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Urban Green-space Availability and Recommended Plantation Area in Dhaka South City Corporation (DSCC) using RS-GIS

Syed Hafizur Rahman[1*] and Mahfuzul Islam[2]

[1]Professor, Department of Environmental Sciences, Jahangirnagar University, Dhaka-1342, Bangladesh.

[2]Undergraduate Student, Department of Environmental Sciences, Jahangirnagar University, Dhaka-1342, Bangladesh.

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Abstract

Urban green spaces (e.g., a park, public playground, riverside, and lakeside footpath) are well-managed regions of a city that acts as a purifier to clean the polluted environment. Previous studies suggest having 15 to 20% green space areas in a city from the environmental and health perspective. The aim was to evaluate the amount and distribution of urban green space (both sparse and dense) in the Dhaka South City Corporation (DSCC) with a landmass of 99.2856 km^2 and recommend available places for the plantation and create new green spaces on-demand. Administratively, DSCC has been divided into ten zones consisting of seventy-five wards. In this study, they were divided into four geographical sectors. Satellite imagery of Sentinel-2B was used with the "minimum-distance" algorithm in the QGIS 3.18.3 to classify the land use of DSCC, where the accuracy was measured and tested by error matrix and kappa value as the method of the land-use classification map. Google-Satellite-Images and Open-street-map were used in QGIS to find available areas to recommend creating new green spaces. DSCC covered about 39.19% of the vegetation. Among them, 31.20% were sparse vegetation. Only a 7.99% dense green-space area was available in DSCC. In the sectoral view, the sparse vegetation cover in the North-West, South-West, South-East, and North-East was 28.66%, 16%, 36.45%, 42.62%, and dense vegetation was 5.05%, 0.74%, 6.59%, and 19.90%. In the zone scenario, the arrangement of zones according to the presence of dense green-space area was 3<4<5<2 <10<9<1<8<6<7. Apart from the North-East sector, all sectors of DSCC had a meager amount of dense green area, which is far below the standard. More specifically, all the zones of DSCC except zone 6 and 7 had a green space of less than 10%, which is below standard. A possible 14.87 km^2 area was detected for the dense green zone (2.55 km^2 in the South-West, 6.58 km^2 in the South-East, 4.14 km^2 in the North-West, and 1.59 km^2 in the North-East sectors). DSCC should use waterbodies, roadsides, riverbanks, lakesides, graveyards, and local and public parks to create new green spaces. The sparse vegetation area should also be turned into dense vegetation, and where the space was very tough to manage, roof-top gardening could be an excellent approach to focusing on ward-wise planning in the DSCC.

Keywords: Sparse vegetation, Dense vegetation, Land Use Land Cover Change (LUCC).

Introduction

Urban green spaces are well-managed city regions that act as a purifier against the polluted environment. Green space may include places that have formed naturally and include particular types

*Corresponding Author (hafizsr@juniv.edu)

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of urban greenery, such as parks, surrounding vegetation of a monument, public playgrounds, riverside footpaths, lakeside, and street trees. It may also include 'blue space' representing water elements like ponds, rivers, lakes, and wetlands. Ultimately, they can depend on particular environment-health pathways under consideration. As cities are the most compact area with lots of roads, buildings, traffic, and people, it is necessary to determine a minimum standard for the green space in the city to keep it habitable. Urban green area standards are divided as standard percentages for the green space in a city, minimum standard green area per capita, a minimum fixed area of green space, a specific number or amount of green spaces, or a standard based on walking distance to the green space in a city (Maryanti et al., 2016).

