MONITORING LAND USE AND LAND COVER CHANGES OF DHAKA CITY: A REMOTE SENSING AND GIS-BASED ANALYSIS

A.B.M. Kamal Pasha[1] , Sagar Mozumder[1*], Md. Alamgir Hossen Bhuiyan[2], Mahfuza Parveen[1,]
[1]Department of Environmental Science and Disaster Management, Daffodil International University, Daffodil Smart City, Ashulia, Dhaka, Bangladesh
[2]Department of Geography and Environment, Jahangirnagar University, Dhaka, Bangladesh
*Corresponding author. E-mail: mozumdersagar@gmail.com
Cell-Phone: +8801777067479

ABSTRACT: *Green vegetation and blue space (water body) dynamics keep the proper ecosystem of an area. Dhaka is one of the most densely populated cities in the world and continuously reducing its green and blue space. The present study has tried to determine the impact of urbanization in Dhaka city by analyzing the temperature, precipitation, solar radiation, and humidity data for the last 30 years; where the green and blue space dynamics are impacted together. The primary and secondary types of data were used for this study. For the green area, satellite image (mainly Landsat 8 and 5) has been used as raster data to analyze the remote sensing image classification and for the blue space, raster data has been used to find out those areas which are impacted throughout the year. With the help of those data, the study can illustrate the reason behind the degradation and transformation of green and blue space with time. From 1988 to 2020 about 7500 hectares of land have been increased by urbanization and at the same time, 6600 hectares of vegetation land were lost. Also, the research has focused on the actual amount of impacted zone and has tried to predict the condition of land use of Dhaka city in 2050. The present study predicted that a significant amount of vegetation will be lost by 2050 and imposed a significant impact on Dhaka city's climate, which is deteriorating mostly by rapid urbanization with a reduction in green and blue space. The study has the potential to use as a reference work and can be used for other areas in the future.*

Key Words: Remote sensing, Urbanization, Satellite image (Landsat-8 and 5), Arc GIS 10.4, supervised image classification, land use land cover (LULC), confusion/error matrix, and Dhaka city.

1. INTRODUCTION

An ecosystem of a city depends on the collaboration of green and blue space dynamics. It has a significant influence on climates such as rainfall, temperature, soil quality, and air quality, and also plays a crucial role in cleaning the air, adjusting the microclimate, eliminating noise, and beautifying the surroundings [1]. An increasing amount of urbanization always harms the green and blue space of a city which ultimately hampers climatic activity [2]. This seems to be very common because the green area is being used for housing and for converting into agricultural land, and the blue areas face the direct impact of that. As a result, water is being polluted over time. Dhaka the capital city of Bangladesh has been experiencing the continuous destruction of its green areas in response to rapid urban expansion ever since Bangladesh's independence. It has been recorded that from the Mughal period (1608-1765), the Dhaka city area stretched in a north-south direction from the river buriganga to the river Tongi [3]. The Dhaka area, which is considered Dhaka north, was the capital of Mughal before [4]. Because of the lack of information on the Mughal period, the population can not be precisely described in the urban zone of that time, but the area we call Kawranbazar now was also a critical commercial zone period. The name khawranbzar originated from the name caravan [5]. Because many marches used to come here for trading purposes at that time, the tejgaon area was used as a trade center for the European traders, and they set up different factories in that area [6]. The traders were mainly Portuguese, Dutch, English, and French traders. From that time, those areas become critical commercial zone, which pushes them toward urbanization. After the liberation in 1947, Dhaka city became a crucial zone for trading, and this time people start migrating to Dhaka for better livelihood [5]. In the Pakistan period, east Pakistan was the central industrial hub of Pakistan, and Dhaka was the capital of East Pakistan so, most of the industrialization happens in these zones. In this way, the urbanization process continues to grow with time. During 1971, urbanization has been slowed down because of the liberation war with West Pakistan. After the war, urbanization in Dhaka city again accelerated due to massive migration and urbanization, and becomes the industrial hub of Bangladesh.

From 1980 the urbanization in Dhaka become rapid, and with time the amount of urbanization increased [7]. The various governments formed other policies, but the urbanization process keeps growing. In 1998 after opening the Bangabandhu Bridge, also known as the Jomuna multipurpose bridge, the connection between Dhaka and the north side of Bangladesh became more flexible, so more people started coming to Dhaka city for working purposes and the migration keeps growing. In this way, Dhaka has become the most polluted and rapidly urbanized city in Bangladesh [8]. A recent study estimated that almost 80% of Greater Dhaka's land was non-urban in the 1960s [9]. These environmental disturbances not only lead the ecosystem to be degraded functioning but also severely affect Dhaka city's climate. [9]. The greenspace of a city has a direct impact on its environment. So, whenever an area's green space was being destroyed, that means it was directly hampering that area's climate. This study intended to show how Dhaka city’s green area had been destroyed and how it had also helped to impact the current environment of this city. An image classification system was used for getting the result. This study has tracked down the land cover use over time and found out the exact amount of loss. Then, The Markov modeling was used to predict the land cover use of 2050. The transition matrix was also used for calculating the prediction of 2050. The projection was helping to show the condition that the capital will face in the future and the land over which the capital will lose in 2050 also the study helped to understand the devastating outcome of today's rapid urbanization [10]. Climate change is a huge factor that is affecting the whole earth as well as the study area. The impact of rapid urbanization on Dhaka city's climate was also tracked down by analyzing the past 40-years period of climate data. Considering the above facts, the objectives of this study are (a) to identify the impact of urbanization on green space dynamics (b) to determine the effect of urbanization on blue space dynamics (c) to predict the future effect of urbanization on green and blue space dynamics.

2. MATERIALS AND METHODS

2.1 Study Area

The present study comprises Dhaka city, Bangladesh, and geographically covers between latitudes 23°52'53.19"N and 90°24'0.84"E to longitudes 23°40'35.43"N and 90°27'37.64"E (Fig.1). The city is one of the densely urbanized cities in the world and surrounded by four major river systems: the Buriganga, Turag, Tongi, and Balu rivers (Fig. 1). As per the study area, a total of 30,418 hectares of land had been used for the land cover raster map classification, and 34,418 hectares of land had been used for the water cover raster image classification. For the water cover, the study used a half kilometer of buffer around the main study area to show each water body's upstream and its effect because of the difference between the water cover raster and the land cover raster.

