IMPACT OF LAND USE LAND COVER CHANGES IN GUWAHATI CITY, ASSAM, INDIA

Dr. A.K.Bora[1] and Dhrubajyoti Rajbangshi[2]
[1]*Professor, Dept. of Geography, Gauhati University, Guwahati-14, Assam*
[2]*Assistant Professor, Dept. of Geography, Guwahati College, Bamunimaidam, Guwahati-21, Assam*

***Abstract*—Land use and land cover study is one of the significant aspects of spatial science. This helps understanding the change detection of the earth resource and physiographic change of the earth surface. It also helps the management of natural resources and monitoring of the environmental changes. The physical setting determines the growth and development of population and their activities in every region of the world. If the location of a particular place is convenient for settlement and trade and commerce, then that place will start developing and become a centre place for the surrounding regions, where economic activities changes from primary to secondary and tertiary activities and gradually urbanization process starts with the rapid land use and land cover change mainly to infrastructure and built up areas. This trend is accelerating day by day in the urban centres due to ever increasing anthropogenic activities and Guwahati city of Assam is also not exception to this.**

This research paper mainly emphasizes on the changing nature of land use and land cover dynamics of Guwahati city and related geo-environmental problems which became a major threat to the city dwellers. GIS (Geographical Information System) and Remote Sensing techniques are used here for better understanding and analysis of the subject matter along with the interpretation of the satellite imageries for the period of 1991 to 2015. Urban expansion is considered to be the major cause of Land use land cover change at large scale in Guwahati City. Frequent transformation and modification of land resource for various human induced activities changed the entire scenario of this urban centre, which leads to the emergence of several geo-environmental problems depending on the intensity of anthropogenic activities at spatio-temporal context. This paper also emphasizes on the importance of study about the changing nature of physical as well as socio-economic structure of the fast growing urban centers for better future planning with a proper scientific approach.

***Index Terms*—Land use land cover, Urbanization, Anthropogenic, GIS and Remote Sensing.**

I. INTRODUCTION

Land use and land cover (LULC) change plays a significant role in changing the entire global environment. A systematic and scientific land use land cover plan is utmost necessary for a sustainable environmental condition without which a number of geo-environmental problems arise with varying dimension and intensity. The greatest force of land transformation on the earth surface is the agricultural activity. The expansion of agriculture has shifted spatially over time, following the general development of human settlement along with other human induced activities both social and economic. In the last few decades landcover has been changing due to the expansion of urban centers globally and this trend is more prominent in the developing countries like India. In recent times specially after 20^{th} century the pace and intensity of land cover change is accelerating worldwide in general. Human alterations of the earth's terrestrial surface are unprecedented in their pace, magnitude and spatial reach, of these none are more important than changes in landcover and land use (Turner et al., 1994). Land change monitoring should also aim to characterize the full land-cover dynamics or land-use transitions, and these dynamics and transitions will require superior detail in the land-cover classes analyzed. Time to time an accurate LULC change information is very essential and important for better understanding of man environmental relationship as well as the interrelation between men-land interaction. In the case of urban landscape and the process of urbanization in Guwahati city these information play a vital role for decision and policy making. Timely updating of such information helps sustainable management and development of urban activities in Guwahati. The urban landscape of

Guwahati is expanding over the different physiographic and geomorphic units. The geomorphic units and their characteristics have direct influence on the growth, expansion and development of the urban landscape.

II. STUDY AREA

Guwahati, the greatest urban centre of North East India is located between $91^0 24^I$ E to $91^0 51^I$ E longitude and $26^0 5^I$ N to $26^0 12^I$ N latitude on the southern bank of the mighty river Brahmaputra. It is surrounded by Nalbari district in the north, Darrang and Morigaon district in the east, Meghalaya stste in the south and Goalpara and Barpeta district in the west. The region is delineated under GMA constitute area of Guwahati Municipal Corporation (GMC), North Guwahati Town Committee, Amingaon Census Town and 21 revenue villages. The total area covered under GMA is approximately 264 km2 . The municipal limit of the city during the period increased from 43.82 sq. km in the year 1971 to 216.79 sq.km in the year 1991 and in 2011 the total area is 262sq.km.