Sustainable Development Solutions Network (SDSN) suggests having a minimum of 45% of a city area as the public open space under SDG goal 11.7, where streets can occupy 30%, and green space will cover around 15% area (UN-Habitat, 2013). These minimum standards also have been set at around 20% (Rahman and Zhang, 2018), where green spaces should be well distributed as it would fulfill the demands like every neighborhood would have access to the green zone within five minutes' walking distance. Within a two km distance, there should be at least one green space with a minimum area of 20 ha or 0.02 sq. km and 100 ha and 500 ha area of green space for every five and ten km(Thompson et al., 2016). From the perspective of per capita green space, the standard provided by the UN is 30 m^2 per person(Khalil, 2014). Apart from that, according to World Health Organization (WHO), 9 m^2 of green space per person is the average value to live a better quality of life (Li and Pussella, 2017). Different cities worldwide provide different amounts of average green space per person. In Europe, in the city of London green space amount is 40 m^2/person. Cities like Washington provide 38 m^2/person, and Los Angeles delivers 48.5 m^2/person in the USA; among the South Asian countries, India has a standard of 8 m^2/person, and Pakistan has a 5.2 m^2/person (Maryanti et al., 2016). Unfortunately, there is no specific standard for Bangladesh, and due to the shortage of land area and unplanned urbanization, Dhaka city cannot maintain the minimum global average (9 m^2 /person). In Dhaka, according to Dhaka Metropolitan Development Plan, 1995 by RAJUK recommended only 0.16 acres for every 1,000 population (Dhaka, 1997), which means around 0.52 m^2/person of green space for each person. This study aims to calculate the total green space area and suggest available areas and ways to create new green space on demand.

Materials and Methods

Description of the study area

In 1977 Dhaka was redesigned as a metropolitan of Bangladesh with 50 different wards. Due to population growth and massive urbanization, the city was divided into two administrative regions: Dhaka South City Corporation (DSCC) and Dhaka North City Corporation (DNCC) (DSCC, 2021b). Our study region, Dhaka South City Corporation (DSCC) (between 90.3474°E to 90.5137°E and 23.661°N to 23.7823°N), has a land area of 99.2856 km^2, which is into ten different zones, and those are consists of a total of 75 wards that carry around 120 million people (DSCC, 2021b). The river Buriganga flows to the city's South-West boundary, and the Balu River lies at the eastern edge. Narayanganj and Keraniganj are situated in the south, and Dhaka North City Corporation is placed in the North according to the position of Dhaka South City Corporation. The population of DSCC was more than 120 million in 2020 (DSCC, 2021b, DSCC, 2021a).

Data Collection

The 10 m resolution Sentinal-2B high-resolution imagery (7 November 2020) from the USGS earth explorer website (https://earthexplorer.usgs.gov/) has been used in the study. The details about the satellite imagery are given in Table 1.

Table 1: Band set data of sentinel 2B (System, 2015)

Data Acquired	Used Band name	Sensor	Band number	Sentinel-2B		Resolution (meters)	WRS Path and Row	Cloud Coverage
				Central wavelength (nm) – 2	Bandwidth (nm) – 2			
7 November 2020	Blue	MSI	2	492.1	65	10	137/44	<10%
	Green	MSI	3	559	35	10	137/44	<10%
	Red	MSI	4	665	30	10	137/44	<10%
	Vegetation Red Edge	MSI	5	703.8	15	20	137/44	<10%
	Vegetation Red Edge	MSI	6	739.1	15	20	137/44	<10%
	Vegetation Red Edge	MSI	7	779.7	20	20	137/44	<10%
	NIR	MSI	8	833	115	10	137/44	<10%
	SWIR – Cirrus	MSI	11	1376.9	30	60	137/44	<10%
	SWIR	MSI	12	1610.4	90	20	137/44	<10%

Image classification

In QGIS 3.18.3, a semi-automatic classification plugin (SCP) has been used with the "minimum distance" algorithm in the supervised classification of Sentinel-2B imagery. The minimum distance algorithm was a famous method suitable for land use classification (Ukrainski, 2017). The band sets 2 to 12 were used except for 9 and 10. Different virtual band sets were used to distinguish various land features; e.g., band sets 2, 3, and 8 were used to identify the vegetation area, reflecting the near-infrared light more than others. Then the region of interest (ROI) polygons for each category were taken based on NDVI values (System, 2019). The land-use categories and their NDVI value ranges are given in Table 2.

