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Dynamic Land Use Changes and Detecting the Direction of Urbanization Using Remote Sensing Technique in the Major Urban Centers of Cumilla, Bangladesh

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Abstract:
Background: *Land use and land cover (LULC) variations are a dynamic phenomenon caused by natural and human-made factors. It is caused by the expansion of impervious surfaces, anthropogenic activities, resulting in encroachment of land and continuous deforestation. This study is an attempt to assess the spatio-temporal LULC changes and calculate the degree of land-use changes along with detecting the direction of urban expansion in the Cumilla City (1999-2019) using the Landsat satellite images.*
Materials and Methods: *LULC changes of major areas of Cumilla city (Cumilla Adarsha Sadar and Sadar Dakshin Upazila) from 1999 to 2019 have investigated using Landsat TM and Landsat OLI images of the year 1999, 2009 and 2019. Supervised classification was conducted to accentuate land use classifications. Weightage of changes in land use classification, land use transfer matrix, spatial pattern of transfer, magnitude of change and dynamic degree of changes have used to evaluate the differences as well as identify the direction of urbanization.*
Results: *Waterbodies had the highest rate of negative progressive change throughout the research period, the most susceptive category for change, and it was highest in 1999-2009 for both territories. From 2009-2019, the mixed forest had a dramatic change, which was 2.26% to -0.69% in Sadar Dakshin. Where the changes in the Adarsha Sadar was normal as it was previously an urban area, but the change in the Sadar Dakshin was surprising because it was predominantly an agrarian area and the speed was increasing indicating urban expansion in the study area. For both areas, urbanization firstly inserts pressure on the conversion of waterbodies and agricultural land. After a certain level of development, this pressure shifted to mixed forest land which was very dynamic.*
Conclusion: *The qualification of LULC of Cumilla city is beneficial for draw attention the local government for land use zoning for proper utilization of land, planned urban development and environmental groups to better understand the surrounding.*
Key Word: *Land Use and Land Cover, Remote Sensing, GIS, Waterbodies and Agricultural Transformation*

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I. Introduction

Land use and land cover (LULC) changes simply mean the modification of the earth land surface by human interaction. Land cover refers to the physical and organic shield over the surface of the land, including water, mixed forest, bare soil, and artificial structures (Ellis, 2007). The endless growth of population exerts severe pressure on land, which is linked with agricultural demand and use, urbanization and economic development, science and technology etc. (Yesmin, et al., 2014). Urban development is a common occurrence in almost all nations over the world though the rate of growth varies. Land use land cover changes are one of the significant environmental concerns that need special attention to analyse and monitor for effecting management of land resources. Land use/land cover inventories are presumptuous growing importance in various sectors like urban planning, agricultural and infrastructural development (Imura et al., 1999). In recent years, urbanization is a crucial trend in large cities around the world (Weber, 2003). The primary transformation of land use in these areas conversion of one kind of land uses into urban land. In the massive city area, land-use change is a complicated process; this process is influenced by a lot of factors, together with physical and human features. On the other hand, rapid urbanization is generally connected and forced by social-economic factors. Again, the urbanization process has a remarkable impact on the economic sector of the society that particular area (Epstein et al., 2002 and He et al., 2006). So, the detection of urban land change is essential for the local government planners. However, Remote Sensing (RS) and Geographic Information Systems (GIS) tools are used for the collection of data from the earth's surface. The research on interaction relationship between human and nature can be analysed from highly accurate data from land use dynamic change detection from satellite image (Li, 2017). The knowledge of spatio-temporal changes of Land Use and Land Cover is vital for understanding the dynamics of the LULC changes of urban and rural-urban transition (Nath, 2018). Land-use change detection has appeared as a striking process in managing and monitoring natural resources and urban growth mainly due to provision of quantitative analysis of the spatial distribution of the population of interest (Hassan, 2016). To detecting the LULC, remote sensing and GIS are the most effective tools. Remote Sensing is a sprouting technology with the potential for donating to studies for land cover and change detection by making globally comprehensive evaluations of many environmental and human actions possible (Hamzah, 2015). Precise and latest land cover change information is essential for understanding and assessment of the ecological concerns of such changes (Giri, et al. 2005). Cumilla, a thriving urban center of Bangladesh which has got the City Corporation status in 2011. The geometric urban center of the city is mainly located on Adarsha Sadar Upazila. As a growing area, the city is now expanding and mainly towards Sadar Dakshin Upazila, which introduces changes in the land use patterns. For the time being, no attention has been paid to the research on land-use change, in the Cumilla district of Bangladesh although many researches on this regard conducted on different areas specially Dhaka, Chittagong and other major urban centers of the country. Considering this gap, this study is an integrated approach of applying GIS and RS to identify and analyse the patterns of land-use changes and provide quantitative and spatial information on changes of urban areas of the respective Upazilas of Cumilla city at the same time identify the direction of urban expansion of the Cumilla city. The specific objectives of the study are:

- To quantitative evolution of spatial and temporal Land use and Land cover changes in the Cumilla Adarsha Sadar and Sadar Dakshin Upazila from 1999-2019 and
- To calculate the degree of land-use changes along with detecting the direction of urban expansion in the study areas.

II. Methods

Study Area: Cumilla is the second-largest city of eastern Bangladesh, is one of the three oldest cities in Bangladesh. Its absolute location is 23°16′N to 23° 27′ N latitude and 91°07′E to 91°12′ E longitude. Currently, Cumilla City Corporation has an area of 53.04 sqkm. and the total wards are 27, with an estimated population of around 500,000 (BBS, 2011). The body was known as Cumilla Municipality, previously. Government of Bangladesh (GoB) declared Cumilla Municipality to the status of City Corporation on 10 July 2011 (Ahmed, 2015). It mainly consists of Adarsha Sadar and Sadar Dakshin Upazila. Cumilla Adarsha Sadar Upazila has an area of 187.71 sqkm. Cumilla Sadar Dakshin Upazila has an area of about 241.66 sq.km (Figure 1). According to population hosing census 2011, area variation in cities having more than 100000 population, Adarsha Sadar and Sadar Dakshin Upazila rank 24 and 31, respectively, in terms of populations in whole Bangladesh.

