Plan of Forest, Udaipur).

Geographically this sanctuary is situated between 73^0 37' – 73^0 40' east longitude and 24^0 35' – 24^0 39' North latitudes. Jaisamand Sanctuary was declared as Wild Life Sanctuary wide Government of Rajasthan Notification No. F39 (2)/ For. 1955 dated 7.11.1955 under the provision of Section 5 of Rajasthan Wild Animals and Birds Protection Act, 1951. Total Geographical area of the sanctuary is 52.342 square kilometers. On the east of this Sanctuary is Jaisamand Lake, whereas western, northern and southern boundaries of this sanctuary are delineated by the village boundaries of Pilader, Juni Jhar and Chandaji Ka Guda revenue villages respectively.

Materials and Method

A requirement of time series change detection is the availability of relatively cloud free data satellite imagery of each date. A supervised classification of the satellite imagery was used to produce Land use/land cover classes. Maximum likelihood classification technique was performed. On the basis of GPS survey points and field knowledge the signatures were assigned for each particular class. A stepwise work design is showed in the Figure 2.

Image Data : Landsat subscenes covering the study area were used. The first subscene was acquired in 2001 by Landsat Thematic Mapper (TM), second subscene was acquired in 2005 by Landsat7 Enhanced Thematic Mapper (ETM), third subscene was acquired in 2010 by Landsat7 Enhanced Thematic Mapper (ETM) and the forth subscene was acquired in 2015 by Landsat8 Operational Land Imager (OLI). All the satellite imagery (Level-2, Reflectance imagery) was downloaded from the USGS Earth Explorer (https://earthexplorer.usgs.gov/). Satellite data specifications have been shown in the Table 1. The downloaded satellite images were processed through several steps before the analysis could occur. Radiometric correction was performed prior to data acquisition. Layer stack operations were used to combine several layers to make a single image for each observation year. All these images and vector data layers, were geo-referenced to World Geodetic System (WGS) 1984 UTM (Universal Transverse Mercator) Zone. All the projected images were clipped to the sanctuary boundary to delineate the study area.

Vector data : Jaisamand Sanctuary area KML file obtained from the Forest Department, Udaipur was converted into shape file in the ARC GIS and used as vector layer (AOI -Area of Interest).

Pixel to Pixel identification : Scatter pattern of different class pixel have been compared with available ground data. Signatures were assigned on the basis of the available GCPs as well as field knowledge of the study area. Yet all the Landsat data images were of month of the October so it is easy to assign signatures for time series analysis.

Supervised classification : It is likely to assemble groups of identical pixels found in remotely sensed data into classes that match the informational categories of user interest by comparing pixels to each identity. All the supervised classifications usually have a sequence of operations that must be followed like- define training site, extraction of signatures, classification of image etc. The Maximum Likelihood Classification system tool was used for the classification of the data into different land use class categories as shown in Table 2.

Data Processing : The raw data and imagery was processed using software -

Table 1. Satellite data specifications

Sl. No.	Data	Date of acquisition	Bands	SpatialResolution	Source
1	Landsat5	2001/10/17	Multispectral	30 m	USGS Earth Explorer
2	Landsat7	2005/10/20	Multispectral	30 m	USGS Earth Explorer
3	Landsat7	2010/10/26	Multispectral	30 m	USGS Earth Explorer
4	Landsat8	2015/10/24	Multispectral	30 m	USGS Earth Explorer

