Acta Sci. Pol.
Architectura 20 (2) 2021, 3–16
content.sciendo.com/aspa ISSN 1644-0633 eISSN 2544-1760 DOI: 10.22630/ASPA.2021.20.2.10

ORIGINAL PAPER

Received: 08.04.2021
Accepted: 17.05.2021

OPTIMIZING THE SPATIAL CONFIGURATIONS OF AN URBAN OPEN SPACE: SYNTACTIC ANALYSIS OF THE RESTORED HATIRJHEEL WETLAND, DHAKA

Md Arifur Rahman✉

School of Applied Sciences and Technology, Shahjalal University of Science and Technology, Sylhet, Bangladesh

ABSTRACT

Due to rapid urbanization, urban open spaces are becoming increasingly significant, both in the inhabitants' daily and societal lives. This significance is even more applicable for the densely populated city of Dhaka, which has historically overseen numerous urban migrations. Regretfully, the inhabitants of Dhaka can access only a few urban recreational facilities, public open spaces in particular. Due to illegal encroachment, low maintenance, and rigid policymaking, those limited number of open spaces are becoming gradually deteriorated and are in the potential danger of greater extinction soon. The Hatirjheel wetland area inside Dhaka has recently been restored as an important public open space to connect the city's green-blue network. Accessibility is a significant spatial parameter to judge its potential success. This research analysed how accessibility would optimize the multi-scalar relationship between neighbourhoods and urban activities. With use a series of syntactic analyses, it was also searched for the Hatirjheel wetland's potentials as an active urban open space to accelerate local and global activity. The possible weaknesses behind those open spaces' inactiveness were investigated both theoretically and practically. Finally, some recommendations were suggested by analysing these circumstances in aim to improve the current conditions and obtain optimum benefits from the existing open space.

Key words: water urbanism, space syntax, accessibility, local integration, global integration

INTRODUCTION

In the urban context, open spaces include all urban green space (UGS) and green-blue infrastructure (GBI), i.e.: urban forestry, woodlands, parks, playgrounds, vacant lots, beeches, wetlands and riverfronts, which belong to the public domain and have open access (Schipperijn, Stigsdotter, Randrup & Troelsen, 2010). Open spaces substantially contribute to preserve the urban ecosystem and maintain the green-blue threshold. Apart from adding environmental and aesthetic value, public open spaces significantly impact social interaction and cohesion at the communal and urban scale. Besides, they significantly affect the urban dwellers' physical and mental health on an individual level. However, the significance of unbuilt lands and public open spaces is repeatedly neglected in the least developed countries worldwide due to their ignorance in balancing the constructed areas and the unbuilt areas during urban and regional planning. Although these countries might contemplate public open spaces as redundant momentarily, open spaces' potential as responsive urban spaces must be acknowledged in the long run (Tabassum & Sharmin, 2013). Permeability, variety, legibility, robustness, visual appropriateness, richness and personalization are the factors that in-

Md Arifur Rahman https://orcid.org/0000-0002-5765-6874
✉ar.kaushik-arc@sust.edu

fluence an environment's responsiveness (Bentley, McGlynn, Smith, Alcock & Murrain, 1985). The omission of these factors might collapse the space's responsiveness.

In his book, *The death and life of great American cities*, Jacobs (1961) stated that the success of an urban open space like a neighbourhood park depends on its generalized utilization, particularly by the underprivileged populations. Besides being used by the local people for livelihood, neighbourhood parks serve multiple social purposes and public interests. The author claimed that under-utilized parks could result in vandalism and discourage public movement in their adjacent roads. According to Gehl (1987), three types of outdoor activities occur in public spaces: compulsory, optional and social. The enhanced quality of outdoor space accelerates the optional and social outdoor activities, as observed in an intense study in Copenhagen. The author also underlined traffic-free pedestrian streets as vital public spaces for a widening spectrum of outdoor activities. Recently urban wetlands are attracting global attention to reduce the deficiency of the public spaces in metropolises. However, research on their use and effectiveness after completion is a comparatively more popular trend than research on their design guidelines (Song, Albert & Prominski, 2020). The authors found several potentials for urban wetlands as public space, such as preserving the cultural and ecological resources, providing recreational activities with amenities, attracting visitors.

