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Detecting Forest Cover Changes of Kokrajhar District Using Remote Sensing and GIS Techniques

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Abstract: *Forests are one of the most complexes and a multifunctional asset of all natural resources. They are a key component of the natural resource base that provides the capabilities, assets and activities required for a means of living. Over utilization of forest resources due to illegal logging conversion to agricultural land and encroachment has resulted to its depletion. The changes in forest cover are the matter of great concern as it disrupt the global environmental system, threatens the global biodiversity and the sustainability of livelihood as well.*

In present study an attempt has been made to detect the changes taking place to the forests of Kokrajhar Districts of BTAD in four consecutive decades, i.e. 1977, 1987, 1997 and 2007 using RS and GIS techniques. Unsupervised classification method of image classification was adopted for generating landuse and landcover map. The results show that there is a sharp decline in all categories of forest from 1977-2007 and the highest change being recorded in moderate forest during 1977-87 where there is a negative change of 23 percent. On the other hand, there is a gradual increase in non-forested land.
Key words: *Forest cover changes, Remote sensing, GIS, livelihood.*

I. Introduction:

Forests provide several ecologically, economically, and social perspective functions to life viz. water supplies, soil conservation, nutrient cycling, species and genetic diversity and green house gases regulations (Rao and Pand, 2001). Forests multifunctional asset provides variety of resources that enables various bases for livelihood (FAO, 2001; Zewdie, 2002). They are a key component of the natural resource base and are capable of providing a wide range of environmental, economic, social and cultural services that enhances the capabilities, assets and activities required for a means of living.

Often, however, utilization objectives tend to override the socio-economic and environmental significance of the forest resource base. Increasing anthropogenic pressure such as land use/land cover changes, air, water and soil pollution (Fearnside, 2001; Sherbinin *et al*., 2007), degradation of soil quality and losses in biological diversity are the important threat to productivity of ecosystem at regional and global scales (Kilic *et al*., 2004; Trigg *et al.*, 2006). Current scenario illustrated that the agricultural practices have been the important factor for land transformation on earth. The increment of nearly one third of the earth's land surface is currently being used for growing of crops or grazing cattle (FAO, 2004). Much of this agriculture land has been created at the expense of natural forests, grassland and wetlands that provide valuable habitats for species and services for mankind (MEA, 2003). It is estimated that approximately half of the original forests (ca. 8000 years ago) have been vanished (Billington *et al.*, 1998). As the rate of habitat and species destruction continue to raise, the need for conserving the biological diversity increasingly imperative during the last decades (Wilson and Peter, 1988; Kondratyev, 1998).

1.2 Remote Sensing in Forestry: In order to design the meaningful conservation strategies, comprehensive information and current status of forest cover/forest types on the basis of species composition as well as information of changes in forest cover with time, is required. It is difficult task, to acquire such information on the basis of field assessment and monitoring (Heywood, 1995). Forest cover changes can be documented locally through field-based studies; however, at regional to global scales it requires an approach based on remote sensing (Trigg *et al*., 2006; Kumar *et al*., 2010). Remote sensing involves measuring or acquiring information about surface properties using sensors typically found onboard aircraft or satellites (Colwell, 1983).

