Monitoring Urban Growth and Detection of Land Use/ Land Cover Change in Silchar City, Assam and Balurghat City, West Bengal

Bhalindar Singh, Chandana Sarkar

Abstract: Rapid growth and development of urban area is a worldwide phenomenon and it has become one of the certain issues facing by most of the urban areas in developing countries like India. The foremost reasons of this type of speedy growth are uncontrolled urbanisation coupled with accelerated population growth, massive influx of illegal immigrants and unorganized expansion of the urban areas. Accordingly, urban growth led to radical changes in land-use/ land-cover, which manifests profound impact on urban environment through the process of fast alteration of natural landscapes. In this context, the present study aims at comparing the pattern of urban growth and concerning land use and land cover change dynamics of two emerging frontier cities in India i.e., Silchar and Balurghat. For the purpose of the study, multi-temporal Landsat data have been used for analysing land use/ land cover changes in both cities for the period of 1988-2019.Hence, land use and land cover maps are prepared by applying maximum likelihood algorithm of supervised classification method with the help of ERDAS Imagine software. The accuracy assessment was also done by applying statistical method of Kappa coefficient. Further, the study reveals that both the cities have experienced with rapid rate of horizontal expansion. This has led to drastic change with sharpe conversion of vegetation and open field to built-up areas and which have caused innumerable environmental problems and hampers the sustainable growth of both two cities. Therefore, there has been dire need for proper planning to sustain balance of future urban growth and overall development of the areas.

Keywords: Urban growth, Land use/ Land cover, Change detection, Silchar and Balurghat.

I. INTRODUCTION

At the present time, almost each and every towns and cities in the developing countries are dealing with problems of widespread urban growth and fast rate of urbanisation. In this context, unprecedented population growth coupled with unplanned developmental activities has resulted in urbanization, which led to enormous pressure on limited natural resources by the random process of land use and land cover changes (Sudhira et al., 2004). So, the change in land use in cities and towns are the domino effect of urbanization and there is a very strong positive relationship between the rate of urbanization and land-use/land-cover as well as landscape change (Puchard et al., 2006; Mandal et al., 2019).

Additionally, in urban areas, the spatio- temporal expansion of build up area is one of the prime reasons for exchanging of arable land and decline in forest cover (Lopez et al., 2001). Land use and land cover (LULC) changes predominantly caused by anthropogenic activities are one of the key driver of local, national, regional and global environmental change (Sala et al., 2000; lambin et al., 2003; Guan et al., 2011; Wu et al., 2013; Halmy et al., 2015). Moreover, these human induced land use and land cover changes altered natural landscapes and resulted significant effect on ecosystem, climate, environment and society. So, understanding and quantifying the spatial and temporal dynamics of urban land use/land cover changes and its trajectories are crucial for urban developers, planners and policy makers to formulate proper plan and strategies for managing the environment and developing the urban areas in sustainable manner. On the basis of above background, two frontier cities located at international border of India and Bangladesh namely Silchar in Assam state and Balurghat in West Bengal state are considered for comparative analysis of the dynamics of land use and land cover changes for the period of 1988-2019. Since, the post-independence period both the cities have been experienced with hasty rate of urban population growth particularly due to influx of huge refugees from East Pakistan or Bangladesh, which changed the demographic scenario of the entire regions and turned into urban centres from tiny hamlets within a short span of time. Moreover, this type of rapid urban growth resulted to haphazard urban sprawling into its hinterlands which was also responsible for the expansion of the boundaries of the cities. In order to the total area of the Silchar city was 6.55 km^2 in 1901 which has now expanded to 15.75 km^2 in 2011. On the other hand, the total city area in Balurghat extended up to 10.56 Km^2 in 2011 from 6.37 Km^2 in 1951. Besides, both two cities are witnessed with relatively high rate of changes in urban morphology by unplanned or unsystematic infrastructural development in the city areas and also outskirts.

Many of the water bodies, agricultural lands, forest land and vacant lands in the outer fringes have been used for residential and commercial purposes, which has changed the overall land use pattern of the city areas and the adjoining periphery areas are coming within its jurisdiction. Therefore, it barely creates abundant pressure on scarce natural resources of the cities, which has already misbalanced the sustainable growth of the areas and exerts numerous socio-environmental problems. In order to mitigate these proliferating problems, immediate actions are required otherwise this process might turn to an extreme hazard for the urbanites and surrounding periphery areas.

