Assessing Accessibility to Public Open Spaces of Rajshahi City Corporation Area Through Space Syntax Analysis

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***Abstract*— Rajshahi, the fourth largest metropolitan city in Bangladesh has numerous public gathering spaces. Open and recreational spaces are the heart of a city & these areas should have high accessibility as huge public gathering occurs here and public interaction are generated over here. It can be observed from the plan of Rajshahi City Corporation that these open and recreational spaces have potential to be accessible from the major residential and other vibrant areas of the city. Therefore, the aim of this paper is to study the accessibility and integration of selected open and recreational spaces of Rajshahi City Corporation using "space syntax" method and also providing strategies for enhancing accessibility to these public open spaces that would contribute to the development of Rajshahi Metropolitan Development Plan (RMDP).**

Index Terms— Open Space, Recreational Space, Accessibility, Space Syntax,Integration

I. INTRODUCTION:

Rajshahi is a divisional and primate city in the northern region of the country . With gradual increase in the importance of Rajshahi as an urban centre, many government establishments and supporting land uses have developed in the city over the years.All the activities in Rajshahi are centered around the Padma river. It's the breathing space of the city and also the city emerged from this point. A city functions soundly when it's public spaces function soundly. Public spaces shape the character of a city. These are essential for the purpose of different public functions, recreational and leisure activities of the urban dwellers. Lack of open spaces is detrimental to urban life**.** Therefore, while planning and designing the city open and recreational spaces should be given utmost importance.

What is alarming is that due to rapid urbanization open spaces are reducing uncontrollably. Hence, time has come to think how a well-connected city layout can be created by ensuring accessibility to all open and recreational spaces of the city so that these can be easily reachable from any point of the city.Accessibility ensures sustainability. As number of access road increases the environment becomes more responsive. Accessibility is important at two levels _ The city as a whole and it's immediate local. Due to limited scope of a paper this research deals with location of open spaces and their access. This paper deals with potential recreational hub of Rajshahi city and accessibility of selected open and recreational spaces are analyzed here using "space syntax.

Paths, roads and airports provide access to destinations and therefore activities(also called opportunities).Accessibility can be defined in terms of potential opportunities that could be reached or in terms of activity (opportunities that are reached). Even people who don't currently use a particular form of access may value having it available for possible future use, called option value. For example, motorists may value having public transit services available in case they are unable to drive in the future. The potential accessibility measures are based on the prediction of travel distribution in which some weights in function of cost, time or distance to arrive to the opportunities are applied [1].Spatial configuration refers to the relative arrangement of parts or elements within three-dimensional space. The spatial configuration affects to pedestrians when they have to take the decision about what route they select for their trips. Therefore, the spatial configuration could encourage or discourage the election of a route about which pedestrian can to arrive to the opportunities [2], even more if the streets have different design properties. This effect of spatial configuration on pedestrian mobility has created a new concept in planning studies, the concept of "the natural movement" [3] (Hillier et al, 1993).Spatial configuration has impact on both pedestrian and vehicular accessibility. The size, volume and type of land use determine the extent of vehicular movement to reach at a public space.

II. BASIC INTRODUCTION OF TERMS RELATED TO SPACE SYNTAX:

Space syntax is a method for describing and analyzing the relationship between social structure and spatial structure. The analysis of the urban grid is based on axial map. The axial map is a planar connected configuration consisting of the fewest longest straight lines covering all urban public spaces. These lines correspond to the image of physical and visual continuity tested by people who are static or in movement in the system [4]. Example below:

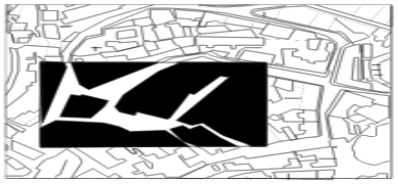


Figure 1.A segment selected in Castelo Lisbon

Figure 2: The corresponding axial map. (Tereza V Heitor ,Jorge Orestes Cerdeira and Roul Cordovil, 1997)[5]

Different terms associated with space syntax is discussed below_

Integration is a key term in space syntax which means the average depth of a space to all other spaces in the system. The spaces can be ranked from most integrated to most segregated. **Global Integration** provides a global index of relative integration and **Local integration** relate to the spatial propertied of space up to three steps (R=3) away from the root. Axial lines with warmer color indicate high global or local integration value.The pedestrian accessibility to public spaces is analyzed usually in terms of time or distance oftrips along the pedestrian network. This network and its configuration is a key factor to collect the pedestrian flows at different scales in the city, neighborhood quarter etc [6].