Remote sensing provide a systematic, synoptic view of earth cover at regular time intervals and useful for changes in land cover and to revels to biological diversity directly (Hall *et al*., 1988; Roughgarden *et al.*, 1991; Turner *et al.*, 2003; Cohen and Goward, 2004; Kumer *et al*., 2010). Satellite image classification, change analysis (Armenteras *et al*., 2004) and econometric modeling are extensively used to identify the rates and drivers of deforestation in global hotspots of biodiversity and tropical ecosystems.Many airborne and satellite sensors with high spatial and spectral resolution, are currently available, to study land cover changes for over the last decades such as Landsat (approximately 30 m pixel size). Landsat is a series of US satellites launched between 1972 and 1999 (Goward *et al*., 2001; USGS, 2003; Arvidson *et al.*, 2006; Trigg *et al.*, 2006) for monitoring the temporal and spatial changes in land cover (Kumar *et al.*, 2010). The satellites main sensors have been the Multispectral Scanner (MSS) carried by Landsat 1-5, the Thematic Mapper (TM) carried on Landsat 4-5 and Enhanced Thematic Mapper Plus (ETM+) carried on current Landsat 7 satellite. Landsat data have been relied on to perform detailed assessments of changes in tropical forests worldwide (Foody, 2003; Kumar *et al.*, 2010). Combination of the three Landsat sensors, MSS, TM and ETM+, have provided the longest time series of images suitable for monitoring changes in the earth's vegetation at high spatial resolution. A part of the Landsat satellite images, several sensors have the potential tool to provide useful data to monitor the forest cover loss in different parts of the world. The Moderate Resolution Imaging Spectroradiometer (MODIS) sensor carried on NASA's Aqua and Terra satellite provides global map of present tree cover, vegetation fires and land cover changes (Savtchenko *et al.*, 2004). However, MODIS data has capacity for global monitoring and forest loss is limited by its 250 m spatial resolution. Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is a high spatial resolution (15 to 90 m) multispectral imager with along-track stereo capabilities (Abrams, 2000). The Indian multisensory ResourceSat's Advanced Wide Field Sensor (AWiFS) uses twin cameras to provide a spatial resolution (56 m) of forest cover (King, 2002).

In several studies, the satellite remote sensing at regional scale have been used to monitoring the changes in forest cover on the basis of spatial and temporal remote sensed data, throughout worldwide. Fine resolution, spatially explicit data on landscape fragmentation were required to understand the impact of forest cover changes on biological diversity (Liu *et al.*, 2003; Kumar *et al.*, 2010a). Satellites data have became a major application in change detection because of the repetitive coverage of the satellites at short time intervals (Mas, 2005). Using remote sensing, spatially explicit time series of environmental data can be quickly obtained (Dewan and Yamaguchi, 2009), with GIS (Geographical Information System) techniques provide information about landscape history, topography, soil, rainfall, temperature and factors on which the distribution of species depends (Noss, 2001).

This study attempts to provide the utility of remote sensing coupled with GIS to understand the changes in forest cover at regional scale spatially and through time.

II. Study Area:

Kokrajhar is one of the twenty-seven districts of Assam. The district occupies an area of 3169.22 sq. km. and it lies between 89˚46′ to 90˚38′ East Longitudes and 26˚19′ to 26˚54′ North Latitudes. The district is bounded on the north by the Himalayan kingdom of Bhutan, by Dhubri district on the south, Chirang and Bongaigaon districts on the east and the Indian state of West Bengal on the west.

Forest is one of the most prominent features of Kokrajhar district. The present estimated area under reserved forests is roughly 1,719 sq. km. i.e. 55 percent of the total geographical area and comprised of six reserved forests- Kachugaon, Ripu, Chirang, Guma, Bengtal and Manas respectively.