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II. STUDY AREA

The two borderline cities of India, Silchar and Balurghat, are selected for comparative analysis in the present study on the basis of same physical and socio- economic background (Fig 1). Silchar city is the head quarter of Cachar district in Assam, situated on the banks of Barak River near the Bangladesh boarder. Approximately the city is situated at distance of 343 Km from the State's head quarter, Guwahati city and connected with roadways, railways and air ways. Geographically, it is located between 24° 22′ N latitude to 93°24′ E longitude and 35 meters above from above mean sea level. It covers an area of 15.75 Km^2 comprises 28 no. of wards, having total population of 1,72,830 (Census of India, 2011).

The city is governed by Silchar Municipality Board. The climate of the city is characterised by humid subtropical climate with average annual temperature ranges between 29°C in summer to 19°C in winter and average annual rainfall is 2134.5 mm. Currently, Silchar City known as a trade and processing centre for tea, rice and other agricultural products and one of the most important administrative and commercial hubs of Assam.
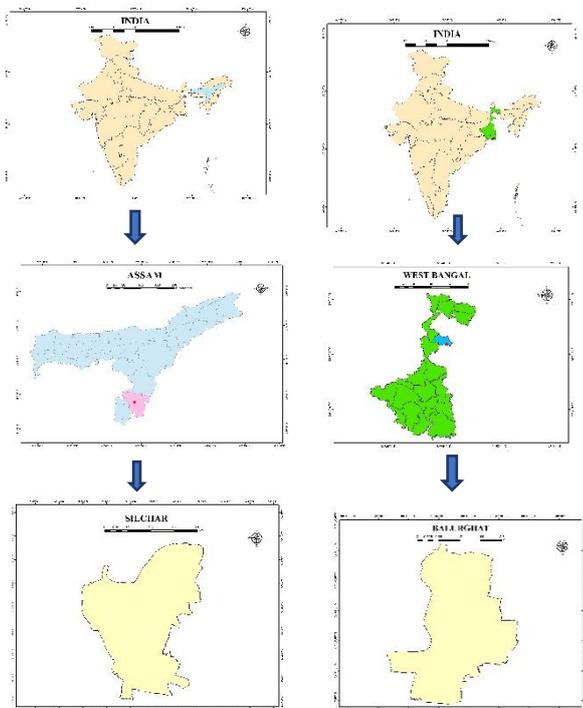

Fig. 1: Location map of the study area

On the other hand, Balurghat City is also a head quarter of Dakshin Dinajpur District in West Bengal situated on the eastern banks of Atreyee River near Bangladesh boarder. Approximately India- Bangladesh boarder is just 3 km. distance from the main city. The city is situated at a distance of 433.6 Km. from the State's head quarter, Kolkata city and connected with roadways and railways. Geographically, it is located between of 25° 12′27″ N latitude to 88°47′43″ E longitude and 24 meters above from mean sea level. It covers an area of 10.56 Km^2 comprises 25 no. of wards, having total population of 1,51,299 (Census of India, 2011). At present the city is governed by Balurghat municipal Corporation Board. The climate of the city is characterised

by humid subtropical climate with annual average temperature ranges between 34°C in summer to 16°C in winter and average annual rainfall is 322.7 mm. However, Balurghat city is not originated as industrial or trade & commerce centre but at present it is emerged as one of the administrative, cultural and entertainment hubs of West Bengal.

III. DATABASE AND METHODOLOGY

The study is based on secondary data. For the purpose of the study eight cloud free Landsat images were acquired from the United States Geological Survey website . In order to fulfill the objective is to compare the two cities, all the images were taken from the same year with same season which have been listed in Table 1.

Accordingly, to understand the dynamics of urban growth pattern in terms of landuse/land cover change analysis, eight land use maps have been prepared with the help of ERDAS IMAGIN and Arc GIS software. Hence, detailed methodology is presented below by flow chart (fig. 2).