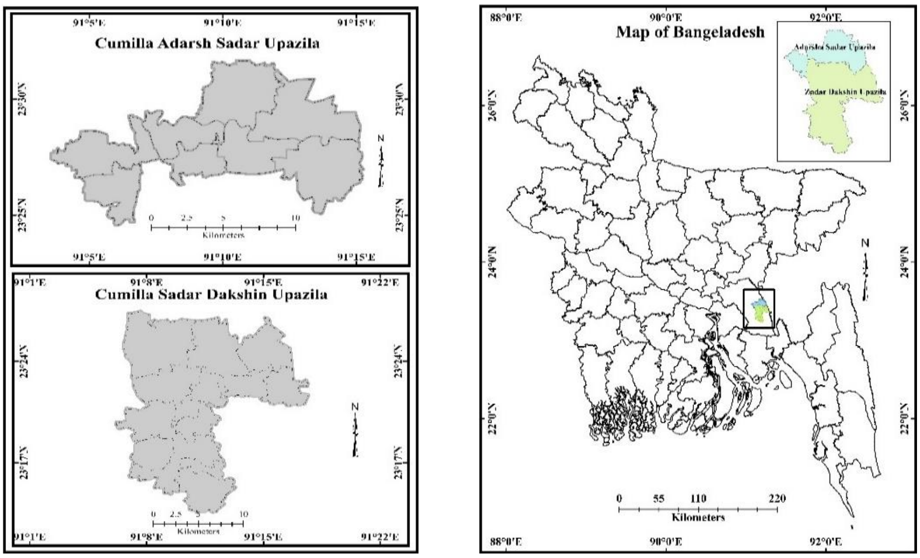


Figure no 1: Map of the study area

Methodology: To find out the spatio-temporal characteristics of LULC changes in two Upazilas (area) of Cumilla, this study used weightage assessment, land use transfer matrix, the magnitude of land-use change, single dynamic index of land use.

Land Use Classification: The study area mainly intermixes of Waterbodies, Agricultural Land, Mixed Forest and Mixed Built-up categories, respectively. The spectral signature was drawn on these four types of LULC on a Landsat image. To identify the pattern of each land-use class, 12 signatures class were drawn separately for each category. Total 48 spectral signatures were drawn. Classification of LULC was performed following the process of Nath, 2018. Supervised image classification with a maximum likelihood classification (MLC) was used for LULC classification. Three LULC temporal maps were prepared and based on the signature files for generating random points using ENVI 5.3 software.

In ArcGIS 10.3 software, using the spatial analyst toolbox, polygon-to-point conversion has been accomplished. For each image, a total of 48 random points was generated and validated with the classified model. Again, these points were converted into KML file and export to Google Earth (GE) and validate the classification.

The same approach is applied to the other images. Accuracy assessment of the classification was performed. Diagrams were prepared by using GraphPad Prism 8.0.1.244.

Table no 1: Types of images used in study

No.	Types of Data	Resolution	Bands	Sources
1.	Landsat OLI	30m	3(R),2(G),1(B)	USGS
2.	Landsat TM	30m	3(G),2(B),1(R)	USGS
3.	Landsat TM	30m	3(G),2(B),1(R)	USGS

Sources: USGS Landsat images from 1999-2019

Weightage of Change: To understand the susceptibility of each land use category to change weight assessment method has been adopted according to the sensitivity to replace. Accordingly, waterbodies, agricultural land, mixed forest and mixed built up are arranged for weightage shown in the following table-2:

Table no 2: Weightage assignment for land use category

SL No	Land Use Category	Weight
1.	Waterbodies	1
2.	Agricultural Land	2
3.	Mixed Forest	3
4.	Mixed Built-up	4

Sources: Based on analysis of USGS Landsat images from 1999-2019 catagorised by author

The rationality of the weightage assignment of land use categories is given below:

1. **Waterbodies:** Waterbodies is one of the key features in the study area, which is decreasing day by day and highly susceptive to transform into others (agricultural land, built-up). Considering this, the waterbodies is weightage as category 1 (one) as it is the highest susceptive to change.
2. **Agricultural Land:** In the study area, agricultural land is covering the most extensive area as agriculture is the main occupation of the study area. With the advancement of urbanization agricultural land is converted into urban uses. Hence, this land-use type is categorised as 2 (two) as it is the second-highest susceptive to change such as built-up area.
3. **Mixed Forest:** The study area has a mixed forest, which is mainly homestead. Other mixed forest includes grassland, some deciduous and evergreen. The general pattern of this category is sparse mixed forest. And there is no specific forested area in the study areas. Because of the nature and distribution of mixed forest type, this land use category is less susceptive change than waterbodies and agricultural land and categorized as 3 (three).
4. **Mixed built up:** This is the fourth category, which is the most stable and increasing day by day. And other land use categories are transformed into this category. For the stability and definite increase of the use, this is categorised as 4 (four).

LULC Transitions Mapping and Spatial Pattern of Transfer and Analysis Method: Transfer matrix is the method of describing dynamism of mutual transformation of the land use categories at the initial and terminal phases of the research at a certain point (Li, 2017). For land-use transform matrix analysis, this study resort data from 1999-2009 and 2009-2019 and then compared the structural change of the land use categories between 1999-2019 period, demeanour by spatial analysis and statistical tools of ENVI 5.3 software. The process of transfer matrix considers initial year image as primary time frame and the final year image as terminal time frame and visualize the dynamic pattern of LULC transfer of different periods.

