



A Quantitative Evaluation of Urban Green Spaces in Rajshahi, Bangladesh

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Abstract

Being a developing country, Bangladesh has faced rapid growth in urbanization in the past few decades. This results in decreasing parks and other green spaces in urban areas. Rajshahi is one of the divisional districts in Bangladesh that is prone to rapid urbanization, though the urbanization rate of Rajshahi is less than the other megacities in Bangladesh. As a result, it is important to preserve the parks in Rajshahi before they are diminished. To assess the quantity and preserve the present urban green infrastructure in Rajshahi, it is necessary to identify and categorize them according to their regional characteristics. This paper aims at evaluating the urban green spaces in Rajshahi and finding out whether the existing urban green spaces are enough to meet the goal of a sustainable city. It is done by analyzing the regional characteristics of urban parks and green spaces located in Rajshahi, Bangladesh, based on GIS data and categorizing them according to their physical size to determine their catchment area. Statistical data and aerial images are processed and simulated through ArcGIS software and correlated with cadastral plans for accurate identification. Explanatory factors regarding UGS loss in a specific region are also investigated using socio-economic, cultural, and geographic in order to find out the reason for UGS change. The resultant data shows that only 6.14 m²/capita urban open space is available for the urban inhabitants which are insufficient for achieving sustainability goals and should be preserved in order to enhance the liveability of the city.

Keywords: Sustainability; Parks; Urban greenery; Catchment area; Rajshahi

1 Introduction

Urban parks, at their core, directly affect the public health of the communities around them. They contribute to public health by reducing stress and enhancing the quality of life on a micro-scale. Despite being a vital urban element, the number of green spaces is decreasing rapidly. According to the World Wildlife Fund, green spaces cover almost 30% of the earth's surface which is decreasing at an alarming rate worldwide (Konijnendijk et al., 2013). Worldwide, the major cause of the diminishing of parks and green spaces is urbanization where around 55% of the world's population live (World Urbanization Prospects, 2018, 2018). Increased densification of urban areas results in an increase in built form thus a decrease in vegetation quantity.

In 1961, around 2.64 million people in Bangladesh lived in the urban areas which is 5.19% of the

population (Bangladesh Bureau of Statistics (BBS), n.d.). In the last few decades, Bangladesh has experienced an extremely high rate of urbanization exceedingly more than two to three times higher than that of the national population growth rate. This rapid urbanization requires more space for industries, commercial establishments, a housing facility for the increased population, and other grey areas of the urban areas.

This rapid urbanization has a negative impact on green spaces. In order to maintain ecological balance, a country should have 33% of greenery. According to FAO, the total forest area covers nearly seventeen percent of the total land area of Bangladesh and it decreasing day by day because of urbanization (Fisher et al., 1997). The overall scenario of Rajshahi is almost the same. Rapid urbanization in Rajshahi in the last few decades has resulted in a tremendous rate of increase in built form and a decrease in open spaces that include tree coverage. Only a few sets of public parks are left intact until now in the city corporation area in Rajshahi. “From 2001 to 2019, Rajshahi lost 12ha of tree cover, equivalent to a 2.9% decrease in tree cover since 2000, and 3.38kt of CO₂ emissions. In 2010, Rajshahi had 105ha of tree cover, extending over 0.043% of its land area. In 2012, it lost 140mha of tree cover” (*Rajshahi Deforestation Rates & Statistics / GFW*, n.d.). This loss in vegetation cover has occurred mainly in urban areas. Study shows that in 2029 and 2039, approximately 70% and 88% of Rajshahi will experience a temperature of more than 38 °C respectively as a result of urbanization, unplanned development, and drastic loss in vegetation cover (Kafy et al., 2020).

This reduction in vegetation cover has adverse effects. Rural and suburban regions generally have 2 to 4 degrees Celsius less land surface temperature than urban regions (Lai & Cheng, 2010). This phenomenon results from urbanization, climate change and rapid global warming (World Bank, 2016). Another study opined for the December-February period, the average maximum and minimum temperatures showed a decreasing and increasing trend of 0.1 0C and 1.60C respectively (Rahman & Lateh, 2017). On the contrary, “A city with substantial green spaces represents good planning and management, a healthy environment for its dwellers, vegetation and wildlife populations” (Adams, Leedy, 1986). The air remains comparatively cool by the urban green spaces it flows through. Thus, urban green spaces purify the air as the “lungs of the city” (*Open Space Protection Plan*, n.d.).

