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Spatial and temporal dynamics of urban land use change analysis by using geospatial technology at Sulakbahar ward in Chittagong City, Bangladesh

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Abstract
The principal aim of this study was to depict the spatio-temporal analysis of urban land use changes of Sulakbahar Ward (No. 8) of Chittagong City from 1998 -2018 by using Landsat 8 OLI-TIRS, Landsat 5TM and Landsat 2MSS satellite imagery. The ArcGIS v10.4 and ERDAS Imagine v15 software were used to process satellite imageries and assessed quantitative data for land use change detection and assessment of this study area. Maximum Likelihood Classification (MLC) algorithm was used for the assessment of supervised land use classification. The study revealed that trends of land use changes from 1998-2018 showed some negative changes; but from 2008-2018 showed comparatively better changes than 1998-2008. It is evident that forest coverage, water body and fallow land decreased whereas infrastructure and road area increased. Maximum increase of infrastructure area were from 41.25% (219.13ha) in 1998 to 49.12% (260.90ha) in 2018 whereas the maximum decrease in fallow land that have been observed from 8.70% (46.19ha) of 1998 to 2.66%(14.12ha) in 2018. Projection of future land use changes for the next 20 years predicts that more than 186.92% Water body (10ha) and 212.46% Fallow land (30ha) tend to decrease; on the other hand, 10.65% Forest coverage (6ha), 9.20% Infrastructure (24ha) and 5.14% Road area (10ha) tend to increase in 2038. The overall accuracy for supervised classification images of 2018, 2008, and 1998 was found to be 93.92%, 87.50% and 87.57%; Kappa value for those years was 0.91, 0.82 and 0.82 respectively. This analytic study would be helpful to the urban planners and decision makers for making a sustainable based urban planning of modern and healthy Ward of Chittagong City Corporation (CCC), Bangladesh.

Keywords: land use, remote sensing, GIS, urban planning, Chittagong City

1. Introduction

Representing the basic transformation of information, technology and culture is termed as Urbanization (Mamun *et al.*, 2013) [11]. Population growth, human migration and urbanization have a contribution to change their environment moreover human/anthropogenic activities exhort change in land use pattern (Parveen *et al.*, 2019; Riaz *et al.*, 2017; Drummond and Loveland, 2010)[12, 14, 5]. From 1950 the world urban population has been enormously increased from 246 million to almost 4 billion in 2015 (Borelli *et al.*, 2018)[2], moreover this growth is awaited to continue in coming decades, with low- and middle-income countries projected to more than double and triple their urban populations by 2050 (UN, 2016)[17]. If planned and managed in sustainable way, cities may be a great place to live, but many urban development programs cause environmental havoc that ultimately conducting to problems such as urban heat island, landslide, flooding, and air pollution. As a result, cities have become more vulnerable to natural disasters and to the effects of climate change that will be highly exposed to food insecurity and poverty among the communities of urban and peri-urban (UN, 2016; Borelli *et al.*, 2018) [17, 2]. For effective land use management, these are the major environmental concerns that have to be analyzed and monitored carefully (Sarwar *et al.*, 2016) [16].Therefore, It is essential and valuable to understand the spatio-temporal dynamic of land use procedures for urban managers to guard and manage the urban environments (Chen *et al.*, 2018) [4]. Remote sensing (RS) and Geographical Information Systems (GIS) are becoming an important tool for understanding and solving many problems of cities and their suburbs by providing accurate and timely information on the spatial distribution of land use/land cover changes (Hossen *et al.*, 2019b; Zsuzsanna *et al.*, 2005; Rogana and Chen, 2004) [10, 20, 15]. GIS is a software aided system to solve some real world problems along with virtual planning processes. One may say that it deals only with geographic problems (Sarwar *et al.*, 2016) [16]. It provides a flexible environment for collecting, storing, displaying and analyzing digital data necessary for change detection (Hossen *et al.*, 2019b; Wu *et al.*, 2006) [10, 19]. On the other hand, Remote sensing imagery is the most important data resources of GIS (Hossen *et al.*, 2019b) [10]. It provides the quantitative analysis of the spatial distribution in the area of interest (Sarwar *et al.*, 2016) [16]. With the advancement of technology, GIS and RS have given scientists a remarkable way to determine the reasons for land use/ land cover changes (LULCC) and the resultant consequences due to anthropogenic activities (Cardille and Foley, 2003) [3].