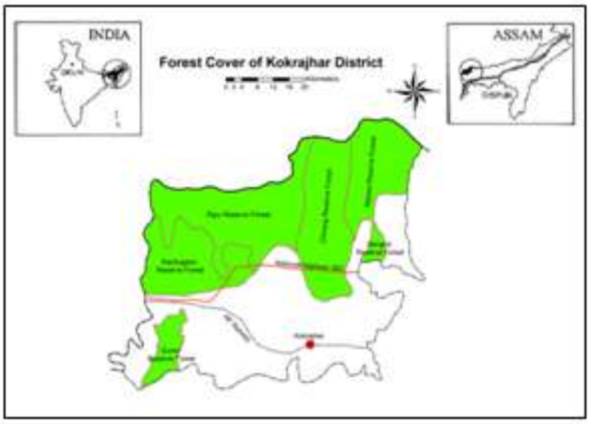


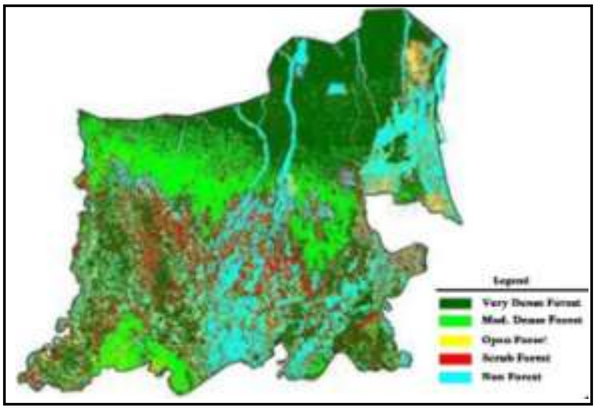
Figure 1: Location of Study Area

Objective: The main objectives of the study are:

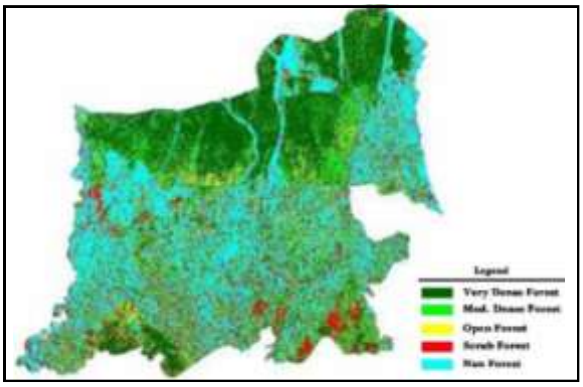
a. To see the present status of forest cover of the study area and
b. To find out the temporal change of the forest cover for the last thirty years within the study area.

III. Methodology and Dataset:

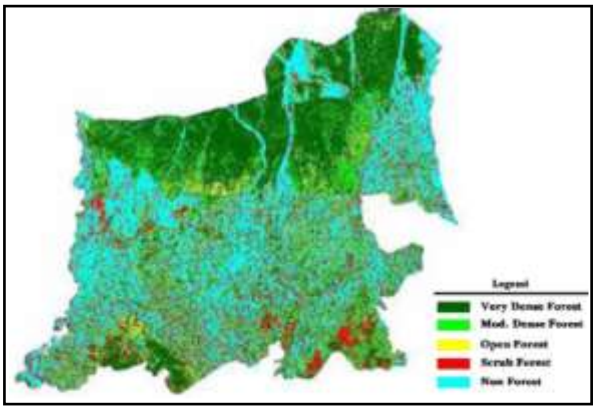
The present data analysis was carried out using Landsat Multispectral Scanner (MSS), Landsat Thematic Mapper ™ and Landsat Enhanced Thematic Mapper plus (ETM+) for the year 1977, 1987, 1997 and 2007 respectively. The orthorectified Landsat data was downloaded from GLCF (Global Land Cover Facilities) websites (http://glcf.umiacs.umd.edu/) at EROS data center, University of Maryland. The images were downloaded as separate bands 1-5 and 7 and then stacked in ERDAS Imagine 9.2 to give the multispectral images. Apart from this Landsat satellite images, Landsat data were registered geometrically using 1:50,000 scale topographical map of Survey of India (SOI) and was used as a base line map for generating maps of the Area of Interest (AOI). The common uniformly distributed GCPs (Ground Control Points) were marked with root mean square of one pixel and the image was resampled at minimum distance to mean rule method of unsupervised classification. After that the study area (Area of Interest) extracted from georeference images of different year by overlaying the boundary data provided by. The spectral behaviour gives the information of the classes of landcover such as dense forest, open forest, degraded forest, agriculture land, scrub and water bodies in the images.