Accuracy assessment

The SCP plugin of QGIS arranged an accuracy assessment of the classified image. The google satellite image was used as the reference map for the real-world comparison with the classified image, which provides a high-resolution image of the real world. A simple random sampling method was used to randomly select region of interest (ROIs) points from the classified map (Congalton, 2001). Total of 476 points was collected in the QGIS software. Each point was compared with the Google satellite image, representing the real world, which was taken at the same period as the satellite image. For the calculation of accuracy, overall user and producer accuracy were calculated, and the kappa coefficient was determined (Overall accuracy [%] = 84.7434, and Kappa hat classification = 0.7739).

Table 2: Categories of land use classification, NDVI range, and description

Categories	NDVI Range	Description
Waterbodies	< 0.06	Physiographic units hold water in them. Like; ponds, rivers, lakes, wetlands.
Built-up area	0.14-0.21	These are the areas occupied by human-made structures, like, buildings, roads, monuments, bridges.

Categories	NDVI Range	Description
Sparse vegetation	0.22-0.46	Very low vegetation covers only 10 to 50% of their surface area, e.g., herbs, shrubs, scattered trees.
Dense vegetation	0.47-0.99	Very high vegetation, especially, large trees that cover more than 50% of their surface area, e.g., parks, forests.
Bare soil	0.061-0.14	Surface areas are mainly bare soil without any other physiographic units.

Shapefile management

The shape file of the DSCC has been divided into four sectors. These are North-West (zone 1 and 2), North-East (zone 6 and 7), South-West (zone 3, 4, and 5), and South-East (zone 8, 9, and 10). These four sectors consisted of ten zones which are in turn divided into 75 wards (the minor administrative boundary units) (Figure 1). These shape-file regions were used to clip out the respective areas from the classified map to calculate the sparse and dense vegetation areas. The area calculation was done by the classification report method under the semi-automatic classification plugin. To recommend the available site for creating green space, QGIS was used. The google satellite image and Open Street Map were used as references for the free space. Polygons were drawn manually and calculated from the accumulated area to find the free space for creating the new green site.

Findings

Green space status

RS-GIS (Remote Sensing-Geographic Information System) exploration of the land use of DSCC has projected out the amount of sparse and green vegetation in the area. As a whole, the study area has an amount of 30.97 km^2 covered with sparse vegetation, which stands at 31.2%, and 7.93 km^2 of dense vegetation, which stands at 7.99% of the total area. Figure 2 illustrates the land use of DSCC. This result has been further evaluated according to the different sectors, zones, and wards:

North-West Sector

The North-West sector consists of two zones (1 and 2). This sector's average sparse and dense vegetation presence is 28.66% and 5.05%, respectively (Table 3). In Zone 1, sparse vegetation is 33.22% with an area of 3.78 $km^{2,}$ and dense vegetation is 7.11% and 0.81 km^2. Zone 1 consists of 7 wards. The percentage of sparse and dense vegetation in these wards is given in Table 4. In Zone 2, sparse vegetation is 24.31% with an area of 2.84 $km^{2,}$ and dense vegetation is 3.08% and 0.37km^2. Zone 2 consists of 12 wards. The percentage of sparse and dense vegetation in these wards is given in Table 5.

