Monitoring of Deforestation and Forest Degradation Using Remote Sensing and GIS: A Case Study of Ranchi in Jharkhand (India)

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Abstract: Forest ecosystem plays very important role in the global carbon cycle. It stores about 80% of all above ground and 40% of all below ground terrestrial organic carbon. Deforestation has many ecological, social and economic consequences, one of which is the loss of biological diversity. The rapid deployment of remote sensing (RS) satellites and development of RS analysis techniques in the past three decades have provided a reliable, effective, and practical way to characterize terrestrial ecosystem properties. The present study focus on the monitoring of deforestation and forest degradation in Ranchi using geospatial approached. The multistage statistical technique incorporated with the satellite data of LISS III (1996 and 2008) gives a precise monitoring of forest degradation. This paper aimed to the analysis involved carrying out post classification change detection. Supervised classification of images of different epochs was carried out and then areas of the resultant classes compared for change detection. [Report and Opinion 2010;2(4):14-20]. (ISSN:1553-9873).

Keyword: Remote Sensing, Deforestation, Supervised Classification, NDVI, Change Detection

1. Introduction

Forests play an important role in global carbon cycles. Policies that influence the rate of Conversion of forest to other land use, or encourage afforestation and reforestation of deforested lands have the potential to have a large impact on concentrations of atmospheric CO_2 (IPCC 2001).Forest conversion is the second largest global source of anthropogenic carbon dioxide emissions, and is likely responsible for 10-25% of carbon dioxide emissions worldwide (Houghton 2003; Santilli *et al*., 2005).Within the U.S. forests are net carbon sinks, sequestering approximately 780 Tg/yr CO_2 Eq. (latest data for 2004), which is approximately 11% of U.S. greenhouse gas emissions (US EPA 2006).A number of existing and proposed policy instruments specifically include the use of forests to capture CO_2. Remote sensing is a very powerful tool in the provision of such information. It involves the acquisition of information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, phenomenon or area under investigation (Lilesand and Kiefer, 1987). It has come to be associated more specifically with the gauging of interactions between earth surface materials and electromagnetic energy. Sensors aboard satellites in space record the amount of electromagnetic energy reflected from various objects on the earth's surface at various wavelengths. From the spectral response patterns, information about the objects is derived. A variety of digital change detection techniques has been developed in the past three decades. Basically, the change vector analysis, transformation (e.g. principal component analysis, multivariate alteration detection, Chi-square transformation), classification (post-classification comparison, unsupervised change detection, expectation maximization algorithm) and hybrid methods. Reviews on the most commonly used techniques are given by i.e. Coppin et al. (2004), Lunetta and Elvidge (1998), Lu *et al*. (2004), Maas (1999), Singh (1989). Through the analysis of remotely sensed data for different epochs, change detection and monitoring of forest destruction can be done.

2. Materials and Methods

2.1 Experimental Site

The area selected for carrying out the present research cover Ranchi city, the capital of Jharkhand state, India and its environs which has spatial extent of 85º15'- 85º29' E to 23º14'-23º29' N. The study area is characterized by sub-tropical climate. Temperature ranges from 20 to 37°C during summer and 3 to 22°C during winter. The rainfall pattern is monsoonal covering the period from middle of June to middle of October with an average annual rainfall of about 1530 mm. The major land cover types that dominate the area are viz. agricultural land, built-up land with and without vegetation, Dense and open forest, dense shrub, plantation and water bodies comprising mainly reservoir, lakes, river and its tributaries and numerous ponds. The agricultural terrain covers the maximum portion of the study area and is spread over the entire study area. A few patches of eucalyptus plantation of different sizes occur within the study area. The natural vegetation comprises both dense and open Sal forest that occurs towards the fringe of the former. The satellite data used are shown in figure 1.