1.1 Study Area

Generally, urban open spaces serve the purpose of public assembly particularly e.g., open markets, parks, grand streets, plazas, playfields, etc. However, this research only focuses on the parks of Rajshahi Development Authority (RDA) authorized area in Rajshahi, Bangladesh, other than its streets and roads or plazas. These parks in Rajshahi have great impacts on human interaction through citizens' sensory involvement and their participation at both the community and district levels.

Public parks within the RDA-authorized area are taken under consideration for this particular research and their physical size and functional characteristics are analysed. According to their physical size, they will be categorized and their catchment area will be determined.

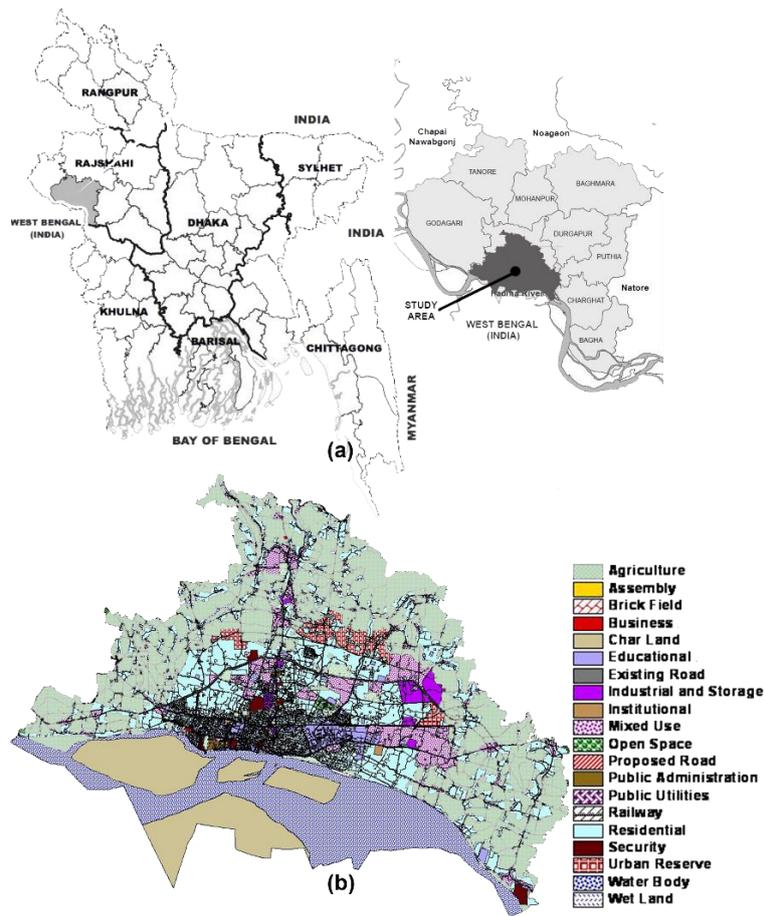


Fig. 1 :(a) Study Area Map, (b) Rajshahi Metropolitan Development Map

The land use map of Rajshahi Metropolitan Development plan shows that green spaces consist in only the suburban areas. These suburban areas contain all the agricultural lands where scarcity of parks can be seen within the dense CBD area. Again, Residential and Institutional zones constitute the most densely populated area of Rajshahi. Parks can be hardly seen in these areas.

2 Literature Review

Understanding the regional characteristics of urban green spaces is necessary prior to categorization. Preserving green spaces can improve the quality of urban life in terms of social and environmental aspects.

2.1 Urban Green Space Categorization

According to the standard, public parks and open spaces that work as community gathering spaces can be divided into seven different categories based on their physical size. This differs with the type of urban green space and the attractiveness and accessibility conditions.

