International Journal of Information Technology and Knowledge Management
July-December 2008, Volume 1, No. 2, pp. 219-226

A COMPARATIVE STUDY OF THE SPECTRAL RESPONSE CURVES AND THE ASSESSMENT OF DIFFERENT LAND USE AND LAND COVER FEATURES IN A PART OF SUNDERBAN AREA, WEST BENGAL, USING GEOINFORMATICS

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Abstract

Sundarban, the largest delta in the world, consists of 10,200 sq km of Mangrove forest, spread over India and Bangladesh. The region is important for its coastal geomorphological characteristics. In the present study, an effort has been made for the comparative study of the spectral response of the different land use and land cover features, the knowledge of which later been used for the spectral classification of IRS IC/ID LISS III satellite data and preparation of major land use / land cover map. The spectral bands have been observed very keenly for the understanding of various land cover classes. Some radiometric enhancement technique has been employed for image enhancement of spectral identification purpose. The study shows agricultural land dominating the northern part where as mangrove forest dominating the southern part comprising 2280 sq km and 3736 sq km area respectively.

Keywords: Delta, Geomorphological, Spectral, Percentage Reflectance, Radiometric Enhancement, Accuracy Assessment

1. Introduction

The huge delta formed in the mouth of Ganga-Bhramaputra river is famous as Sundarban. This is a perfect example of active delta formation. The rivers of the area carry a large amount of sediments and their silt deposition has formed the huge delta. It is possible to map the area through Remote Sensing and GIS in different land cover perspective. In Remote Sensing, information transfer is accomplished by use of electromagnetic radiation (Lillesand & Kiefer, 2000). Through the satellite images the land use/land cover mapping is done more accurately. Now-a-days the Satellite Remote Sensing has been used largely as an important basis for land use/land cover classification, and understanding of the environmental and social relations. Many land use studies has been carried out successfully using Remote Sensing approach (Anderson, *et al*., (1976); Panigrahy *et al*., 2004; Reddi and Maji, 2004; Mundia and Aniya, 2005; Choudhury *et al*., 2006; Ganguly *et al*., 2006). In India, National Remote Sensing Agency (NRSA) has formulated a land use/land cover classification system for mapping at various scales.

A good and useful mapping exercise requires a large amount of information that comes from various resources like satellite images, ground truth etc. Several recent studies however carried out for the mapping, management and conservation of mangrove ecosystem (Robertson and Alongi, 1992; Ricklefs and Latham, 1993; Ellison *et al*., 1999).

2. STUDY AREA

The Sundarban region is at extreme south to the 24 Pargana District, located between 21º 322 North latitude to 22º 402 North latitude and 88º 052 East longitude to 89º 002 East longitude and is at the southern part of the Gangetic delta. The region is demarcated by the river Hoogly on the west, the Ichhamati-Kalindi-Raimongal river on the east, Bay of Bengal on the south. It comprises 19 blocks of north and south 24 Pargana districts of West Bengal (Hunter, 1998). There are 54 islands in this area. The overall elevation of the area is ranging between 3 to 5 meters above the mean sea level. The total area is monotonous plain and predominated by sedimentary unconsolidated material. Most of the soils derived from alluvial deposits (Chaudhuri and Choudhury, 1994; Sarkar *et al*., 1999). The southern islands are dissected by many channels which are not directly connected with the major rivers, but fed by the backwater of Bay of Bengal in the period of tide. Salinity is found varying throughout the region. The intensity of salinity of soil found in the southern portion due to frequent inundation of land with seawater (West Bengal Dist Gazetters,1994). This portion is mainly swampy and covered with dense mangrove forest (Prain, 1903). The Sundarban and surrounding area is the area of interest. For the study purpose the whole north and south 24 Pargana district of West Bengal has been considered.

3. MATERIALS AND METHODOLOGY

Four scenes of digital satellite data of IRS 1C/1D LISS III of the year 2004 have been used for the present study. The details of the path and row of the satellite data used have been shown in. Other reference data were collected from the District Administration. ERDAS IMAGINE and Arc GIS software have been used for the mapping and analysis purpose.

3.1. Image Mosaicking and Study Area Extraction

The digital satellite data has been geo-referenced with respect to the reference data collected from the district administration. The study area was extracted scene wise according to the district boundary. Histogram matching has been done for the four images. The histograms of digital values of the slave scenes were adjusted to mach the histogram brightness values of the master image. For this purpose, first the slave image 109/57 was radiometrically matched with the master image 109/56 and then the 108/

57, 108/56 was matched respectively. The image 109/56 was taken as master scene for mosaicking purpose. Then mosaicing has been done for 109/57, 108/57, 108/56 images respectively [Fig. 1] . The spectral values of Water body, Vegetation (Mangrove Forest), Sand, Swamp and Fallow Land have been taken from the each scene. Five random DN values have been taken and averaged from each class and spectral reflectance curve have been developed [Fig. 2].