Chittagong is the second largest city of Bangladesh that earned a significant diversified biodiversity, economic activities, natural beauties, industrial activities and obviously of its suitable geographical location in the regional map (Haque, 2012; Rahman *et al.*, 2010) [6, 13]. The diversified flora and fauna (Biodiversity) is our national asset considering its ecological and economic importance (Hossen and Hossain, 2018; Hossain *et al.*, 2019a) [8, 9]. Unfortunately, the rapid unplanned urbanization of Chittagong City Corporation (CCC) loss her natural beauty very recently and the lush green forests or biodiversity disappear with anthropogenic activities (Hossen *et al.*, 2019a) [9]. During this time (October 2018 to December 2018), an integrated approach of RS and GIS has been applied to identify, analyze and evaluate the patterns of urban land cover/land use changes and provide quantitative and spatio-temporal information on changes of urban areas of the respective 8No. Sulakbahar Ward of CCC, Bangladesh. It may tend for achieving sustainable development and includes a specific goal on urban development (Sustainable Development Goals-11): "*make cities and human settlements inclusive, safe, resilient and sustainable*".

2. Materials and Methods

2.1 Study Area

Chittagong, the second largest metropolis of Bangladesh and the economic gateway of the country, is situated between 22°14' - 22°24'N latitude and between 91°46' - 91°53'E longitude (Fig. 1) on the right bank of the river Karnaphuli (Haque, 2012; Rahman *et al.*, 2010)[6,13]. Among the 41 wards, Sulakbahar is one of the larger administrative Ward (No. 8) of Chittagong City Corporation. It is located in between 22°21´ - 22°23´ N latitude and 91°21´ - 91°52´ E longitude (Sarwar *et al.*, 2016)[16]. Out of 171 km^2 area of Chittagong City Corporation, Sulakbahar possess 3 km^2 (300 hectares) which is about 1.75% of the total CCC area (Sarwar *et al.*, 2016)[16] with around 6 lakhs/0.6 million (Personal communication with CCC). Geographically this ward comprises of hills, plain lands, ponds, ditches, canals along with other features. A greater portion of the ward is occupied by infrastructures for settlement, offices and educational institutes.

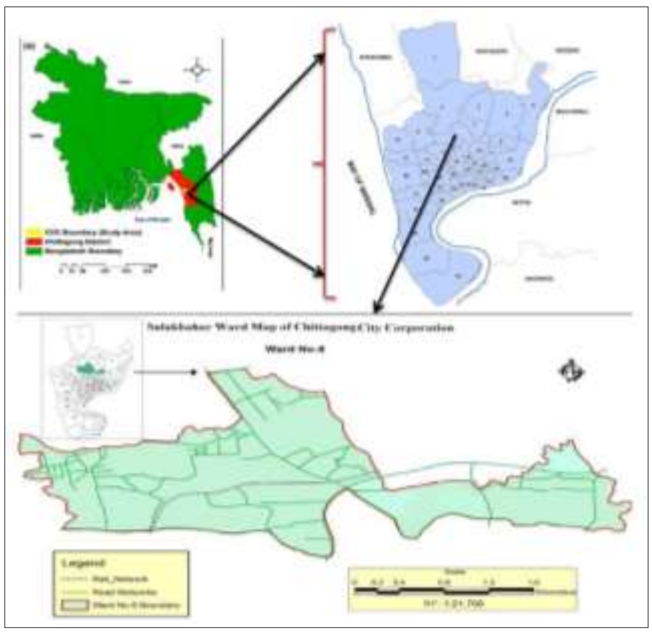

Fig 1: Location of 8No. Sulakbahar Ward in Chittagong City Corporation, Bangladesh

2.2 Data acquisition

The latest high resolution satellite imagery provided by USGS (United States Geological Survey) for Landsat 8 OLI-TIRS (Operational Land Imager/Thermal Infrared Sensor), Landsat 5 TM (Thematic Mapper) and Landsat 2 MSS satellite imagery for the time period of 2018, 2008 and 1998 were used for visual image interpretation, land use identification and land use classification. The spatial resolution of Landsat 8 is 30 m and 60 m for Landsat 5 and 2 (Table-1). A total of 531.16 Hectare (ha) of the land area was estimated for the whole Sulakbahar Ward after supervised image classification by using ERDAS Imagine v15. But the actual total area of the Ward is 532ha, which is very close to estimated value of this study. So, considered this value as accurate for the study.