III. METHODOLOGY

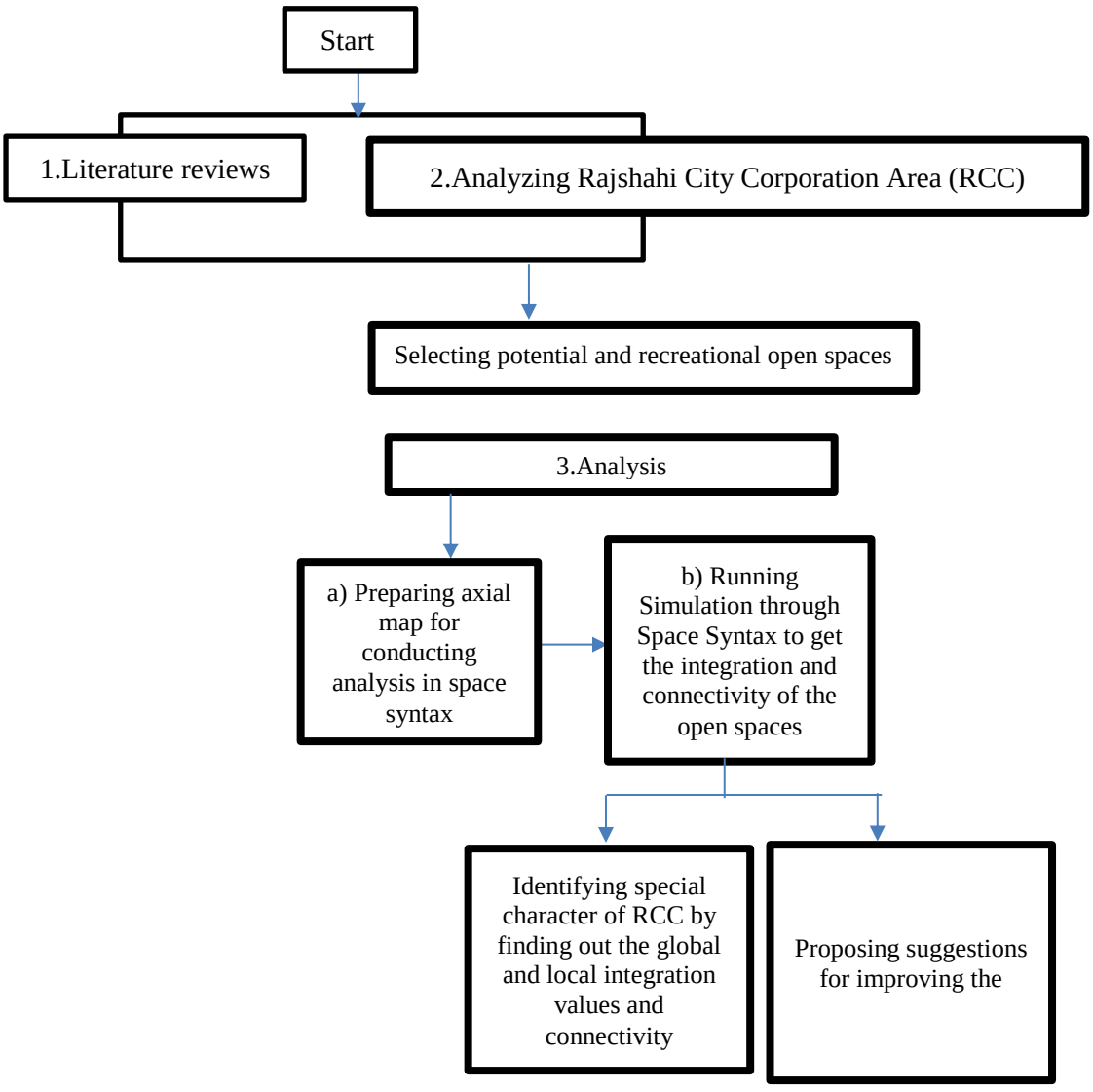


Figure:03: Flow chart diagram showing the research methodology

The steps followed in the research are given below-

1.Literature review explaining the context of pedestrian accessibility in urban scenario, the impact of spatial configuration on accessibility.

2.Analyzing thoroughly the RCC area to find out potential open and recreational spaces.

3.The analysis part is divided into following steps-

- First of all the axial map of Rajshahi City Corporation have been prepared form GIS.
- Then the map have been imported to depth map (Space syntax) and from that graph analysis have been done.
- From the graph analysis Global integration (R=n) and local integration (R=3) map andalso the connectivity map have been prepared.
- The global, local integration values and the connectivity of roads are collected from table using depth map.
- From observing the values of integration and connectivity of each of the open spaces suggestions regarding development of accessibility is further proposed in the later part of this research

IV. STUDY AREA

This research work is developed on the pedestrian network of Rajshahi City Corporation and it's public spaces. **Public space** is a social space that is generally open and accessible to people. Public space refers to diversity of spaces such as roads (including the pavement), public squares, parks and beaches etc. The term 'public space' is also often misconstrued to mean other things such as 'gathering place' which is an element of the larger concept of social space.

Under functional Master plan of Rajshahi division, 25 Spatial Planning Zones (SPZ) have been created for the purpose of detailed area planning. Of these 12 zones are in proposed urban area and 13 zones are within extended area.For the purpose of study of this paper, open and recreational zones from SPZ-17 have been chosen due to existence of higher percentage of public space in this zone compared to other SPZs of Rajshahi division (Souce-Detailed Area Plan of Rajshahi)

From studying all the SPZs , it has been identified that SPZ-17 has one of the major effective recreational spaces . It has padma river on the south which is the primary source of recreation for the inhabitants. Therefore, six sample areas from SPZ-17 have been chosen for analyzing accessibility due to it's major volume of public use.

General Info of SPZ-17

Area -1679.85 acres ,
Population- 91384 (Census-2001),110564(Census-2014),
Open space- Existing land use-50.46 acre (3%),
Proposed land use-90.34 acre(5.38%) ,
Public utilities , communication and transport- Existing land use- 102.42 acres (6.10%)
Proposed land use- 30.53 acres (1.82%)
(Source RMDP 2004-2024)[7]

The major important establishments of SPZ-17 are:

Parjatan Motel, National Tennis Complex, Shilpakala Academy, Barendra Museum,Public Library,National zoo, Central Park, Shah Makdum Mazar,5 play fields including trade fair field,T & I Groin, Open space and recreational activities at bank of Padma etc. It also has major educational buildings, Bangladesh Bank, BTV, Bangladesh Betar etc.

The land use map of RCC area, blow up of land use plan of SPZ-17, selected open and recreational spaces from RCC area, the global and local integration map and connectivity map of RCC area are shown in Figure-04, 05, 06, 07, 08 and 09 respectively. In Table-01 the names of the selected open and recreational spaces are given.