Table 1: Green Space categorization (*Policy 7.18 Protecting Open Space and Addressing Deficiency | London City Hall, n.d.*)

Green Space categorization	Size Guideline	Distance from Home
<p>Regional Parks</p> <p>Large areas, corridors, or networks of open space, the majority of which will be publicly accessible and provide a range of facilities and features offering recreational, ecological, landscape, cultural, or green infrastructure benefits. Offer a combination of facilities and features that are unique within London, are readily accessible by public transport, and are managed to meet best practice quality standards</p>	400 hectares	3.2 to 8 kilometres

Green Space categorization	Size Guideline	Distance from Home
Metropolitan Parks Large areas of open space that provide a similar range of benefits to Regional Parks and offer a combination of facilities at a sub-regional level, are readily accessible by public transport and are managed to meet best practice quality standards	60 hectares	3.2 kilometres
District Parks Large areas of open space provide a landscape setting with a variety of natural features providing a wide range of activities, including outdoor sports facilities and playing fields, children's play for different age groups, and informal recreation pursuits.	20 hectares	1.2 kilometres
Local Parks and Open Spaces Providing for court games, children's play, sitting-out areas, and nature conservation areas.	2 hectares	400 meters
Small Open Spaces Gardens, sitting-out areas, children's play spaces, or other areas of a specialist nature, including nature conservation areas	Under 2 hectares	Less than 400 meters (300m)
Pocket Parks Small areas of open space that provide natural surfaces and shaded areas for informal play and passive recreation that sometimes have seating and play equipment.	Under 0.4	Less than 400 meters (200m)
Linear Open Spaces Open spaces and towpaths alongside the Thames, canals, and other waterways; paths, disused railways; nature conservation areas; and other routes that provide opportunities for informal recreation. Often characterized by features or attractive areas which are not fully accessible to the public but contribute to the enjoyment of the space.	Variable	Wherever feasible

2.2 Per Capita Urban Green Space (UGS)

UGS Per capita is determined by the ratio of total UGS covered area in square meters to the total urban population in the study area. The resultant value is expressed in m²/capita unit (Russo & Cirella, 2018). Symbolically,

$$Per\ Capita\ UGS = \frac{Total\ UGS\ Area\ (TUGS)}{Total\ Population\ in\ the\ Study\ area\ (TP)} \quad (1)$$

According to the WHO, a minimum of 9m² of urban green space per capita is needed for healthy living (Russo & Cirella, 2018).

2.3 Urban Green Space Abundance (%UA)

Percentage of UGS abundance i.e., %UA is the rate of UGS area to the total study area where the areas are expressed in Km² unit (M'Ikiugu et al., 2012).

Symbolically,

$$\%UA = \frac{UGS\ Area(UA)}{Total\ Study\ Area\ (TA)} \times 100\% \quad (2)$$

This percentage can be calculated for each UGS category as well which is then called Proportional UGS abundance (PUA). PUA is the percentage of total area (TA) comprised of a specific class of UGS (M'Ikiugu et al., 2012).

Symbolically,

$$PUA = \frac{\text{Specific Class of UGS Area}(SUA)}{\text{Total Study Area}(TA)} \times 100\% \quad (3)$$

Proportional UGS abundance (PUA) provides a basis for determining which category of UGS is deficient and needs expansion. Proportional diversity of UGS (PDU) is also used to evaluate the correlation among UGC categories. The proportional diversity of UGS (PDU) is the percentage area of UGS occupied by a specific class (M'ikiugu et al., 2012).

Symbolically,

$$PDU = \frac{\text{Specific Class of UGS Area}(SUA)}{\text{Total UGS Area}(UA)} \times 100\% \quad (4)$$

3 Research Methodology

Statistical data from RDA and arial image with an average resolution of 5m is taken. To integrate the data into a spatial database, ArcGIS 10.8 software is used. The data were then correlated with cadastral plans for an accurate identification of the urban green categories.