Table 1: Types of satellite data used in the study

Satellite	Resolution	Path/ Row	Observation Date
Silchar City			
LANDSAT_5 TM	30m	138/43	26 Nov,1988
LANDSAT _5 TM	30m	138/43	24 Dec,1998
LANDSAT_5 TM	30m	138/43	19 Dec, 2008
LANDSAT_8 OLI TIRS	30m	138/43	16 Nov, 2019
Balurghat City			
Satellite	Resolution	Path/ Row	Observation Date
LANDSAT 5 TM	30m	138/43	8 Nov,1988
LANDSAT 5 TM	30m	138/43	22 Dec,1998
LANDSAT 5 TM	30m	138/43	1 Dec, 2008
LANDSAT 8 OLI TIRS	30m	138/43	30 Nov, 2019

Source: USGS Earth Explorer.

A. Land Use/ Land Cover Classification

Satellite images are classified through the process of supervised classification by using maximum likelihood method.

Hence, ground verification has been also done by ground control point of Google Earth pro software and extensive GPS based field survey to get proper accuracy of result obtained for different land use categories.

Moreover, with help of image interpretation elements, screen digitation were done and five land use classes have been identified like water body, built up area, vegetation, waste land and open field. Further, change detection analysis of two maps, 1988 to 2019 also have prepared.

B. Classification Accuracy Assessment

Accuracy assessment is done for validating the digitally classified images. For accurqacy assessment ground reference data were collected from google earth map and field visits also done by GPS. So that accuracy assessment
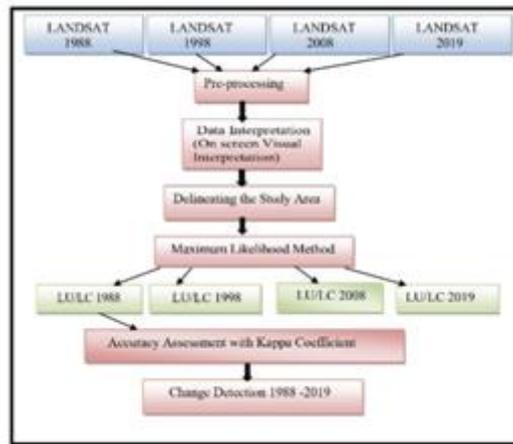
Fig. 2: Methodology flow chart of the present study

Table 2: Confusion (Error) matrix for 1988 LU/LC change map of Silchar City and Balurghat City

Reference Data of Silchar City

Classified Image Categories	Water Body	Build up Area	Sparse Vegetation	Wasteland	Open Field	Row Total	User's Accuracy
Water Body	49	0	0	0	0	49	100%
Built up Area	0	50	0	0	1	51	98.03%
Sparse Vegetation	1	0	50	1	1	53	94.33%
Wasteland	0	0	0	49	0	49	100%
Open Field	0	0	0	0	48	48	100%
Coloum Total	50	50	50	50	50	250	
Producer's Accuracy	98.00%	100%	100%	98.00%	96.00%		
Overall Accuracy		98.40%					
Kappa coefficient		0.98					

Reference Data of Balurghat City

Classified Image Categories	Water Body	Build up Area	Sparse Vegetation	Waste land	Open Field	Row Total	User's Accuracy
Water Body	49	0	0	0	1	50	98%
Built up Area	0	50	0	0	0	50	100%
Sparse Vegetation	0	0	49	1	2	52	94.23%
Wasteland	1	0	0	47	0	48	97.91%
Open Field	0	0	1	1	48	50	96.00%
Coloum Total	50	50	50	49	51	250	