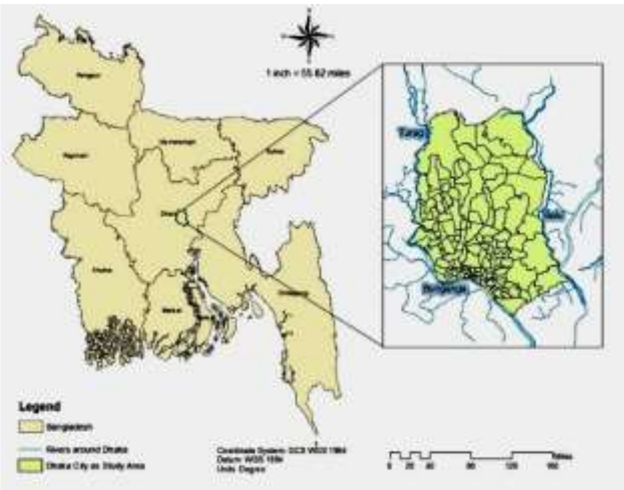


Figure 1: Location map of Dhaka city, Bangladesh.

2.2 Data Collection Method

Both primary and secondary data were used in this study. To understand the importance of green spaces and immediate causes of loss, intensive fieldwork was carried out in the study area also a pilot survey was carried out in the study area. Earth-observing satellites are an essential medium to get historical land-use records. Several historical images from various platforms were acquired. To understand spatiotemporal changes in the green and blue spaces. Landsat 8 and Landsat 5 data from the ESRI official site was used with a time range of 32(1988-2020) years. [11]

2.2.1 Primary Data Collection

Primary data for this study has been collected directly from ESRI's official website. The Landsat 8 and Landsat 5 images for image classification have been used for this study. There is some particular specific process that has been followed strictly for every picture which has been downloaded directly from ESRI. Also, a primary raster image was collected for geoprocessing on ArcGIS from the Google Erath pro map where the time slider was being used for getting the data of a particular date, which was downloaded as primary data from the Landsat satellite so that further analysis could show the appropriate result for the study.

2.3 Data Processing Method

ArcGIS 10.4 has been used to prepare the maps and calculations. Remote sensing and image classification tool have been used to prepare the distribution map. For getting a more accurate result, this study has used supervised image classification. It used maximum likelihood classification in supervised image classification, which gives more accurate results than other classification tools.

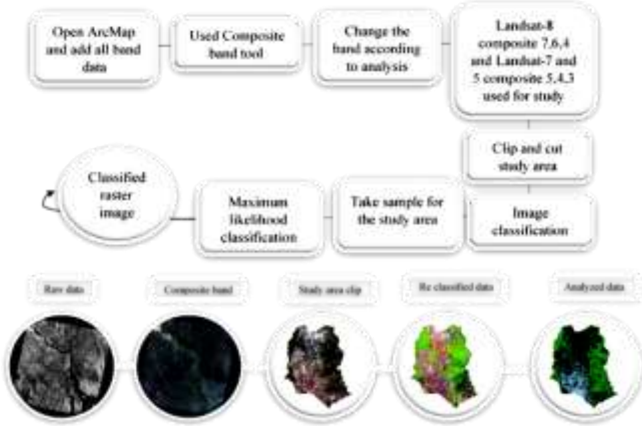


Figure 2: Pictorial presentation of the methodology of the study

2.4 ArcGIS

ArcGIS is software used for GIS (geographic information system), developed by ESRI. ArcGIS has four essential software parts, which are (1. Geographic information model for real-world modeling 2. Components for managing and analyzing GIS datasets 3. software can be used to create editing manipulate mapping and analyze geographic information 4. A collection of web service which provides content and helps software clients or users) A company called Environmental system research institute has made the ArcGIS software. [11]

2.5 Supervised Image Classification

The method used here is to identify and calculate the land cover amount of the study area. In this process researcher manually input some supervised samples in ArcGis software, later the software itself calculate the pixel of the image data and shows the output. The amount of land cover used in an area can be calculated with the help of produced raster map . In this case, the land cover shows the amount of increase or decrease meant for a particular land cover category.

2.6 Accuracy Assessment Method

Accuracy assessment is mainly defined as the comparison of two data sets one which is remotely sensed classified data which is produced by the author or the primary information another one is the actual map or the referenced map, with which the producer's preliminary plan has been compared [12]. For performing an accuracy test on those maps Error matrix or the confusion matrix method has been used. In this process 30 random points have been used for each category that means for finding out the green space dynamics, we have used a total of 90 random topics, and for the blue space, 60 points have been taken from our actual map, which is a high-resolution picture, was downloaded from the Google earth with the same date of the Landsat data which has been used in the study. Then the high-resolution picture has been used as a base map after geo-referencing with our produced map and taking sample points. After taking sample points, the facts are compared with the raster map created with remote sensing [9].

2.6.1 Accuracy assessment

This is a significant step in remote sensing data. Proper utilization of the data will only be possible if the data quality is identified. Here is the study several types of accuracy were shown. They were overall accuracy, kappa accuracy, producer accuracy, and user accuracy. Overall accuracy refers to how each pixel is classified versus the actual land cover condition obtained from their corresponding ground truth data. Producer accuracy measures how error or omission is a measure of how well real-world land cover types can be classified. User accuracy measures commission error, representing the likelihood of a classified pixel matching the land cover types of its corresponding real-world location. The error matrix and kappa coefficient have become standard means of assessment of image classification accuracy [13]. In this study, an error matrix has been used to derive all the accuracy tests. The kappa coefficient is also measured with the help of the error matrix. It is the most commonly used method to show the accuracy of image classification in remotely sensed data. An error matrix is a square array of numbers that expresses the number of pixels assigned to a particular category related to a correct variety as verified on the ground. The column represents reference data in the error matrix, and the row represents classification generated remotely sensed data [14].