III. OBJECTIVES

The study is mainly focusing on the following objectives:

1. To study the Landuse Landcover pattern of Guwahati City
2. To know the impact of changing Landuse Landcover on the city environment.

IV. DATABASE AND METHODOLOGY

This study is mainly based on both primary and secondary data sources. Primary data source includes field survey and secondary data source includes reports from government departments, statistical handbooks, census reports and reports from research organizations. Satellite imageries are used to detect spatio-temporal change in Landuse Landcover i.e. Land sat 5 and Land sat 8(30m) and SRTM Dem (90m) along with LISS III imagery of 1991, 2000 and 2009. For spatial analysis techniques in Arc GIS 9.3 is used for classification of image to interpret the Landuse Landcover of Guwahati City. Temporal landsat imageries were classified into built-up and nonbuilt-up area using supervised classification and the other hand height above 71 meters above mean sea level is extracted from SRTM DEM data as hilly region .using spatial analysis techniques in Arc GIS both the classified image and hill extracted image were overlay and processed .Conducting high accuracy surveys for establishing ground reference points to be used to create very accurate GIS based spatial data and attribute data, topographic surveys.

V. ANALYSIS AND DISCUSSION

Land use change is the outcome of various human induced activities over a particular space in different time periods. The intensity and frequency of land use is more prominent and complex in urban areas compared to other places. Human interventions in particular and natural phenomena in general are considered to be the factors affecting the pattern of land use change. Population growth, demand of agriculture and trade, development of various economic activities and consumption pattern, process of urbanization, development of science and technology etc. are the major causes leading to land use change from time to time.

A reasonably accurate and updated existing land use map is an essential prerequisite for preparing a development plan for any area. Understanding and analysis of existing land use pattern is necessary for establishing development policies for future uses of lands. Appreciation of existing land use pattern is necessary for the preparation of sustainable development plan. In conventional practice one has to depend on the available cadastral maps and land use maps that are available from the responsible authorities or municipalities. But, it has become necessary to take the help of space data for better analysis and interpretation. In this regard the land use and land cover of Guwahati Municipal Corporation Area has been analysed based on the base map prepared by the Guwahati Municipal Corporation. Later on detailed landuse categories are outlined on the basis of satellite image interpretation.

The procured satellite images are geo-referenced along with the prepared base map, which are later divided into total 1857 grids, each grid having size of 1.8 km x 1.1 km. Detailed analysis is done for each grid. The urban area has been divided into eight main land use categories - residential, commercial, industrial, public and semi-public, transport, public utilities and service, water body, and open space. These categories have been listed in table 3.3 and discussed in the following paragraphs.

Table 1: The Land use categories of Guwahati city

Sl. No	**Land Use Category**	**Characteristic Features**
1	Residential area (R)	General residential, multistoried, sparsely residential settlement in agricultural field-sand, sparsely located hilly settlement.
2	Commercial area (C)	Street shopping, shopping complex, hotel, petrol pump, wholesale business, warehousing and go-downs, general commercial, mix use commercials, and recreational facilities such as cinema hall, sport complex, club, etc.
3	Industrial area (I)	Industrial and manufacturing activities and services
4	Public and Semi-Public area (PSP)	Educational, medical (hospital, nursing homes, dispensaries), and religious establishment, government uses, and defense area
5	Transport (T)	National and state highways, major district roads, airport, railways, bus terminal and depots, and truck terminals and depots Note: Other roads are considered as an open space, except in Guwahati Municipal Corporation.
6	Public Utilities and Services (PUS)	Waterworks, pump house, sewerage treatment plant, electric substation, oil pipe line, cemetery and graveyards, drainage channels, and dumping grounds
7	Open Space (OS)	Park, garden, playgroup, stadium, open field, agriculture field, vacant land, farm, hill, brick klins, marshy land, wetlands, reserve forest, and other forest, and other roads
8	Water Body (WBB)	River, canal, water pond, lake, water tank, beels, streams, fishing ponds, other water bodies, and dry river bed

Source: Guwahati Metropolitan Development Authority and image analysis by the researcher.