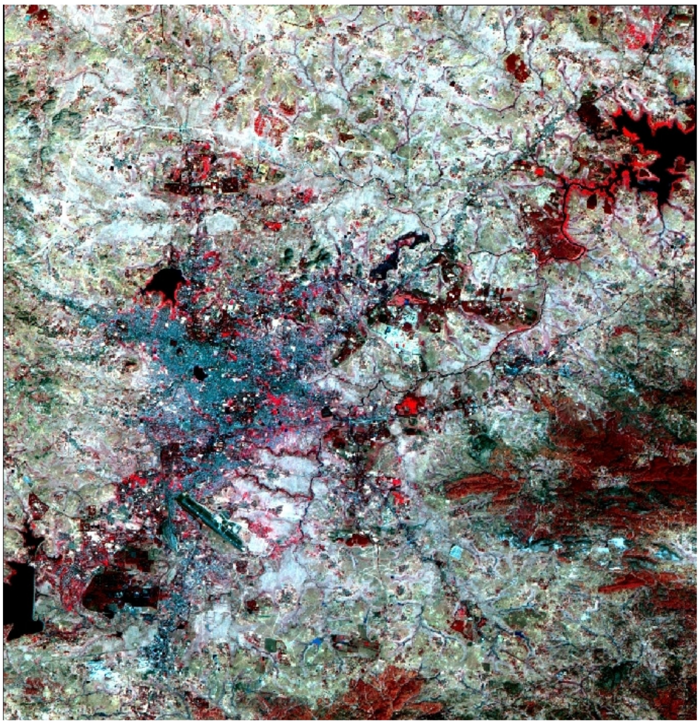

Figure 1. False Colour Composite of Ranchi city showing IRS 1C LISS-III of 2008

2.2 Data Used

Satellite data and Survey of India (SOI) topographic maps at 1:50,000 scales were used for carrying out the research work. The details of the satellite data are shown in table 1. LISS III satellite data for two different years 1996 and 2008 are used for the proposed work.

Table 1.

Particulates	
Satellite	IRS 1C
Sensor	LISS III
Scale	1:50000
Band combination	3,2,1
Temporal Resolution	5 days
Spatial Resolution	5.8(PAN),23.5m,70.5m
Year	1996 and 2008

2.3 Methodology

The methodology for the assessment of forest cover using digital image processing (ERDAS IMAGINE 9.1) has been followed with intensive field verification. The following steps are involved:

2.3.1 Data Inputs

The satellite data for the study was procured from National Remote Sensing Agency (NRSA), Hyderabad in the digital format. While procuring the satellite data, care was taken to ensure that the data was cloud free and did not belong to dry and leafless season.

2.3.2 Flow Chart

The flow chart of the applied methodology is shown in figure 2.