Again, thematic change module of ENVI 5.3 software is used for delineating the spatial variation of land use transfer from 1999-2019 as 1999-2009, 2009-2019 and 1999-2019 as well as at the same time identified the dynamics of land-use changes and operative core grounds of changes during 20 years in the study areas by estimating the transition from initial and terminal stages of the research period.

The Magnitude of Land-use Changes: To measuring the susceptibility of land use transformation, the extent of overall land-use changes from 1999-2019 has observed. For this, weightage of land use categories has used and the most susceptive group is assigned as category 1. When the land use category changed from waterbodies (category weightage 1) in 1999 to mixed built-up (category weightage 4) in 2019, the weights for those areas are calculated as -3 (1-4). Likewise, a category changing from mixed built up to waterbodies gets a weightage of +3 (4-1). The absolute value of the weightage indicates the magnitude of change over the period 1999-2019 (Thomas, 2014). The +/- sign indicates the trend of the change, -ve sign indicates change towards increased susceptibility to transform the area and +ve sign indicates that stability of the category.

LULC Dynamic Degree: In this study, data of Land use Land cover used from 1999-2019 for decadal change detection analysis. ArcGIS 10.3 software was used for preparing the map. Supervised classification was performed for better assessment where overall accuracy was above 90%. The single dynamic index of land use describes the shifting rate of land use of a region which is vital for comparing differences of land-use change and analysing the changing trend of land use of a part (Li, 2017). According to the estimation approach of Li (2017), the single dynamic degree has performed. The formula is-

$$p = \frac{Wb - Wa}{Wa} \times \frac{1}{T} \times 100\% \dots\dots\dots (1)$$

Where, Wb, Wa is the area of a specific land use category at the terminal and initial year of the research, respectively, and T is the duration of the research period which is in this study is 10 and 20 years, respectively.

III. Results

Accuracy of Land Use Land Cover: The reliability of Landsat image classification results depends on the overall accuracies of the classified images (Nath, 2018). In the current study, the accuracy assessment for classified LULC of 1999, 2009 and 2019 for both Adarsha Sadar and Sadar Dakshin Upazilas have been assessed (See table 3). Accuracy results are satisfactory as the overall accuracy for both areas are over 90% which is quite higher than the minimum acceptable standard of USGS Landsat image classification of ≥ 85%. The overall classification accuracy and Kappa coefficient for both areas are as follows:

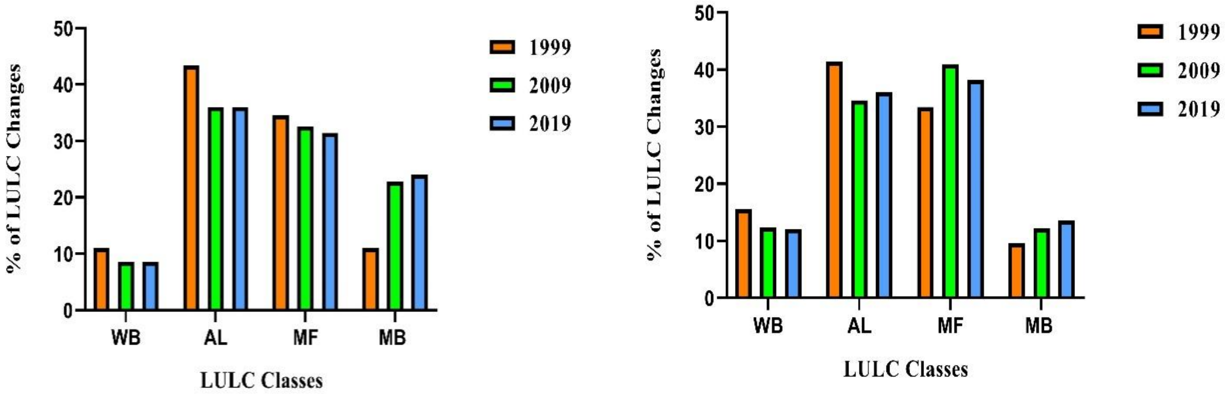
Table no 3: LULC changes analysis accuracy

Areas	Years	Accuracy	Kappa Coefficient
Adarsha Sadar	1999	98.33%	0.97
	2009	98.59%	0.98
	2019	98.26%	0.97
Sadar Dakshin	1999	96.84%	0.95
	2009	93.30%	0.90
	2019	95.40%	0.93

Source: Analysis of Landsat images of 1999, 2009 and 2019

Land Use Extent and Spatial Characteristics in the Study Area: Based on observations of land use classification data of Cumilla Adarsha Sadar and Sadar Dakshin Upazila land use of these Upazilas are classified as waterbodies, agricultural land, mixed forest and mixed built up using USGS (United State Geological Survey) land use classification module of Anderson (1976), with necessary and logical changes. In this research, fallow land also categorised as agricultural land as the quantity of this type is tiny, and it is intermixed with agricultural land. Where agricultural land is the most significant percentage and distributes all over the two Upazilas. Waterbodies are the most dynamic land use in the study areas. Waterbodies category includes ponds, river, wetlands and beels. Beels are converted into agricultural land seasonally. Mixed forest category includes mainly homestead mixed forest, deciduous and evergreen patches of natural and planted mixed forest in the Lalmai hilly region and seasonal and occasional grasslands. Mixed built-up category consists of all types of settlement rural, urban, built up.