2.3 Data/Image processing

Image processing and performing supervised image classification helps to extract information from imageries. ERDAS Imagine v15 software was used for image processing. Layer stacking of this software was used to convert three bands (5, 4, 3 for Landsat 8; 4, 3, 2 for both Landsat 5 and 2) into a single layer. From the layer file, the Ward was clipped by using sub-set tool and shape file of 8No. (Sulakbahar) Ward (Fig. 2). Vector layer of the Ward was collected from the WFP (World Food Programme) website.

Table 1: Specifications of Satellite data

Satellite	Sensor	Path/Row	Data Acquisition	Spatial Resolution (m)	Data sources
Landsat 8	OLI-TIRS	136/44	27-10-2018	30	USGS
Landsat 5	TM	146/44	19-10-2008	60	
Landsat 2	MSS	146/44	02-10-1998	60	

2.4 Procedure for Land Use change detection

The base map of the study area was prepared by using satellite imageries and shape file of Bangladesh administrative area which was obtained from WFP website. For image interpretation, ERDAS Imagine v15 and ArcGIS v10.4 software were used to prepare land use category map of the study area considering field survey data using the base map to identify different categories of land uses. A field survey was conducted in 8No. (Sulakbahar) Ward to find out latitude and longitude of specific land use category and recorded. During (October 2018 to December 2018) field survey, the study area's land uses were categorized into following 5 groups including (1) Forest Coverage, (2) Water body, (3) Infrastructure, (4) Road area, (5) and (5) Fallow land respectively (Table-2).

Table 2: Classes categorized based on supervised land use classification

Land cover/Land use categories	Description
Forest Coverage	Hilly forest, hills with mixed forest land, homestead forest, vegetable lands, bush and shrubs, fruits and other cultivated lands etc.
Water Body	Permanent open water, lake, ponds, canals, reservoirs, ditches, permanent and seasonal wetlands, low-lying areas, marshy land, aqua fishing etc.
Infrastructure	Residential, commercial and services, industrial, socio-economic, educational/institutional area etc.
Road Area	Transportation infrastructure, roads etc.
Fallow Land	Vacant space, exposed land, barren land, landfill sites, uncultivated land, construction sites, excavation sites etc.

After image classification on the basis of above land use categories, relevant map layouts were prepared on 1(inch):0.375(km) scale. The latitude-longitude of a specific area was collected from a wider area as it would be easily traceable. The collected land uses data was used to find out the color tone of 2018 Landsat 8 images while training dataset.

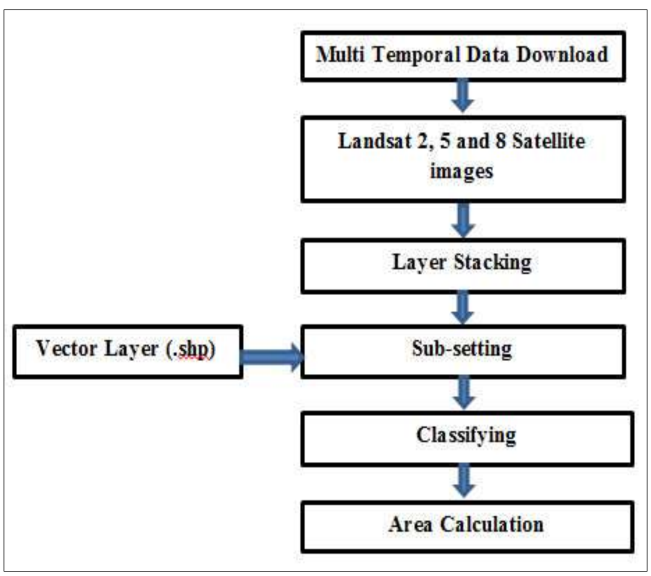

Fig 2: Procedure of Satellite image classification

2.5 Data analysis

For land cover/land use change assessment Maximum likelihood classification (MLC) approach is being used widely. For quantitative analysis of the spatial distribution of land use pattern the following equations are followed:

1. Magnitude of change = Magnitude of the new year – Magnitude of the previous year
2. $$\text{Percentage Change} = \frac{\text{Magnitude of Change} * 100}{\text{Base Year}}$$
3. $$\text{Annual Rate of Change} = \frac{\text{Final year} - \text{Initial Year}}{\text{No.of Years}}$$

Accuracy was enumerated from the error matrix by dividing the sum of the entries that make major diagonal by the total number of examined pixels. Kappa co-efficient of agreement was also enumerated by using following equations (Hossen *et al.*, 2019b; Afify, 2011) [10, 1].