Land use map of RCC area

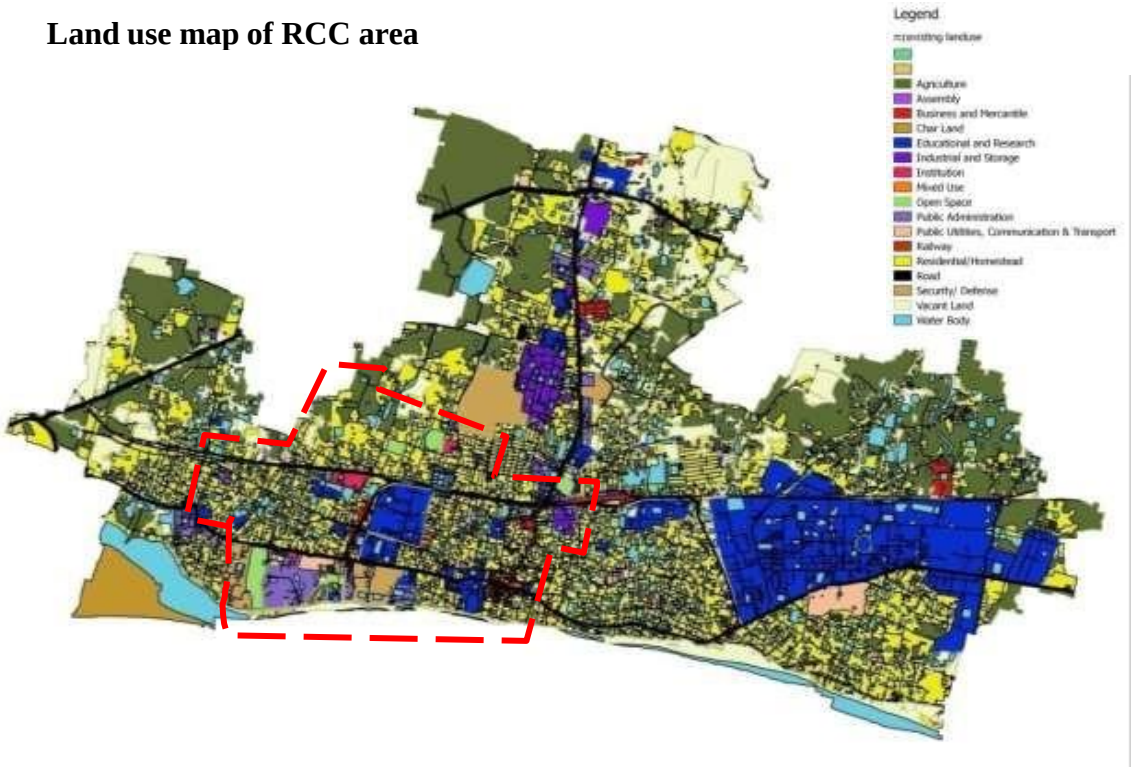


Figure-04: Land use map of RCC demarcated area shows SPZ-17(Source: Rajshahi Development Authority, RDA)

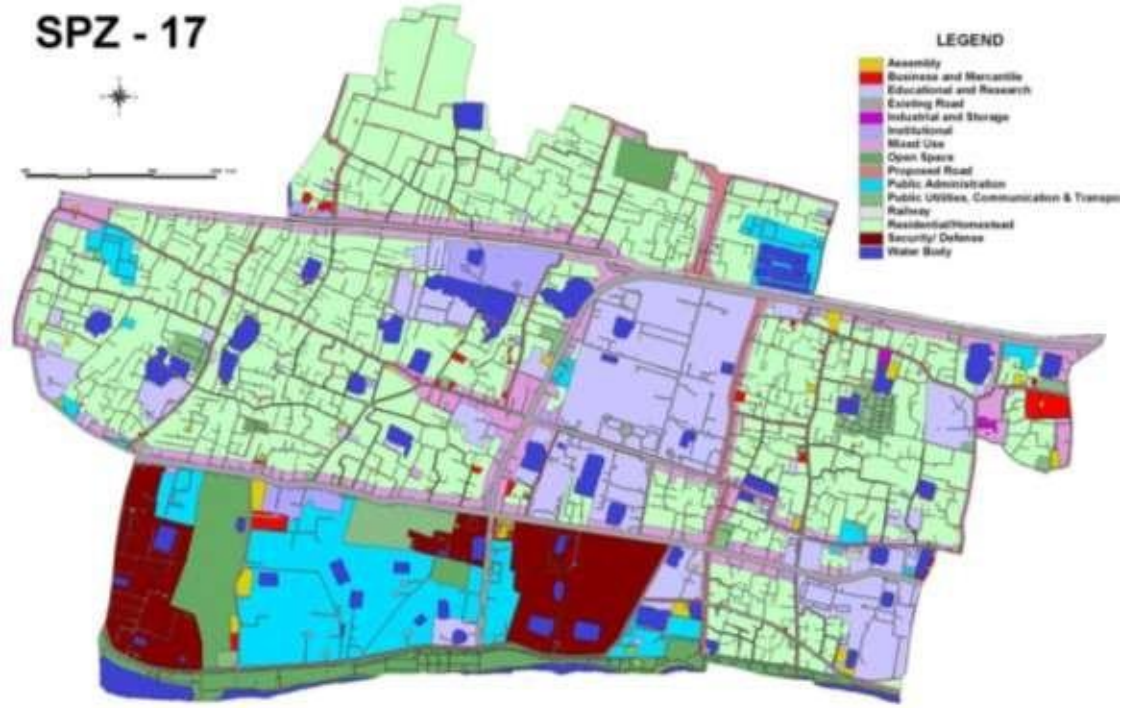


Figure-05: Blow up land use of SPZ-17 (Source: Rajshahi Development Authority, RDA)

