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Landuse and Land cover change detection by Remote Sensing and GIS Application: A case study of the environs in and around Silsako and Borsola wetland of Guwahati City, India

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Introduction

Landuse refers to man's activities and the varied uses which are carried on over land. **Land Cover** defined as the assemblage of biotic and a biotic component on the earth's surface is one of the most crucial properties of the earth system. Land use and land cover (LULC) change is a major issue of global environment change. Knowledge of land use and land cover is important for many planning and management activities and considered as essential element for modeling and understanding the earth as a system.

Landuse change is the modification in the purpose of the land, which is not necessarily only the change in land cover but also changes in intensity and management. Change detection is a process of identifying and analyzing the differences of an object or a phenomenon through monitoring at different times. The detection and analysis of changes in multi-temporal remote-sensing data have assumed an ever-increasing strategic role in several application domains. A wide range of applications can be benefited from the study of change process over a specified area at different times.

Landuse and land cover change are critical issues due to their great influence in global warming, loss of biodiversity, and impact in human life. Because of their enormous impact and implications, the International Geospehere-Biosphere Program (IGBP) and the International Human Dimension Program (IHDP) initiated a joint international program of study on Land Use /Cover Change (LUCC) (Lambin, 2003). They recognized the necessity to improve understanding, modeling, and projections of land dynamics from global to regional scale and focusing particularly on the spatial explicitness of processes and outcomes. Land use and land cover information is required for a great variety of applications including residential-industrial-commercial site selection, population estimation, tax assessment, development of zoning vegetation, utilizing and management of natural resources (Lillesand, 2000). Land use land cover information act as input for various different application studies or project or research. In India on land use/land cover in the form of thematic map, records are inadequate and do not provide an up to date information on the changing land use pattern. In most cases, as the time gap between reporting, collection and availability of data is more, the data often becomes out-dated (NRSA, 2006). The spatial setting of landscape elements is characterized by the combination of both biophysical and human forces. In temporal scales of decades, human activities are basic factors in shaping land use change. Some of them are due to specific management practices and the rest are due to social, political and economical forces that control land uses.

Utility of multi-sensor satellite data for land use/land cover change detection is proven technique (Kamini, *et al*. 2006) for making the information available at the required time. Thus Remote Sensing (RS) and Geographic Information System (GIS) are now considered as an important tool for change dynamic study. The collection of remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time. Thus, remote sensing data which depicts spatial location of various land use land cover over space provide the following advantages:

- It provides reliable data at regular intervals
- It provides land use land cover information
- It provides base for plan monitoring and implementation

In addition to this Geographical Information System also is useful in land use land cover change studies. The advantages are listed as follows:

- Data is maintained in a physical compact data files
- Large amount of data can be maintained and extracted at will with great speed
- Various computerised software modules/tools allow a variety/type of manipulation, including map measurement, map overlay, transformation and geographical design and data manipulation
- Graphic and non-graphic information can be merged and manipulated simultaneously in a related manner.

Multispectral-sensor satellites like Landsat series are very effective at mapping LULC at the first two levels, by identifying the spectral signature of a particular type of feature, and broadly classifying areas like forests, grasslands and urban. However, finer details cannot be reliably differentiated.

Objective

The study was taken up with the objective to analyse the nature and extent of land use/land cover changes in and around Silsako and Borsola wetlands of Guwahati City in the past 15 years (1991-2006).

Study Area

For analysing the land use/land cover change in and around the wetlands in the heart of Guwahati city, two linear wetlands Borsola and Silsako were selected. As there is a close link between the two, they can be treated as a single system. A buffer of 1 km^2 was generated from the centre of each wetland, thus Borsola area is about 9.6 km^2 and Silsako is about 27.0 km^2 (Figure 1). This area is selected as a number of land use classes are found to exist in this area.

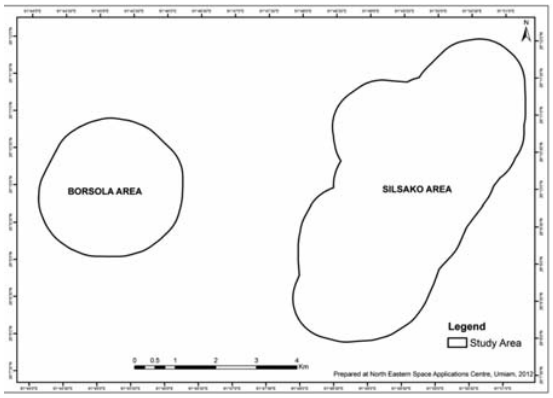

Figure 1: Study Area- Environs in and around Borsala and Silsako

Methodology

For the study, interpretation has been done on a scale of 1:50000 with a minimum mapping unit of 22,500 m^2. Temporal Sensing data were used for the study. For land use land cover change dynamic analysis the following methodology was adopted.

