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Land Use/Land Cover Change of Sylhet City using Remote Sensing and GIS

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Abstract: Due to various socioeconomic activities and natural phenomena, the Earth's surface is undergoing rapid Land Use and Land Cover (LULC) changes. A significant growth in built-up areas, i.e., urban development is increasingly transforming the landscape from natural cover types to Impervious Surface (IS). These changes break down the Earth's ecological system. Therefore, detecting the changes for future development is important. For this research, Sylhet city have been selected over the time period 2006-2019. The city is classified into two major land use and land cover changes such as water body and non-water body. Analysis of change detection has been conducted to compare the quantities of conversions of land cover class between time intervals. The aim of this study is to detect the change in land-use/land-cover from 2006-20019 and to analyze possible causes of change. The objective of this research is to use Geospatial Information System (GIS) methods to classify and map land-use/land-cover of the study region use. Geospatial Information System (GIS) one of the tools that is very important for the production of land use maps and land cover maps. One of the major section for this research is Land Use/Land cover (LULC), we used NDVI method to classify water and non-water body. The rate of change in LULC between the year 2006 and 2019 is estimated by assessing percentage change in LULC between these periods divided by number of years (13 years). The rate of change indicates that Sylhet city has lost 7.41% water bodies between 2006-2019. Finally, some methods to protect the land cover are suggested and provide an overview of the present trends in land use and land cover modifications.

INTRODUCTION

Land is definitely one of the most important natural resources, since, life and developmental activities are based on it. Land use refers to the type of utilization to which man has put the land. Land cover refers to the characteristics and surface cover of Earth's surface as represented by natural elements such as vegetation, water, bare Earth, impermeable surface and other physical characteristics of the Earth. Land covering is a combination of natural and human factors including vegetation, soil, glaciers, lakes, wetlands and a variety of buildings. Land use relates to human-induced modifications for agricultural, industrial, residential or recreational purposes land use describes how individuals use land for socio-economic reasons urban and agricultural land use are two of the most widely known high-level groups of use. Land use and land cover data are essential for planners, decision makers and those concerned with land resources management[1]. Monitoring and analysis of the urban environment make use of up-to-date. Land Use and Land Cover (LULC) information for proficient and sustainable management of urban areas. Unfortunately, on the other hand, there is a general lack of accurate and current LULC maps in Sylhet. Every parcel of land on the Earth's surface is unique in the cover it possesses[2]. Land use and land cover are distinct yet closely linked characteristics of the Earth's surface. The use to which we put land could be grazing, agriculture, urban development, logging and mining among many others. Frankovich carried out research on LULC classification using Landsat TM data in Modland, Michigan[3]. In his study, he used a combination of principal component analysis; some original hands Tasseled Cap Transform (TCT) for LULC classification. He revealed that, it is possible to delineate LULC features using this approach[3]. He reported that, bands 3-5 were particularly useful for separating forest from non-forest areas as well as the stratification of forested regions into Conifer, hardwood and mixed conifer-hardwood classes. The Geographic Information System (GIS) is used successfully to visualize the extent of land use and land cover changes as well as to analyze the major Earth surface change. GIS based spatial simulation of impacts of urban development on changing both land cover area and land use changing in Dhaka city December, 2012. A comprehensive literature review was done to have a clear understanding of the effects of urban and rural development on land use and changes in land cover. This review also examines how GIS and remote sensing data can be used to measure these parameters. Various journal papers, books, reports, conference papers and dissertation have been overviewed to understand the methods of measuring Land Cover Areas (LCA) and the changes on the land. Maggiore, used GIS technology with remote sensing for land use pattern change in threatened landscapes[4]. Kuchay used remote sensing with GIS for identification of urban area, forest area, fallow land, water bodies in Abbottabad district[5]. Land use land cover change detection using remote sensing data and GIS tools were done by Mehta and Gangtok[6]. Case studies are specific examples of how GIS was used to solve a problem or made information sharing easier in a particular industry. Rai *et al*.[7] successfully have shown the change of land use and land cover during 1930-2015 in Bangladesh. Land use and land cover change analysis of Uttara Kannada using remote sensing data Landsat MSS (1979), TM (1999), ETM+(2013)[5]. In particular, this special issue considers the important role of wetlands in the environment and how land-use and environmental change might effect, so, the study is essential for planners, developers and property owners.