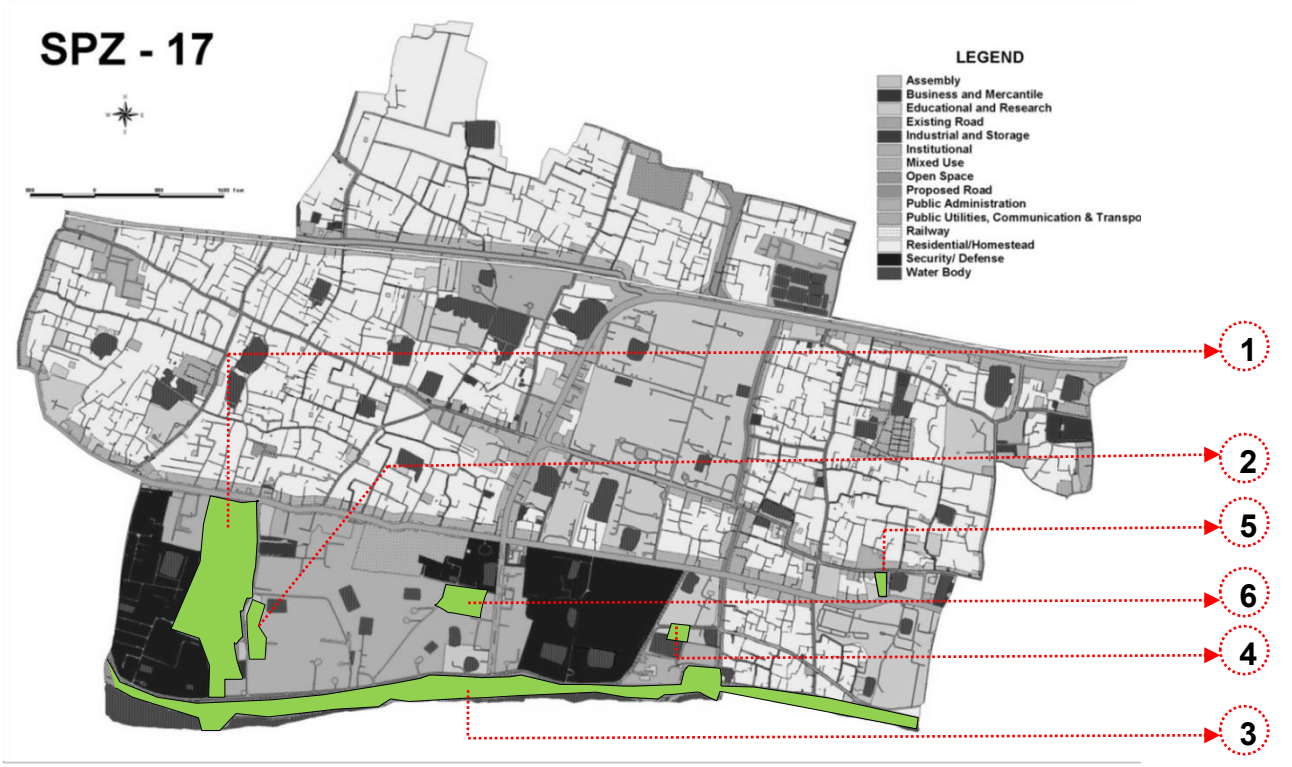


Figure 06:Significant open and recreational spaces of SPZ-17 chosen as sample areas

Table 1: Sample areas that are chosen from SPZ-17 for analyzing accessibility and integration

Space No.	Space Name	Space No.	Space Name
1	Central Park & National Zoo	**4**	Public Library
2	Tennis Complex	**5**	Barendra Museum
3	Open Space at bank of Padma	**6**	Trade fair field

V. SPATIAL ANALYSIS OF RAJSHAHI CITY CORPORATION: AN ASSESSMENT OF RECREATIONAL OPEN SPACES,GENERAL SPATIAL CHARACTER OF RAJSHAHI CITY CORPORATION:

In the process of analysis on depth map, after preparing the integration and connectivity maps, the most integrated road from global and local integration map and road with maximum connectivity are identified. Then access roads to the sample areas have to be identified and the integration and connectivity values need to be identified. Finally by comparing the individual public spaces with respect to the mean integration value of the region we can observe the existing scenario of accessibility within selected areas and also can identify the points to improve.