2.6.2 Error matrix: Error matrix is the most commonly used method to show the accuracy of image classification in remotely sensed data. An error matrix is a square array of numbers that expresses the number of pixels assigned to a particular category related to a correct variety as verified on the ground. The column represents reference data in the error matrix, and the row represents classification generated remotely sensed data. [14]

Sensitivity = $\frac{a}{a+b}$ (equivalent to producer accuracy)

Specificity = $\frac{d}{b+d}$

Commission error = 1 – Specificity

Omission error = 1 – Sensitivity

Positive predictive power = $\frac{a}{a+b}$ (equivalent to users accuracy)

Where**,**

a = number of times a classification agreed with the observed value

b = number of times a point was classified as X when it was observed not to be X.

c = number of times a point was not classified as X when it was observed to be X.

d = number of times a point was not classified as X when it was not observed

to be X. Total points = N = (a + b + c + d)

KAPPA analysis is a discrete multivariate technique used in accuracy assessment. KAPPA analysis yields a Khat statistic (an estimate of KAPPA) that is a measure of agreement or accuracy. The Khat statistic is computed as,

$$K = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_i + Xx_{+1})}{N^2 - \sum_{i=1}^{r}(x_{ii}\, Xx_{+1})}$$

where;

r = number of rows and columns in error matrix, N = total number of observations (pixels), Xii = observation in row I and column I, Xi+ = marginal total of row I, and X+i = marginal total of column I, A Kappa coefficient equal to 1 means perfect agreement whereas a value close to zero means that the agreement is no better than would be expected by chance. [12]. All the results will be shown in percentages. Depending on the error, the accuracy will be changed.

2.7 Markov modeling for probability matrix: Markov chain is a discrete-time stochastic process [15]. Here the condition of the future can be determined by analyzing the present state of that individual area[16]. Markovian property can be described and stated with

$i_0, i_1, \ldots, i_{t-1}, i_t, i_{t+1}, and\ all\ t \geq 0$

$$P(x_{t+1} = i_{t+1} \mid x_t = i_t, x_{t-1} = i_{t-1}, \ldots, x_1 = i_1, x_0 = i_0) = P(x_{t+1} = i_{t+1} \mid x_t = i_t \quad (1)$$

The Markov chain assumes that the conditional probability does not change over time. for all States, i and j and all $t, P(x_{t+1} = j \mid x_t = i)$ is independent of t,as expressed in Eq (2)

$$P(x_{t+1} = j \mid x_t = i) = p_{ij} \quad (2)$$

Where P_{ij} = transition probability that, given the system is in state i at time t, it will be in a state j at the time $(t+1)$

The transition probabilities are expressed as an $m \times m$ matrix and it is called the transition probability matrix or transition matrix, P. The characteristics of the transition probability matrix as p are given bellow

$$P = \begin{matrix} p_{11} & p_{12} \cdots & p_{1m} \\ p_{21} & p_{22} \cdots & p_{2m} \\ p_{m1} & p_{m2} \cdots & p_{mm} \end{matrix}$$

The estimation of transition probabilities in a Markov chain-based deterioration model requires data from the condition assessments of existing systems[17].

2.8 Land surface temperature (LST)

Land surface temperature is the temperature that can be felt when one touches an area's ground. It is different from the air temperature or the atmospheric temperature. It is mainly monitored to get information about the effect of the greenhouse on land surface temperature. In this study, two different types of Landsat data were used, which are Landsat-8 and Landsat-5. For those two different Landsat data, calculating land surface temperature is different because both Landsat data have different band values. For Landsat 8, there are eleven bands from that we used band-10 TIRS for our LST calculation [18]. The Landsat 8 data band-10 TIRS defines the thermal band with a 100-meter resolution and is used for thermal mapping. In the same way, Landsat 4-5 has in total seven bands, which indicates a different class depending on the band (https://www.usgs.gov). In Landsat 4-5, band number 6 is the thermal infrared band, which is often used to calculate an area's thermal mapping [19]. The calculation has been done by using Arc GIS 10.4 software. There were certain formulas being used in the raster calculator for getting the LST.

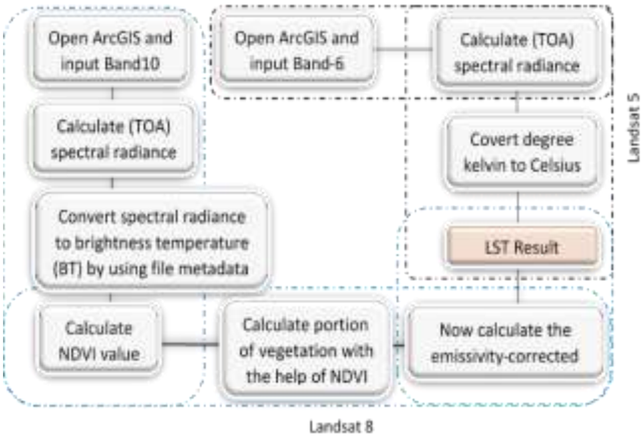


Figure 3: Graphical method of Landsat 8 and 5 LST calculation.