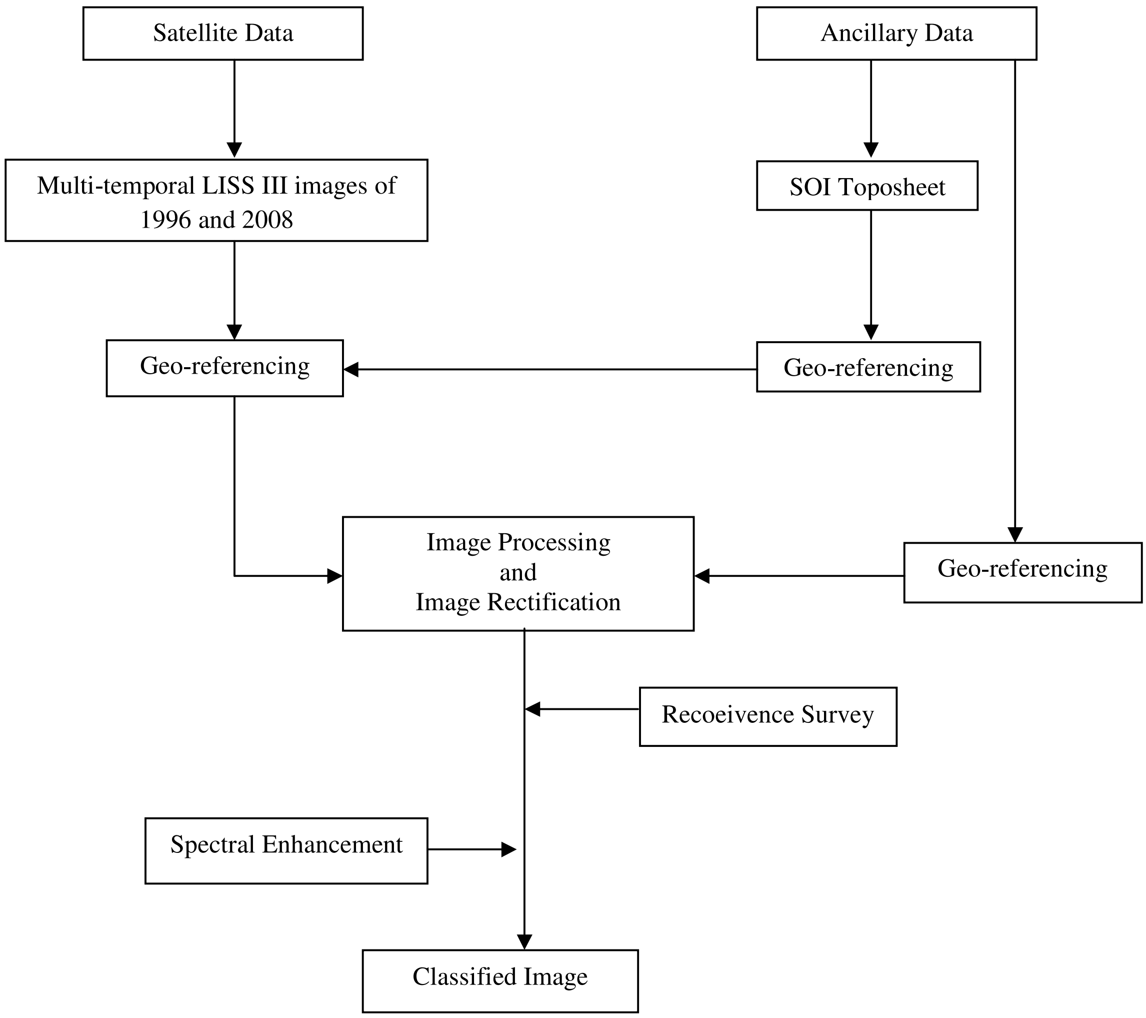

Figure 2. Paradigm for monitoring of forest

2.3.3 Digital Interpretation

Using ERDAS EMAGINE 9.1 software, the data was loaded onto the computer. Radiometric and correction was applied for removing radiometric defects and improving the visual impact of satellite data. Geometric rectification of the data was carried out with the help of scanned Survey of India (SOI) toposheets for assigning geographical coordinates to keep pixel of the image. Supervised image classification is a method in which the analyst defines small areas, called training sites, on the image which are representative of each desired land cover category. The delineation of training areas representatives of a cover type is most effective when an image analyst has knowledge of the geography of a region and experience with the spectral properties of the cover classes. The image analyst then trains the software to recognize spectral values or signatures associated with the training sites. After the signatures for each land cover category have been defined, the software then uses these signatures to classify the remaining (figure 3 and figure 4). Areas were calculated using ARC GIS 9.3 software and compared changes for both images.

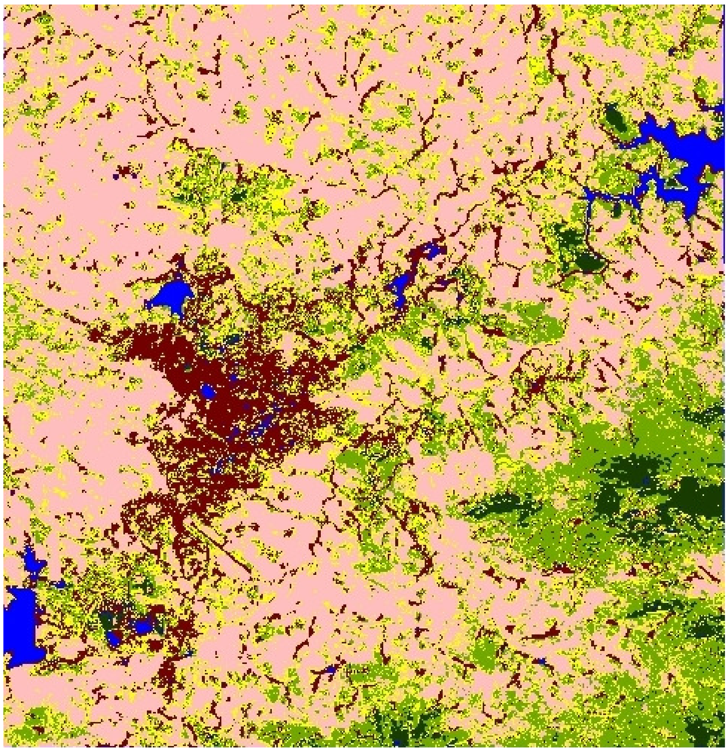

Figure 3. False Colour Composite of classified image for Ranchi city, year 1996.