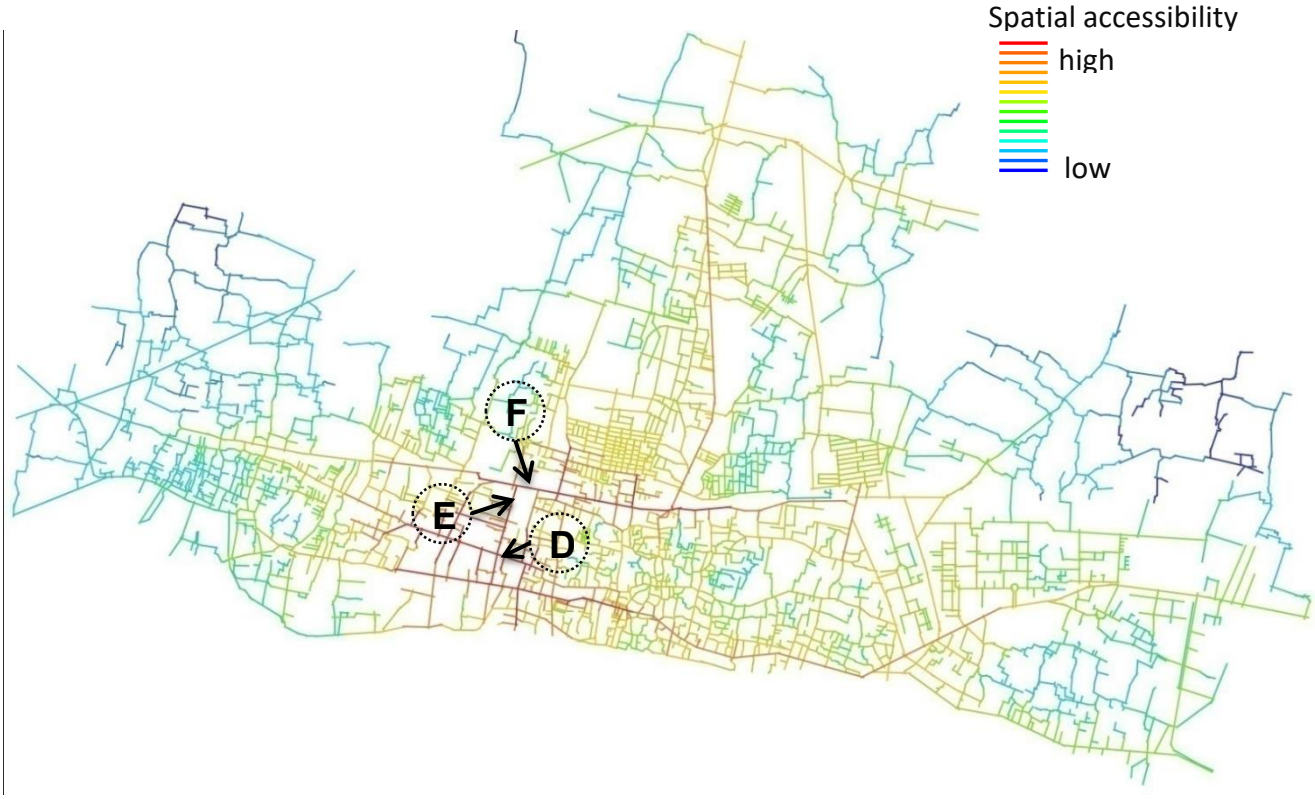


Figure-07: Analysis of Global Integration of RCC area [HH] R=n

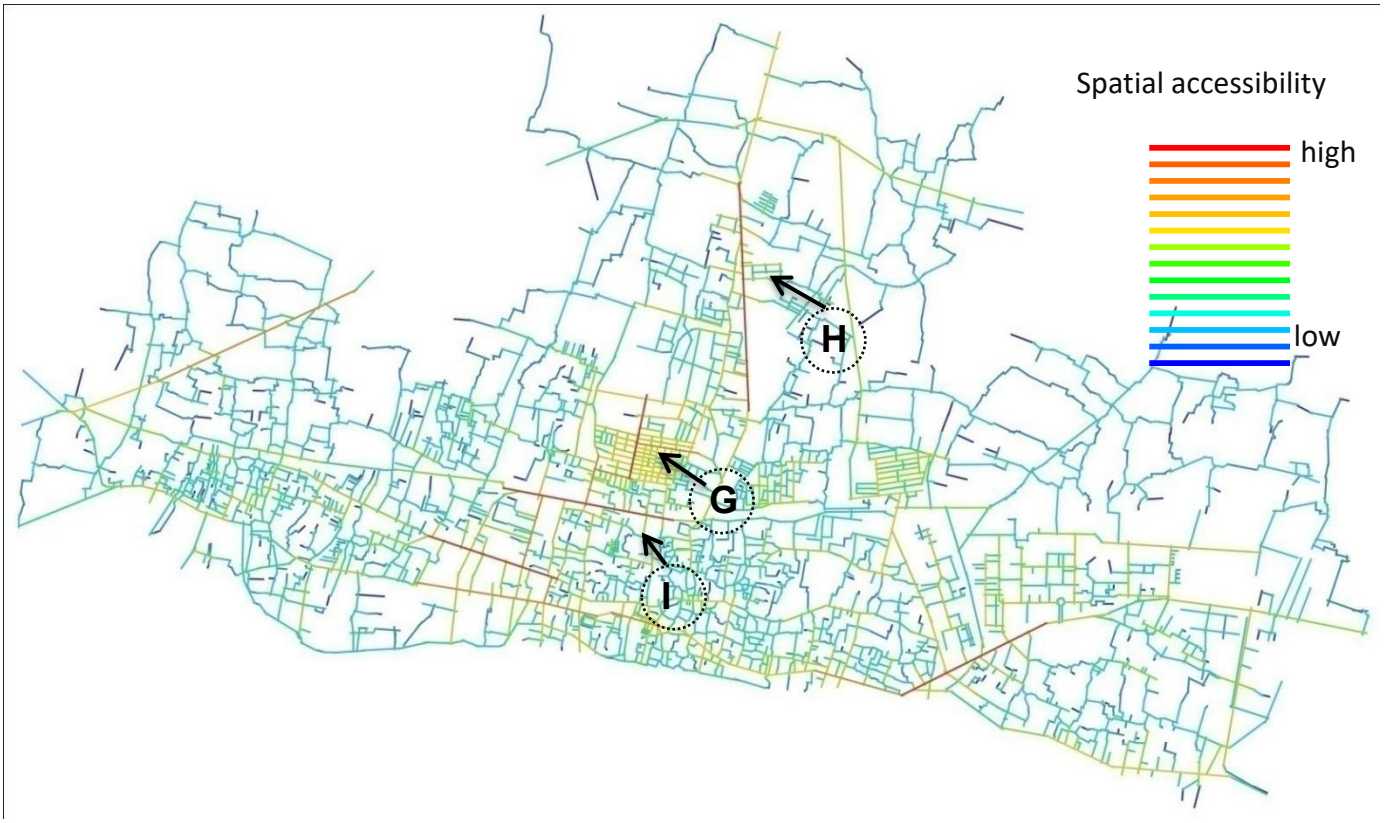


Figure-08: Analysis of local Integration of RCC area[HH] R=3

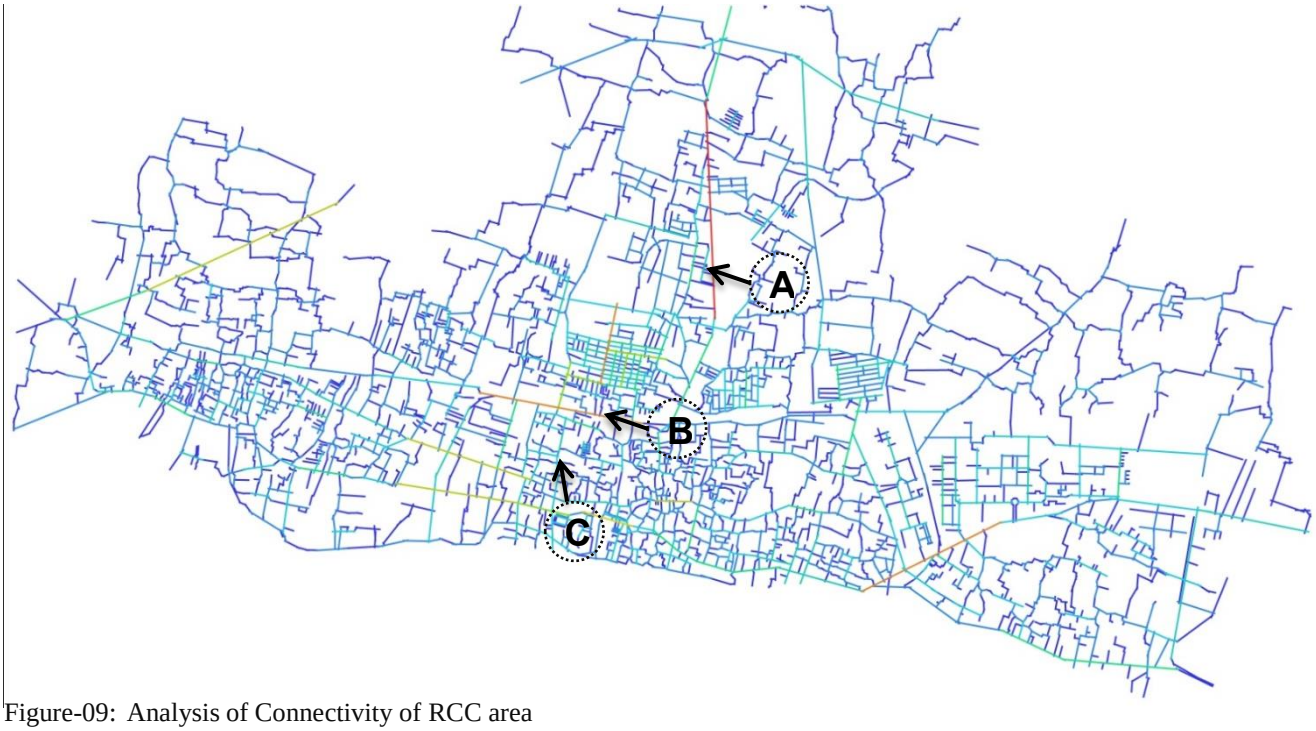


Figure-09: Analysis of Connectivity of RCC area

From Figure-07, 08 and 09 it is observed that the axial map of Rajshahi City corporation have been analyzed by depth map and Globalintegration (R=n), Local integration (R=3) and connectivity measures are identified. The most integrated roads in terms of global and local integration and roads with maximum connectivity are identified from Figure-07, 08 and 09 (Table-02). **1%** core is