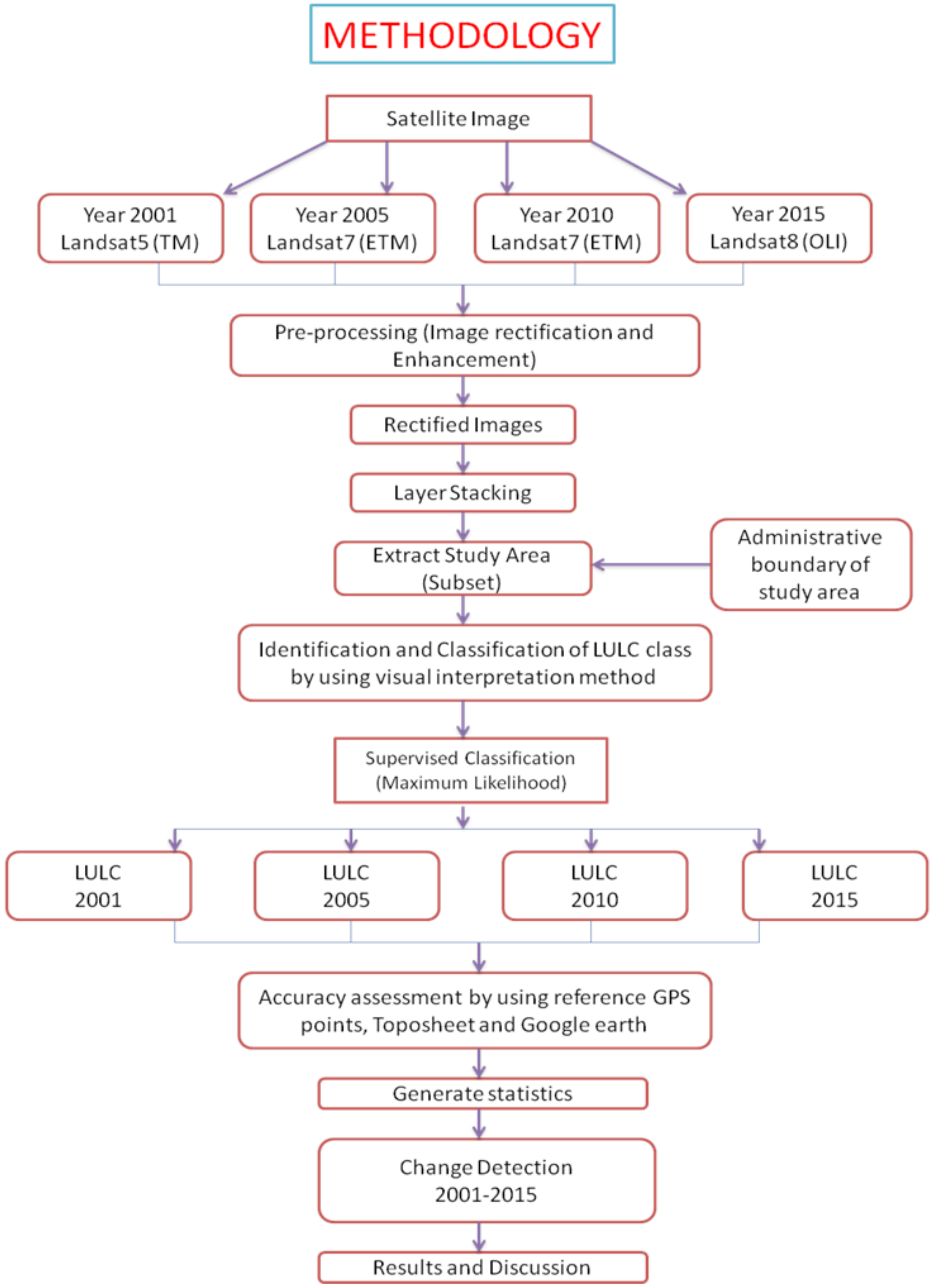

Fig. 2. Methodology Chart

Table 2. Land use/land cover class details

Sl. No.	Class	Specifications
1	Forest	Lands with forest cover with canopy density greater than 10%
2	Scrubland	Lands generally in and around forest areas, having bushes and or poor tree growth, chiefly small or stunted trees with canopy density less than 10%
3	Water	Lakes, Ponds etc.
4	Barren/Rocky land	Unproductive bare soil including rocks

- ERDAS Imagine
- Arc GIS

Accuracy assessment- A standard overall accuracy for land-cover and land-use maps is set between 85 (Anderson *et al.*, 1976) and 90 percent (Lins and Kleckner, 1996).

In this study the overall classification accuracy was found to be 94.82% percent for 2015. However it was not possible to check accuracy of year 2001, 2005 and 2010 LULC maps but as it is assumed that the overall accuracy of these maps is more than 85 percent. Details of single class error and accuracy for 2015 map are given in the Figure 3 and 4 respectively. Accuracy assessment were not performed on the 2001 TM , 2005 ETM and 2010 ETM images due to unavailability of ground validation data and reference points. This has being one of the major problems of remote sensing (Jensen and Cowen, 1999). The Kappa Statistics values are shown in the Figure 5.