3.2. Digital Image Classification

Classification of mosaic image is difficult because of the scene wise variations in radiometry; therefore each image was subjected to classify separately. Training sets were assigned to discriminate among 11 land use/land cover classes for supervised

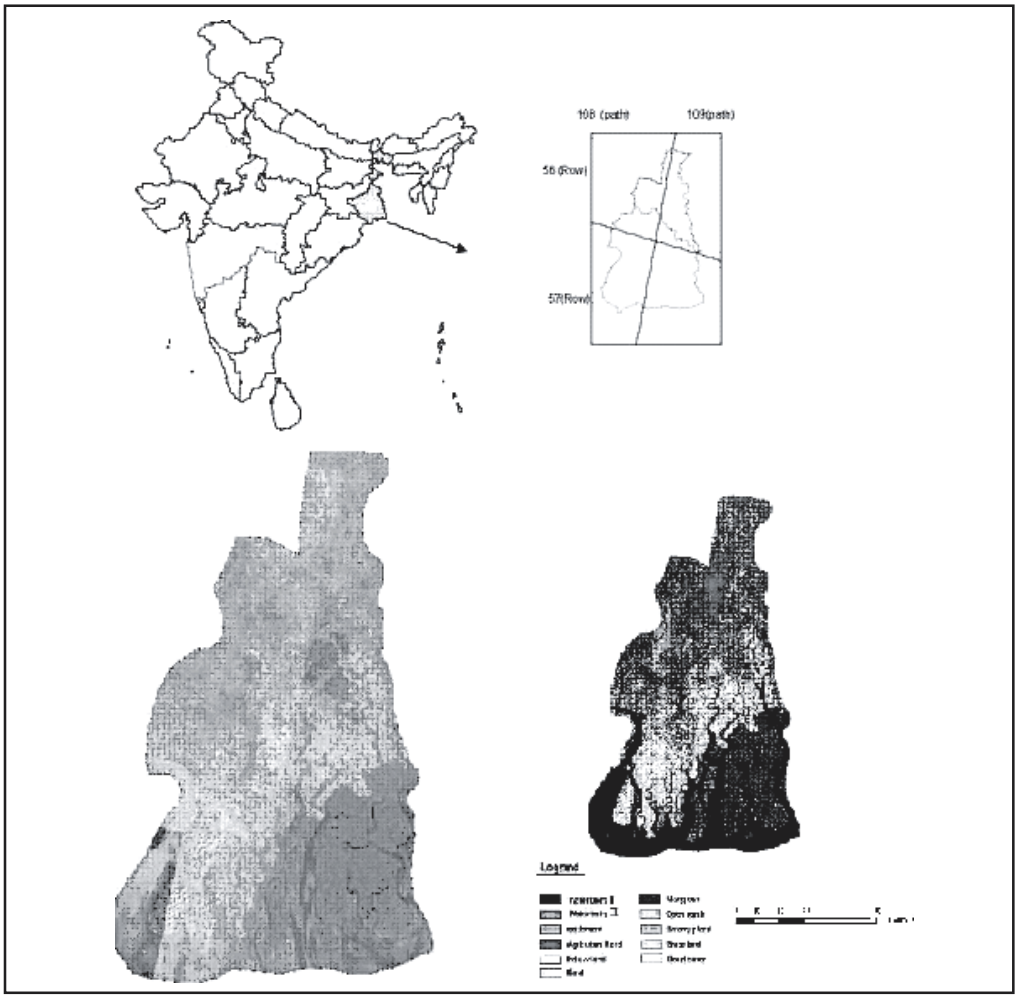
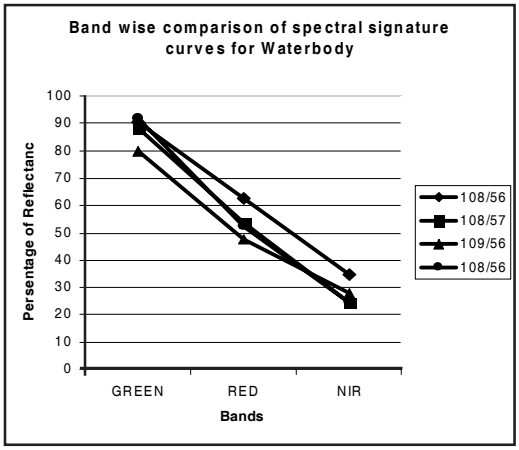
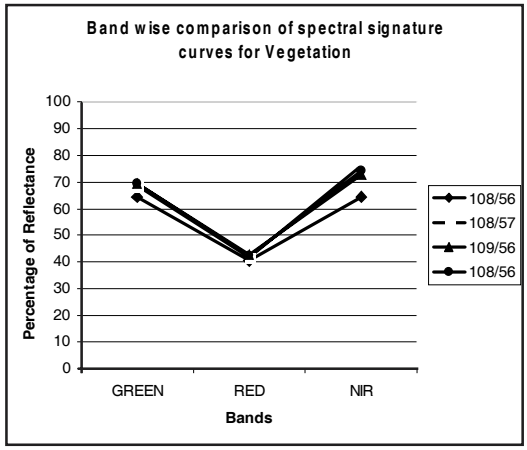