considered for analyzing highest values in Global context(Road-D-F,Fig: 4),LocalContext (Road-G-I,fig-5) and also for analyzing connectivity (Road-A-C,Fig-6).Roads havinghigher values are marked with warmer colors such as red, orange.

Table 2: Most integrated road and Roads with maximum connectivity

D,E,F (Fig-07)	Most integrated road(R=n)
G,H,I (Fig-08)	Most integrated road(R=3)
A,B,C (Fig-09)	Roads with maximum connectivity

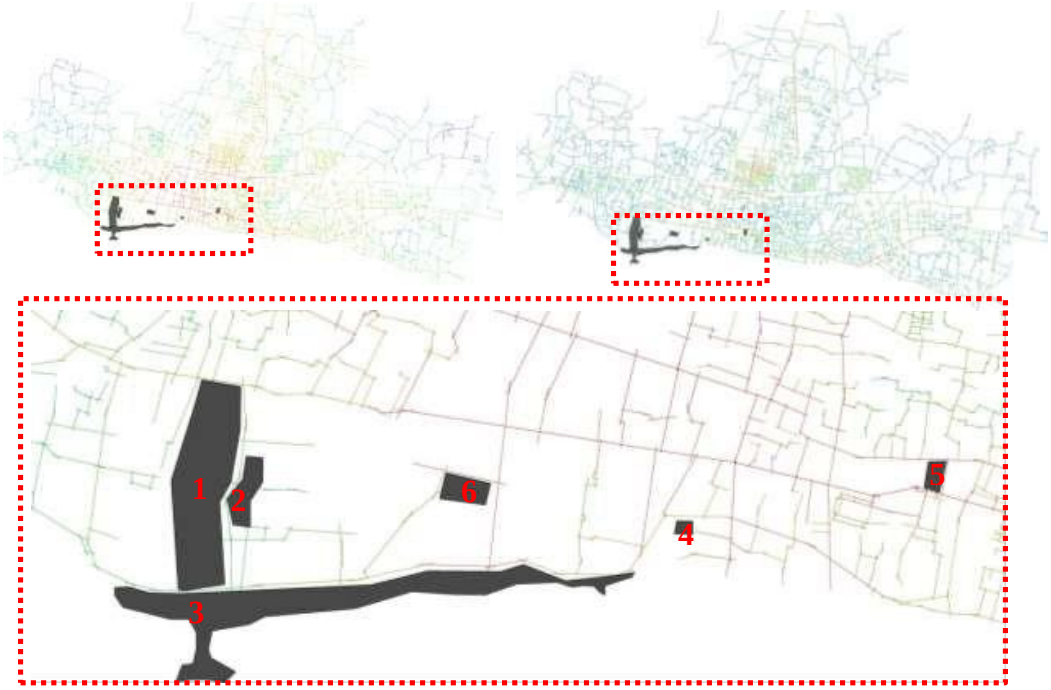
Table 3: Global Integration values, Local Integration values and connectivity of roadsshown on Figure-07,08,09 (Roads having high integration globally and locally and most connected roads, also their mean, max, min value)