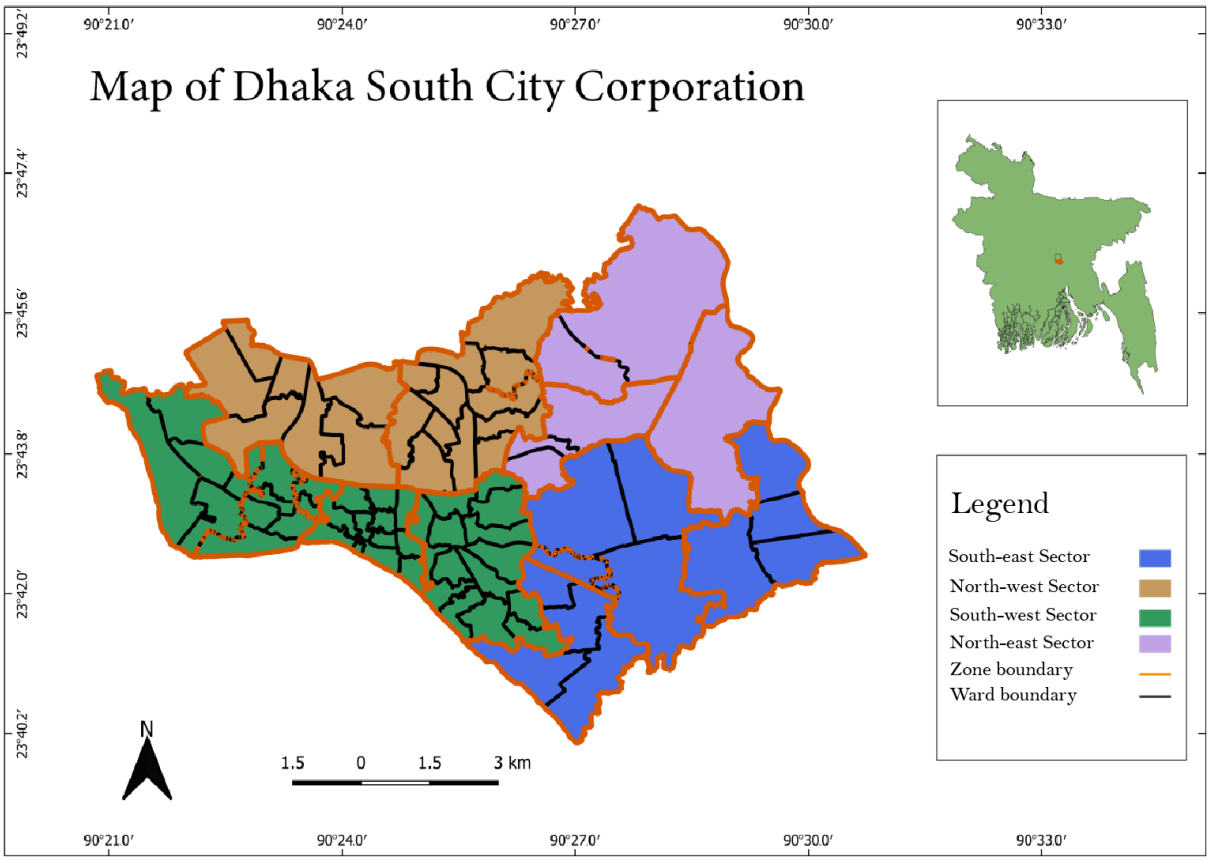

Figure 1: Shapefile of base map (DSCC) used for the study.

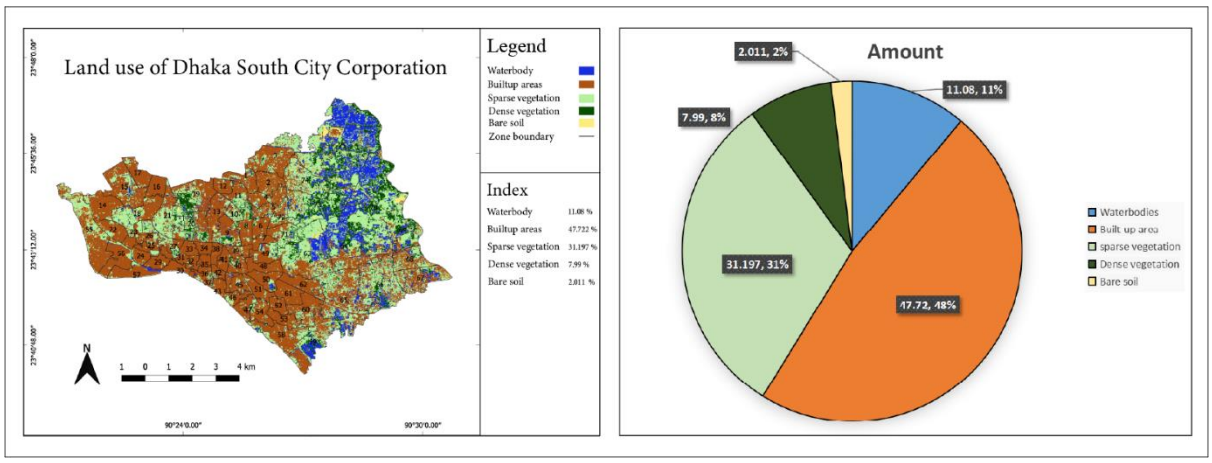

Figure 2: Land use of Dhaka South City Corporation.