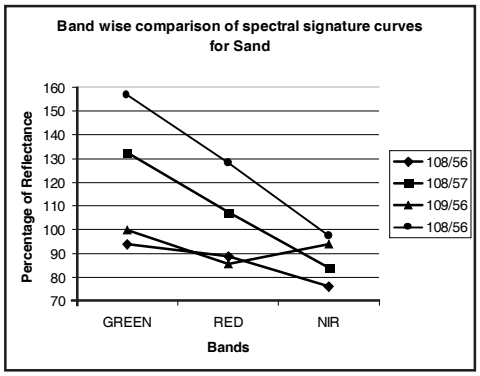
Figure 1: Study Area and Land use Land Cover Map



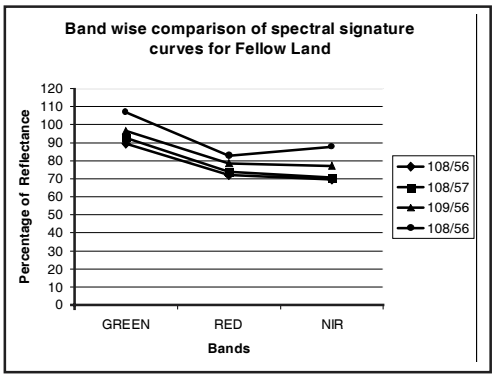
(a)



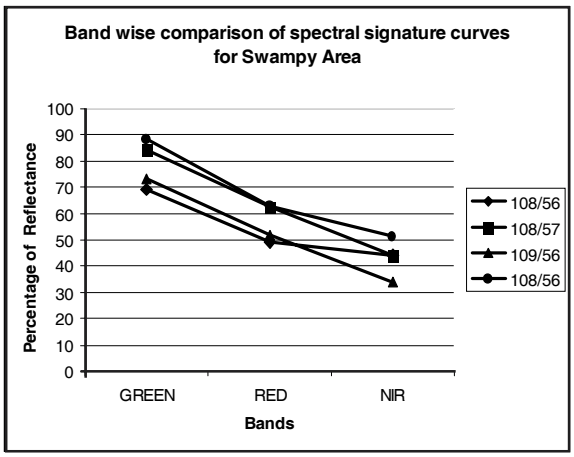
(b)



(c)



(d)



(e)

Figure 2: Spectral Response Curves

classification. The scene wise supervised classification has been done using the maximum likelihood classifier. Each cluster was judged for its origin and accordingly put under the same class. Then the attribute table of each scene was recoded in same class values. All the four classified scenes are then mosaicked. Finally the classified image was smoothed with a 3×3 majority filter.

4. Results and Discussion

4.1. Spectral Reflectance Curves

Maximum reflectance occurs at green region and maximum absorption occurs at Near Infra Red (NIR) region of Electro Magnetic (EM) spectrum. The pattern of reflectance curve for each image is nearly similar i.e., decreasing from green to NIR region. The water body shows high reflectance value in green band, whereas more absorption occurred in NIR region. The highest reflectance values for water body were observed in NIR band for 109/57 image. [Fig. 2a]. The healthy vegetation has high reflectance in green and NIR band due to high chlorophyll content. The absorption is very high in red band. The reflectance of Electro Magnetic Radiation (EMR) depends on the canopy. Dense canopy reflects more in green and NIR band. As the vegetations in mangrove forest area are bushy in nature and possess less woody structures and with moist soil background, the reflectance observed in NIR band is not very high as expected in case of a typical forest vegetation [Fig. 2b]. In case of sand, the highest reflectance is observed in green band and the red band reflectance is medium. The reflectance at NIR band is less because of the moist sand. The highest reflectance values for sands were observed in NIR band for 109/57 image [Fig. 2c]. The Fallow land is showing high reflectance value in green band. The pattern of reflectance curve for each image is nearly similar i.e., decreasing from green to red and NIR region. The Fallow land shows high reflectance value in green band. The highest reflectance values for Fallow land are observed in 109/57 image [Fig. 2d]. The reflectance curve of the swampy area depends on the moisture content. The soil containing more moisture reflects fewer amounts in NIR band. Here the more reflectance found in the green band and the less at the NIR band due to high moisture content The highest reflectance values for sands were observed in NIR band for 109/57image [Fig. 2e]. The land use/land cover map prepared by unsupervised classification technique shows, 11 classes. Mainly the level I land use classification has been done [Fig. 1].