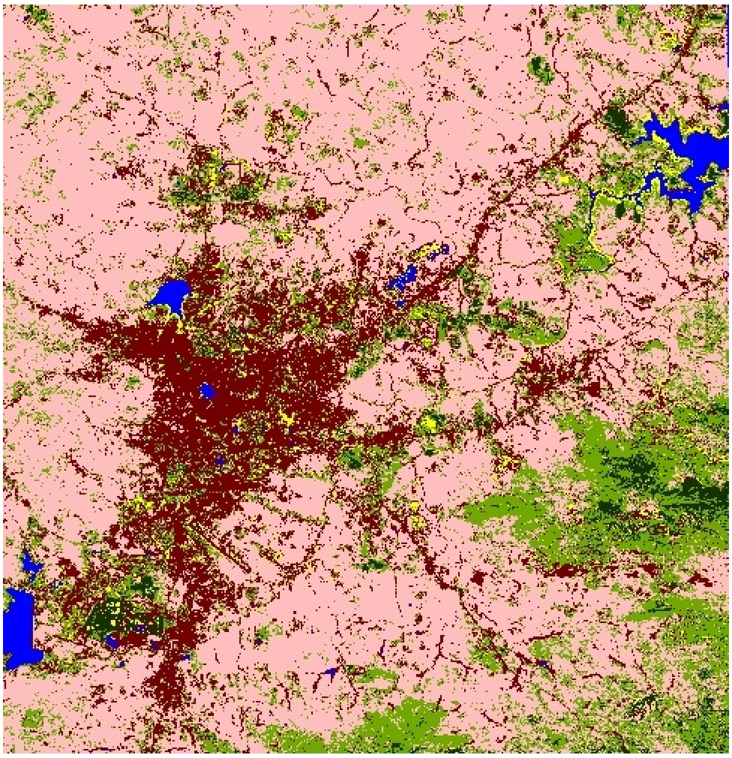

Figure 4. False Colour Composite of classified image for Ranchi city, year 2008.

3. Results

In the below classified images dense forest cover is represented by dark green color and degraded forest is represented by light green color. Figure 5 and figure 6 are resultant classified images. ARC GIS 9.3 software was used to compute areas of the dense forest and degraded forest that resulted from the supervised classification approach. The summary of the forested area results are shown in table 2.