Software Used

Software like ERDAS IMAGINE 9.2. was used for Image processing and ArcGIS 9.3. for feature extraction and analysis.

Data Used

Remote Sensing Data used for the study are listed in Table 1.

Table 1: Remote Sensing Data

SI. NO.	REMOTE SENSING DATA	PATH/ ROW	DATE OF ACQUISITION
1	LANDSAT -TM	137/42	26.11.1991
2	LANDSAT- TM	136/42	19.12.1999
3	IRS LISS III	110/53	10.04.2006

Projected LANDSAT satellite data were used for geo-referencing RESOURCESAT-1 LISS III data. Visual interpretation techniques have been used to extract information from the digital image on the basis of the image characteristics such as tone, texture, shape, size, shadow, pattern, etc. identification and delineation of various features of land use land cover and judging their significance in delineating thematic information. Finally, statistics were generated and changes were analysed.

The methodology adopted for this study is presented in the Figure 2.

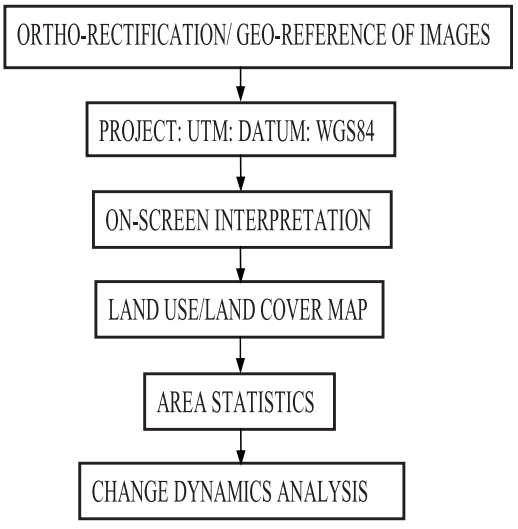

Figure 2:
Methodology for Land Use Change Analysis

Analysis

The areas in and around the wetlands are surrounded by hillocks on the Eastern and Southern sides. Few hills are found in the central part as well. As such there is a considerable forest cover in and around the study area. The area under different land use/land cover is presented in Table 2.

According to the study, built-up area constituted about 45% 0f the study area in 1991. Other land-use like water-bodies was 0.41 Km^2, agriculture was 1.9 Km^2 (5.1%), marshy land was 2.05 Km^2 (5.5 %), forest was about 2.98 Km^2 (8.13%) and scrubland was 10.24 Km^2 (27.27%) of the study area as in 1991. Borsola wetland was 0.06 Km^2 and Silsako wetland was 2.45 Km^2 in the same year (Figure 3).

In the year 1999 the forest cover decreased to 2.70 Km^2. This may be due to deforestation because of forest land being converted to built-up areas. Areas under water bodies and scrubland have decreased to 0.29 Km^2 and 9.38 Km^2 respectively. There is an increase in areas under built up (16.87 Km^2), agriculture (2.23Km^2) and marshy land (2.66 Km^2). There was shrinkage in the sizes of both the wetlands in this year- Borsola wetland (0.05 Km^2) and Silsako (2.43 Km^2). This is presented in Figure 4.

In 2006, the built up area had increased to 20.86 Km^2. Forest area was also showing a little increase in this year covering an area of about 2.79 Km^2. In the other land use classes, there was a decreasing trend- scrubland was 6.64 Km^2, agriculture was 1.87 Km^2, marshy land was 1.92 Km^2, water bodies was 0.09 Km^2. Borsola wetland area remained stagnant at 0.05 Km^2 whereas Silsako wetland had decreased to 2.39 Km^2 (Figure 5).