Road No(ref:Figure:7,8,9)	**Global Integration[HH]**	**Local Integration[HH]**	**Connectivity**
A			21
B			19
C			17
D	0.692952		
E	0.687539		

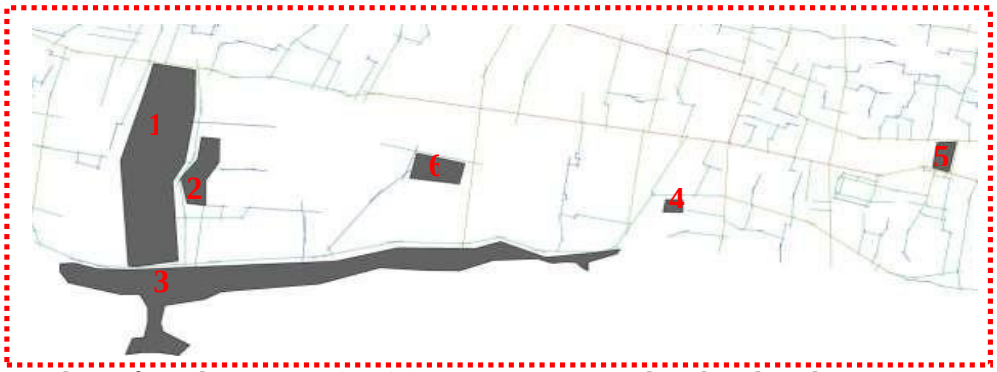
F	0.685126		
G		3.41512	
H		3.24024	
I		3.19106	
Max	**0.692952**	**3.41512**	**21**
Min	**0.185717**	**0.33333**	**1**
Mean	**0.444504**	**1.33877**	**2.5185**

VI. SPATIAL EVALUATION OF SELECTED OPEN AND RECREATIONAL SPACES:

Six sample areas have been chosen (Table-01, Figure-06) for analyzing the accessibility of open spaces in RCC area as mentioned in Section-04.The blow up of global, local integration and connectivity maps are shown in Figure-10 featuring the spatial condition of the six selected open spaces.



Analysis of Global integration (R=n)(zoom in map surrounding the selected open spaces)

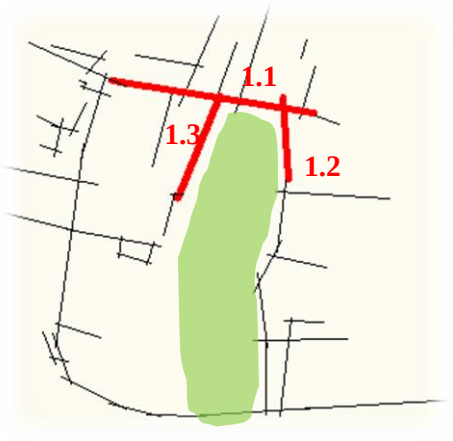


Analysis of Local integration (R=3) (zoom in map surrounding the selected open spaces)

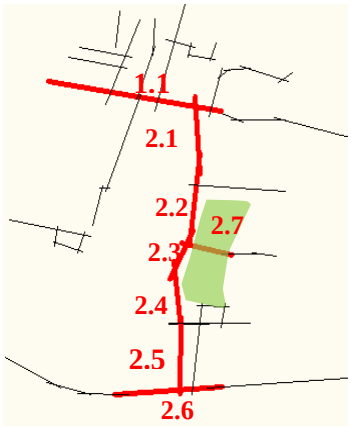
Figure-10: Zoom in view of spatial analysis on depth map of the selected open spaces

VI.I Identifying access road to sample area:

Here in Section-6.1 the access roads to the sample areas (Figure-11) are identified and the roads are denoted by names such as road no. 1.1, 1.2, 1.3 etc-



a) Space:01:Central Park & National Zoo

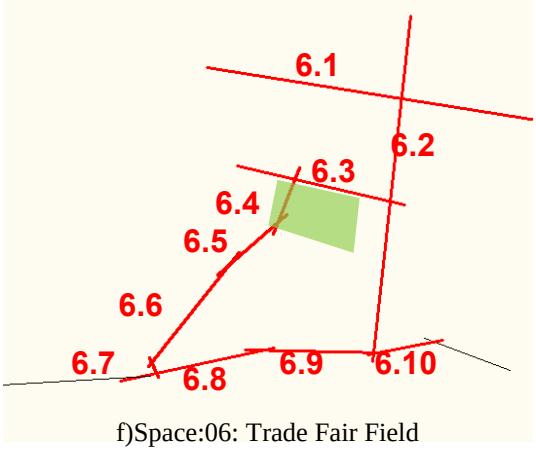


b)Space:02:Central Tennis Complex

c) Space:03: Open Space at Bank of Padma

d) Space:04: Public Library

e) Space:05: Barendra Museum



f)Space:06: Trade Fair Field

Figure-11:Access road identification

Table 4: Selected Public Open spaces with their connectivity and integration value

No.	Space Name	Accessroad	Connectivity	Global Integration(R=n)	Local Integration(R=3)
1	Central Park & National Zoo	1.1	9	0.532572	2.48214
		1.2	2	0.504606	1.66934
		1.3	2	0.504399	1.59927
2	Tennis Complex	2.1	2	0.504606	1.66934
		2.2	3	0.479463	1.29062
		2.3	3	0.456741	1.38456
		2.4	3	0.436329	1.46441
		2.5	3	0.431855	1.38737
		2.6	3	0.413485	1.30573
		2.7	2	0.435863	1.00000