3. RESULTS AND DISCUSSIONS

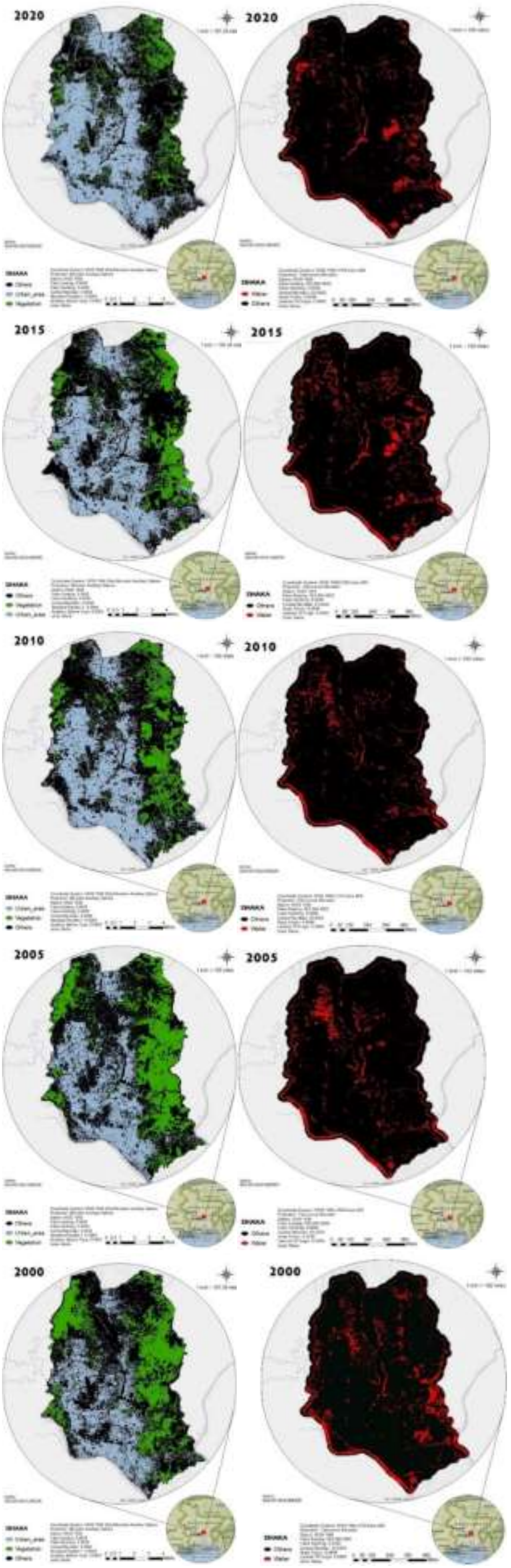
3.1 Land Use Land Cover Classification

The supervised raster image classification has shown the direct impact of urbanization on the green space dynamics, which was reasonably expected from the beginning of the study. The image classification has shown how much the area has gone under urban construction for the last 32 years (Fig 4), and the area of urbanization from the variety was also calculated, which can show the exact amount of land use for urbanization. The maps will also show the amount of vegetation land losses during the past 32 years, and it also indicates clearly which and how much area of the land was previously under vegetation, which is under urban buildup now.

3.1.1 Urban area classification: From the map 1988, the study found that the area of the total urban buildup was 5,262 hector (Table 1) which is like 17% of the whole land of Dhaka city (Table 1), which turned into 6484 hectors (Table 1) or 21% of total land area in 1994 (Table 1), that means it increased by about 1,222 hectors of land or 4% of total land area. In the following way, the full size of land in 2000 is 7,411 hector (Table 1) which is 24% of the total land area (Table 1), increased by about 9,27 hector which means 3% of the total land area. So the speed of urbanization was quite the same. Then in 2005, the study found that the location of urban buildup area is about 8,115 hectors (Table 1) and 26% of total land area (Table 1), increased by 704 hectors and 2% of total land area continuously growing, resulting in 2010 the area of land is 10,218 hectors (Table 1) that are 33% of whole land cover (Table 1), increased by 2103 hectors of land means in total 7% of entire land cover. According to [9] Dhaka city saw huge urbanization in this timezone. So in 2010, a drastic leap can be observed in urbanization compared to previous data. However, it continues in 2015, in which the area of the urban area was found 10,713 hectors (Table 1) and 35% of total land cover (Table 1), which means the urbanization speed dropped, but still, it increased by 2% compared to previous land use and about 495 hectors of land area which was also mentioned in [2]. Nevertheless, in 2020, the study again showed a tremendous amount of acceleration in urban area building, resulting in 12,833 hectares (Table1) of land covered by urban construction, which is about 42% (Table 1) of the total Dhaka city area, so here the study indicated a significant amount of urbanization. Compared to 2015, the urban area has increased by nearly 2,120 hectares of land, 7% of the total land area in Dhaka city. So from 1988 to 2020, the metropolitan building area is continuously increasing from year to year (Fig 4).

3.1.2 Green cover classification: In the vegetation section, the story is the opposite of the urban building. In green or vegetation areas, a significant amount of loss was observed in every map classification (Fig 4). Sometimes the number of drops decreases, but the study never found an increase in vegetation in the study's total area. In 1988 the amount of vegetation area was quite heavy, about 10,118 hectares (Table 1) and 33% of the whole land cover (Table 1), almost double the urban building in 1988, about 17% of the total land cover. However, the total amount of vegetation has dropped to 9,603 hectares (Table 1), about 31% of the land cover (Table 1) that miss we lose 525 hectares and 2% of vegetation cover compared to 1988. Further analysis in the year 2000, showed the vegetation amount is about 7,540 hectares of land (Table 1), 24.7% of the total land cover area (Table 1). In 2000, approximately 2,063 hectares of vegetation cover were lost, representing 7% of the vegetation cover loss in 5 years.

According to [20] Dhaka city faced a continuous vegetation loss during this time. Whereas, in 2005 some hope was found in vegetation because the amount of vegetation area in 2005 was 7,383 hectors (Table 1) and about 24% of total land (Table 1), which means the vegetation area drop is much lesser than the previous map, but still it lost about 157 hectors of the land, but it was a promising result. The calculation becomes hopeless again when the study found in 2010, the vegetation area in total is 5,292 hectors (Table 1) and 17% of total land cover (Table 1) which means the study area was lost similarly about 7% of vegetation which is 2,091 hectors of land. In the same way, in 2015, about 4652 hectares (Table 1) and 15% of the land were under vegetation, resulting in about a 2% drop from the previous one and about 640 hectors of land user vegetation has lost which was also mentioned in [21]. In our final map, in the recent year 2020, the greenery amount is approximately 3,484 hectares of land (Table 1) and 11% of total land cover (Table 1), showing vegetation. That means 1,168 hectares and 2% of the land was being lost, which was previously under vegetation. So in the final result, only 11% of vegetation was left, which was 33% in 1988. Compared to1988, it was a massive loss of land in vegetation area.