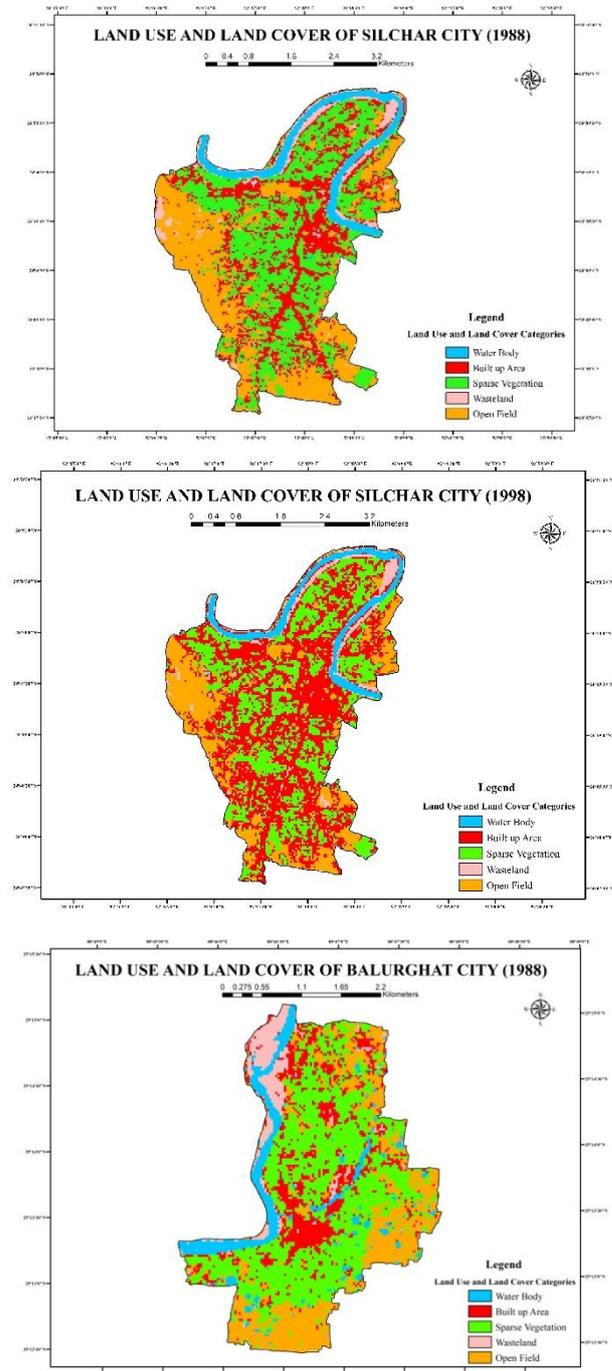|					
Producer's Accuracy	98%	100%	98%	96%	94.11%
Overall Accuracy			97.20%		
Kappa coefficient			0.96		

Source: Computed by Author.

was done for 1988 image only and a total 250 testing pixels were generated randomly. Afterthat, testing pixels were comapred with the classified map. Error matrix was applied to evaluate the user's and producer's accuracy and then compare the relationship between classified map data and reference data. Finally land use/ land cover maps were produced with the help of user's accuracy, producer's accuracy, overall accuracy and kappa coefficient. The overall accuracy for 1988 classified maps of Silchar city and Balurghat city are 98.40 per cent and 97.20 per cent respectively. Hence, the higher value of users accuracy in the land use class for Silchar city was found in water body, open field and waste land with 100 per cent, and the lower accuracy was occurred in sparse vegetation with 94.33 per cent in the year of 1988 (Table 2). On the other hand the higher value of users accuracy in the land use class for Balurghat city was found in built up area with 100 per cent and the lower accuracy was occurred in sparse vegetation with 97.91 per cent in the year of 1988. Similarly Kappa coefficient was found to be 0.98 for Silchar city and 0.96 for Balurghat city. Therefore, both the maps of study area are carried out the minimum accuracy requirements to be used for the subsequent post-classification operation.