On the other hand, the built-up area comprises residential, commercial and industrial zones etc. Sectors, all of these are intermixed in such a way that cannot differentiate. The area of waterbodies category shows a progressive and rapid decline from 1999 to 2019 in both Upazilas. In Adarsha Sadar Upazila waterbodies acquires 8.5% of the total area, which was decreased from 11% in 1999 to 8.6% in 2009 and 8.5% in 2019. Similarly, in Sadar Dakshin Upazila, this category occupies 12.1% of the total area, which was account for 15.4% in 1999 and 12.3% in 2009 and 12.1% in 2019. Agricultural land has the most substantial area coverage in both Upazilas. Still, in Adarsha Sadar Upazila, most of this category includes fallow land for settlement purpose, and there was 43.4% of agricultural land in 1999, whichever steadily decline into 36.0% in 2009 and remain stable and unchanged in 2019.



(a) Adarsha Sadar **(b) Sadar Dakshin**

Figure no 2: Land use characteristics in the study area (Adarsha Sadar and Sadar Dakshin Upazila) [WB=Waterbodies, AL=Agricultural Land, MF=Mixed Forest, MB=Mixed Built-up]
Source: Analysis of Landsat images

But the land use pattern is changed from agriculture to fallow land. On the contrary, in Sadar Dakshin Upazila, this category decreased from 41.4% to 34.3% in 2009 and slightly increased in 2019 into 36.1%.

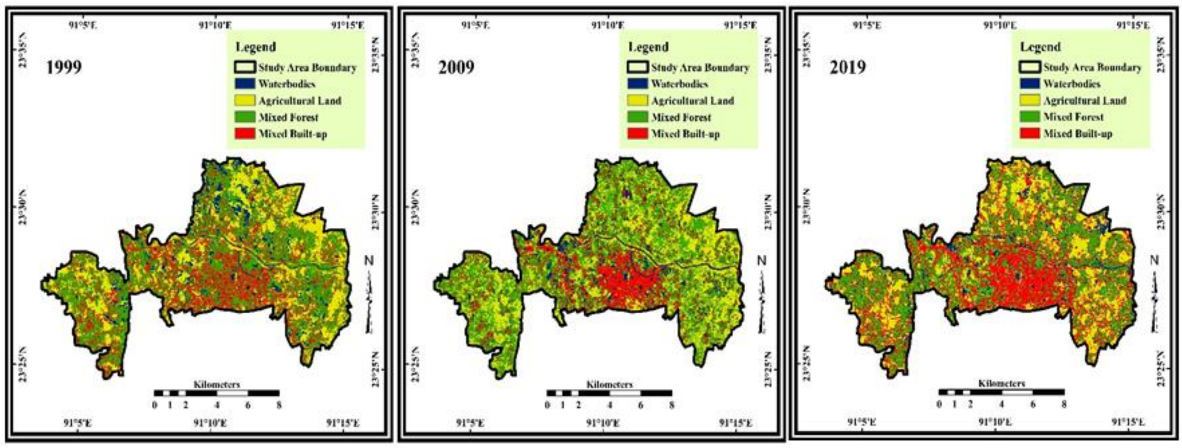


Figure no 3: LULC changes of Adarsha Sadar Upazila in 1999, 2009 and 2019
Source: Analysis of Landsat images

Mixed forest land has fluctuating area coverage and shows a general pattern of steady decline from 34.4%. 32.4% and 31.3 % respectively, in Adarsha Sadar Upazila. Most of the mixed forest was cut down for settlement purpose. Whereas, in Sadar Dakshin Upazila, mixed forest scenario is quite different. This area has less mixed forest of 33.4% in 1999, which sharply increased to 40.9% in 2009, and after 2009, the amount of this category was likely to decrease into 38.1% in 2019. Mixed built up category is the most constant land use category. The general pattern of this category is increasing in both areas. The figures 3-4 reveal that there has been marked an increase in the area of this category since 1999-2019 as 11% to 24% in Adarsha Sadar Upazila and 9.6% to 13.6% in Sadar Dakshin Upazila, respectively.

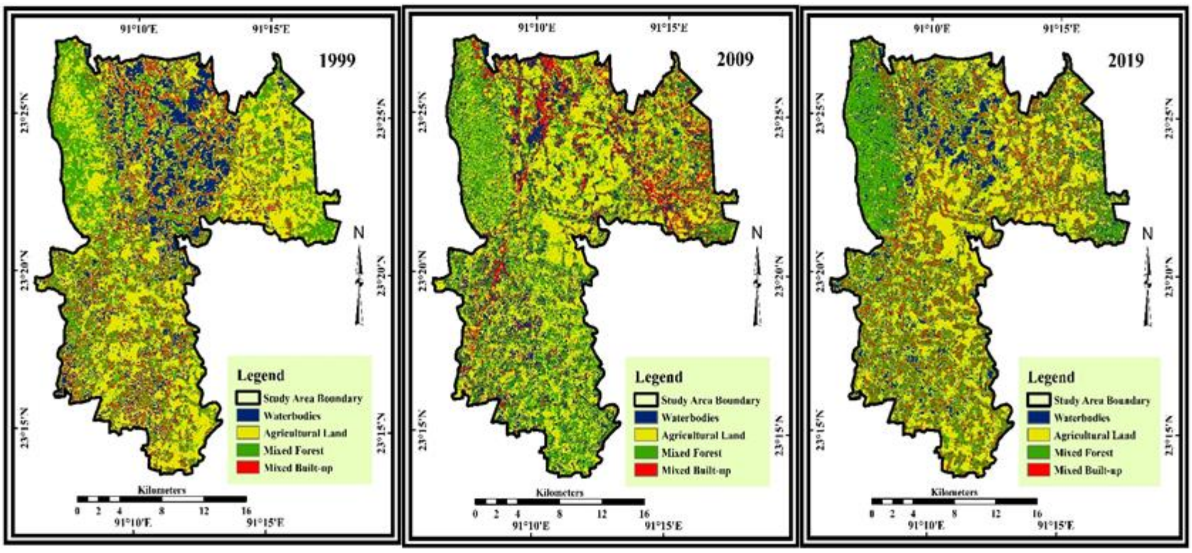


Figure no 4: LULC changes of Sadar Dakshin Upazila in 1999, 2009 and 2019
Source: Analysis of Landsat images