4. $$K^{\wedge} = \frac{P_o - P_c}{1 - P_c}$$
5. $$P_o = \sum_{i=1}^{r} Pii$$
6. $$P_c = \sum_{i=1}^{r} (Pi_1 * Pi_2)$$

Here,

r = Number of rows in the matrix of error.

Pii = Proportion of pixels in row 'i' and column 'i'.

Pi_1 = Proportion of the marginal total of row 'i'.

Pi_2 = Proportion of the marginal total of column 'i'.

3. Results and Discussion

3.1 Land-use pattern of 8No. (Sulakbahar) Ward in 1998

The land-use pattern identified (Five classes) for the year 1998 is presented in Table-2. From the identified land-use categories, it was found that Infrastructure (219.13ha, 41.25% of total land area) was the dominant land use during 1998. the remaining land uses were 34.56% Road area (183.59ha), 12.61% Forest coverage (66.98ha), 8.70% Fallow land (46.19ha) and 2.87% Water body (15.27 ha) (Table-3 and Fig. 3).

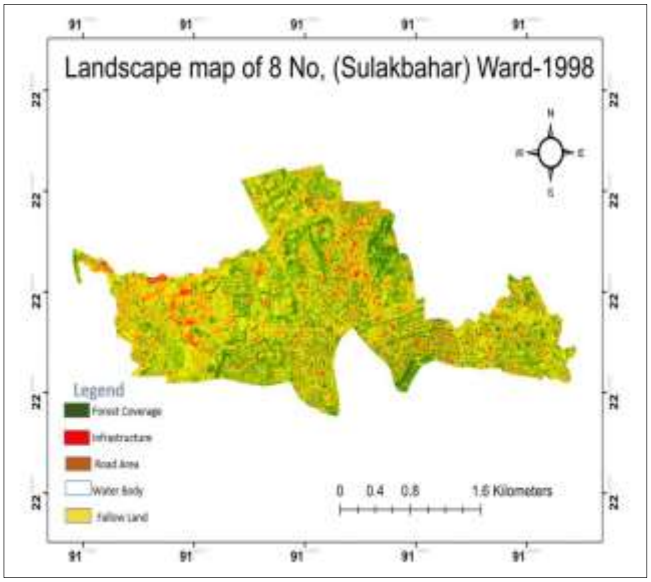

Fig 3: Land-use classification of 8No. (Sulakbahar) Ward of CCC-1998

3.2 Land-use pattern of 8No. (Sulakbahar) Ward in 2008

The 2008 image classification results revealed that the highest category was Infrastructure (248.65ha, 46.81% of total land area). Other land uses were 35.74% Road area (189.84ha), 10.12% Forest coverage (53.77ha), 5.46% Fallow land (28.99ha) and 1.87% Water body (9.91ha) (Table-3). Compared to the previous time (1998) period, the land uses of the study area changed drastically. The land uses of infrastructure started to grow very fast and expanding the road area. The expansion of infrastructure and road area is occurred in exchange of losing the fallow land, forest coverage and water body at 8No. (Sulakbahar) Ward (Fig. 4).