Table 2:
Land use/Land cover Area

Area (sq. km)

Land Use Classes	Years		
	1991	1999	2006
Agricultural Land	1.95	2.23	1.87
Borsola Wetland	0.06	0.05	0.05
Built Up	16.47	16.87	20.86
Forest Area	2.98	2.70	2.79
Marshy Land	2.05	2.66	1.92
Scrub Land	10.24	9.38	6.64
Silsako Wetland	2.45	2.43	2.39
Water Body	0.41	0.29	0.09
Grand Total	**36.61**	**36.61**	**36.61**

Table 2:
Land use/Land cover Area

Area (sq. km)

Land Use Classes	Years			Change (in %)
	1991	1999	2006	1999-2006
Agricultural Land	1.95	2.23	1.87	(-) 80.20
Borsola Wetland	0.06	0.05	0.05	0
Built Up	16.47	16.87	20.86	23.65
Forest Area	2.98	2.70	2.79	3.33
Marshy Land	2.05	2.66	1.92	(-) 27.81
Scrub Land	10.24	9.38	6.64	(-) 29.21
Silsako Wetland	2.45	2.43	2.39	(-) 1.64
Water Body	0.41	0.29	0.09	(-) 68.96
Grand Total	**36.61**	**36.61**	**36.61**	

Conclusion

There was an increase of area under forest in 2006 compared to 1999. This may be due to reclamation of forest land. In case of area under agriculture, there was an increase from 1991 to 1999, but the area decreased again in 2006. There was a decrease in the coverage of water bodies, scrubland and marshy land. The wetlands are showing shrinkage in their extent, except for Borsola in 1999 and 2006. The increase in the area under built up may have led to the depletion of these wetlands, which in turn led to a lot of environmental and ecological problems. Barren scrub land is converted to Agricultural land, Built-up. Due to these changes the natural ecosystem and biodiversity is adversely affected. A change of land use between 1999 and 2006 in percentage is presented in Table 3. In case of Borsola wetland (0%), Built-up (23.65 %) and forest area (3.33 %), there is a positive change or increase in the areas in these classes. Other classes namely agriculture (- 80.20 %), water body (-68.96), scrubland (-29.21%), marshy land (- 27.81%) and Silsako wetland (-1.64 %) are showing a negative change.

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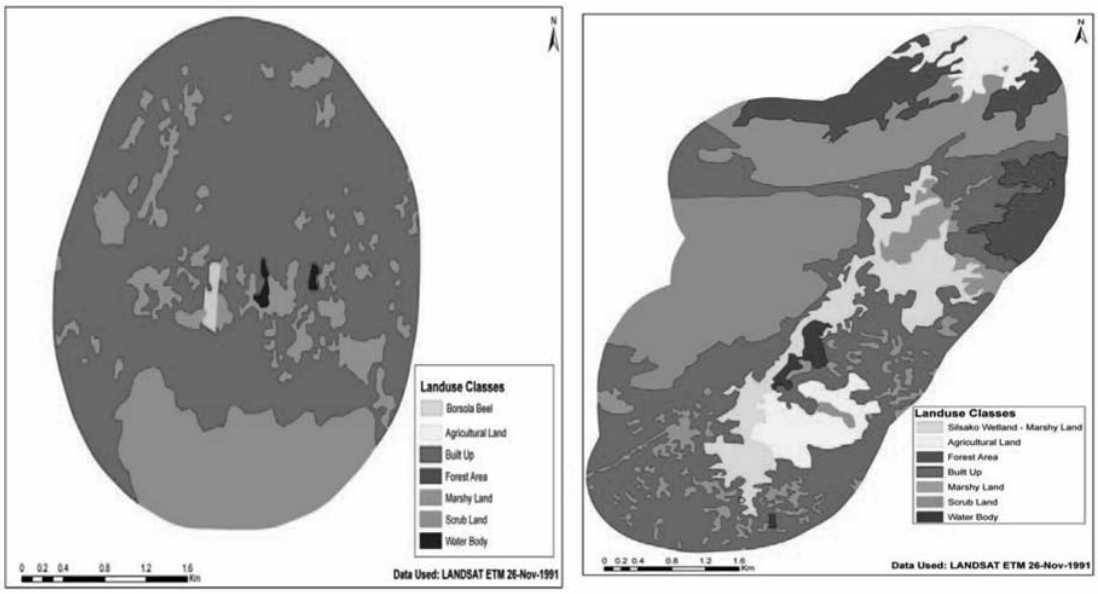