IV. RESULTS AND DISCUSSION

A. Land Use/ Land Cover Changes of Silchar City and Balurghat City (1988-1998):

Land, one of the important natural resources, is an essential ingredient for all human activities and a fundamental requirement for any form of production and development (Thakur and Poudel, 2000). Rapid population growth and their increasing demand for various activities generatively effect in the world wide land use and land cover change (Seto and Kaufmann, 2003; Kumar, 2011).Moreover, land use and land cover (LU/LC) changes attributed to anthropogenic activities are one of the fundamental drivers of local, regional and global environmental changes (Munthali et al., 2019). Therefore, the studies of LU/LC have become vital in enhancing our understanding and measuring urban growth and its impact on environmental change. In this context the study area, Silchar city and
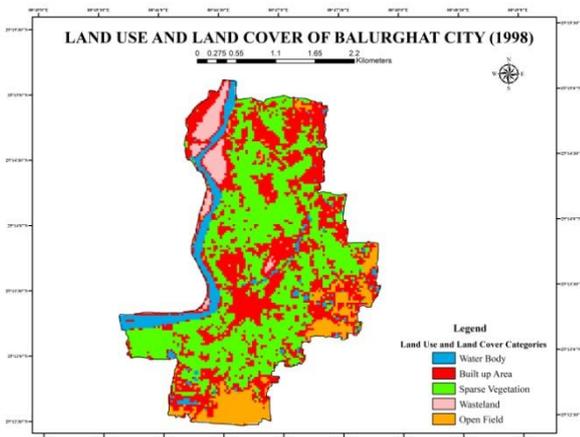
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Fig. 3: LU/LC of the study area (1988-1998)

Balurghat city have witnessed with fast land transformation since prolonged period (1988-2019) due to growing population pressure and expanding commercial and administrative functions in and around the city areas (Fig 3) & (Fig 4). In the 1988, total built up area of the Silchar city was 25.97 per cent of the total area, which has increased to 35.49 per cent in 1998. Similarly, vegetation cover area is increased at 37.59 per cent in 1998 from 33.84 per cent in 1988. But water body, waste land and open field areas are

decreased at 5.59 per cent, 4.00 per cent and 17.33 percent in 1998. On the other hand, in 1988 built up area of the Balurghat city was 24.62 per cent of the total area, which has increased to 35.80 per cent in the year 1998. Likewise, water body, vegetation cover and waste land areas are decreased and accounted for 8.43 per cent, 38.26 per cent and 3. 60 per cent respectively in the year 1998. Which were 8.90 per cent, 38.45 per cent and 5.97 per cent in the year 1988 (Table 3).

B. Land Use/ Land Cover Changes of Silchar City and Balurghat City (1998-2008):

Similar to changes observed over the period (1998-2008), more than half proportion of the area in Silchar city covered by built up area has increased by 66.03 per cent from 1998 to 2008. Whereas water body, vegetation, waste land and open field areas were reduced and accounted for 5.14 per cent, 18.98 per cent,1.97 per cent and 7.87 per cent respectively in the year 2008. On the other hand, similar type of changes has been observed as built up area holds the top position (53.13 per cent) in terms of encroaching land from other classes in the Balurghat city during the period(1998-2008). Whereas water body, vegetation and
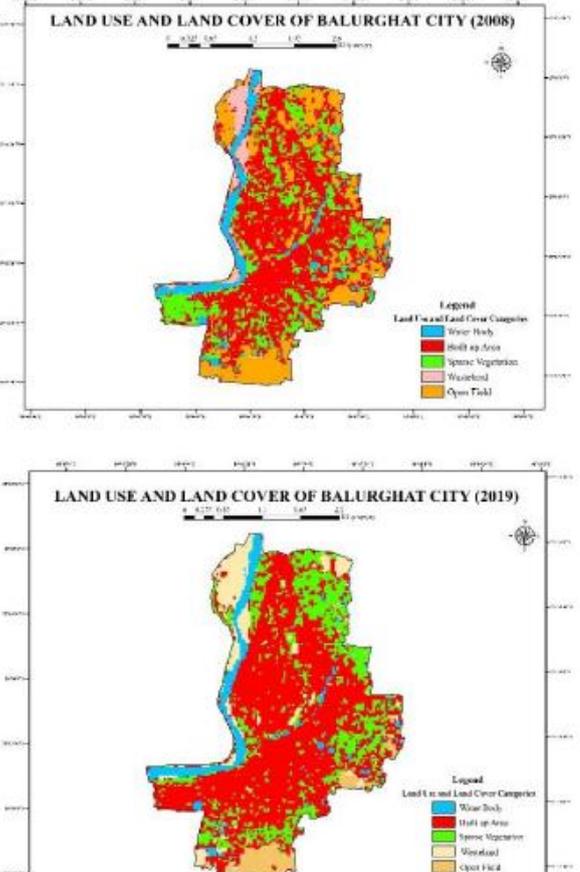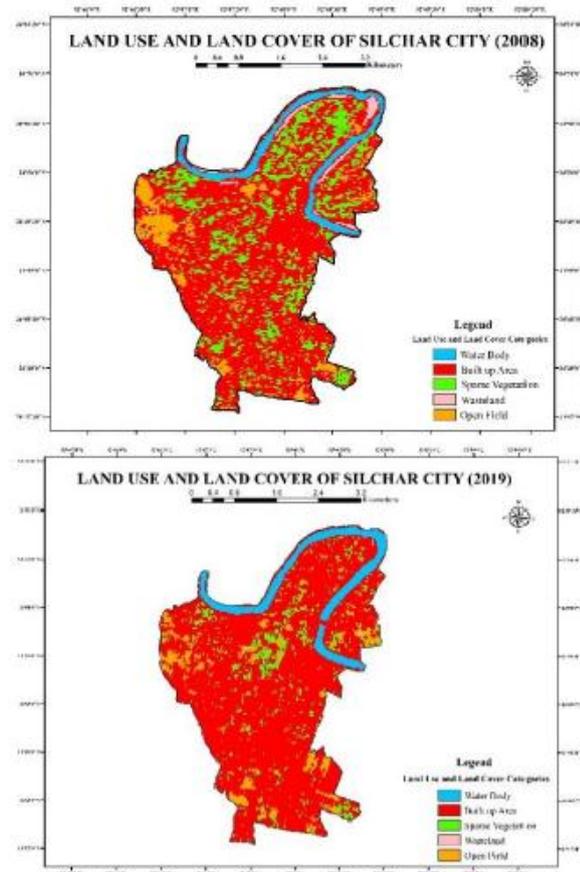