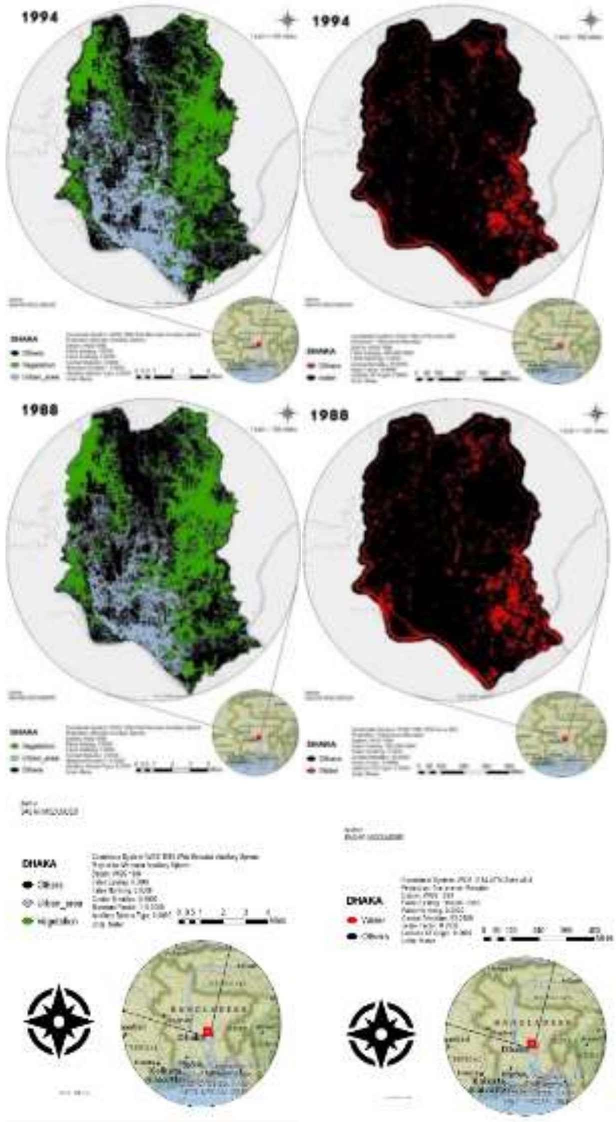


Figure 4: Land cover image classification from 1988-2020.

3.1.3 Other Catagory classification: The other land area is mainly containing (bare land and sand land), which does not show any vegetation. This empty land area is often fluctuating from time to time (Fig 4), but most of the bare land was under vegetation land area, which becomes sand land with time. The bare ground has been used for urban building also, which ultimately the loss of vegetation. So in the barren land calculation, 1988 shows the other category land is about 1537 hector (Table 1), and 49% of total land cover (Table 1) dropped by 2% in 1994 and become 47% with a total area of 14,330 hectares (Table 1) and the analysis shows most of them are used for urban building. Moreover, very few of them showed vegetation. In 2000, the number of other category land increased because the vegetation land was lost and the vegetation land turned into the bare or sand ground, resulting in 3% of other category land area increased by 15,465 hectors of land (Table 1). In 2005, the area of other category land decreased because a portion of them was used as urban area buildings, and the total area of other category land stands at 14,919 hectares (Table 1), which covers 49% of the total land area (Table 1), which shows 1% of other category land used from the urban building it was also

Table 1: Land cover classification of urban, others, and vegetation spaces in the study area from 1988-2020 (Area in Hector and %)

Land cover type	1988		1994		2000		2005		2010		2015		2020	
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
Urban	5262.3	17.3	6484.3	21.3	7411.7	24.3	8115.2	26.6	10218.4	33.5	10713.2	35.2	12833.5	42.1
Others	15037.2	49.4	14330	47.1	15465.9	50.8	14919.1	49.0	14906.7	49.0	15052.4	49.4	14100.0	46.3
Vegetation	10118.1	33.2	9603.3	31.5	7540.4	24.7	7383.4	24.2	5292.6	17.4	4652.5	15.3	3484.6	11.4
Total	**30,418**	**100**	**30,418**	**100**	**30,418**	**100**	**30,418**	**100**	**30,418**	**100**	**30,418**	**100**	**30418**	**100**
Others	30847.5	89.6	31354.5	91.0	31145.7	90.4	31979.3	92.9	32309.3	93.8	31492.4	91.4	31870.7	92.5
Waterbody	3570.7	10.3	3063.7	8.9	3272.5	9.5	2439.0	7.0	2108.9	6.1	2925.9	8.5	2547.6	7.4
Total	**34,418**	**100**	**34,418**	**100**	**34,418**	**100**	**34,418**	**100**	**34,418**	**100**	**34,418**	**100**	**34,418**	**100**

identified by [9]. In the same way, we see in 2010 the size of other category land is about 49 %, but if the vegetation area of 2010 was considered, then the study shows that the vegetation area decreased, which means the other area and urban area took the area of vegetation in 2010. Compared to 2015, the area of others again remain the same with 49% of the total land cover area (Table 1), but the size of urban increased and the area of vegetation decreased significantly, which showed the area from vegetation gone under others and metropolitan area in the year of 2015, that was also indicated in [21]. In 2020 the land cover of other category land had finally decreased by 3%, but it does not show vegetation because the urban area increased a considerable amount. Because of heavy urbanization, both the other category land area and vegetation area decreased. The size of the additional land cover became 14,100 hectares (Table 1), 46% of the total land cover (Table 1)area decreased from 2015 when the area was 15,052 and 49% of total land cover. So from the result of the classification, one thing is very clear urbanization has affected the City's landcover by a significant amount. Which has created a direct effect on the vegetation land cover of the city, and the vegetation land cover decreased continuously in these 32 years of the study area, which is equally harmful to the overall environment of Dhaka city.

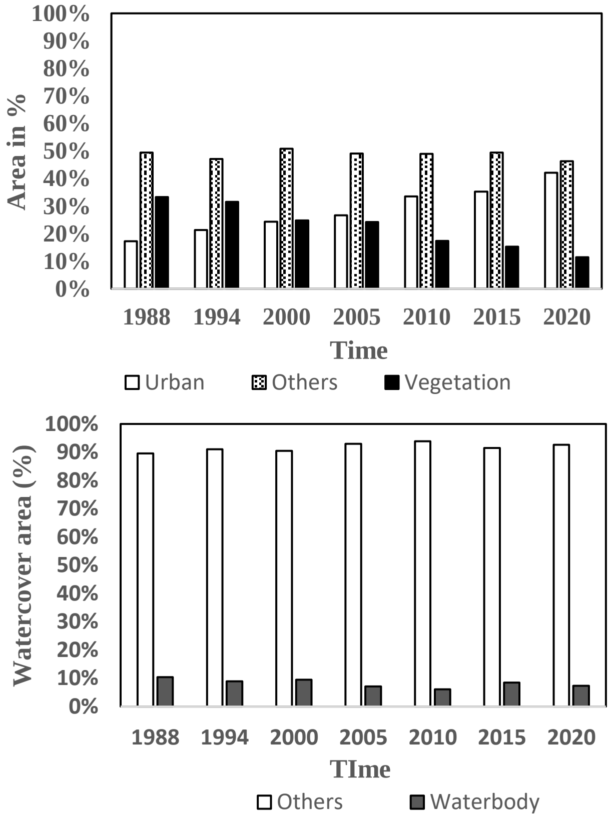


Fig 5: Land cover percentages of urban, others, and vegetation and water spaces in the study area