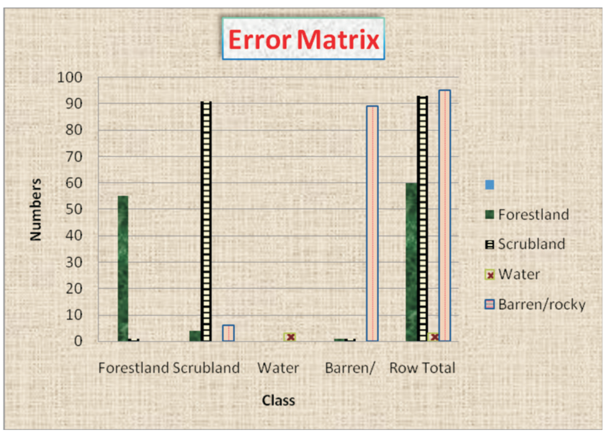

Fig. 3. Error matrix of 2015

The Figure 4 shows that the highest accuracy is for the water is 100 percent this is due to the integration of the visual interpretation. The lowest accuracy was for Forest land, i.e. – 91.67 percent respectively that could be explained by the fact that the area is semi-arid and the vegetation is sparse with the Scrubland which led to the confusion.

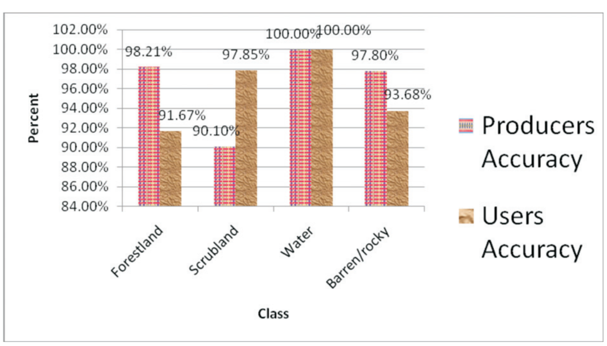

Fig. 4. Accuracy % of year 2015

Results and Discussion

The trends of forest cover change can be observed by comparing the change detection time period from 2001 to 2015. Change detection analysis brings out the actual land loss and land gain Forest land, with scrub and Waste/rocky land. Of course, the aerial extent of water body such Lakes has been maintained without neither any loss nor gain during 2001 to 2015. As depicted in the Figure 6 it is clearly visible that the total forest land cover has decreased during last fifteen years and possible reason may be due to anthropogenic disturbances (Kumar Arvind and Ram Jeet, 2005). However the table shows a sharp increase in the scrubland which is more prone to grazing animals. The ultimate consequences of anthropogenic interferences has resulted in deterioration of forest land rather conversion of forest into scrubland and pastures (Smail and Lewis David (2009). The change in the land use pattern (Figure 7) can be vividly seen in the map of land use/land cover which is attached for clear visual change which can be observed. The overall land use pattern indicates the human activities have reduced the barren land but the forest cover has also decreased (Figure 8) which is a matter of concern since the forest are the natural habitat for wildlife and source of many endemic plant species. A huge decrease in forest land states that the increase in the demand of food and fodder. At a greatest rate forests has been lost were converted into Scrubland (Figure 8) indicates the degradation. Also the livestock grazing has created serious problems in the