Analysis of Extent of Land Use Transfer: It was essential to mapping Land Use and Land Cover Transfer on different periods through a visual, as well as a numerical manner to identify the transformation of each LULC (Nath, 2018). To analyse the changes of varying land use categories throughout the research period, land use transfer matrix is used. This was performed by the workflow module of the ENVI 5.3 software by overlaying each earlier year with the recent year as 1999-2009, 2009-2019 and 1999-2019 for both areas according to land use weightage category structure identified earlier where land-use area measuring in percentage. Transfer matrix of land use for both areas shown in table 4-9.

Table no 4: Transfer Matrix of Land Use in Adarsha Sadar from 1999 to 2009(%)

Land Use Category	Waterbodies	Agricultural Land	Mixed Forest	Mixed Built-up
Waterbodies	17.3	6.8	9.1	7.7
Agricultural land	26.4	41.5	20.1	29.8
Mixed Forest	13.4	23.2	59.6	15.5
Mixed Built-up	42.7	28.3	10.9	46.7

Source: Analysis of Landsat image

Table no 5: Transfer Matrix of Land Use in Adarsha Sadar from 2009 to 2019(%)

Land Use Category	Waterbodies	Agricultural land	Mixed Forest	Mixed Built-up
Waterbodies	31.2	7.4	6.3	4.8
Agricultural Land	15.3	56.6	29.8	20.2
Mixed Forest	30.8	22.5	45.6	24.9
Mixed Built-up	22.5	13.3	18.1	49.9

Source: Analysis of Landsat image

Table 6: Transfer Matrix of Land Use in Adarsha Sadar from 1999 to 2019(%)

Land Use Category	Waterbodies	Agricultural Land	Mixed Forest	Mixed Built-up
Waterbodies	18.6	9.8	5.2	3.9
Agricultural Land	61.8	49.4	19.7	8.2
Mixed Forest	9.7	22.9	49.5	29.0
Mixed Built-up	9.7	17.7	25.4	58.7

Source: Analysis of Landsat image

Table 7: Transfer Matrix of Land Use in Sadar Dakshin from 1999 to 2009(%)

Land Use Category	Waterbodies	Agricultural Land	Mixed Forest	Mixed Built-up
Waterbodies	9.1	13.2	14.2	12.3
Agricultural Land	42.3	54.1	31.8	31.9
Mixed Forest	11.9	11.5	16.7	11.9
Mixed Built-up	36.5	20.9	37.0	43.7

Source: Analysis of Landsat image

Table 8: Transfer Matrix of Land Use in Sadar Dakshin from 2009 to 2019(%)

Land Use Category	Waterbodies	Agricultural Land	Mixed Forest	Mixed Built-up
Waterbodies	14.9	12.0	10.7	14.3
Agricultural land	32.3	51.9	24.5	34.1
Mixed Forest	34.6	27.2	50.4	30.9
Mixed Built-up	18.0	8.7	14.3	20.4

Source: Analysis of Landsat image

Table 9: Transfer Matrix of Land Use in Sadar Dakshin from 1999 to 2019(%)

Land Use Category	Waterbodies	Agricultural Land	Mixed Forest	Mixed Built-up
Waterbodies	21.7	12.3	7.5	11.9
Agricultural land	41.5	50.6	13.9	41.9
Mixed Forest	26.2	28.6	57.3	31.3
Mixed Built-up	10.4	8.3	21.2	14.7

Source: Analysis of Landsat image

From 1999-2019, in Adarsha Sadar, major transferred out from waterbodies and mixed forest was agricultural land 9.8% (as fallow land for settlement) and mixed built up which was 29%, respectively, due to rapid urbanization. These two land use categories were the most susceptive of changes during the whole study period and both of the study areas. In 1999-2009, transferred out from agricultural land was mixed built-up 29.8% and waterbodies 26.4% where from mixed forest was agricultural land 23.2% and mixed built-up 15.5%. On the other hand, in 2009-2019, transferred out from agricultural land was mixed forest 45.6% and mixed built-up 20.2% where from mixed forest was mixed built-up 24.9%. All the study periods, settlement has increased in the area and other land use converted to this type which is evident as it was predominantly an urban area. On the contrary, for Sadar Dakshin, leading transferred-out from waterbodies were agricultural land 12.3% & mixed built up 11.9% in 1999-2009 and agricultural land to mixed built up 41.9% & waterbodies 41.5% in 1999-2019 because of the same reason as Adarsha Sadar Upazila and mixed forest to mixed built up 31.4%. Again, from 1999-2009, waterbodies 42.3% and mixed built-up, 31.9% were significant transferred out from agricultural land. During that time 11.9% of mixed forest turned into mixed built-up in that area. Whereas, from 2009-2019, 34.1% of agricultural land transferred out in mixed built-up category and 30.9% of mixed forest to mixed built-up and 34.6% of mixed forest turned into waterbodies. All the dominant land-use types conversion in this area during the study period was mainly into settlement, and the rate was quite high. That is the indication of population explosion and urban expansion in the area contrast to its agricultural nature.