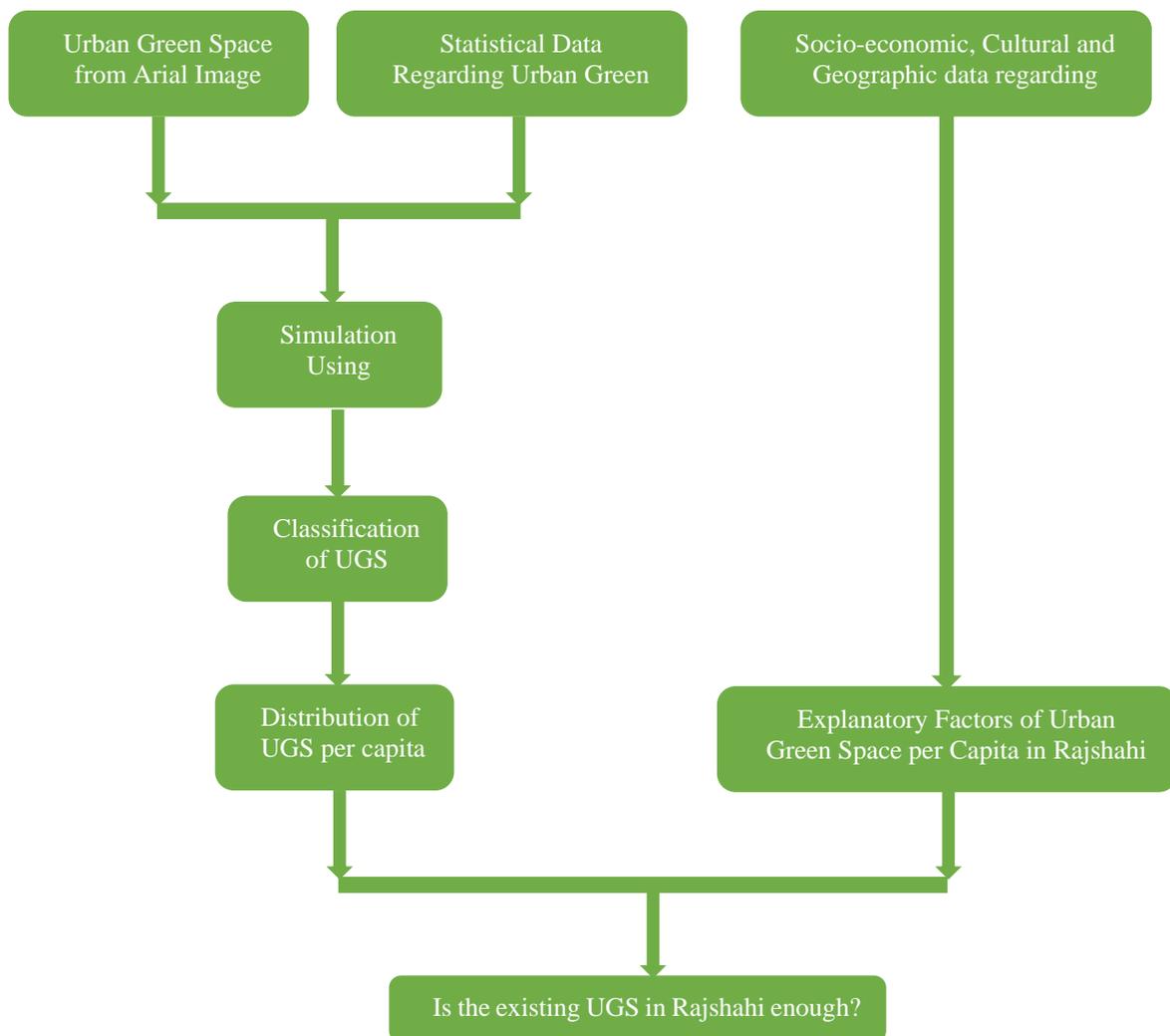


Fig. 2: Flow Diagram for Evaluating Urban Green Spaces in Rajshahi

3.1 Selecting Urban Green Spaces in Rajshahi

A set of regional characteristics of public open space is taken under consideration for selecting the suitable green spaces for this research. These regional characteristics include public accessibility, function, vegetation, etc. Green spaces which are not publicly accessible, such as private lawns, roof gardens etc. are not considered for this study.