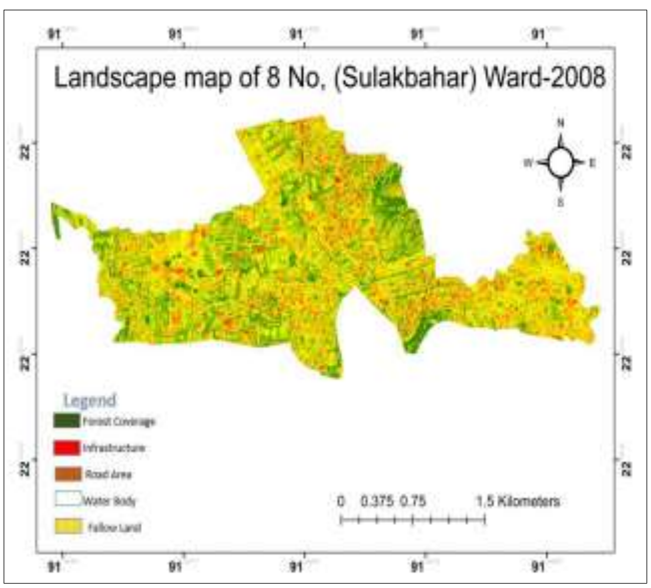

Fig 4: Land-use classification of 8No. (Sulakbahar) Ward of CCC-2008

3.3 Land-use pattern of 8No. (Sulakbahar) Ward 2018

The increasing urban growth is linked to multiple possible drivers, including natural population growth rate, increased job facilities and social-cultural opportunities to urban life, but most importantly increased rural to urban migration, resulting from natural haphazard and economic insolvencies in the countryside. For this reason, the land-use pattern of Sulakbahar significantly changed between 1998 and 2008. It is noticed that infrastructure land use is still dominant in the area (260.90ha, 49.12%) (Fig. 5). Other land uses are Forest coverage (56.36ha, 10.61%) and Road area (194.43ha, 36.60%) that increased slightly compared to 2008. From the 2018 image analysis, it was noticed that Fallow land (14.12ha, 2.66%) and Water body (5.35ha, 1.01%) decreased (Table-3).

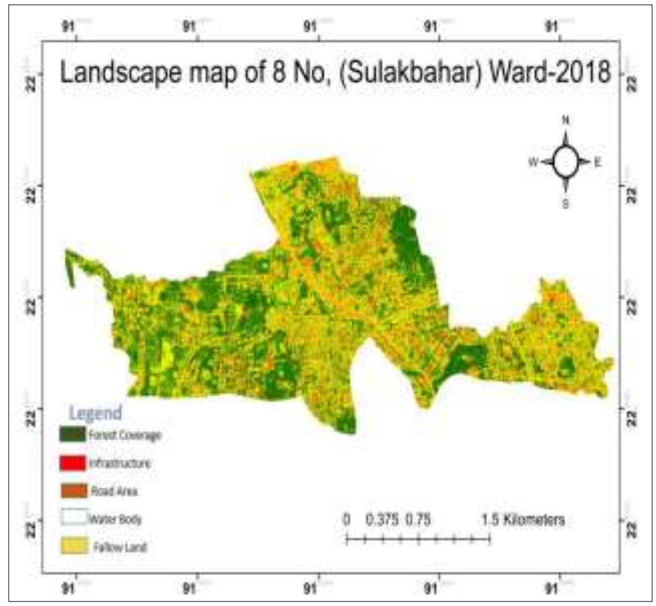

Fig 5: Land-use classification of 8No. (Sulakbahar) Ward of CCC-2018

3.4 Relative changes of land use in 8No. (Sulakbahar) Ward

Relative changes in land uses of 8No. (Sulakbahar) Ward was assessed based on data presented in Tables-3 and 4. Trends of land use changes from 1998-2018 showed some negative changes; but land use changes pattern from 2008-2018 showed comparatively better changes than 1998-2008 time period (Fig. 6 and 7). It is evident that forest coverage, water body and fallow land decreased whereas infrastructure and road area increased (Table-4 and Fig. 7).

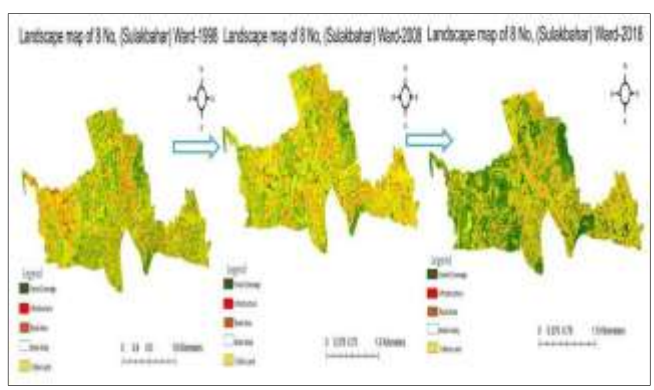

Fig 6: Relative changes of land use from 1998-2018 in 8No. (Sulakbahar) Ward of CCC

Table 3: Category wise land use distribution of Sulakbahar Ward from 1998-2018

Land Use Category	Land Use (A) in 1998		Land Use (B) in 2008		Land Use (C) in 2018	
	Land Area (ha)	% of Land Area	Land Area (ha)	% of Land Area	Land Area (ha)	% of Land Area
Forest Coverage	66.98	12.61	53.77	10.12	56.36	10.61
Water Body	15.27	2.87	9.91	1.87	5.35	1.01
Infrastructure	219.13	41.25	248.65	46.81	260.90	49.12
Road Area	183.59	34.56	189.84	35.74	194.43	36.60
Fallow Land	46.19	8.70	28.99	5.46	14.12	2.66
Total	531.16	100.00	531.16	100.00	531.16	100.00