No.	Space Name	Access road	Connectivity	Global Integration	Local Integration
3	Open Space at bank of Padma	3.1	3	0.490286	1.83484
		3.2	2	0.616602	2.02868
		3.3	2	0.57983	1.56279
		3.4	4	0.579926	1.69925
		3.5	2	0.546912	1.23882
		3.6	3	0.532808	1.21234
		3.7	2	0.563608	1.13657
		3.8	2	0.532923	1.00000
		3.9	3	0.413485	1.30573
		3.10	2	0.403603	1.00000
		3.11	2	0.407596	0.887022
		3.12	2	0.425474	1.06971
		3.13	3	0.445157	1.53958
		3.14	2	0.427558	1.09529
		3.15	2	0.413741	1.00000
		3.16	2	0.401834	1.20639
		3.17	2	0.391839	0.98558
		3.18	2	0.408238	0.91666
		3.19	2	0.426169	1.13657
		3.20	2	0.445956	1.60714
		3.21	2	0.434213	1.39035
		3.22	6	0.466739	1.99165

No.	Space Name	Access road	Connectivity	Global Integration	Local Integration
4	Public Library	4.1	15	0.65915	3.04912
		4.2	2	0.61660	2.02868
		4.3	4	0.57673	1.85185
		4.4	4	0.57992	1.69925
		4.5	8	0.65483	2.73232
		4.6	2	0.61355	2.39025
5	Barendra Museum	5.1	8	0.603181	1.55929
		5.2	4	0.661038	2.50514
		5.3	16	0.652592	3.04512
		5.4	2	0.613592	2.22817
6	Trade Fair field	6.1	15	0.659169	3.04912
		6.2	5	0.638595	2.41225
		6.3	2	0.598528	1.51456
		6.4	2	0.563192	0.91667
		6.5	2	0.532045	0.84912
		6.6	2	0.504284	0.86196
		6.7	2	0.532430	1.00000
		6.8	3	0.563904	1.30066
		6.9	3	0.598930	1.64609
		6.10	3	0.598819	1.61616
	Max		16	0.661038	3.04912
	Min		2	0.391839	0.84912
	Mean		4	0.529182	1.600673

VI.II Analysis of Access road to sample area:
To improve accessibility to public and open paces spatial configuration needs to be analyzed during spatial planning period. From the values of Table-3 we can compare the intelligibility of the recreational spaces and can understand the accessibility situation within the selected public areas.

Global Integration of Access Roads:

The mean global integration of the city is 0.444504. This value is compared with regard to thevalues of the recreational spaces in following description_

Central Park: (Space No;01:Road-1.1-1.3): The average integration value of the access roads central park is 0.513859 which is higher than mean global integration (0.444504) of Rajshahi city. Therefore, the park is fairly accessible from the north side

(from shaheb bazar road) but accessibility should be addressed from the river side also as major people gather on the south side for recreational activities. It is recommended to enhance accessibility from river side by enhancingconnectivity of the access roads.

Tennis Complex: (Space No;02:Road-2.1-2.7) :The average integration value of the access roads of tennis complex is 0.461364 which is higher than mean global integration of Rahshahi but the access roads (2.1-2.7) to the tennis complex is very narrow. Moreover this roads are connected to the shaheb bazar road on the north which is a significant road because it is connected to major recreational spaces of the city so to attract more visitors it shouldbe more integrated to the city. Therefore, the access roads to the tennis complex can be increased in width to accommodate more people at a time. It can also be major connection between the city and the Padma river.

Open Space at Padma : (Space No;03:Road-3.1-3.22) : The river side of Padma has open spaces parallel to the river which is higher in length than width. So it can be accessed from many points of Shaheb bazar road toward the river. The average integration value of the access roads are 0.470659 which has scope for improvement to make the river side more connected to the city dwellers as it is the major source of recreation for the people.

Public Library,Barendra Museum,Trade Fair field: (Space No;04,05,06:Road-4.1-4.6,5.1- 5.4,6.1-6.10 respectively) :The average integration values of the access roads of Public Library, Barendra Museum and Trade Fair field are 0.616797 , 0.632601 , 0.57899 respectively which suggest comparatively higher global integration value and also higher than mean globalintegration of Rajshahi .Therefore, these public spaces are working more or less successfully with regard to accessibility.

Local Integration of Access Roads:

The mean local integration of the city is **1.33877.** This value is compared with regard to the values of the recreational spaces in following description_

Public Library, Barendra Museum:(SpaceNo;04,05,06:Road-4.1-4.6,5.1-5.4,respectively) :The average local integration value s of the access roads of Public Library, Barendra Museum are2.33443 and 2.291912 which is higher than mean local integration of the city (**1.33877).Therefore, these public spaces are locally well connected and can be utilized for local benefits and for such activities which needs to be detached from the city. Out of the selected recreational spaces these two spaces**

Connectivity of Access Roads:

Here it is seen that an access road of public library (4.6) has low connectivity (2) but has higher global integration value (0.61355).Similarly an access road of space no:3 (3.22) has higher connectivity (6) but has low global integration value 0.466739 and thus not well integrated tothe city. Therefore, good connectivity doesn't necessarily ensure good global integration, it rather suggests better local integration. Hence it does not portray higher accessibility to public spaces.

VII. CONCLUSION:

RCC is a small metropolitan area. From analysis it's seen that the selected public spaces are more or less accessible with respect to the city. Some improvements can be proposed to enhance accessibility, to attract more common people to these public recreational places. From analysis it can also be said that only higher local integration value does not determine higher accessibility to a public space it also needs to be connected well, globally. It is also evident that roads with higher connectivity can be globally less integrated so higher connectivity does not state better accessibility to a public space. Therefore, from depth map analysis we can get a clear view on how accessibility ofpublic spaces can be developed while spatial planning. Rajshahi city has scope for showcasing it's public spaces more to city dwellers by implementing better accessibility as per the syntactic analysis.

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