Spatial Distribution of Land Use Transfer: The spatial distribution of land use transfer from 1999 to 2019, as shown in Figure 5-6. During the two periods, there were distinct spatial differences in the research. In 1999-2009, the transferred land of the Adarsha Sadar area was located around the center of the urban area of where waterbodies, agricultural land and mixed forest converted to mixed built-up and some other parts waterbodies and diverse forest areas turned into agricultural and fallow land.

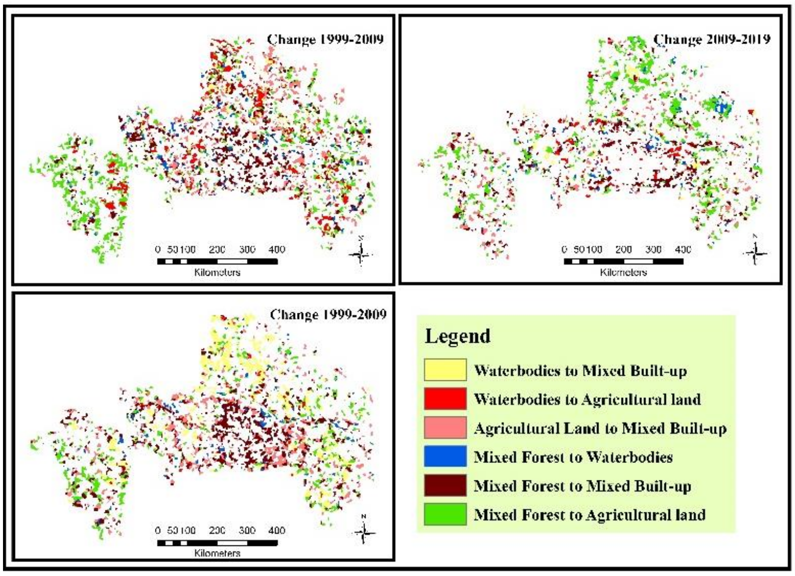


Figure no 5: Transfer distribution of land use of Adarsha Sadar Upazila
Source: Analysis of Landsat images

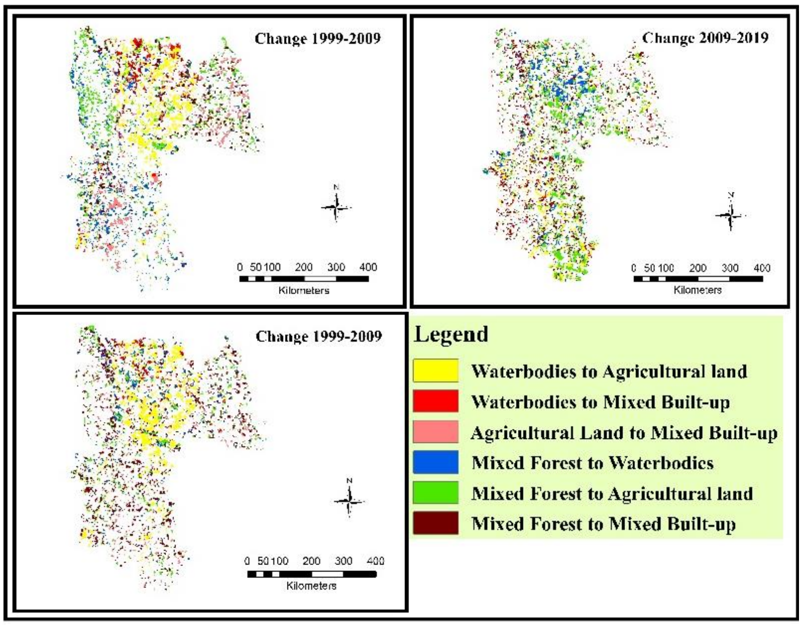


Figure no 6: Transfer distribution of land use of Sadar Dakshin Upazila
Source: Analysis of Landsat images

From 2009 to 2019, the active area of land transfer was spread all the domain from the center, and the significant transformation was mixed forest to agricultural land and agricultural land to mixed built up. And from 1999-2019, conversion for this Upazila was waterbodies to agricultural land, agricultural land as well as mixed forest to mixed built up. While, in Sadar Dakshin Upazila in 1999-2009, a significant change occurred from waterbodies to agricultural land, mainly concentrated in the central portion of the area and waterbodies to the mixed built-up in the marginal zone of Adarsha Sadar to Sadar Dakshin and conversion from agricultural land to mixed built-up occurred throughout the whole Upazila. Again, from 2009-2019 that change transferred from mixed forest to waterbodies, agricultural land and mixed built-up in the central part and southern portion of the area. And waterbodies, mixed forest to mixed built-up took place around everywhere in the area.

The magnitude of land-use changes: The magnitude of land-use change is performed to observe overall changes happened in the area during the last 20 years and is shown in Figure-6. The resultant weightage for magnitude class can range from -3 to 3. This weightage is classified into three groups as shown in Table-10.