Study area: A portion of Sylhet city area has been selected for this study which can be extracted from a single scene (WRS2: 137/43) of Landsat images. The area of investigation is about 27.36 km^2. The study area lies between 24°51' and 24°55' North latitudes and in between 91°50' and 91°54' East longitudes. Sylhet is a major city that lies on the banks of Surma river in North-East Bangladesh. The city has more than a half million population which experienced rapid urbanization and changing land cover nature. Surma, Kushiyara, Khowai, Dholai, Monu, Kalni and Piain rivers are the main river surround Sylhet city. Sylhet has a typical tropical monsoon climate in Bangladesh bordering higher elevations on a humid subtropical climate. Rapid urbanization of Sylhet city causes the unplanned transformation of the landscape without considering the possible consequences and requirement for environmental sustainability. It was reported that water bodies of Sylhet district were 81535.2, 34535.7 and 28435.6 ha in 1988, 1997 and 2006, respectively and unplanned urbanization played the key rules in the reduction in water bodies[8]. On the contrary, it was found that the settlement area of Sylhet district was 52930.1 and 46713 ha in 1988 and 2006, respectively[8]. No classification scheme was applied in the study of Haque. On the other hand, it was mentioned the urbanization process of Sylhet city is unplanned and it creates of obstacles in all spheres of life[9].

MATERIALS AND METHODS

The methodology of the study has been discussed in this chapter. The procedure adopted in the research work provides the basis for calculating land use/land cover statistics and subsequently the change. Land use land cover of the entire district of Sylhet was performed from three sets of satellite imagery collected over three distinct periods of time 2001, 2009 and 2017.

Data sources: For the study, Landsat satellite images of Sylhet district were acquired for two time periods of 2006 and 2019. To achieve the research objective, Landsat satellite images of the Sylhet city area are compiled as a zip format from the United States Geological Survey (USGS) website over different time periods (2006 and

Table 1: Landsat TM/OLI images used in the study

Sensor	Path/Row	Acquisition date	Resolution (m)
Landsat 5, Thematic Mapper (TM)	137/43	13 February, 2006	30
Landsat 8, Operational Land Imager (OLI)		01 February, 2019	30

2019). The detail of the Landsat data for analysis is shown in Table 1. All pictures have a 30 m spatial resolution. The images were taken from same season as it is required for comparing images of different time period.

Data collection: This study is depended on secondary data. To achieve the research objective, Landsat satellite images of the Sylhet area are compiled as a zip format from the USGS website over different time periods (2006 and 2019). The detail of the Landsat data for analysis is shown in Table 1. The Landsat TM/OLI image is collected as Universal Transverse Mercator (UTM) within 46N datum World Geodetic System (WGS) 1984. The pixel size of all bands Landsat images is 30 m.

Sylhet district shape file: Shape files are a simple, topological format to store geometric place and attribute geographic feature data. One of the spatial data formats you can use and edit in ArcGIS is a shape file. The format of a file defines the geometry and attributes of geographically referenced features in three or more files with specific file extensions to be stored in the same project workspace. Shape file is an ESRI vector data storage format for storing geographic feature location, shape and attributes. It is stored as a set of related files and includes one feature class. Sylhet city corporation shape file is extracted and it is used in arc GIS Software for layer stacking images. The shape file extracted from the map of Bangladesh.

Layer stack of image: Use the Arc Map image analysis extension to produce a layer-stacked picture. A layer stack often combines distinct picture bands into a single multi-spectral image file. For further analysis, layer stacking is also commonly used to combine image derivatives with spectral bands (i.e., layer stacking an NDVI image with spectral bands for input to image classification). This document discusses how a layer stack can be created using ArcGIS from two or more pictures. This blog responds to a remark on how to build an ArcGIS layer stack that overlays various information frames in your MXD. Only pictures or transparencies from individual information frames are combined into one picture layer when you export to layer.

Projection and subset by mask extraction: Mask extraction has created the projection and subset in this study. Tools for raster data extraction include tools that simplify complex or noisy data and tools that create a raster spatial subset or sample. There are several ways to extract a subset of neurons into a fresh raster by choosing an attribute or a specified shape or using another raster. Those locations that are not no data in a mask raster will retain the value assigned to that location in the Input raster in the extraction tool as shown in the image below. A datum was assigned as a preference as far as projection is concerned. Two bands of TM and OLI excluding the thermal band were considered for layers stacking. The nature of these different bands had to be considered to make a decision as to which two band combination would be most helpful for classification and visual interpretation.