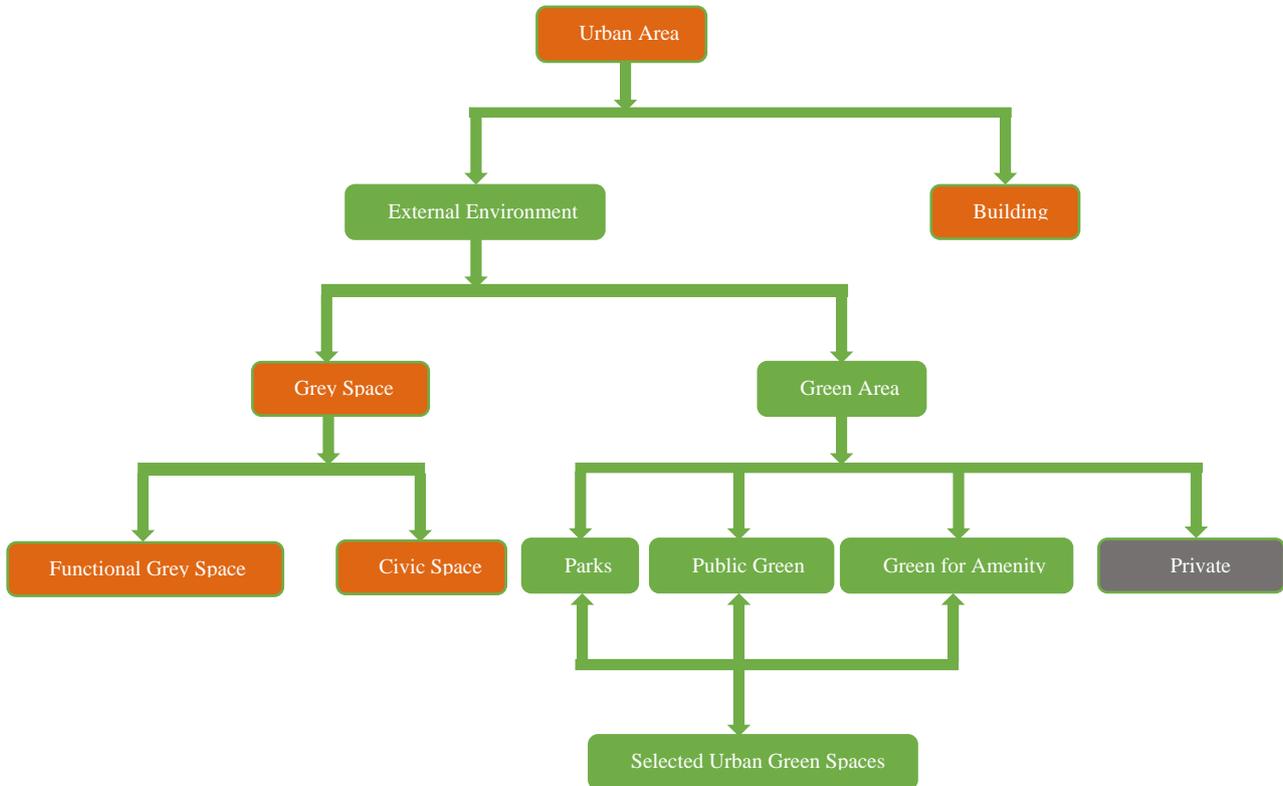


Fig. 3: Selection Criteria

3.2 Classification of Urban Green Spaces

A digitized land use map of the area authorized by the Rajshahi Development Authority (RDA) is considered as the base map in ArcGIS software. Urban open spaces that include public parks, gardens, playgrounds, and roadside linear parks are extracted from the attribute table content. These open spaces are then categorized according to their physical sizes. A universal urban open space categorization dataset prepared in the “London Plan” is used in categorizing the open spaces in Rajshahi (*Policy 7.18 Protecting Open Space and Addressing Deficiency | London City Hall, n.d.*). These urban open spaces are then extracted as separate shapefile layers according to their category.

3.3 Defining Catchment Area

After extracting the shapefiles of each category, they are linked in QGIS software for determining their catchment area. Each category of urban open space has a different catchment area. The universal urban open space categorization dataset prepared in the “London Plan” is also used herein determining the catchment area. QGIS buffer tool is used for determining the catchment area. Here the buffer area ranges from 200m to up to 1.2 km according to their category (*Policy 7.18 Protecting Open Space and Addressing Deficiency | London City Hall, n.d.*). This buffer area graphically shows the green catchment coverage in overall Rajshahi city and helps to determine the grey area where the green network is poor.