Table 3: Land use in North-west sector under five categories

Category	Percentage (%)	Area (m^2)
Water bodies	4.50	1048600
Sparse vegetation	28.66	6674900
Dense vegetation	5.05	1176200
Built-up area	60.53	14098100
Bare soil	1.26	293200

Table 4: Sparse and dense vegetation percentage in different wards of zone 1

Ward No.	Name of area	Sparse vegetation (%)	Dense Vegetation (%)
15	Dhanmondi	20.50	0.82
16	Kathal Bagan	0.87	0
17	Sobhanbag, Shukrabad, Kolabagan, PanthoPath	11.23	0.04
18	Dhaka college and Newmarket area	48.28	1.97
19	Mouchak, Baily road	28.06	10.12
20	Ramna Park, Shegun Bagicha, High Court area	37.20	22.18
21	Dhaka University Area	57.26	4.60

Table 5: Sparse and dense vegetation percentage in different wards of zone 2

Ward No.	Name of area	Sparse vegetation (%)	Dense Vegetation (%)
1	Khilgaon	18.27	1.85
2	Goran	10.73	0.04
3	Ansarbag, Aftabnagar	33.20	1.25
4	Bashabo, Wahab Colony, Mother Tek	18.74	0.28
5	AhmedBag, RazarBag	29.82	1.16
6	Mugdapara	13.86	2.32
8	Komlapur	23.87	12.17
9	Motijheel	22.61	8.98
10	Motijheel	59.55	4.68
11	Shahidbag	36.76	5.67
12	Malibag bazar road, Matijhil, Malibag, Bakshi Bag, GulBag, Shanti Bag, Indrapuri	7.22	0.36
13	Chameli Bag, Aminbag, Rajarbag Police line, Old Paltan GPO, Baitul Mukarram Stadium, (Swimming pool, Sport Council), Outer Stadium, bijay nagar, New Paltan, Old Paltan Line, Traffic Police Barack, Police Hospital and C and B Field, Shantinagar and Shantinagar Bazar Area	12.80	0.30

South-West sector

The South-West sector consists of zone 3, 4, and 5. This sector's average sparse and dense vegetation presence is 15.999% and 0.74%, respectively (Table 6). In Zone 3, sparse vegetation is 21.88% with an area of 2.39 km^2 and dense vegetation is 0.28% and 0.03 km^2. Zone 3 consists of 12 wards. The percentage of sparse and dense vegetation in these wards is given in Table 7. In Zone 4, sparse vegetation is 7.94% with an area of 0.3 km^2, and dense vegetation is 1.10% and 0.043 km^2. Zone 4 consists of 11 wards. The percentage of sparse and dense vegetation in these wards is given in Table 8. In Zone 5, sparse vegetation is 12.296% with an area of 1.10 $km^{2,}$ and dense vegetation is 1.15% and 0.103 Km^2. Zone 5 consists of 15 wards. The percentage of sparse and dense vegetation in these wards is given in Table 9.