3.1.4 Water cover classification

In water cover image classification, two categories of data were analyzed. The water category will show the water body throughout our study, and the others include all the (urban, bare land, sand land, and vegetation area). Some changes were observed in the water body and the water body type throughout our study time. However, most of the changes were being found in wetland areas. From 1988 the wetland area continuously decreased and again increased after a certain period (Fig 5). In 1988, most of the water bodies are under the wetland area. The total size of a water body was calculated here as 3,570 hectares of land (Table 1), roughly 10 percent of the entire land cover(Table 1). However, after considering the 1994 map, a drop was observed in the land area, mainly in wetland areas. The main rivers and the streams have remained the same in this time zone. The location of the water body in 1994 was 3,063, which is about 9% of the total land area (Table 1) dropped by 1%, and 507 hectares of land, which mainly dropped from the wetland area. However, in the year 2000, after analyzing the map, the total area was found about 3,272 hectors (Table 1) and which is 9% of the whole land cover that means the water body has increased by 1% here and the land cover for the 1% is about 209 hectors. But in 2005 there was a significant drop in a water body, total by 2,439 hectors of land and roughly about 7% of total land use (Table 1) which means about 833 hectors and 2% of total land use was lost, a considerably high amount of water body loss which was clearly mentioned in [20]. But the previous map analysis showed that the vegetation was not lost a high amount, and the urban building was also increased by a marginal amount. So the wetland was gone under landfill or sand fill in this time, which can be seen in the map analysis of land cover change in 2005. Similarly, in 2010 the water body continuously decreased, resulting in the amount of water body becoming 2,108 hectares and 6% of total land cover (Table 1). That means about 1% of land cover was lost from the water body previously, which was about 331 hectares of land area. However, things change slightly after 2010. Some new wetlands can be seen in some areas which as once not there. That means these areas the wetland which has been newly showing up because of massive urbanization. In 2015 we can see the size of the wetland increased in total to about 2,925 hectares (Table 1) and 8% of the total land area, which means the wetland has risen by about 2% and 817 hectares. This is a vast area of land compared to our study. However, the map with the older time zone refers that the wetland area has been changed, and in 2015, the new site went under wetland. Massive urbanization can also be monitored in 2015, which continued in 2020 because of excess runoff water from the urban area, as urbanization has a proportionate relation with the runoff water amount. So the newly made wetland is mainly the impact of urbanization, which is also identified by [21]. Similarly, in 2020, the water body area becomes 2,547 hectares (Table 1), 7% of the total land area (Table 1), which means a 1% drop in the entire land cover area, which is about 378 hectares. However, the matter of fact is that the previously made wetland we found out about in 2015 is still there, which means some natural water body has been lost in this time zone. Moreover, according to land cover map analysis, there was colossal urbanization or urban building process that happened from 2015 to 2020, which means that most of the water bodies goes under landfill and were used for urban area building during this time. The loss amount of total water body from 1988 to 2020 was about 1,023 hectares, 28% of the entire water body from 1988. That means about 28% of the water body was lost which was in Dhaka city in 1988. This clearly shows how rapid urbanization affects Dhaka city's water body and how it becomes a reason for urban flooding (Fig 5). Because of the decreased amount of wetland, the city runoff water has no place to create temporary new wetlands, ultimately creating problems like urban flooding.

3.2 The Gain of Urban Area and Loss of Vegetation Area From 1988-2020

From 1988 to 2020, a massive land area has been gone under urban construction or urban building (Fig 6), and a significantly large area of land has been lost previously under vegetation (Fig 6). Figure 8 showed that the area that previously was either bare land or vegetation area, which was later converted into urban areas in the last 32 years [2]. The area symbolized in red color was not a metropolitan area in 1988, from 1988 the urban area increased, so the size of the red zone is that area that becomes urban after 1988. The total area of urban buildings increased from 1988 is about 7,571 hectares of land, which is about a 143% increase compared to the 1988 urban space land (Fig 6). According to [9] Dhaka city saw huge urbanization right after 1988. For the vegetation area (Fig 6), the scene is the opposite of the urban area. Because a vast vegetation loss was found in the study in the last 32 years. In Fig. 9, the red zone area was previously vegetated but now it is either an urban area or a bare land area. That means the red site is that area from where the vegetation has been lost for the last 32 years. The total loss of vegetation is about 6,634 hectares of land from 1988 and about 65% of vegetation has been lost in 32 years (Fig 6). That is a massive amount of vegetation loss for any city. It was also described in [20] that the capital suffered a huge vegetation loss after the year 1988. So, from the map analysis, it is clear that the urban gain is about 143% from 1988, and the vegetation loss is about 65% from 1988, which is undoubtedly impacting the environment of Dhaka city directly.