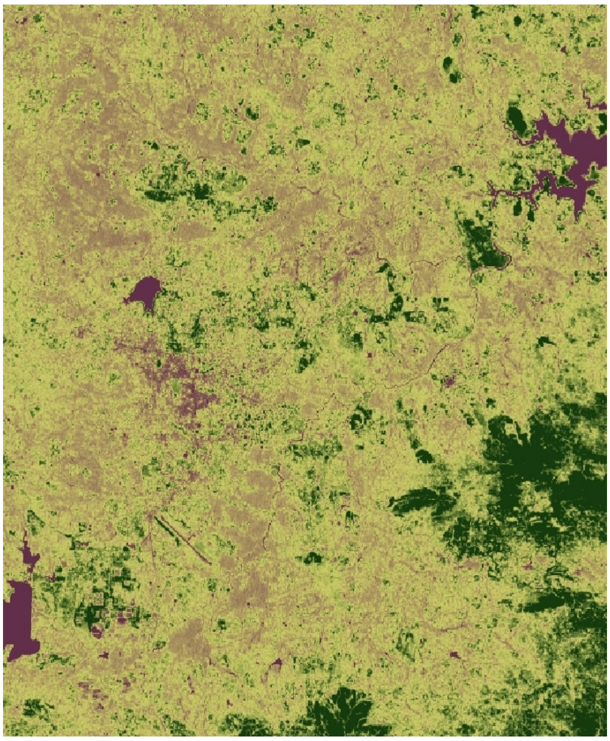

Figure 5. 1996 NDVI image for Ranchi city

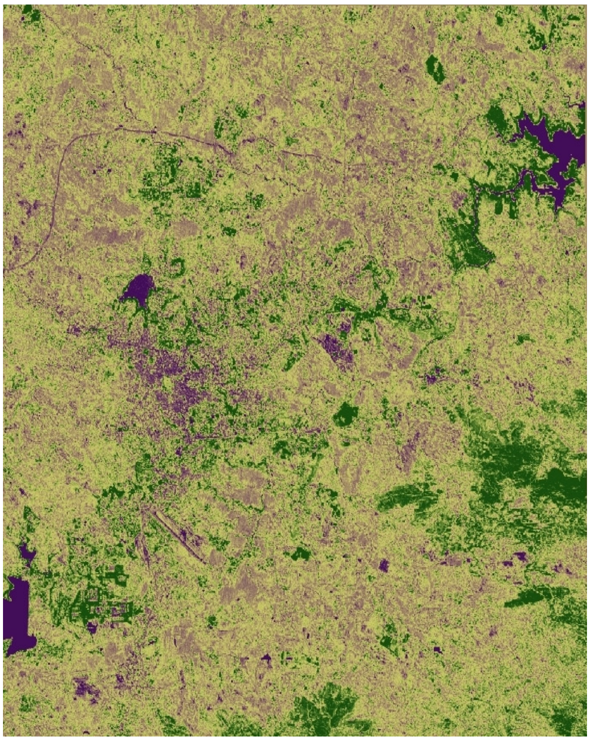

Figure 6. 2008 NDVI image for Ranchi city

Table 2. Total forest area

Total forest area 1996 (hectare)	Total forest area 2008 (hectare)
5248.52	4683.50

3.1 NDVI Differencing Change Detection

Vegetation index reflects the approximation relation between the spectral response and vegetation cover. The essential characteristic of desertification is the lower the productivity of land. Changes in vegetation index can reflect the changing process of land productivity. Therefore vegetation index can be used as desertification monitoring indicators to monitor land desertification and dynamic changes.

The Normalized Difference Vegetation Index (NDVI) is a simple numerical indicator that can be used to analyze remote sensing measurements, typically but not necessarily from a space platform, and assess whether the target being observed contains live green vegetation or not.

NDVI = (near I.R - Red)/ (near I.R + Red)

The sub-scene bands 2 and 3 for each were used to create an NDVI image for each year and then differencing of the images was carried out to detect change. Differencing involved the subtraction of the 2008 NDVI image from the 1996 NDVI image using an image calculator in the software. Table 3 and table 4 is showing histogram data for NDVI difference (NDVI 1996-NDVI 2008).

Table 3. NDVI results under frequency classes

Class	Lower Limit	Upper Limit	Frequency	Cumulative Frequency
1	-0.955	-0.875	108	108
2	-0.875	-0.759	660	768
3	-0.759	-0.652	1636	2404
4	-0.652	-0.551	3184	5588
5	-0.551	-0.458	7860	13448
6	-0.458	-0.359	16552	30000
7	-0.359	-0.258	47924	77924
8	-0.258	-0.152	195615	273539
9	-0.152	-0.052	1169760	1443299
10	-0.052	+0.051	2693796	4137095
11	+0.051	+0.158	571480	4708575
12	+0.158	+0.251	13162	4721737
13	+0.251	+0.352	2828	4724565
14	+0.352	+0.458	366	4724931
15	+0.458	+0.555	44	4724975
16	+0.555	+0.678	36	4725011

Table 4. Statistical parameter of NDVI results

Actual Maximum	0.679
Mean	+0.068
Standard Deviation	0.080

3.4 Analyses of Results

A positive mean of 2008-1996 NDVI differencing is an indication of reduction in above ground biomass within 12 years. This implies a decline in vegetation. It thus confirms the change detected through post classification analysis. From the post classification results there was tremendous reduction in forest cover area by 565.02 hectares within a period of 12 years between 1996 and 2008.So it is equivalent to 10.76% decrease in the forest area. With the help of remote sensing and GIS techniques it is clearly shows that the total forest cover is continuously degrading and transforming into various land use/land cover category.

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