Band combination: Landsat pictures consist of seven distinct bands, each representing another part of the electromagnetic spectrum. To operate with Landsat band we must first comprehend each band's requirements. While all the bands from previous Landsat missions are still in place, there are a few new ones such as the coastal blue band water penetration/aerosol detection and the cloud band cirrus for cloud masking and other applications.

NDVI calculation: According to this formula, the density of vegetation (NDVI) at a certain point of the image is equal to the difference in the intensities of reflected light in the red and infrared range divided by the sum of these intensities. Calculation of the Normalized Difference Vegetation Index (NDVI) which is available on-the-fly come fast. In addition, NDVI is often used around the world to monitor drought, forecast agricultural production and assist in forecasting fire zones and desert offensive maps. NDVI is preferable for global vegetation monitoring, since, it helps to compensate for changes in lighting conditions, surface slope, exposure and other external factors. NDVI is calculated in accordance with the formula:

$$\text{NDVI} = \frac{\text{NIR-RED}}{\text{NIR+RED}}$$

Where:

NIR = Reflection in the near-infrared spectrum
RED = Reflection in the red range of the spectrum

For this study, the formula were used for identification of water body and non-water body were as:

$$\text{Normalized Difference Vegetation Index (NDVI)} = \frac{\text{Band 5-Band 4}}{\text{Band 5+Band 4}} \text{ for LANDSAT 8}$$

$$\text{Normalized Difference Vegetation Index (NDVI)} = \frac{\text{Band 4-Band 3}}{\text{Band 4+Band 3}} \text{ for LANDSAT 5}$$

This index defines values from -1.0 to 1.0, basically representing greens where negative values are mainly formed from clouds, water and snow and values close to zero are primarily formed rocks and bare soil. Values from -1 to 0 are water bodies and >0 are the non-water bodies.

Enhancement of image: Image improvement is intended to enhance the interpretability or understanding of data for evaluation in pictures or to provide 'better' input for other automated image processing techniques. Image can be enhanced in several ways such as contrast enhancement, intensity/hue/saturation transformations, density slicing, etc. Landsat image can also be improved by combining composite bands.

Projection and subset of satellite image: All geographic datasets have a coordinate system for displaying, measuring and transforming geographic data throughout ArcGIS. If the coordinate system for a dataset collection is different then the image analysis will be inappropriate.

Composite band combination: Landsat TM/OLI image has several bands. Using various combinations of bands that were used to classify pictures. These composite bands are used to identify and select the area of interest to create the image classification signature. This study calculate NDVI using raster scale then get a mixed band picture for Landsat 5 after choosing band 3 and band 4 for Landsat 5. Again, for Landsat 8, first calculate NDVI using raster scale. Then a combined band image for Landsat 8 was found.

Clipped study area: In this process first, we add shape file of Sylhet city for create a new layer. We have already gotten a new layer (Raster scale) from the previous study and now we are creating a new layer with the help of clip option (Fig. 1 and 2).

Creating signature file: In this step, the composite band image are used to digitize the known land cover, so that, signature value can be collected. Selected ground control points that include the major land cover classes were sampled to create a signature file to help the software to