Table no 10: Table showing the magnitude of land-use changes

SL No	Weightage	Magnitude Class	Category
1.	0 to +3	+1	Positive
2.	0	0	No Change/Stable
3.	-3 to 0	-1	Negative

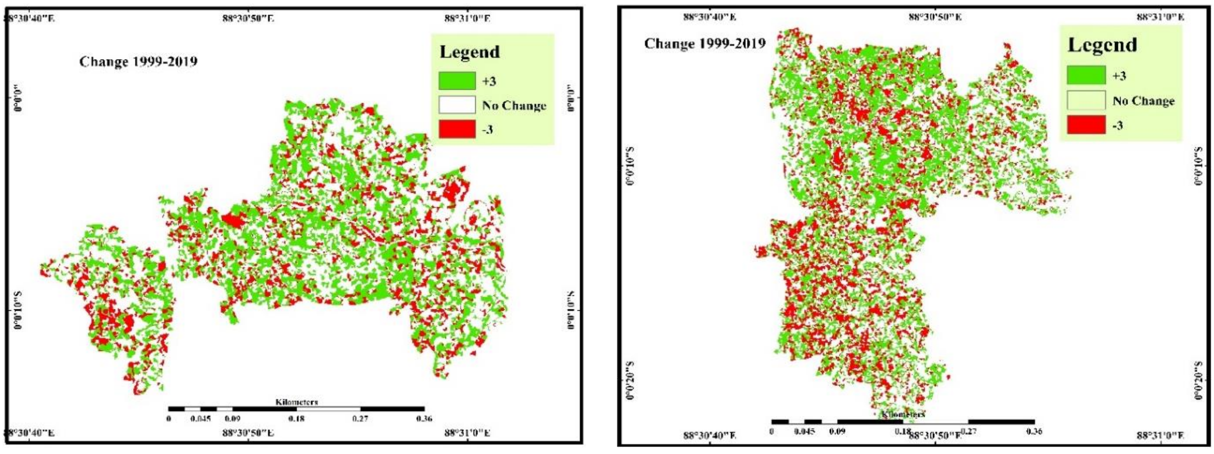


Figure no 7: Magnitude of LULC changes in Adarsha Sadar and Sadar Dakshin Upazila
Source: Analysis of Landsat images

The class -3 to 0 is called negative change because the changes indicate that the susceptibility of this land use category to transform has increased. The second class is no change class (magnitude 0). The third category is the positive change category (scale 0 to -3), which indicates the stability of the land use category has increased, and susceptibility to transformed has reduced. Hence the stability and area have increased day by day for this class. On the contrary to this, waterbodies had the highest susceptibility to change, and it was the least stable land use category for both the areas.

Land Use Dynamic in the Study Area: Dynamism represents the speed of changes in the land uses of an area (Thomas, 2014). According to formula (1), the single dynamic degree of the research regions in 1999–2019 was calculated. As shown in Table 10, the most extensive single dynamic degree of land-use in 1999-2009 & 2009-2019, in the Adarsha Sadar was the waterbodies -2.17% & agricultural land -1.7% and waterbodies -0.11% & mixed forest -0.34%, respectively. For Sadar Dakshin, it was the waterbodies-2.01% & agricultural land-1.7% in 1999-2009 and waterbodies -0.16% & mixed forest -0.69% in 2009-2019, respectively, indicating that the urban area developed rapidly in these periods and occupied the waterbodies, agricultural land and mixed forest for economic activities and intense dynamic changes. Agricultural land has different dynamic change from 1999-2009 and 2009-2019 for both areas from -1.7% to 0.003% in Adarsha Sadar, and -1.7% to 0.5% in Sadar Dakshin. Negative to positive change indicates that transfer out of agricultural land increased initially then transfer in increased later, but change speed increased. In this period, the mixed forest land had the lowest single dynamic degree of land use, for Adarsha Sadar only −0.59% in 1999-2009 and -0.34% in 2009-2019 but the change direction of the dynamic degree was negative.

Table no 11: The single land uses the dynamic degree in study areas in 1999 to 2019

Dynamic Degree of Land use in Adarsha Sadar			
	1999-2009	**2009-2019**	**1999-2019**
Land Type	**Dynamic Degree**	**Dynamic Degree**	**Dynamic Degree**
Waterbodies	-2.17	-0.11	-1.12
Agricultural Land	-1.7	0.003	-0.84
Mixed Forest	-0.59	-0.34	-0.45
Mixed Built-up	10.71	0.52	5.89
Dynamic Degree of Land use in Sadar Dakshin			
	1999-2009	**2009-2019**	**1999-2019**
Land Type	**Dynamic Degree**	**Dynamic Degree**	**Dynamic Degree**
Waterbodies	-2.01	-0.16	-1.07
Agricultural Land	-1.7	0.5	-0.64
Mixed Forest	2.26	-0.69	0.7
Mixed Built-up	2.7	1.09	2.04

Source: Analysis of Landsat images

From 1999-2009 and 2009-2019, in Sadar Dakshin, mixed forest category had the most dynamic change from 2.26% to -0.69% indicating that sharp decreased in this category and increasing change speed reflecting that the acceleration of urbanization inserts an intense pressure on the mixed forest land. From 1999-2019, the mixed built-up area had the most considerable positive single dynamic degree of land use, which was 10.71%, 0.52% and 5.89% for Adarsha Sadar and 2.7%, 1.09% and 2.04% for Sadar Dakshin, respectively with positive dynamic degree. Overall, from 1999 to 2019, the waterbodies had the most significant negative single dynamic degree of land use, up to -1.12% and -1.07% in both areas.