Fig. 4: LU/LC pattern of the study area from 2008 to 2019

wasteland areas were reduced by 7.01 per cent, 18.84 per cent and 3.22 per cent respectively in the same span of time. However, open field area slightly increased at 17.80 per cent

Table 3: LU/LC Statistics of the study area (1988-2019)

Silchar City

Land-use/ Land cover Categories	1988		1998		2008		2019	
	Area (in Sq. Km.)	Area (in Per cent)	Area (in Sq. Km.)	Area (in Per cent)	Area (in Sq. Km.)	Area (in Per cent)	Area (in Sq. Km.)	Area (in Per cent)
Water Body	1.06	6.73	0.88	5.59	0.81	5.14	1.16	7.37
Build- up Area	4.09	25.97	5.59	35.49	10.4	66.03	12.34	78.34
Vegetation	5.33	33.84	5.92	37.59	2.99	18.98	1.1	6.98
Waste Land	0.74	4.7	0.63	4	0.31	1.97	0.04	0.25
Open field	4.53	28.76	2.73	17.33	1.24	7.87	1.11	7.05
Total	15.75	100	15.75	100	15.75	100	15.75	100

Balurghat City

Land-use/ Land cover Categories	1988		1998		2008		2019	
	Area (in Sq. Km.)	Area (in Per cent)	Area (in Sq. Km.)	Area (in Per cent)	Area (in Sq. Km.)	Area (in Per cent)	Area (in Sq. Km.)	Area (in Per cent)
Water Body	0.94	8.9	0.89	8.43	0.74	7.01	0.68	6.43
Build- up Area	2.6	24.62	3.78	35.8	5.61	53.13	6.56	62.12
Vegetation	4.06	38.45	4.04	38.26	1.99	18.84	2.09	19.79
Waste Land	0.63	5.97	0.38	3.6	0.34	3.22	0.81	7.67
Open field	2.33	22.06	1.47	13.92	1.88	17.8	0.42	3.98
Total	10.56	100	10.56	100	10.56	100	10.56	100

Source: Calculated Based on Data from Landsat imagery

From 1998 to 2008 due to deforestation and expansion of city area towards its adjoining hinterlands (Table 3). Which is mainly due to lack of available space and increasing the demand of land for residential purpose in the core of the city area, people are forced to settle in periphery region of the city.