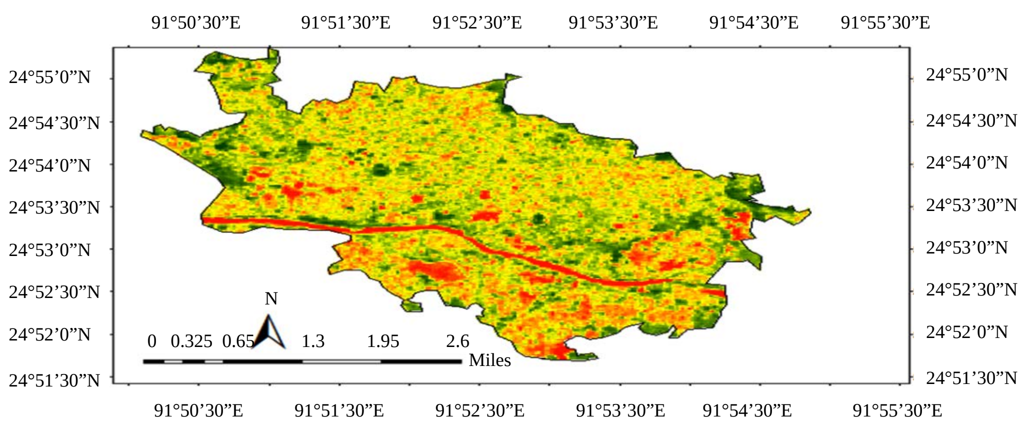

Fig. 1: Clipped image of study area for the year 2006

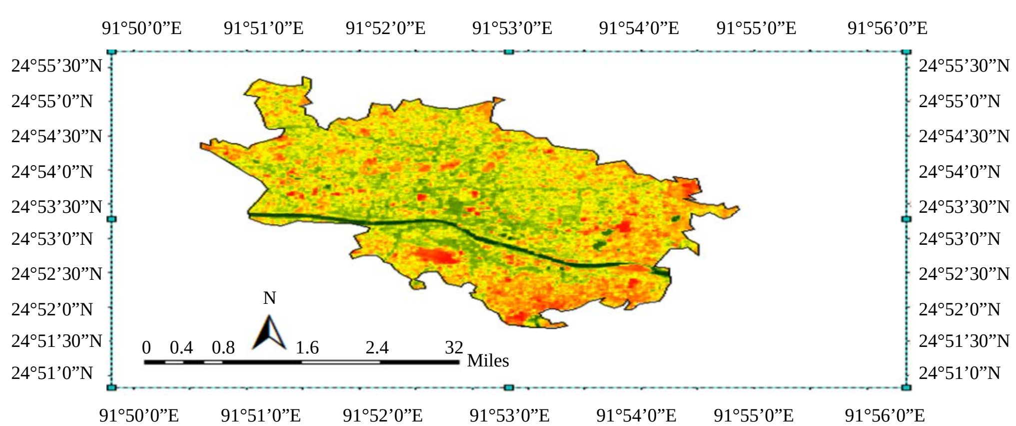

Fig. 2: Clipped image of study area for the year 2019

classify the entire study areas. For less error care was taken to avoid mixed pixel value and attention was made to include areas relatively uniform in spectral pattern. In this way as more as possible signature value have been collected for each land cover types based on reference data. For this study, 2 types of land cover have been selected on the basis of their similar character shown in Table 2. Information was provided by taking sample signature points, so as to supervise and help the computer to accomplish the classification process in the whole study area based on selected sample.

Table 2: Selected criteria for land cover area classification

Land use	Details of land cover types
Water bodies	River, open water, lakes, ponds etc.
Non water bodies	Residential area, mixed urban area, mixed forest lands, vegetable lands, sand fill, land fill and exposed soils etc.

RESULTS AND DISCUSSION

Temporal pattern of land use land cover from 2006-2019 in Sylhet City Corporation (SCC) are shown in Fig. 3. Table 3 shows the area obtained from the land cover classification of two types (i.e., water body and non-water body) and percentage of total area.

The nature of land cover changes revealed that non-water area (build up and base soil) categories have been increased significantly. It is clear from the trend that there is an incredible pressure of urbanization on natural land covers. Figure 4 shows that between 2006 and 2019, non-water area increased in a rapid rate. The aforementioned result revealed indiscriminate changes in LULC's land measure from 2006-2019. From Table 3, we see that in 2006 water body was 11.11% and non-water bodies was 88.89% but in 2019 water body is 3.70% and