Under each land use categories various types of features are included which are similar in their nature as mentioned in the table 3.3. The residential category includes general residential, multistoried, sparsely residential settlement in agricultural field-sand sparsely located hilly settlement of Guwahati which cover the highest area. Another important land use category of the city i.e. commercial areas including street shopping, shopping complex, hotel, petrol pump, wholesale business, warehousing and go-downs, general commercial, mix use commercials, and recreational facilities such as cinema hall, sport complex, club, etc. Being the commercial hub the city's commercial activities are expanding with the process of urbanization. The areas of industrial and manufacturing activities and services are under the industrial land use class. As mentioned earlier, Guwahati is the center of almost all the administrative activities. Therefore, Public and Semi-Public land use category is considered to include waterworks, pump house, sewerage treatment plant, electric substation, oil pipe line, cemetery and graveyards, drainage channels, and dumping grounds. These categories are serving the large group of urban population of the city. The National and State Highways, major district roads, airport, railways, bus terminal and depots, and truck terminals and depots are included under the head of transport category. In Guwahati the network of transportation is very complex pattern of land use along with the growth of the city. As per the master plan the open space category is mentioned to include the park, garden, playgroup, stadium, open field, agriculture field, vacant land, farm, hill, brick kilns, marshy land, wetlands, reserve forest, and other forest, and other roads. Here almost all the non built-up areas are included and its covers a significant area of the city's total area. All the water bodies, i.e. rivers, canals, water ponds , lakes, water tanks, wetlands, streams,

fishing ponds, other water bodies, and dry river bed etc. are incorporated under the category of water bodies.

Spatio-temporal pattern of Landuse and Landcover change of Guwahati City:

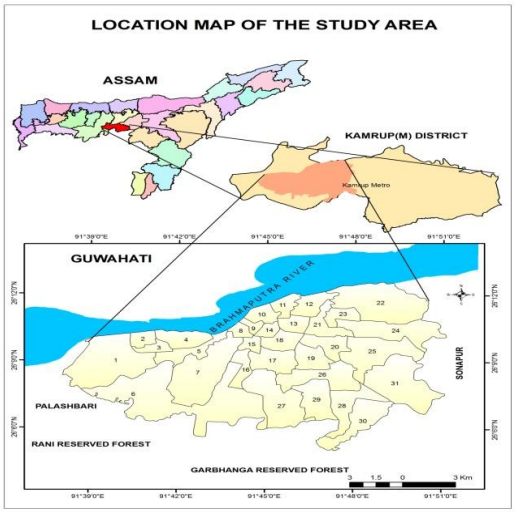
Table 2: Changing pattern of land use and land cover in Guwahati, 1991-2015

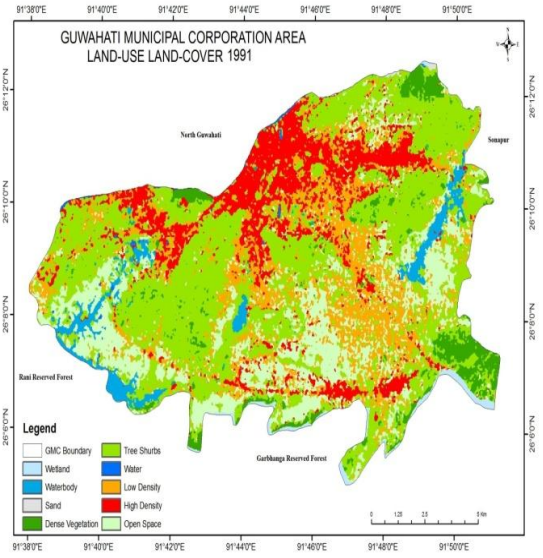
LULC class	1991		2002		2004		2015	
	Area in km^2	Area in %	Area in km^2	Area in %	Area in km^2	Area in %	Area in km^2	Area in %
Wetlands	10.35	4.77	10.04	4.62	10.71	4.93	10.68	4.92
Water body	6.56	3.02	4.00	1.84	2.72	1.25	2.07	0.95
Riverine sand	1.16	0.53	1.07	0.49	0.80	0.37	1.44	0.67
Forest	18.41	8.48	15.29	7.05	15.20	7.00	12.34	5.68
Tree & shrubs	70.49	32.46	60.27	27.76	49.63	22.86	47.11	21.69
Low density settlement	37.23	17.15	40.79	18.78	60.89	28.04	64.04	29.49
High density settlement	39.74	18.30	62.06	28.58	64.42	29.67	67.37	31.04
Open space	33.20	15.29	23.62	10.88	12.77	5.88	12.09	5.57
Total	217.14	100.00	217.14	100.00	217.14	100.00	217.14	100.00