Haaland and Bosch (2015) identified the current global position and challenges of urban open space planning. The rapid expansion of cities tremendously exploits urban forests in industrializing countries in the Global South. Furthermore, consolidation and infill developments are significantly threatening the urban open spaces in the Asian and Australian cities to a greater extent compared to the European and North American cities. The major challenges in current planning practice include providing green space in densification areas, the unequal distribution of open space, especially in the older half of the cities, providing outdoor space for the younger generations, degradation of recreational experiences, preserving biodiversity, and institutional constraints (Haaland & Bosch, 2015). Besides, public parks are the place for social transformation where people can meet strangers and also feel anonymous and private simultaneously, even though virtual networking and recent technological revolution have challenged the necessity of direct human contact. Otherwise, the public spaces will become loose-fit spaces with a substantial gap in their design purpose and practical use (Thompson, 2002).

Dhaka, the capital of Bangladesh, is a rapid-growing city due to the heavy urban migration and the recent establishment of mega-infrastructures. It has more than 17 million dwellers and has been enlisted as one of the most inhabited cities globally (Islam, Mahmud & Islam, 2015). The growing re-settlers require an increased number of public open spaces for satisfying their recreational and social demands, most importantly, without declining the existing ecological corridors and footprints. Dhaka structure plan (Government of Bangladesh & Rajdhani Unnayan Kartripakkha [GoB & RAJUK], 1995) recommended that urban open spaces should cover no less than 20% of the entire land use of Dhaka city. Unfortunately, parks and open spaces averaged a meagre value of 14.5% of the whole city's land area, which is below par for the standard UGS requirement of 25% to maintain a sustainable ecosystem of a city. The scarcity of urban open spaces was more evident in the Dhaka Metropolitan Development Plan: 1995–2015 (GoB & RAJUK, 1995), which alarmingly stated that open spaces in the old Dhaka constituted merely 5% of the whole land area, compared to 12% of open spaces in the new Dhaka (Islam et al., 2015). Expansion of open spaces would be complex in the existing situation for the land unavailability due to the high density of buildings, inflated land price, and pre-dominant peripheral wetland landscapes. Even the already limited number of open spaces were under serious threat because of massive human encroachment and conversion of woodlands to changed land use. Consequently, the city's corresponding ecological balance was severely damaged with the frequent occurrence of waterlogging, overflooding and environmental pollution (Nilufar, 1999). These open spaces also suffered from human-caused problems such as inappropriate management, under-utilization, lack of accessibility and security, unhealthy conditions, criminal and anti-social activities, and inadequate

infrastructures to facilitate people (Islam et al., 2015). Long-term land-use planning based on their spatial configuration should be implemented immediately so that the existing limited resources could be accessed and utilized appropriately and preserved for a better liveable environment. Otherwise, there will be a severe crisis of public open spaces in Dhaka city in the immediate future.

Considering the lack of scope to expand the existing natural resources and open spaces, recently, the Hatirjheel waterfront area was redeveloped as primary urban open space (Fig. 1). This integrated wetland development aimed to restore the city's water edge activities which were initiated through a rich tradition of water edge activities alongside the Buriganga riverfront (Mowla, 2013). The restoration project also intended to link the older communities and residents of the newly developed part of the city. In the past, Hatirjheel wetland was directly connected to the Dhanmondi lake, another major wetland in Dhaka, through canals. But land infilling and construction of covered box culverts over the canals disrupted the connectivity in recent times. The integrated restoration would re-establish these lacustrine networks. Hence urban planners had identified Hatirjheel as a core blue infrastructure. It would enhance ecological connectivity between the green and blue corridors and the peripheral riverine networks of the capital city (Fig. 2). As a result, the wetland would act as a retention tank of stormwater and mitigate environmental hazards such as waterlogging and overflooding (Vitti Sthapati Brindo Limited, 2015). During the recent restoration, the Hatirjheel waterfront area was incorporated with some significant urban recreational spaces, such as an open-to-sky amphitheater, an urban park beside the Gulshan-Hatirjheel Link Road, walkways, ghats, boating facilities, and restaurants. The entire restored area, covering 311 acres, was surrounded by several highly