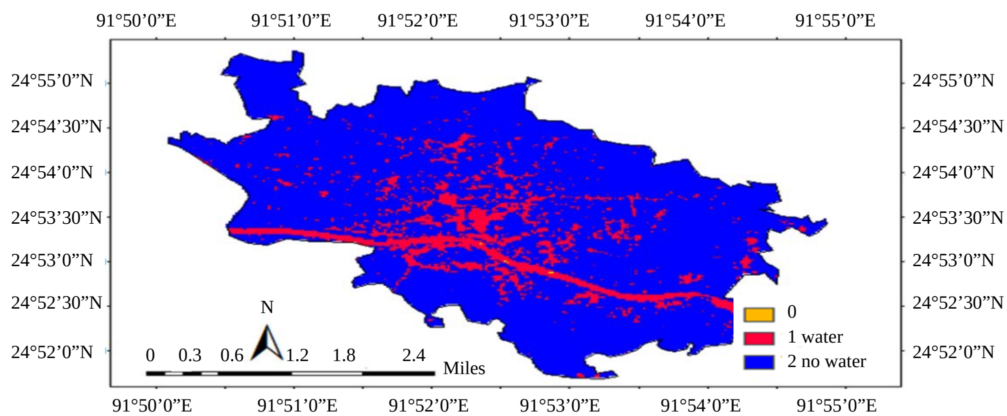

Fig. 3: LULC map of Sylhet city, 2006

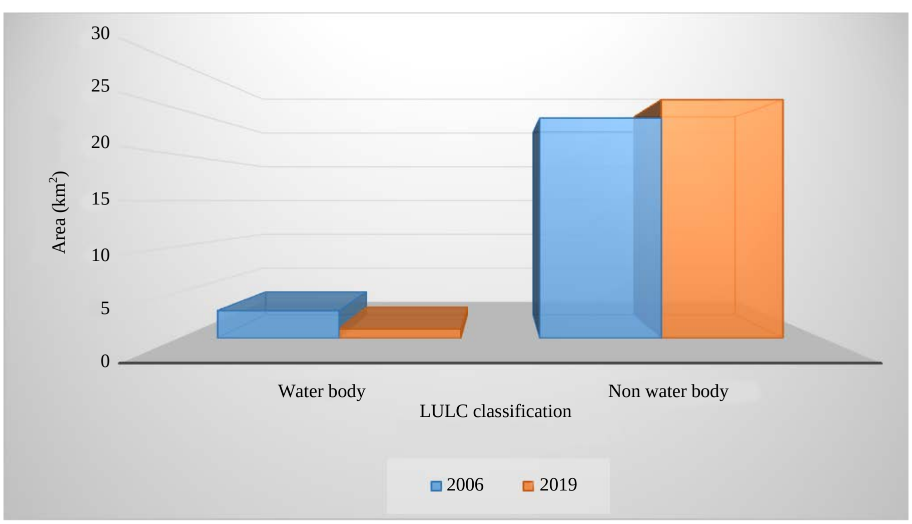

Fig. 4: Comparison of LULC classification of 2006 and 2019

Table 3: Summary of land classification statistics between 2006 and 2019

	2006		2019	
Classified class	Area (km^2)	Percentage	Area (km^2)	Percentage
Water body	3	11.11	1	3.70
Non water body	24	88.89	26	96.30
Total	27	100.00	27	100.00

non-water bodies are 96.30%. The rate of change in LULC between the year 2006 and 2019 is estimated by assessing percentage change in LULC between these periods divided by number of years (13 years). The rate of change indicates that Sylhet city has lost 7.41% water bodies between 2006-2019. On the other hand, the rate of change indicate that 7.41% non-water bodies are increased.

To accumulate, the increasing population, the city has been expanded extensively. Therefore, most of the development has been resulted in the loss of natural resources. It has been observed that the growth of Sylhet city is moderately faster than mega cities of developed countries. During 2006-2019, the conversion pressure mainly onto cultivated land and low land as it shows the maximum loss. Urbanization in the study area has been rapid another land covers with discontinuous patches which resulted in diversified and uneven expansion. 68% respondents agree with this reason. Inadequate housing, unplanned and haphazard development, absence of proper land use policy inequity of lands, etc. are contributing to the urban sprawling. It causes unconceivable emergence of slums and squatters. It is estimated that presently 13.8% of the city's population live in slum. The environment of these slumps is extremely unhygienic.

CONCLUSION

Land use/land cover classification of Sylhet city corporation using remote sensing and GIS was described in this study. Landsat image of Sylhet city of year 2006 and 2019 are analyzed by cover classification image and land cover type (water and non-water bodies) over 2006-2019 and land cover change of Sylhet city is found. Unplanned increase in non-water bodies and urbanization included landfill, snatches the agricultural and low land which is environmentally not sustainable. Moreover, unplanned development, poor political communities, poor legislative action and inadequate strategies are also responsible for land use change.

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