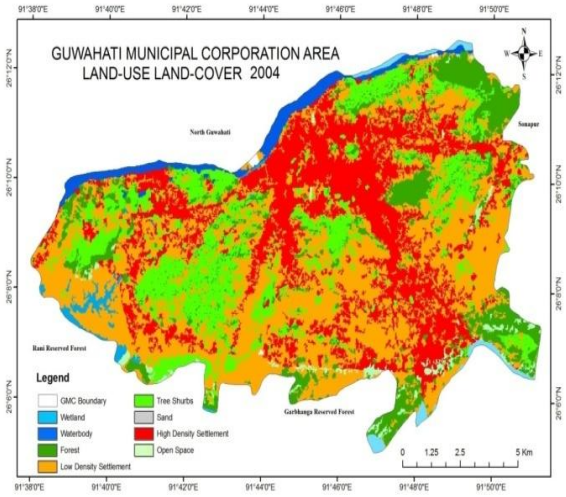
To study the changing LULC pattern of Guwahati for the year 1991, 2002, 2004 and 2015, the images were classified into eight LULC classes, viz. forest, tree and shrubs, low density settlement, high density settlement, wetland, water body, Riverine sand and open space. The settlement class encompasses built-up areas including roads and buildings. Open space includes vacant land plots, bare soil etc. The table 3.6 explains about the LULC changing pattern in the years 1991, 2002, 2004 and 2015. The status of wetland was 4.77% in 1991 and it became 4.62%, 4.93% and 4.92% of the total city area respectively in the year 2002, 2004 and 2015. The water bodies of the city have shown a decreasing trend from 3.02% in 1991 to 0.95% in 2015. It is because of the earthfilling of the low lying areas and large scale encroachment caused by human activities. The amount of riverine sand is very low, it varies from 0.53% to 0.67% in 1991 and 2015. Most significantly forest cover within the city is also decreasing throughout the year. There are a number of Reserved Forests within the city boundary, but illegal cutting of trees is going on due to which forest cover is changing. In the year 1991 forest area was 8.48% of the total city area. This has been decreasing gradually to 7.05%, 7.00% and 5.68% in 2002, 2004 and 2015 respectively. The degradation of 2.81% of the forest land is recorded within the period of 25 years. In the same way, the areas covered by tree and shrubs were also decreasing from 32.46 % in 1991 to 27.76% in 2002 and 22.86% in 2004 to 21.69% in 2015. But there is significant growth in the case of built-up areas and expansion of settlement areas. In the year 1991, the low density settlement covers an area of 17.15% of the total city area, which became 18.78%, 28.04% and 29.49% in the year 2002, 2004 and 2015 respectively. Due to the increase of population in the city, settlement areas are expanding rapidly. It was the increase of 12.34% of the total land area of the city. On the other hand, high density settlement areas are also increasing from 18.30% to 31.04% from the year 1991 to 2015. Regarding the status of open space, it covered in 1991 only 15.29% and in 2015 it covered 5.57%. The open space of the city has decreased by 9.72% from 1991 to 2015. The LULC pattern of the city has been changing frequently because of the increasing human population and expansion of their various developmental activities. Frequent LULC change has

been observed in the periphery areas of the city along with the growth of market and commercial areas and growth of settlement areas.