Figure 3:
Landuse Map-1991 of (A)Borsola Area and (B) Silsako Area

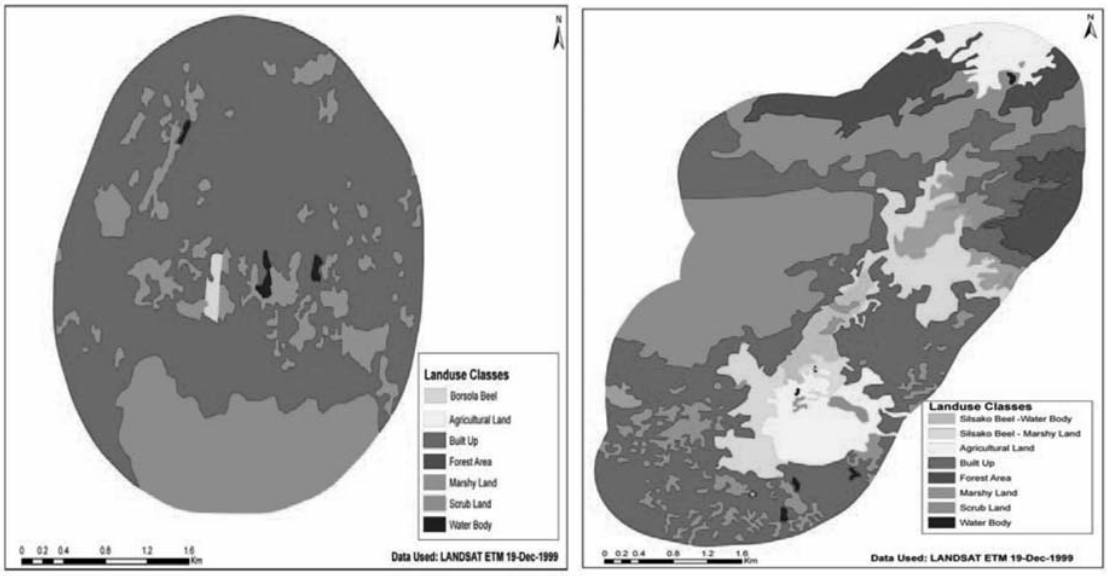

Figure 4:
Landuse Map-1999 of (A)Borsola Area and (B) Silsako Area

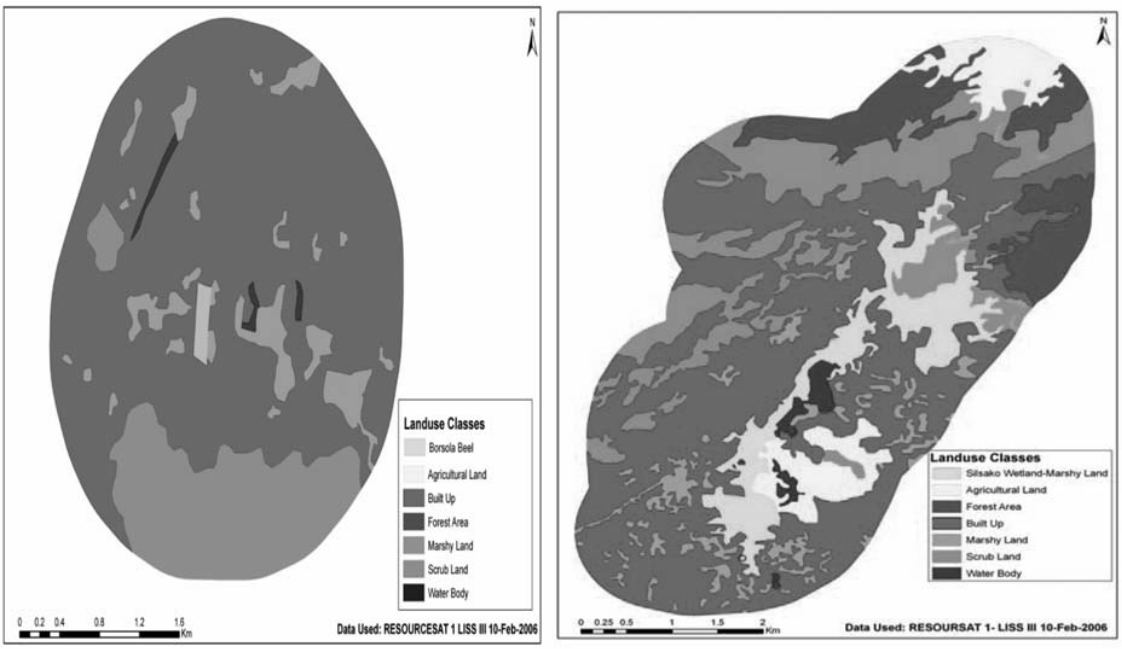

Figure 5:
Landuse Map-2006 of (A)Borsola Area and (B) Silsako Area