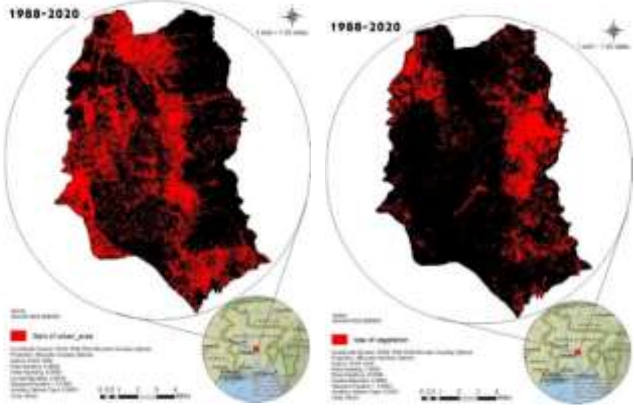


Figure 6: Gain and Loss of Urban and Vegetation area

3.3 Land surface temperature

Land surface temperature is the ground temperature calculated with satellite imagery (Fig 7). The land surface temperature can be deferred with the pattern of the landscape of an area. Higher altitude often shows less temperature than lower altitude areas (earthobservatory.nasa.gov). It is monitored to analyze the greenhouse gas effect on the land surface like sand land and glacier or water body (earthobservatory.nasa.gov). The study of land surface temperature showed some interesting results. At the beginning of Dhaka city's urbanization, the temperature of the land continuously increased (Fig 7). Sometimes the higher the temperature was increased and sometimes the lower temperature was increased like, in 1994 the high temperature increased 1 degree (Table 2), but in 2000 the lower temp decreased by 2 degrees (Table 2). However, again, we saw the increased amount of lower temp in 2005. In 2010 both temp. Went down by almost 4 degrees (Table 2). However, in 2015 and 2020, only the lower temp went down by 2 degrees and 1 degree (Table 2). The reason could be the newly made sand land which was not their previous years. The bare ground can capture more temp. Then urban build, so we can see much high land temp during the last year, but the rapid urbanization from 1988 to 2020 decreased the temperature in winter season almost 2-degree average (Table 2). That shows the instability. In (2015-2020), sand land shows the hottest temp in an area that was not there in 1988. That means urbanization has decreased the average temperature but has increased the overall high-temperature size in Dhaka city.

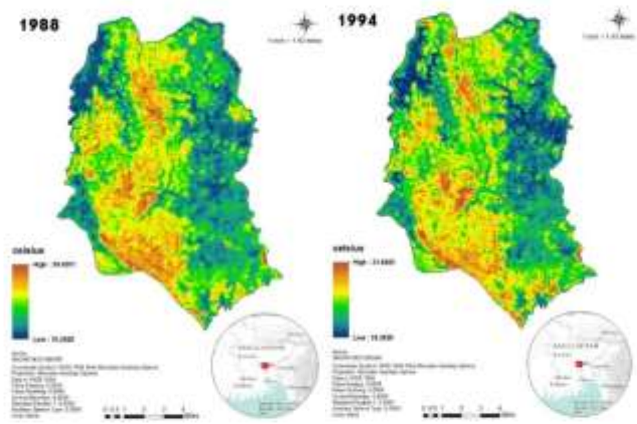


Table 2: Land surface temperature from 1988-2020 (Celsius)

Classes	1988	1994	2000	2005	2010	2015	2020
Date	19/02/88	19/02/94	20/2/2000	5/03/2005	15/02/10	13/02/15	11/02/20
H. Temp.	30.42	31.64	31.64	31.23	27.93	28.04	28.23
L. Temp.	19.28	19.28	17.93	22.37	17.93	14.39	16.65

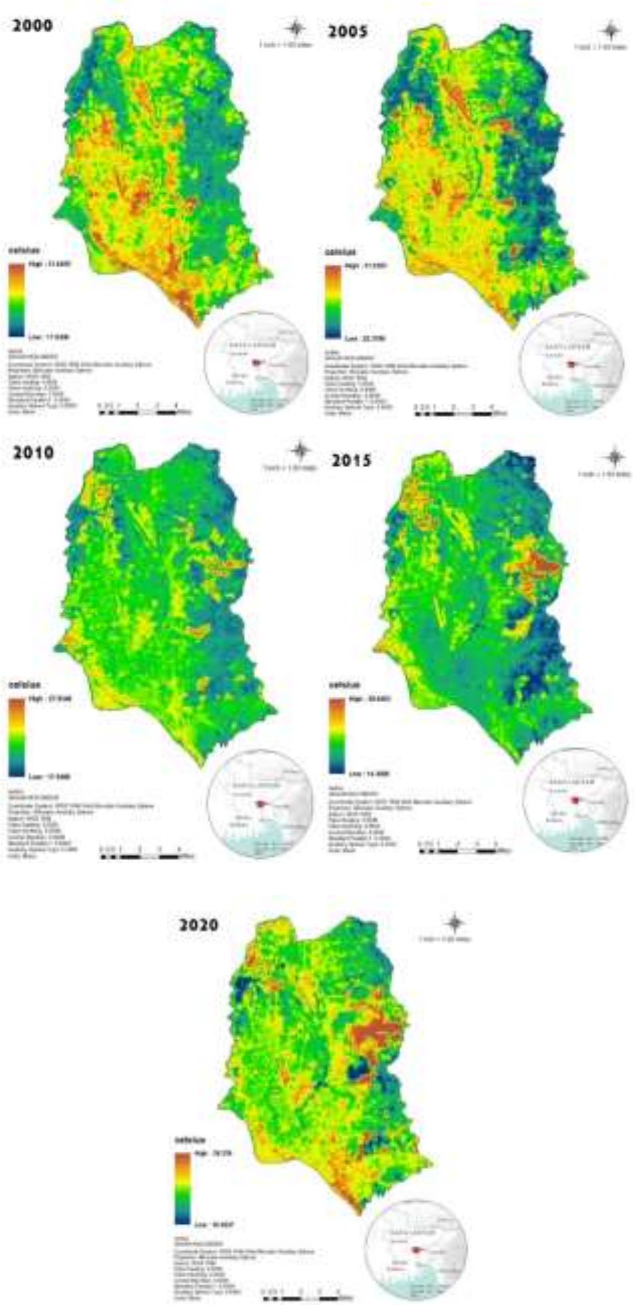


Figure 7 Analytical presentation of land surface temperature from 1988-2020

3.4 Markov prediction of land use change in the next 32 years

A Markovian process is a process that can determine the future state of a system in time with the same design's current state. It is a random process that depends on the current state. Markov produces a transition matrix or a transition area matrix by analyzing two qualitative land use from two different dates[22]. In this case, 1988 to 2020, a total of 32 years. The rows represent older land cover use, and the column represents the more recent land cover use.