Table 6: Land use in South-West sector under five categories

Category	Percentage	Area m^2
Water bodies	2.71	643200
Sparse vegetation	16.00	3798600
Dense vegetation	0.74	175700
Built-up area	79.20	18805500
Bare soil	1.35	320200

Table 7: Sparse and dense vegetation percentage in different wards of zone 3

Ward No.	Name of area	Sparse vegetation (%)	Dense Vegetation (%)
14	Neemtola, Jigatola, Hajaribag Tenary area, Shikary tola Slum, Shonatongor	12.47	0
22	Hajaribag, Kalunagar, Bot tola	15.12	0
23	Azimpur, Nababgonj	27.70	0.29
24	Lal Bag, Amligola	10.97	0
25	Lalbag	25.08	0
26	Eden College area	39.95	2.45
27	Dhakesshori Mondir, Hosseni Dalal	36.59	0.02
28	Churi Hatta	2.08	0
29	Islam Bag	4.50	0
55	Hasan Nagar, Gudara Ghat	32.96	0.23
56	Rasulpur, Islamnagar, Kamrangi Char, Rupnagar	12.26	0.01
57	Momin Bag, Ashrafabad, Nurbag, Muslimbag, Rahamatbag	9.94	0

Table 8: Sparse and dense vegetation percentage in different wards of zone 4

Ward No.	Name of area	Sparse vegetation (%)	Dense Vegetation (%)
30	Chakbajar, Babubazar, Badamtoli.	1.16	0
31	Jail Road, Tara Mosjid	26.82	6.32
32	Jindabajar, Koshaituli	3.07	0
33	Neemtoli, Bongshal	2.46	0.02
34	Siddik Bazar, Alu Bazar, Nazira Bazar	1.22	0
35	Nayabazar, Malitola, Nababpur	0.23	0

Ward No.	Name of area	Sparse vegetation (%)	Dense Vegetation (%)
36	Ray Shaheb Bazar, Shakhari Bazar, Tati Bazar	4.08	0
37	Bangla Bazar, Patuatuli	21.21	2.59
38	Kaptan Bazar, Thatari Bazar	1.38	0
42	Dholai khal, KoltaBazar, Lakhsmi Bazar	10.19	1.09
43	Shyam Bazar, kagojitola, Forashganj, Dalpotti	8.17	0.28

Table 9: Sparse and dense vegetation percentage in different wards of zone 5

Ward No.	Name of area	Sparse vegetation (%)	Dense Vegetation (%)
7	Manik Nagar	7.85	0.07
39	Hat Khola, Tika Tuli	13.06	0.32
40	Dayaganj	15.27	4.84
41	wari	3.86	1.21
44	Kolutola, Shutrapur	6.04	0.85
45	Dhupkhola	15.49	0.09
46	Mil Barack, Gendaria	21.88	0.29
47	FaridaBad	12.75	0.07
48	Sayedabad, North Jatrabari	2.60	0
49	Golapbag	30.44	2.18
50	Jatrabari	10.03	1.72
51	Mir Hajirbag, Dolairpar	6.28	0.02
52	Janata market	3.70	0
53	Shyampur	7.49	0.31
54	Jurain	14.85	3.00

South-East sector

The South-East sector consists of zone 8, 9, and 10. This sector's average sparse and dense vegetation presence is 36.45% and 6.59%, respectively (Table 10). In Zone 8, sparse vegetation is 42.58% with an area of 3.67 km^2 and dense vegetation is 9.83% and 0.85 Km^2. Zone 8 consists of 4 wards. The percentage of sparse and dense vegetation in these wards is given in Table 11. In Zone 9, sparse vegetation is 39.40% with an area of 5.23 km^2, and dense vegetation is 5.91% and 0.785 Km^2. Zone 9 consists of 4 wards. The percentage of sparse and dense vegetation in these wards is given in Table 12. In Zone 10, sparse vegetation is 22.86% with an area of 1.55 km^2, and dense vegetation is 3.79% and 0.256 Km^2. Zone 10 consists of 4 wards. The percentage of sparse and dense vegetation in these wards is given in Table 13.