Figure 1: Location map of Guwahati City along with Landuse Landcover map for the year 1991,2004 and 2015 (Based on satellite imageries)







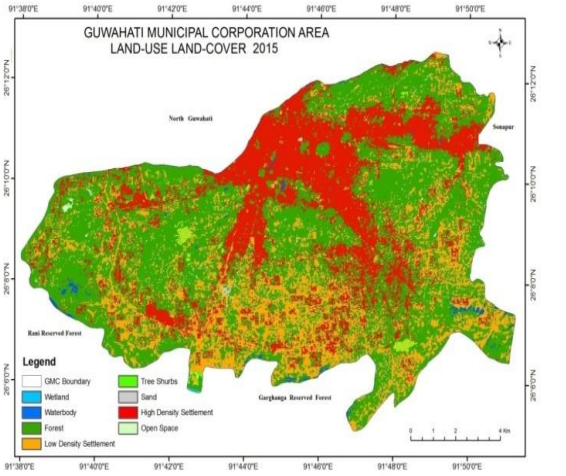


Table 3.: Major LULC types of Guwahati, 1977-2015

Sl.no	LULC category	Area in percentage (1977)	Area in percentage (2015)	Change of area (in percentage 0
1	Forest cover	27.17	17.19	- 9.98
2	Open area	14.12	4.42	- 9.7
3	Built-up area	22.59	63.24	+ 40.65

Source: Survey Of India toposheet, Satellite data

The forest cover of the city is decreasing from 27.17 % in 1977 to 17.19 % in 2015. In the same way open areas are also decreasing from 14.12 % in 1977 to 4.42 % in 2015. On the other hand, built-up areas are increasing significantly from 22.59 % in 1977 to 63.24 % in 2015. It records a growth of 40.65 %

between the year 1977 and 2015. The forest covers and open areas are also decreasing by 9.98 % and 9.7 % respectively between the same time periods.

VI. CONCLUSION

The land use pattern of the Guwahati city has been changing with time. With the steady increase of the population the area classified as residential has steadly increased from 6.59 sq.kms to 137.36 sq.kms during 1911 to 2015. Although, when compared as a percent of area covered it seems to have declined over the period which can be attributed to the expansion of the city. On the other hand, the total area under roads between the two years seems to be nearly same, showing almost no development of the city roads. But there has been a very rapid rise in the area under commercial, industrial uses.

The conclusion of the research work has been drawn in form of the following findings:

i. Guwahati city has been experiencing a large scale and rapid land use and land cover change (LULC), which is more prominent on the periphery areas of the city compared to the other areas. LULC changes are moe conspicuous on the eastern and western periphery areas of the city.

ii. Changing pattern of land use and land cover is observed significantly on both the sides of the National Highway 37 extending from sixmile and Jalukbari. In those areas industrial and commercial activities are growing more distinctly.

iii. The core areas of the city comprising Panbazar, Uzanbazar, Paltan Bazar, Ulubari, Lakhtakia, Lachit Nagar, Ganeshguri, Silpukhuri and areas along the GS Road, GNB Road and RG Baroah roads have no significant Land use and land cover change during the last decade because of the early growth of the city in those areas.

iv. Land use land cover change is more around the wet lands, i.e. Deepar Beel, Silsako Bel, Borsola Beel, Sorusola Beel etc. of the city in the last decade. This is because of the transformation of those areas into settlement areas and also for use in constructional activities, which had led to decrease of wetland area from 13.80 sq.km. in 1986 to 11.11 sq.km. in 2015.

v. Encroachment on the hills is a serious problem causing to land use land cover change directly and affecting the drainage sewerage system indirectly. Human settlements on the hills of the city have been alarmingly increasing from 6.13% to 21.2% of the total city population during the period from 1996 to 2015.

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