Table 4: Change Detection Analysis of the study area

| Silchar City		Balurghat City	
LU/LC Change	Area (Km^2)	LU/LC Change	Area (Km^2)
Built up Area- Open Field	0.055627	Built up Area- Open Field	0.00002
Built up Area- Sparse Vegetation	0.157892	Built up Area- Sparse Vegetation	0.291835
Built up Area – Waste land	0.003173	Built up Area – Waste land	0.070455
Built up Area- Water Body	0.064467	Built up Area- Water Body	0.009481
Open Field- Built up Area	3.546281	Open Field- Built up Area	0.866508
Open Field-Sparse Vegetation	0.14433	Open Field-Sparse Vegetation	0.817205
Open Field - Wasteland	0.006298	Open Field - Wasteland	0.188741
Open Field- Water Body	0.012472	Open Field- Water Body	0.038868
Sparse Vegetation- Built up Area	4.581229	Sparse Vegetation- Built up Area	3.206505
Sparse Vegetation- Open Field	0.142995	Sparse Vegetation- Open Field	0.01123
Sparse Vegetation- Waste Land	0.002813	Sparse Vegetation- Waste Land	0.016203
Sparse Vegetation- Water Body	0.016255	Sparse Vegetation- Water Body	0.017008
Waste Land- Built up Area	0.477566	Waste Land- Build up Area	0.076512
Waste Land- Open Field	0.060549	Waste Land – Sparse Vegetation	0.057299
Waste Land – Sparse Vegetation	0.019358	Waste Land – Water Body	0.095164
Waste Land – Water Body	0.138201	Water Body – Built up Area	0.190136
Water Body- Built up Area	0.163481	Water Body- Open Field	0.00015
Water Body – Open Field	0.001095	Water Body – Sparse Vegetation	0.092587
Water Body – Sparse Vegetation	0.005765	Water Body- Waste Land	0.133234
Grand Total	9.599847	Grand Total	6.179141

Source: Computed by Author.

C. Land Use/ Land Cover Changes of Silchar City and Balurghat City (2008-2019)

During this period (2008-2019) a remarkable land use transformation has been observed in both the city areas. In the year 2019 built up area covered almost entire part of Silchar city area and accounted for 78.34 per cent. Whereas Vegetation, waste land and open field areas reduced by 6.98 per cent,0.25 per cent, and 7.05 percent respectively during the period 2008-2019 (Table 3). However, water body area has increased (7.37 per cent) due to improvement of water resource management in the same time of span. On the other hand, in the year 2019, built-up areas accounted for 62.12 per cent of the total area in Balurghat city. Whereas water body and open field areas reduced by 6.43 per cent and 3.98 percent respectively during the period of 2008-2019. Moreover, the vegetation areas and the waste land area in this city found to be slightly increased from 19.79 per cent to 7.67 per cent in the same time span but it is still far from satisfactory level of optimum use of land.Thereby, over the period (1988-2019) increasing trend of built up area indicates that both the cities have witnessed with hapazard growth and sprawling as a result of unplanned and uncontrolled development of different infrastructural set up, which leads to drastic change of previous land-use system (Fig 4).