Table 10: Land use in South-East sector under five categories

Category	Percentage	Area m^2
Water bodies	12.76	3658000
Sparse vegetation	36.45	10447500
Dense vegetation	6.59	1887400
Built-up area	41.56	11909400
Bare soil	2.64	757000

Table 11: Sparse and dense vegetation percentage in different wards of zone 8

Ward No.	Name of area	Sparse vegetation (%)	Dense Vegetation (%)
66	Dogair	48.05	7.11
67	Tengra, Golakata bridge	32.37	2.81
68	Hazi Nagar, Balur Ghat	35.87	4.48
69	Demra Police Station, Mirpara Mosque	47.72	25.07

Table 12: Sparse and dense vegetation percentage in different wards of zone 9

Ward No.	Name of area	Sparse vegetation (%)	Dense Vegetation (%)
62	Shanir Akhra	8.63	0.13
63	Matuail waste treatment plant, Mridhapara	51.01	8.11
64	Konapara, Dharmikpara	37.32	8.84
65	Matuail, Tushardhara	36.93	3.25

Table 13: Sparse and dense vegetation percentage in different wards of zone 10

Ward No.	Name of area	Sparse vegetation (%)	Dense Vegetation (%)
58	Shyampur	23.37	1.82
59	Mohammadbag, Pagla	31.83	8.50
60	Rayerbag	19.66	0.73
61	Dania	2.62	0

North-East sector

The North-East sector consists of zone 6 and 7. This sector's average sparse and dense vegetation presence is 42.62% and 19.89%, respectively (Table 14). In Zone 6, sparse vegetation is 41.09% with an area of 7.73 km^2, and dense vegetation is 19.36% and 3.64 Km^2. Zone 6 consists of 3 wards. The percentage of sparse and dense vegetation in these wards is given in Table 15. In Zone 7, sparse vegetation is 48.61% with an area of 2.32 $km^{2,}$ and dense vegetation is 22.02% and 1.02 Km^2. Zone 7 consists of 3 wards. The percentage of sparse and dense vegetation in these wards is given in Table 16.

Table 14: Land use of North-East sector

Category	Percentage	Area m^2
Water bodies	23.96	5651000
Sparse vegetation	42.62	10052400
Dense vegetation	19.89	4692900
Built-up area	10.88	2565800
Bare soil	2.66	626300

Table 15: Sparse and dense vegetation percentage in different wards of zone 6

Ward No.	Name of area	Sparse vegetation (%)	Dense Vegetation (%)
70	Demra, Nalshata	42.88	22.47
74	Nandipara	54.98	12.25
75	Trimohini area	36.27	18.43

Table 16: Sparse and dense vegetation percentage in different wards of zone 7

Ward No.	Name of area	Sparse vegetation (%)	Dense Vegetation (%)
71	Manda	48.59	11.15
72	Manda	55.88	6.51
73	BegunBari, Dokhingaon	47.43	28.23

Discussion

From the data of sparse and dense vegetation in DSCC, it is clear that the distribution of green space in the city is neither equal nor in balance. In the sectoral view, only the North-East sector has sufficient dense vegetation (19.89), representing green space. But in the other three sectors, North-West (5.05%), South-West (0.74%), and South-East (6.59%) were below the minimum standard (15 to 20%) of the total area. The situation is evident at the ward level. Seventeen wards in the city contain no dense vegetation at all. Twenty-two wards have less than 1%, and the other twenty-seven wards have less than 10% dense vegetation of their total area.

Recommendation

It was an approach to find some available space to create a green zone or dense vegetation to enhance green space in the city (Figure 3). The area which was low in dense vegetation was prioritized in the process. The availability of space in each sector is given in Table 17. Besides, the DSCC covers a considerable amount of land (47.7%), where roof-top gardening could be a good solution for green space enrichment. Especially where shortages of available space for green space and scarcity of dense vegetation are present. Roadside planting and plantation around the water bodies, especially the rivers and lakes, could be a nice way to improve the city's green space. Another excellent approach would be turning the sparse vegetation area into dense vegetation. If that is possible, the scarcity of green space could be extricated in many wards. Besides these, ward-wise planning is required for sustainable management of the green space.