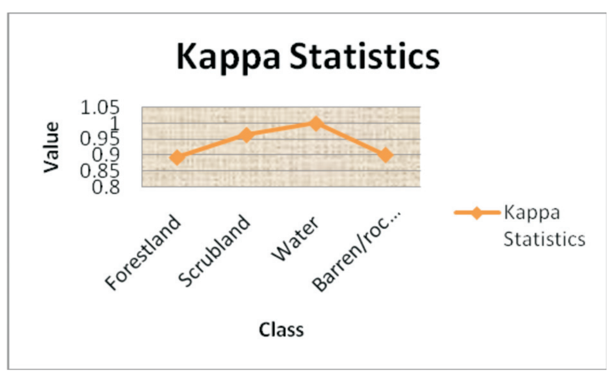

Fig. 5. Kappa (K^) Statistics of 2015

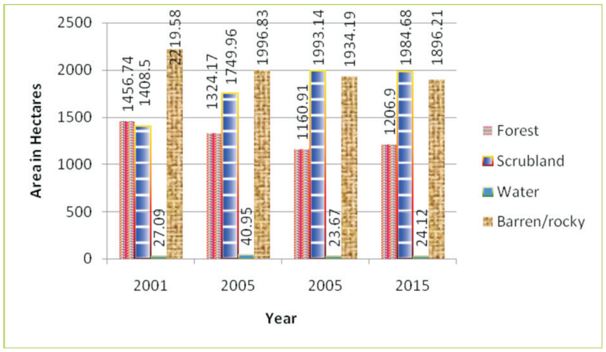

Fig. 6. Year wise change in area of different class

forest area. Maximum pressure is exerted during rainy seasons; almost maximum of cattle of these villages goes into the forest area for grazing. Most of the forest area is predominantly surrounded by the villages having good percentage of tribal population, which includes Bhils, Garasias and Meena etc. They largely depend on forest resources for their livelihood and sustenance. Hence, the present study proved that the important technologies for temporal analysis and quantification of spatial phenomena are remote sensing and GIS. These are otherwise not possible to attempt through conventional mapping techniques.