IV. Discussion

The data of the study derived from USGS Landsat images where the average LULC classification accuracy is 93% which satisfied the standard of satellite image classification. According to the study, waterbodies was the most susceptive category which undergone rapid changes. Nearly 2.5% reduction in Adarsha Sadar and 3.3% in Sadar Dakshin Upazila due to the rapid growth of urbanization. Other groups interchanged primarily with this type and then with agricultural land and mixed forest. And for both Upazilas most stable land use is mixed built up and it showed continuous increasing trend while mixed forest land was most unstable with increasing, and decreasing trend, especially for Sadar Dakshin as this area had scanty of mixed forest in 1999 which was increased to a great extent in 2009 and drop slightly in 2019. In Adarsha Sadar Upazila, transformation result showed different pattern as this area was already urbanized where waterbodies and the mixed forest turned into agriculture as fallow land ultimately towards built-up and increased in agriculture to waterbodies was due to beels were used as croplands seasonally. Contrary to this, rapid changes of this category occurred in Sadar Dakshin from 1999-2009 and slightly increase in the area in 2019 as a significant portion of the beels are permanently filled up for commercial housing business purpose which can be tagged as fallow land. Mixed forest categories showed decline nature in Adarsha Sadar but fluctuating in Sadar Dakshin as it was less extent in 1999 but increase in 2009 and again reduced in 2019 because of urban development. Mixed built up is the most dynamic category of all. Relative change of this category is very intense. But the concentration is remarkably high in Adarsha Sadar as the primary urban center is cluster into this Upazila. While, in Sadar Dakshin area mixed built up was gradually increased and the rate was as almost same as Adarsha Sadar, which indicates the expansion of urban center in this Upazila. From 2009 to 2019, this trend shifted gradually from Adarsha Sadar to Sadar Dakshin Upazila because the civic center is expanding towards this Upazila. The overall land use category changes in the both areas reveal that, in comparison, rate of land conversion is quite higher in the Sadar Dakshin than the Adarsha Sadar and housing and commercial industries were also amplified in this area than the other study area.

Moreover, spatial distribution pattern of land use in Adarsha Sadar and Sadar Dakshin initially located at the center of the urban area in 1999-2009 but for both area situation changes from 2009-2019. This changing pattern hit the whole study areas with concentration in the center. From the spatial distribution of land use transfer, the central area of land use transfer continuously shifted from Cumilla Adarsha Sadar to Sadar Dakshin in 1999–2019.

Land Use magnitude of change for both areas showed that susceptibility of land use types increased in all over for both the study areas. Waterbodies were the most susceptive group in all areas than came mixed forest and agricultural land. All of these land-use types were changes due to increasing human activities. As filling the waterbodies and turned the agricultural land for settlement and cut off trees for growing demand for wood in the newly developed houses. Where the mixed built-up was the most stable group, and it was gradually increased it as areal extent, which was remarkably high in Sadar Dakshin Upazila.

The dynamic change trends of land categories were, indicating that, with the excavating of growth in the studied regions, the waterbodies decreased sharply, and the mixed built-up land increased rapidly. Matched with the situation between 1999–2009 and 2009–2019, the speed of urbanization was the fastest in 1999-2009 when the major conversion occurred, and the mixed built-up land amplified comparatively rapidly in Sadar Dakshin which was opposite to the general agrarian characteristics of the area.

From the above discussions, it is revealed that both the study areas, urbanization has increased which in turn changes the land use pattern. And these changes are brought by anthropogenic activities of human. Urban expansion in Adarsha Sadar Upazila is relatively reasonable as it was previously the primary urban center of the Cumilla city, and further development of the area lead to the conversion of leftover waterbodies, agricultural land and mixed forest land to mixed built-up. Contrary to the agrarian nature of Sadar Dakshin Upazila, the urbanization speed was exceedingly astounding. The speed of urban development in this area is almost at the rate of the Adarsha Sadar that is the evidence of rapid urbanization in Sadar Dakshin which is very alarming because it affects all types of land use types in the area to turn into commercial uses. If this rate continues, the area will lose its agrarian nature in a flash and turned into an urban society. This will bring massive scale environmental degradation for the whole area because development in this area is unplanned. There is no implementation of land-use zoning for specific land-use type, municipal planning and urban development planning. As a result of which, there already a substantial loss of agricultural land, waterbodies and forest and it will increase in the future, which in turn hit the food security and environmental balance of the area. Again, this will enormously intensify the flood hazard in both of the study areas. Due to urban expansion in this area in recent years and consequent increasing population and transportation loads in the roads, to cope up with these, roads width has increased by the government with filling up by roadside waterbodies (beel), leaving narrow drains for water discharge. Cumilla is facing rainwater flooding during the rainy season almost every year, according to Rasheed, 2016. This floodwater runs through the seasonal wetlands and beels of both of the study area. But because of filling up of these wetlands and roadside beels now, floodwater won't find any way to discharge and consequently submerged the agricultural land and houses of people, and the duration of the flood will extend. Thus, this unplanned urban expansion in Sadar Dakshin will bring untold sufferings of the people which should bring under the attention of Local Planning government as early as possible.

V. Conclusion

Cumilla is now one of the fastest-growing urban centers of Bangladesh which has both national and regional importance. This study analysed the numerical and spatial characteristics of dynamic land-use changes from 1999 to 2019. Depending on the analysis of Cumilla Adarsha Sadar and Sadar Dakshin Upazila the trend of land-use and direction urban expansion of the city identified. The results showed that agricultural land was the largest area in the both studied regions, accounting for nearly 36% of the total area for both study areas and agricultural land decreased from 1999 to 2009 for both study areas and from 2009-2019 slightly increased. Waterbodies had the second largest area coverage and most vulnerable to change. The built-up land was the most active category, which was expanded rapidly, for both areas. Comparing the data for both Upazilas, it is found that urbanization is rapid and growing in Sadar Dakshin Upazila, which is mainly agricultural region previously, and this is now the growing urban center of Cumilla. That will bring significant environmental degradation in turn if the change is not performed in a planned way. It is an urgent necessity for these two areas, especially for Sadar Dakshin Upazila, a proper land-use zoning scheme with a specific area for agricultural land, waterbodies, forest cover and settlement. To maintain the environmental balance as well as meet the need for food security and water balance along with municipal and drainage conditions there require proper land utilization and appropriate land use management. This will help to make the Cumilla a green, a healthy and well-organized city as well as maintaining the land for present and future generations. The government should take immediate steps to control the unplanned urbanization and implement a proper development plan for the Cumilla city.

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