About 66.98 ha land was covered by forest coverage during 1998 which started to decrease in the subsequent years and reached 56.36ha in 2018. Declining in this type of land use/land cover would raise a significant environmental negative effect and would disorganize completely for achieving a sustainable based environmental development of the city. The study reveals that the infrastructure area was increasing in high rate over the years, and the main contributors to this change were fallow land and forest coverage. About 219.13ha land was covered by infrastructure during 1998 which started to increase significantly in the subsequent years and reached 260.90ha in 2018. On the contrast, the significant land cover decline was found in the fallow land (32.07ha) and forest coverage (10.62 ha) in between 1998 and 2018. This is indeed a matter of serious concern (Tables-3 and 4).

Table 4: Land use change assessment of Sulakbahar Ward based on time frame 1998-2018

Land Use Category	Land Use Change (B-A): 1998-2008			Land Use Change (C-B): 2008-2018			Land Use Change (C-A): 1998-2018		
	Changed Land Area (ha)	% of Land Change	Annual rate of change (ha)	Changed Land Area (ha)	% of Land Change	Annual rate of change (ha)	Changed Land Area (ha)	% of Land Change	Annual rate of change (ha)
Forest Coverage	-13.2	-19.7	-1.3	+2.6	+4.6	+0.3	-10.62	-15.9	-0.5
Water Body	-5.4	-35.1	-0.5	-4.6	-85.2	-0.5	-9.92	-65.0	-0.5
Infrastructure	+29.5	+13.5	+3.0	+12.3	+4.7	+1.2	+41.77	+19.1	+2.1
Road Area	+6.3	+3.4	+0.6	+4.6	+2.4	+0.5	+10.84	+5.9	+0.5
Fallow Land	-17.2	-37.2	-1.7	-14.9	-105.3	-1.5	-32.07	-69.4	-1.6

Note: (+) sign denotes increase and (-) sign denotes decrease of magnitude of change of land use category in different time frame.

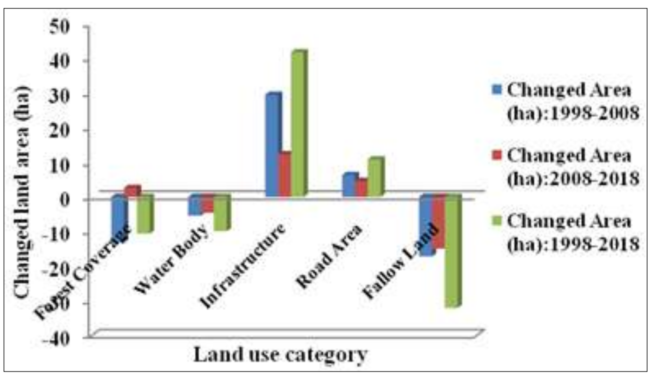

Fig 7: Relative changes of land use in 8No. (Sulakbahar) Ward from 1998-2018

3.5 Trend of Land use/Land cover changes

The line diagram (Fig. 8) shows a comparative picture of the changing trend of land use and land cover of 8No. (Sulakbahar) Ward of Chittagong City Corporation (CCC) by selected years. It will reveal how the land surface of Ward had been changed over the time span of almost three decades through various land covers. The areas of forest coverage had decreased from 12.61% to 10.12% in 2008 (Table-3). The overall value was sequential, but there was a breakup at 2018, where the area (10.61%) of forest coverage seemed to rise from the previous year (2008) (Fig. 8). It happened because different plantation program and conservation program to conserve the natural forest were initiated by authority of CCC.

It was found that the areas of water bodies had decreased from 2.87% to 1.01% in 2018 (Table-3). The continuous fall was indicating a negative linear relationship between time and water bodies (Fig. 8). It happened because small water bodies (Lakes, Ponds, Wetlands etc.) were being removed through the process of landfill and sand fill. It was found that area under the fallow land was about 8.7% in 1998 which fall to 2.66% by 2018. It indicated the negative relationship between time and fallow land (Fig. 8). This pattern of transformation was indicating that fallow land might be occupied rapidly in an unplanned way for settlement/housing construction or some other purposes at this particular time. A strong downward trend was seen in the area which was alarming.