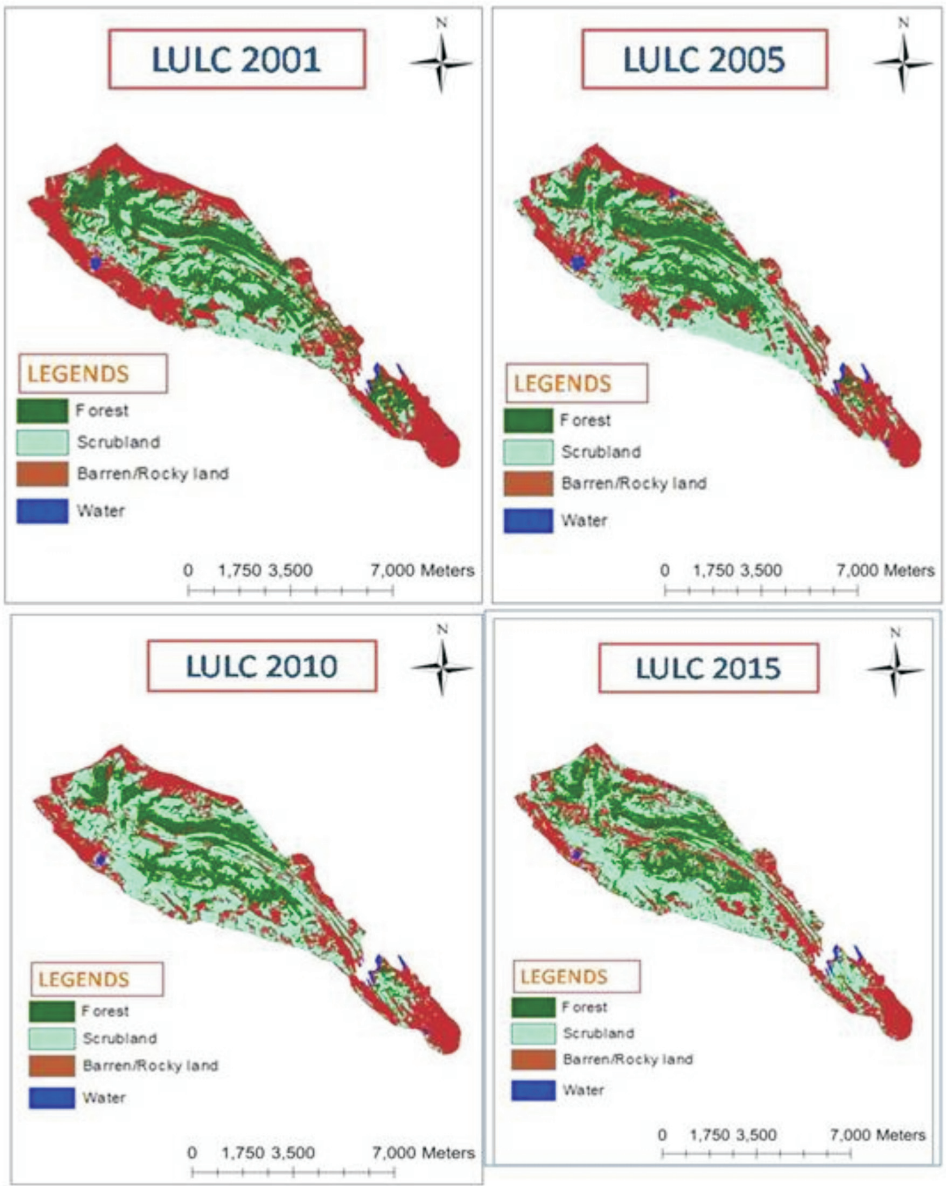

Fig. 7. LULC maps of different time period

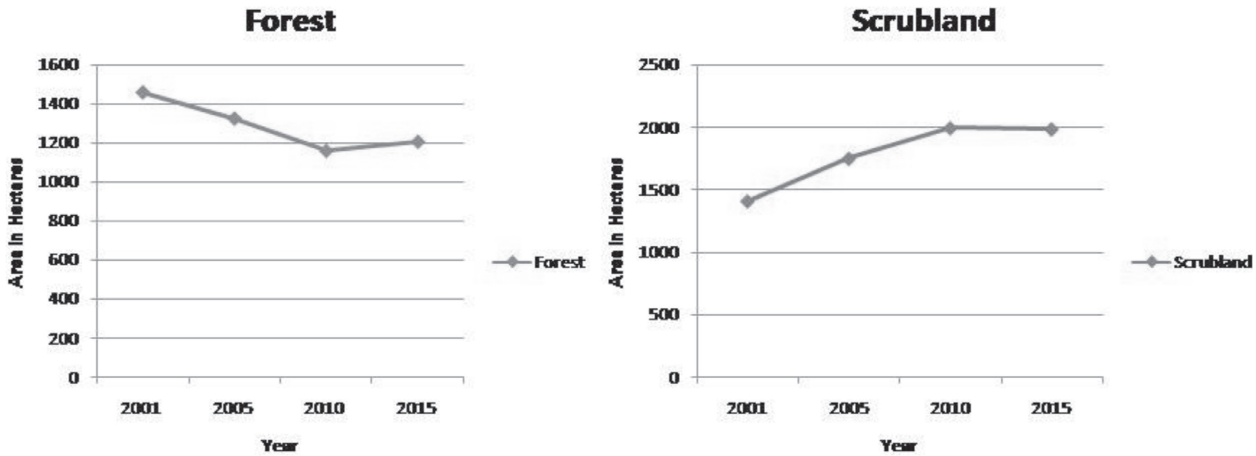

Fig. 8. Year wise change in Forest and Scrubland

Table 3. Change detection Matrix between 2001 and 2015

Sum of Area		2015				
2001	Class	Forest	Scrubland	Water	Barren/rocky	Grand Total
	Forest	930.51	213.03	0	17.37	1160.91
	Scrubland	197.19	1292.22	0.09	503.64	1993.14
	Water	0	0	19.44	4.23	23.67
	Barren/rocky land	79.2	479.43	4.59	1370.97	1934.19
	Grand Total	1206.9	1984.68	24.12	1896.21	5111.91

The classification was performed with the standard maximum likelihood estimation approach at 30-meter (m) spatial resolution and was verified and improved using existing maps and field data. Post-classification comparison was found to be the most accurate procedure and presented the advantage of indicating the nature of the changes (Mas, 1999).

Conclusion

As the overall accuracy of the change detection results exceeded 85% recommend the result of the mentioned work clearly indicates the change in the forest cover. The main conclusion of the study which is clearly revealed is the deterioration of forest land cover which is a threat to biodiversity of Jaisamand area. The study has demonstrated the utility of multi-temporal satellite data and GIS to monitor changes in the forest cover. This is very simple, fast and effective technique to detect change in land use/land cover of a particular region. It is very powerful tool in the monitoring and research especially in the inaccessible areas to eliminate the lot of time, money and human power. The main LULC classes identified were forest, scrubland, water and Barren/rocky land. Other high resolution satellite imagery will be useful to do further studies on deforestation and forest monitoring. The overall study recommended some suggestions like creation of awareness among the local tribal population, plantation of local growing species and proper fencing on the boundary of the sanctuary.

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