4.2. Land Use/Land Cover Classes

Eleven different classes have been derived as Water body-I, Water body-II, Settlements, Agricultural land, Fallow land, Mangrove forest, Scrub, Swampy area, Grassland, Cloud Cover and Sand. The geographical distribution of these classes and their percentage of

coverage of total study area is tabulated in [Table 1]. Seawater, rivers and lakes are included in Water body-I category. It comprises 25% of the total land use/land cover class. Some shallow water found in the study area is categorized as Water body-II. Mainly they are used for Pisces culture. Only 2.45% of the total area is covered by this class. The dense settlement area is concentrated in the bank of river Ganga. The settlements of Calcutta metropolitan area can be distinguished distinctly. The settlement area is covering nearly 2.25% of the total area, which is nearly 373.481 km^2. Agricultural lands are mainly prevailing in the northern portion of the study area. All different types of agricultural croplands have been classified in the same agricultural class. They mainly found in the banks of river and ox bow lakes of the northern part of the study area. All the cultivated land has been categorized in the same agricultural land. In southern part the soil does not permit better production. Here the soil is mainly salty. Only some crops, which are favorable of this soil condition, are cultivated here. The amount of agricultural land is comparatively less here. It is covering total 2280.83 km^2 and the 13.73 % of the total area. Fallow land is indicated by light yellow signature. This class is mainly prevailing at the southern portion. Agriculture is quite difficult here because of the salty soil. The major portion of the southern part of the district are fallow lands, which covers about 4084.86 km^2 area and are nearly 24.585% of the total area. The mangrove forest class occurs at the southern most part of south 24 Pargana district. This forest cover is very dense and developed at the deltaic islands. The dense forest cover is locally known as 'Sundarban'. The typical mangrove species dominate the central part of the forest. The areal extension of this class is 3736.30 km2 and is covering 22.48% of the total area. The scrub area in mainly found scattered over 454.731 km^2 and is 2.74% of the total land cover area. The mangrove vegetation in some places giving same reflectance with the scrub, so in many places mangrove classes are found mixed with it. The southern deltaic area is swampy. The soils of this area are subjected

Table 1
Area Statistics for Various Land Use/land Cover Classes

Sl no.	*Class Names*	*Area (Km^2)*	*%Area*
1	Water body-I	4233.58	25.48
2	Water body-II	372.449	2.24
3	Settlements	373.481	2.25
4	Agricultural land	2280.83	13.73
5	Fallow land	4084.86	24.58
6	Mangrove forest	3736.30	22.48
7	Open scrub	454.731	2.74
8	Swampy Area	671.097	4.04
9	Grass land	367.47	2.21
10	Cloud cover	35.2385	0.21
11	Sand	7.30714	0.04
	Total area	16617.34	100.00

to salinity and water logging. This is categorized as swampy area. It is covering only the 4.04% of the total study area. Grassland is found along the riverbank. The long grasses can be found in the southern part at the Sundarban area. Total area covered by grassland is 367.47 km^2 and the 2.2% of the total area. Some fragmented clouds are found in the southwestern part of the study area, which is categorized in this class. This comprises only 0.21% of the total. At some areas of the river Ganges dry riverbed developed due to silt. Some dry sands are prevailing in the banks of the fragmented island at the southern portion of the study area. It covers only 0.04 % of the total area.

5. Conclusion

The land use/land cover map for South and North 24 Parganas districts extracted using IRS LISS III Satellite image was found with reasonable good accuracy. The classification accuracy using supervised technique was an average of 90%. For all four scenes water body occupies maximum area i.e. an area of 4233.58 sq km and is 25.48% of the total area followed by fallow land 4084.86 sq km. (24.58%) and agricultural land 2280.83 sq km (13.73%). Total 0.21% of the area falls under cloud cover which is a known demerit of optical remote sensing data. Vegetation class has shown maximum reflectance in NIR band where water body has shown maximum reflectance value for blue region. The moist soil gives less reflection in NIR band. This observation explains clearly the behavior of different land features on satellite image. The vast fallow land in the northern portion of the mangrove forest area indicates that the soil is less fertile here. This is due to salinisation.

Acknowledgements

The satellite data made available for this study at RRSSC, Kharagpur is thankfully acknowledged.

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