From the line chart, it can be noticed that the road area in 1998 was 34.56% and in 2018 (Table-3), it dramatically increased to 36.6%. From the data, it was found that road area of this Ward showed a positive linear relationship with time and had increased gradually (Fig. 8). The most important feature of any city's land use is its infrastructure area. It can be also noticed that the infrastructure area in 1998 was 41.25%; but it increased dramatically to 49.12% in 2018 (Table-3). This indicates to the rapid urbanization process in this Ward. From the data, it was found that the infrastructure area of this Ward showed a positive linear relationship with time and had increased extensively (Fig. 8). This area had a strong influence on other land cover features.

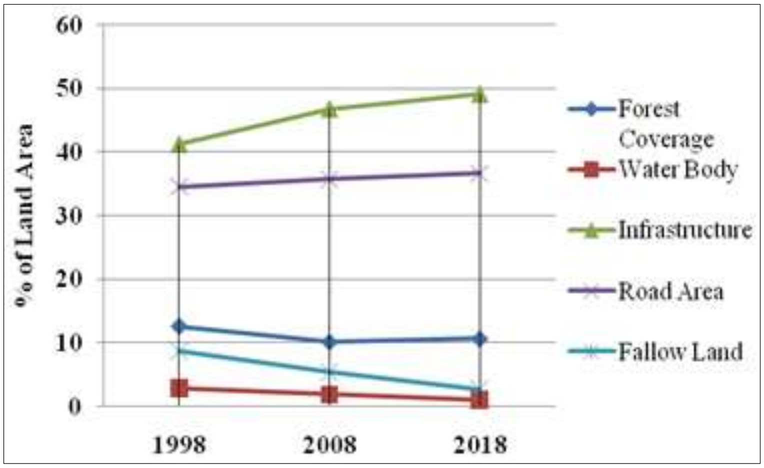

Fig 8: Temporal patterns of LULC area at 8No. (Sulakbahar) Ward

3.6 Prediction of future (2028 and 2038) land uses of 8No. (Sulakbahar) Ward

The prediction method which was followed to estimate the future land uses of the Ward is not empirical. During the estimation it was assumed that the growth trend of the ward will remain constant. If the present growth trend remains unchanged, projection of future land use changes for the next 10 years predicts that more than 106.23% Fallow land (15ha) and 93.46% Water body (5ha) shall be decreased; on the other hand, 5.32% Forest coverage (3ha), 4.60% Infrastructure (12ha) and 2.57% Road area (5ha) shall be increased in 2028 (Table-5).

Table 5: Predicted land cover/land use change assessment for time frame 2018-2028

Land Use Category	Predicted Land Use in 2028		Land Use in 2018		Predicted Land Use Change: 2018-2028		
	Land Area (ha)	% of Land Area	Land Area (ha)	Annual rate of change (ha)	Changed Land Area (ha)	% of Land change	Annual rate of change (ha)
Forest Coverage	59.36	11.18	56.36	+0.3	+3.00	+5.32	0.30
Water Body	0.35	0.07	5.35	-0.5	-5.00	-93.46	-0.50
Infrastructure	272.90	51.38	260.90	+1.2	+12.00	+4.60	1.20
Road Area	199.43	37.55	194.43	+0.5	+5.00	+2.57	0.50
Fallow Land	-0.88	-0.17	14.12	-1.5	-15.00	-106.23	-1.50

On the other hand, If the present growth trend remains unchanged, projection of future land use changes for the next 20 years predicts that more than about 186.92% Water body (10ha) and 212.46% Fallow land (30ha) shall be decreased; on the other hand, 10.65% Forest coverage (6ha), 9.20% Infrastructure (24ha) and 5.14% Road area (10ha) shall be increased in 2038 (Table-6).

Table 6: Predicted land cover/land use change assessment for time frame 2018-2038

Land Use Category	Predicted Land Use in 2038		Land Use in 2018		Predicted Land Use Change: 2018-2038		
	Land Area (ha)	% of Land Area	Land Area (ha)	Annual rate of change (ha)	Changed Land Area (ha)	% of Land change	Annual rate of change (ha)
Forest Coverage	62.36	11.74	56.36	+0.3	+6.00	+10.65	0.30
Water Body	-4.65	-0.88	5.35	-0.5	-10.00	-186.92	-0.50
Infrastructure	284.90	53.64	260.90	+1.2	+24.00	+9.20	1.20
Road Area	204.43	38.49	194.43	+0.5	+10.00	+5.14	0.50
Fallow Land	-15.88	-2.99	14.12	-1.5	-30.00	-212.46	-1.50