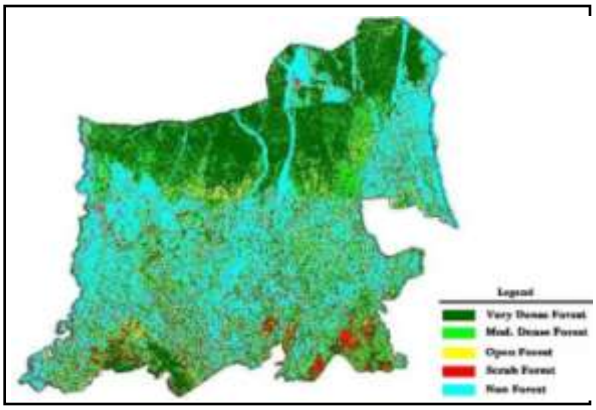
Landsat MSS Satellite Imagery of December 8, 1977



Landsat TM Satellite Imagery of December 14, 1987



Landsat MSS Satellite Imagery of December 14, 1997



IRS P6 LISS III Imagery of November 14, 2007

Figure 2: Landuse Landcover Map of Kokrajhar District

IV. Results and Discussions:

Five major classes of landuse and landcover categories were delineated using Landsat data viz., very dense forest, moderately dense forest, open forest, scrub forest and non-forest. The area under various forest class and their corresponding values for the three decades in Kokrajhar district are shown in the ***Table 1*** in the page below.

V. Deforestation of the district:

During the last three decades i.e. 1977 to 2007, there was a reduction of 693.76 sq km of forest cover of the district, which is about 38 percent of the

Table 1: Class wise Forest Cover of Kokrajhar District obtained from Satellite Images (in sq km)

Year	Very Dense forest	Moderately dense forest	Open forest	Scrub forest	Non-forest
1977	872.00	539.70	410.87	485.39	860.77
1987	721.96	410.59	336.90	469.64	1229.91
1997	661.92	385.45	310.58	425.36	1385.69
2007	464.25	367.84	296.72	387.21	1651.98

Total Change	-407.75	-171.86	-114.15	-98.18	+791.21

total forest area available in 1977. During the decade of 1977-1987, deforestation was the highest so as to loss large forests cover of 353.41 sq km. However, during the middle decade of 1987-1997, there was a sudden decline in deforestation, losing an area of 111.5 sq km of forest. Then during the last decade of 1997-2007, deforestation rose up again to 228.16 sq km. During the study period, very dense class of forest suffered

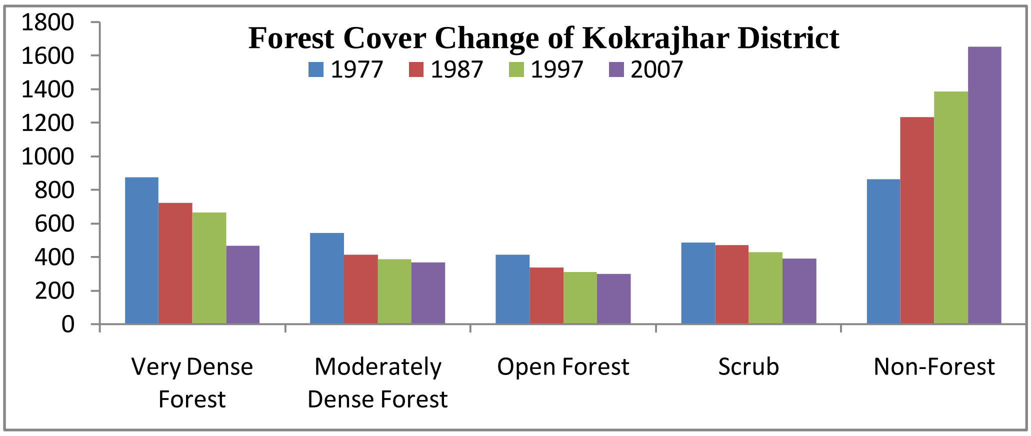


Figure 3: Changing Class-wise Forest Cover of Kokrajhar District

maximum loss (46.73%), followed by moderately dense forest (31.84%) and open forest (27.78%). There was a decrease of 20.23% in scrub forest. The absolute non-forested area was increased by 91.92% in the period. This suggested that deforested lands were being converted for use in other purposes. ***Figure 2*** shows the class wise changes in forest cover of the district during the period. The rate of deforestation during the three decades 1977-1987, 1987-1997 and 1997-2007 were 2.15, 0.79 and 1.84 respectively.