Here the categories chronologically represent others (wetland, sand land, water), land cover, urban, and vegetation. Here the Markov analysis will predict the land cover use in 2050 by using the matrix. [10]. According to the transition matrix, the probability of other classes staying in the same area as other classes after the next 32 years is 49%, and the probability of conversion from others to urban is 41%. Vegetation is 10% which means in 2050, from other category land areas, 41% of the land will go under urban construction, and 10% of the land will go into vegetation (Table 3). In the same way, in 2050, the probability of urban areas will stay urban is 91%, which means 91% of the urban area will remain the same in 2050 and 8% of the metropolitan area could go under other categories also 0.31% can go under vegetation area (Table 3)[10]. If we consider vegetation area, then the probability of vegetation land cover is only 15% to stay as vegetation area (Table 3). This indicates only 15% of the current vegetation will show vegetation in 2050, and 22% of the existing vegetation area will go under urban construction. Also, 62% of land from vegetation will go under others, mainly (bare land, sand land, and water) (Table 3). From the above analysis of the 2050 prediction, we can see that the vegetation land cover area is in a very fragile state. If everything remains the same in the next 32 years, then in 2050, the vegetation cover in Dhaka city will face severe disruption. Almost the area of vegetation will be empty according to the prediction. Only hope the prediction shows that 10% of land area could convert into vegetation area from the other category. Also, the other category is in a vulnerable state, which means the area which is holding water right now could be in danger in 2050 because 41% of another area of land could be converted into an urban that means there is a possibility that the water body will also be filled up for making an urban building (Table 3)[10]. The only thing that is stable in this probability matrix is the urban area. According to our prediction, the urban area will stay very stable in 2050 land cover use because almost more than 91% of the urban area shall remain urban in 2050, and very few amounts of the site could convert into bare land, and almost negligible amount of land will be restored in vegetation (Table 3). According to the study prediction, a tremendous amount of vegetation area will be decreased in 2050.

Table 3: Probability of changes in the year 2050 land cover (prediction) using the transition matrix

Category	Others	Urban area	Vegetation
Others	48.83%	41.57%	9.60%
Urban Area	8.30%	91.39%	0.31%
Vegetation	62.46%	22.04%	15.50%

Table 4: Accuracy assessment results for land cover

Year	LAND COVER TYPES						For the whole map area	
	Urban		Vegetation		Others			
	Producers Accuracy (PA) %	**Users Accuracy (UA) %**	**Producers Accuracy (PA) %**	**Users accuracy (UA)%**	**Producers accuracy (PA) %**	**Users accuracy (UA) %**	**Overall Accuracy %**	**Kappa Coefficient %**
1988	90	93.11	93.34	100	96.67	87.88	93.33	90.07
1994	93.34	96.56	86.67	96.3	93.34	82.36	91.11	86.79
2000	93.66	100	93.66	96.55	100	90.91	95.56	93.48
2005	96.67	93.55	96.67	100	93.33	93.34	95.56	93.48
2010	93.33	100	100	100	100	93.75	97.78	96.59
2015	96.66	100	100	93.75	93.33	96.55	96.67	95.05
2020	96.7	100	100	100	100	96.8	98.89	98.51

Table 5: Accuracy assessment result for water cover

Year	LAND COVER TYPES				For the whole map area	
	Others		Water			
	Producers Accuracy (PA) %	**Users Accuracy (UA) %**	**Producers Accuracy (PA) %**	**Users accuracy (UA) %**	**Overall Accuracy %**	**Kappa Coefficient %**
1988	96.67	96.67	96.67	96.67	96.67	93.4
1994	93.34	93.34	93.34	93.34	93.33	86.6
2000	96.67	100	100	96.77	98.33	96.6
2005	96.67	96.67	96.67	96.67	96.67	93.4
2010	100	96.77	96.67	100	98.33	96.6
2015	93.34	100	100	93.75	96.67	93.4
2020	100	100	100	100	100	100

3.5 Accuracy assessment

From the accuracy assessment, it can be observed that most accuracy was over 90%, (Table 4,5) indicating good image classification work. The kappa coefficient's result was very close to 1 for most of the maps (Table 4,5). As per the kappa coefficient rules, if a coefficient result was near 1, that means the image classification of the remotely sensed data is near the actual information on the map. [14]. So, from the result, it can be ensured that the classification is almost representing the same feature related to the natural or actual map. However, after considering the result, it can be found that the accuracy level is continuously decreasing, though it slightly drops but decreases with the map's time. In the accuracy test from 1988 to 2000, all the map accuracy is over 90%, (Table 4,5) and the kappa coefficient is also near the value 1(Table 4,5). Moreover, from 2005 to 2020, the accuracy is more than 95% (Table 4,5), which indicates the excellent result from the map classification, and the kappa coefficient is very close to the value one, which again shows an accurate map classification result. Overall, it can be said that the accuracy result matched the actual world map, which means the study calculation from urban, vegetation, and other categories were very near to accurate data. Only two classification class is identified in the water cover map, resulting in a more accurate result than the land cover classification. Almost all results in this accuracy assessment were very close to reality and even one was100%, which means the map accuracy is very near the actual land cover (Table 4,5). Few errors could be noticed, which usually happen for the same type of reflection from the ground. The exact reflection takes some error pixel in other classes, but supervised image classification was used, which ensured a high accuracy that can be seen in our accuracy assessment result.

4. CONCLUSION

Green and Blue space dynamics are significantly crucial for a rapidly growing city like Dhaka although both of them are decreasing and hampering drastically with time. The present study stated that about 7571 hectares of vegetation land and water cover area were lost due to rapid urbanization. However, this rapid development has left its shadow behind it by increasing surface temperatures. Overall, the high-temperature surface area increases daily, ultimately showing the desertification effect in Dhaka city. Last 32 years (1988-2020), the surface temperature of Dhaka city changed significantly. The lower temperature decreased, and the higher temperature increased. That means in the daytime, it feels hotter than before and, at the night, it feels colder than before, which directly indicates that Dhaka city is already starting to face a desertification effect. At the same time, the amount of water-covered area is also decreasing day by day including both ground and surface water. For a sustainable city, a sufficient amount of green and blue spaces are necessary, which can improve environmental quality as well as ecological biodiversity. Destruction of green and blue spaces is not only demolishing land and aquatic ecosystems but also accelerating the poor quality of urban life. This process effects slowly on the urban population and obviously the next generation. Therefore comprehensive green space management should be implemented for Dhaka city as early as possible which was also reported by [9]. The present study will help to prepare a comprehensive green space management strategy for Dhaka city and can be used as a baseline study in recent times.

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