D. Change Detection Analysis of Silchar City and Balurghat City (1988-2019)

Change detection describes and quantifies the changes that are associated with LU/LC changes in the landscape using geo-referenced multi-temporal remote sensing images acquired on the same geographical area between the considered acquisition dates (Ramachandra and Kumar, 2004). In terms of the change detection analysis in Silchar city and Balurghat city, the results reveal that significant LU/LC changes occurred during the 31 years study period (1988 - 2019). Hence, increase in built-up areas within 31 years interval used for the study contributed to increasing demand for land from the growing urban population as well as the infrastructural developments that are taking place in and around the Silchar city as well as Balurghat city. About 3.54 km^2 Open field area, 0.16 km^2 water body area and 4.58 km^2 sparse vegetation area converted to built up area while only 0.15 km^2 built up area converted to sparse vegetation area and 0.05km^2 built up area transformed to open space area in Silchar city. On the other hand, about 3.20 km^2 sparse vegetation area converted to built up area, 0.19 Km^2 water body area converted to built up area and 0.87 km^2 open space area converted to built up area while only 0.29 km^2 built up area transformed in to sparse vegetation area in Balurghat city (Table 4). Therefore, harsh conversion of open field area, water body area and sparse vegetation area
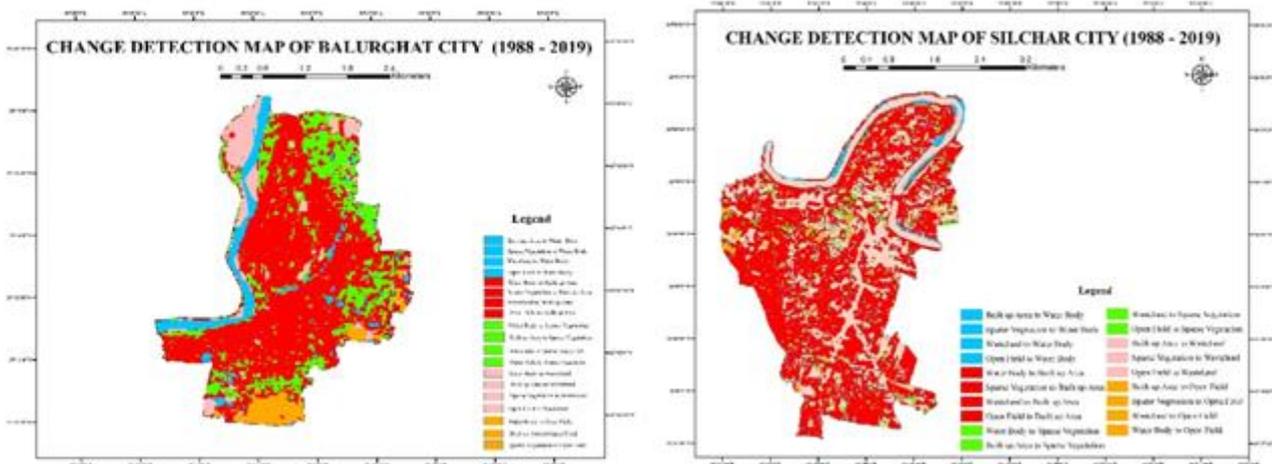
Fig 5. Change detection of the study area (1988-2019)

to build up area is ultimately resulted in enormous pressure on existing limited natural resources and which can destroy the ecological balance and generate various environmental issues in and around the city areas. Although both the cities have grown on all directions but it was more prominent on the southern and south eastern parts of Silchar city as well as Balurghat city (Fig 5). This is the clear indication of alteration of LU/LC classes due to rapid rate of urban growth. Thus, the foregoing analysis reveals that however Silchar city experiences maximum growth rate than Balurghat city, but both the cities have undergone similar nature of urban growth and pattern of land use changes. Silchar city has witnessed with faster rate of increasing built-up area and which indicates that there has been large scale clearing of vegetation and encroachment of open field area and waste land area mainly for commercial and residential purposes. When the Balurghat city also experienced with rapid rate of clearing vegetation, open field and water body area to built up area. Hence it is important to notify that the nature of urban development pattern of both two cities is dissimilar, this is reflected in the sluggish development of city area with more priority given on primary sector based economy than secondary or tertiary sector, poor connectivity with nearby major commercial hub regions and absence of proper implementation of urban planning in Balurghat city. While Silchar city is developed in a faster speed with its secondary and tertiary based economy and regional connectivity.

V. CONCLUSION

On the light of above discussion, it may be concluded that both the cities have experienced with unplanned growth and rapid horizontal expansion which altered the previous land-use pattern and has a negative impact on the environment of the cities. Besides, both the cities have undergone with the process of urban sprawl with chaotic urban development in and around the city areas as already mentioned above. In order to build up areas in both two cities have increased more than three times than earlier within these 31 years of time span (1988-2019). This has led to quick change with rapid alteration of other land-use classes and by this process vegetation areas are affected in a large scale. Moreover, open land and water body areas also decreased by infilling the low lying and swampy areas near river bank region of both two city areas. Therefore, systematic and optimum utilization of land resources is needed in both city areas to control haphazard urban growth; it can be possible by strict execution of appropriate urban planning and strategies; utilizing waste land areas for the purpose of planting trees and developing new build up areas in both two cities.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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