Table 17: Land area of recommendation for new green space

Sector	Available Sparse vegetation (km^2)	Available Desnse vegetation (km^2)	Recommended Area for New Green space (km^2)
North-East	6.67	1.18	1.59
North-West	3.80	0.18	4.143
South-east	10.45	1.89	6.58
South-West	10.05	4.69	2.55

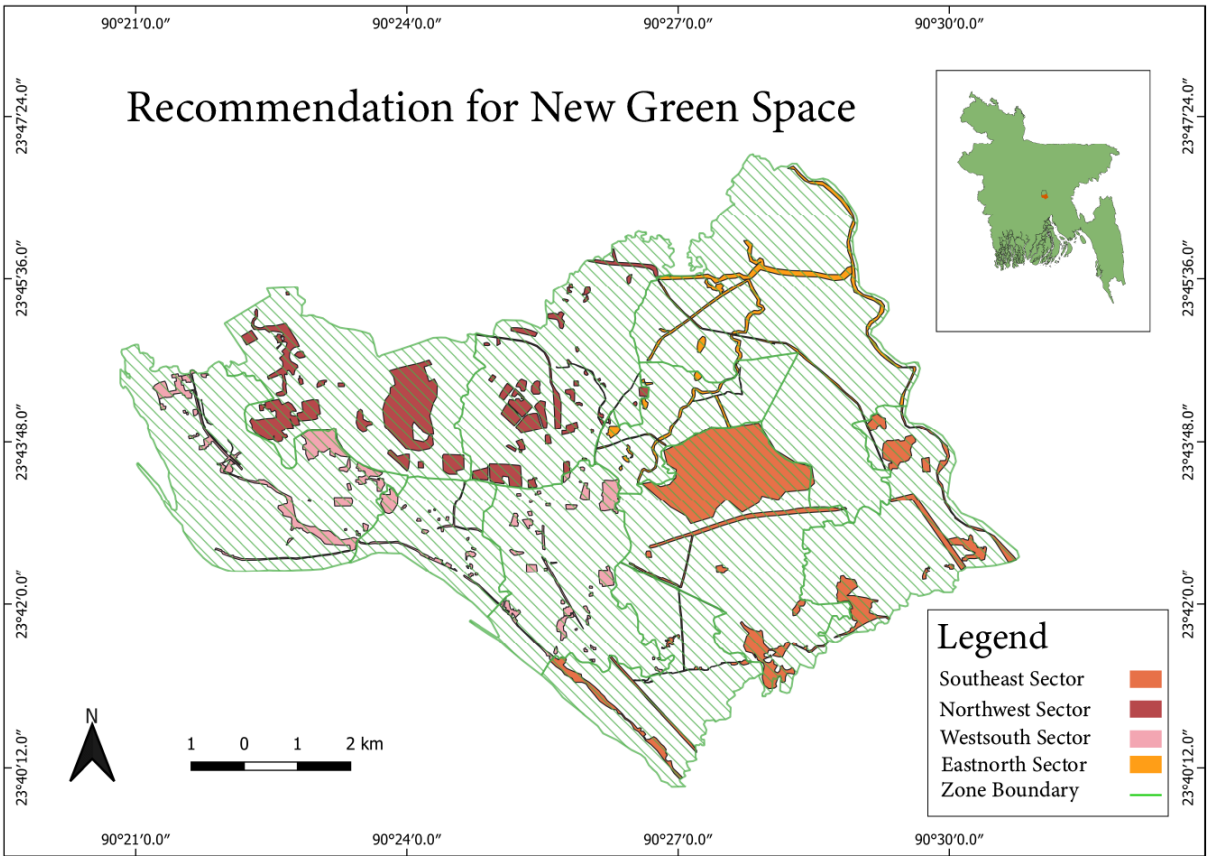

Figure 3: Map of Recommended area for new green space in different sectors.

Conclusion

According to the findings of this study, the amount of total dense vegetation that acts as the representative of green space in DSCC is way below the standard, which is 7.99%. Besides, another big concern is that the green space all over the city is not adequately distributed. 65% of green space is situated in the North-East sector, which is more than two-thirds of the total vegetation in less than one-fourth of the entire area. This kind of situation makes this city's condition more vulnerable than measured. That's why ensuring the proper distribution of green space is necessary for this city. Ward by ward approach with the appropriate planning according to the need for green space could be a convenient way in this kind of situation.

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