LULC Class	1977-1987		1987-1997		1997-2007		% Change (1977-2007
	Area Change	% Change	Area Change	% Change	Area Change	% Change	
Very dense forest	-150.04	-4.7	-60.04	-1.9	-197.67	-6.2	-46.76
Moderately dense forest	-129.11	-4.1	-25.14	-0.8	-17.61	-0.6	-31.84
Open forest	-73.97	-2.3	-26.32	-0.8	-13.86	-0.4	-27.78
Scrub forest	-15.75	-0.5	-44.28	-1.4	-38.15	-1.2	-20.23
Non-forest	369.14	11.6	155.78	4.9	266.29	8.4	91.92

Table 2: Decadal Change in Forest Cover Area (in sq km) and its Rate (in %)

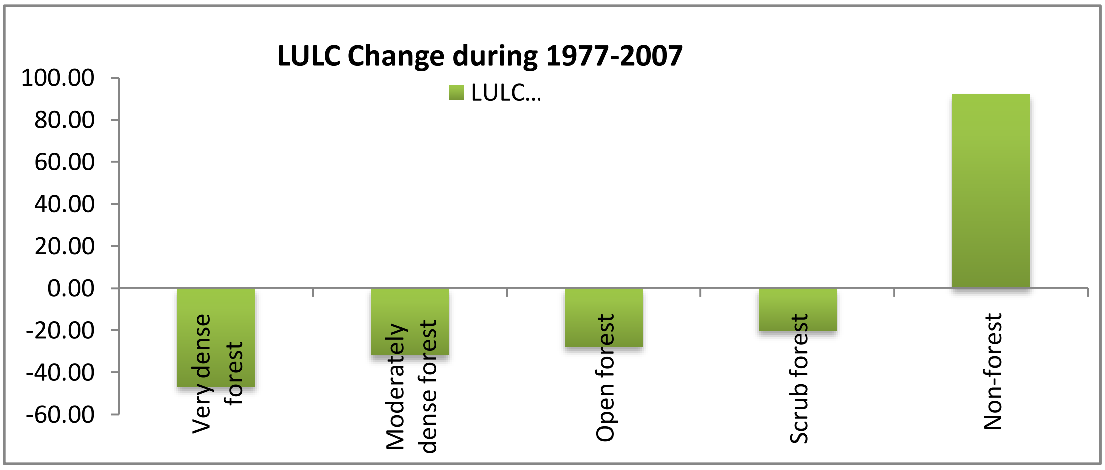


Figure 4: Forest Cover Change during 1977-2007

VI. Conclusions:

In the present scenario, deforestation is a global issue with many implications and hence constraint in resources leads to exploitation of biological diversity and thereby fulfillment of necessitate, large forest area is being encroached by populace, resulting in the loss of overall environmental conditions including soil quality degradation, surface run-off, siltation of rivers. Remote sensing brings together a multitude of tools to better analyze the scope and scale of deforestation. Multi temporal data provides for change detection analysis (Kumar *et al.*, 2010). Assessment of forest cover using remote sensing techniques has established recent trends of forest cover change at regional to global scale. Long term monitoring the changes in forest covers using high resolution remotely sensed data sets provide a detailed view of forest depletion. With the availability of high-resolution satellite data, monitoring of land cover at local scales has become possible to resource managers as a way to create timely and reliable assessments.

GIS offers powerful tools for collection, storage, management and display of map related information and supports in judging management decisions. Multiresolution and multisensory remote sensing data can be used to meet these goals. The remote sensing and GIS technologies can be exploited in creating a wealth of relevant information about various components of biodiversity in developing countries and generating an integrated Decision Support System (DSS) to assist forestry researchers in making informed decisions. It is expected that the developing an integrated decision support system would enable policy makers/managers to better understand the linkages between local, regional and global processes, take effective management decisions and achieve the goal of sustainable development.

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