3.7 Accuracy assessment

The accuracy of supervised classification for the 3 different time frames (2018, 2008 and 1998) that found from accuracy assessment is shown in Tables 7-9. On the other hand, Kappa statistics is an essential measurement system between referenced data and identified classified data. It is also used to check the accuracy in classification system and having a Kappa value (0.81–1.00) denotes almost a perfect/perfect match between the classified and referenced data (Hossen *et al.*, 2019b; Van Vliet *et al.*, 2011)[10, 18].The overall accuracy for supervised classification images of 2018, 2008, and 1998 was found to be 93.92%, 87.50% and 87.57% and Kappa value for those years was 0.91, 0.82 and 0.82 respectively (Tables 7-9). These Kappa values depict that accuracy of land use classification on 8No. Sulakbahar Ward is acceptable.

Table 7: Error matrix showing accuracy and Kappa statistics of supervised land use classification-2018

Reference Data							PA	UA
Classified Data	**FC**	**WB**	**INF**	**RA**	**FL**	**Tl**	**%**	**%**
FC	115	2	1	3	1	122	95.04	94.26
WB	2	29	1	2	2	36	87.88	80.56
INF	1	1	177	1	0	180	96.72	98.33
RA	2	0	2	35	0	39	85.37	89.74
FL	1	1	2	0	30	34	90.91	88.24
Tl	121	33	183	41	33	411		
Overall accuracy = 93.92%; Kappa statistics = 0.91								

Table 8: Error matrix showing accuracy and Kappa statistics of supervised land use classification-2008

Reference Data							PA	UA
Classified Data	**FC**	**WB**	**INF**	**RA**	**FL**	**Tl**	**%**	**%**
FC	145	2	2	3	3	155	91.19	93.55
WB	5	17	2	2	1	27	73.91	62.96
INF	2	2	110	3	2	119	91.67	92.44
RA	3	1	4	30	1	39	76.92	76.92
FL	4	1	2	1	20	28	74.07	71.43
Tl	159	23	120	39	27	368		
Overall accuracy = 87.50%; Kappa statistics = 0.82								

Table 9: Error matrix showing accuracy and Kappa statistics of supervised land use classification-1998

Reference Data							PA	UA
Classified Data	**FC**	**WB**	**INF**	**RA**	**FL**	**Tl**	**%**	**%**
FC	110	3	1	2	1	117	88.71	94.02
WB	3	15	2	2	1	23	65.22	65.22
INF	4	2	125	3	2	136	93.28	91.91
RA	3	2	4	45	1	55	84.91	81.82
FL	4	1	2	1	15	23	75.00	65.22
Tl	124	23	134	53	20	354		
Overall accuracy = 87.57%; Kappa statistics = 0.82								

[Here, From Table (7-9): FC= Forest Coverage, WB= Water Body, INF= Infrastructure, RA= Road Area, Fl= Fellow Land, Tl= Total, PA= Producer's Accuracy and UA= User's Accuracy].

4. Conclusion

The land cover/land use change detection can be easily identified by using geospatial technique. The area of Sulakbahar Ward (No. 8) has experienced rapid urbanization, which has evolved in remarkable changes in land use and land cover over the 20-year period studied here. The outcome of this research reveals that, the area is highly indicating the urban sprawl as the transformation of lands into the un-planned Infrastructure area and road area have been going on which is environmentally not sustainable. The rapid and high amount of decline in fallow land and water body is pointing to environmental deterioration and ecological imbalances. The reasons of this kind of resource shortening urbanization are considerable amount of migration from rural due to un-planned development, exhibited opportunities, political problem, poor legislative actions and policies.

This study recommends that it is important to extend and strengthen the protective measures by administrative bodies of CCC against the threats like migration, population pressure, illegal felling of trees, built up area, and un-planned housing/construction/settlement within the ward area. Awareness raising and consciousness of local inhabitants regarding the importance of urban forestry, wildlife, environmental conservation, biodiversity protection is mandatory. Green non-governmental organizations can develop partnerships and synergies with government and private bodies to ensure a sustainable environment of Sulakbahar Ward (No.8). So, the successful outcome of this analytic study would be helpful tool to the decision makers as well the city planners for having a sustainable based urban planning and management system for the Sulakbahar Ward (No.8) of Chittagong City Corporation (CCC), Bangladesh.

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6. Conflict of interest

The authors declared that they do not have any potential conflict of interest.

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