3.4 Analysing Urban Open Spaces

For Analysing and calculating the %UA, PUA, and PDU of the extracted open spaces from the digitized map, the ‘Summary Statistics’ tool is used in ArcGIS software. The summation of the area of each UGS category is calculated by the ‘Summary Statistics’ tool and then %UA, PUA, and PDU are calculated using equations (1), (2), and (3), respectively.

4 Result and Discussion

4.1 Mapping Urban Green Spaces according to Category

Analysing the GIS data, it is found that a total of 411 parks of four different categories are found within the site area. There are 53 district parks, 83 small open spaces, 270 pocket parks, and 5 linear parks present in the site area. No parks have met the criteria of being regional parks, metropolitan parks, or local parks.

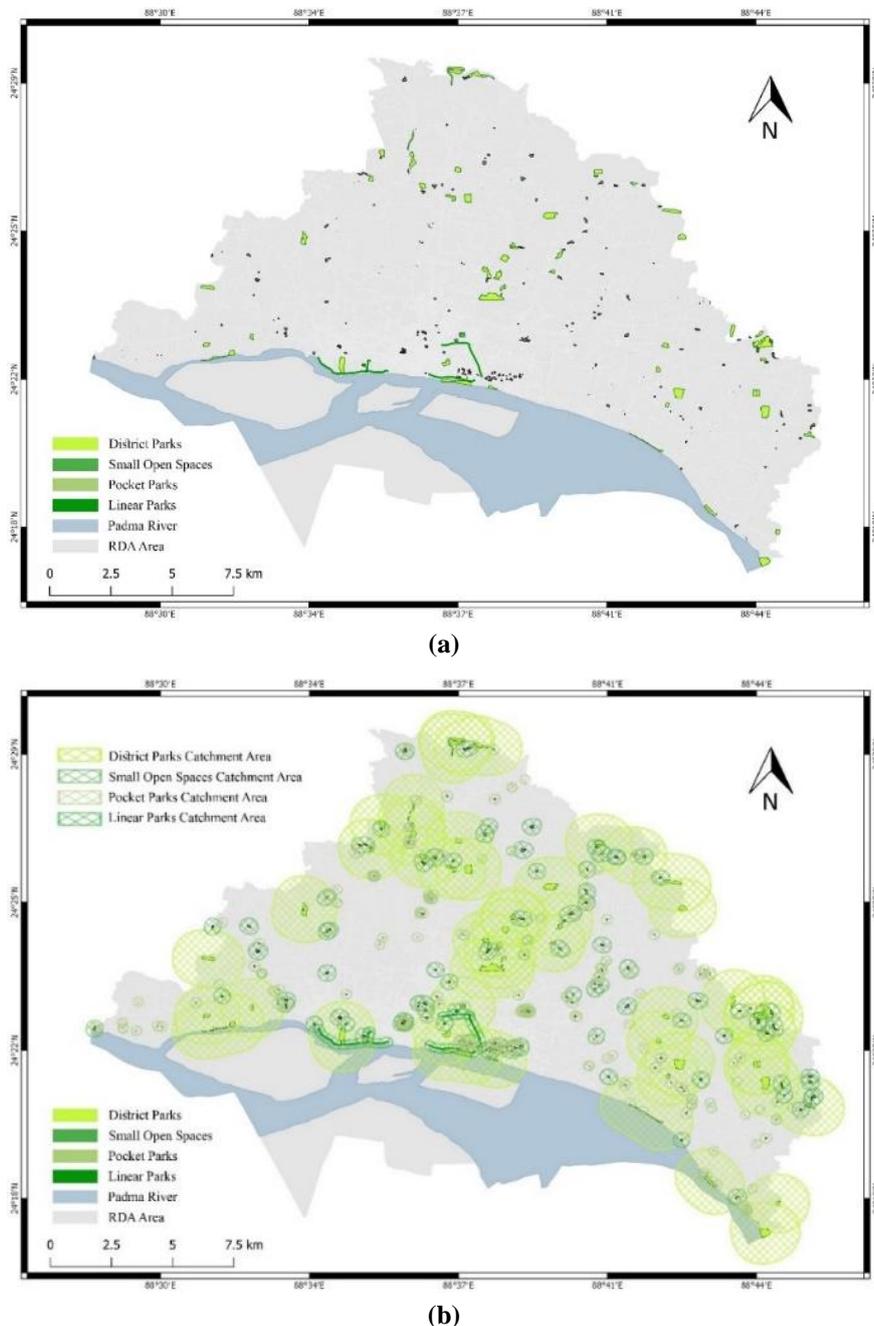


Fig. 8: (a) Urban Green spaces in Rajshahi, (b) Catchment Area of All Urban Green Spaces

Figure 8 shows the catchment area of each urban green spaces in Rajshahi. It shows that approximately 50% of the study area is deprived of the catchment area of any green spaces. Again, all the green spaces are in a clustered formation. It occurs due to clustered urban development characteristics of Rajshahi. The city centre is located at the bank of Padma River. This CBD area is covered with a large catchment area of a linear district park. Socio-demographic data shows that all the deprived neighbourhoods from the catchment area are commercially advanced compared to other zones. From the analysis of the catchment area of each urban park and open spaces available in Rajshahi, it is found that urban parks are situated in a clustered manner. Some locations have a considerable number of parks where the other parts of the city have no parks at all. Again, small open spaces and pocket parks cannot serve the city equally but accessibility is high here. The scarcity of linear parks shows the uninviting walking environment in the streets of Rajshahi.

4.2 Per Capita Urban Green Space (UGS) Calculation

Analysing the attribute tables of each urban park category, the area of District Parks, Small Open Spaces, Pocket Parks, and Linear Parks are found and their summation is calculated by using the ‘Summary Statistics’ tool in ArcGIS.

Table 2: Area of Each Park Category

Category	Area in Sqm Unit
District Parks	3319770
Small Open Spaces	753020
Pocket Parks	202080
Linear Parks	25200
Sum	4300070

From this data, UGS per capita in Rajshahi can be calculated using equation (1)

$$\text{Per Capita UGS} = \frac{4300070}{700133} = 6.14 \text{ m}^2/\text{capita}$$

Rajshahi has 6.14 m²/Capita UGS where the mean ideal value is 9m²/capita according to WHO. This result explains the deficiency of urban parks in Rajshahi City. This does not meet the minimum UGS per capita criteria. Hence, number of parks and other green spaces must be increased in order to enhance liveability.

4.3 Urban Green Space (UGS) Abundance (%UA) Calculation

The total area covered by urban parks in Rajshahi and the total study area are calculated from the attribute table. Data shows that the total area covered by urban parks in the study area is 4.30 km², and the total study area consists of 364.825 km². From this data, the percentage of urban green space abundance can be calculated using equation (2)

$$\%UA = \frac{4.30}{364.825} \times 100\% = 1.179\%$$

Proportional UGS abundance (PUA) is also calculated from the attribute table data. PUA is calculated using equation (3) for each category.

Table 3: PUA Calculation for Each Park Category

Category	$PUA = \frac{\text{Specific Class of UGS Area}(SUA)}{\text{Total Study Area (TA)}} \times 100\%$
District Parks	0.91%
Small Open Spaces	0.206%
Pocket Parks	0.06%
Linear Parks	0.007%

Proportional diversity of UGS (PDU) is also calculated with the data found from the attribute table using equation (4) to evaluate the correlation among UGC categories. This PDU data for each category helps to determine which category needs future expansion.

Table 4: PDU Calculation for Each Park Category

Category	$PDU = \frac{\text{Specific Class of UGS Area}(SUA)}{\text{Total UGS Area (UA)}} \times 100\%$
District Parks	77.20%
Small Open Spaces	17.51%
Pocket Parks	4.70%
Linear Parks	0.59%

5 Conclusion

The government of Bangladesh aims to make cities and human settlements inclusive, safe, resilient and sustainable and provide universal access to safe, inclusive and accessible, green and public spaces (Johnston, 2016). This study shows that only 6.14 m²/capita urban green space is available for the inhabitants which are only 1.179% of the total study area. Proportional UGS abundance (PUA) and Proportional diversity of UGS (PDU) are also calculated for each open space type. These urban parks and open spaces safeguard the quality of precious life-giving resources that are very limited in quantity in the case of Rajshahi. Hence, preserving the open spaces in Rajshahi should be given top priority that can be achieved through proper planning and collaboration of the governing bodies.

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