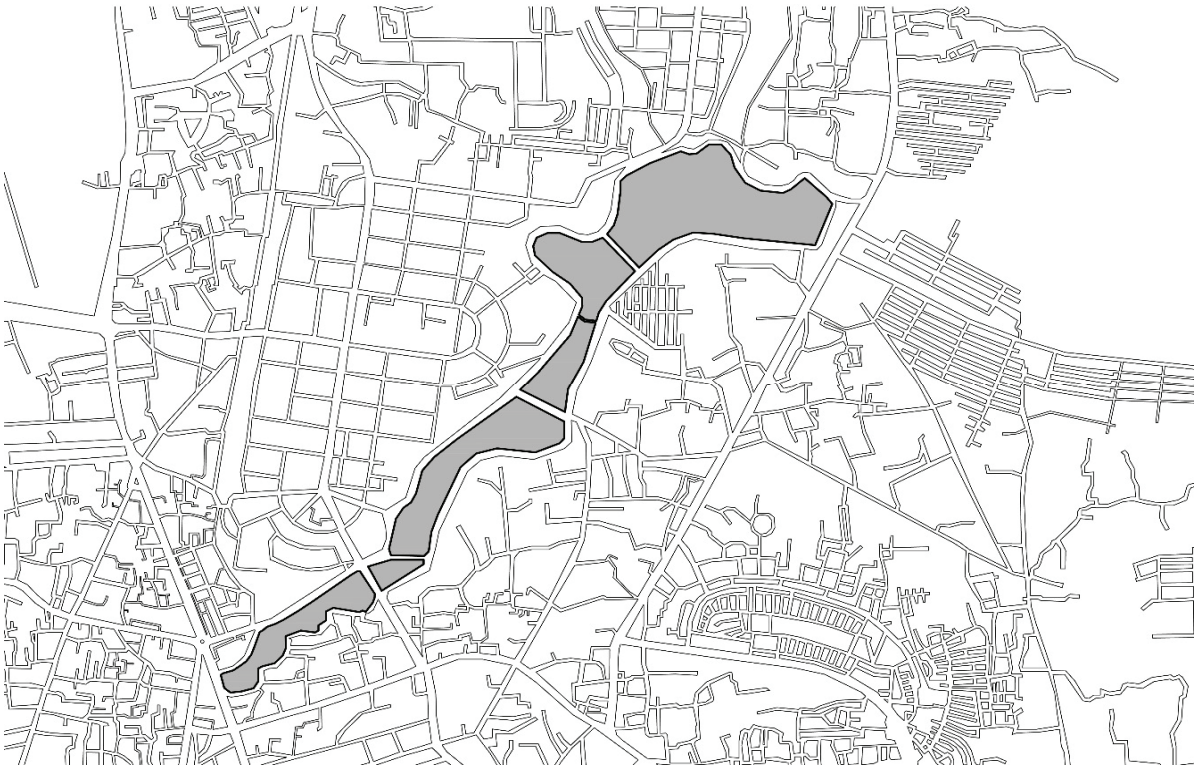

Fig. 1. The Hatirjheel wetland, including the Begunbari canal after the restoration (based on Vitti Sthapati Brindo Limited, 2015, retrieved from: http://vitti.com.bd/project/integrated-development-of-hatirjheel-area/#ad-image-852, accessed 21.06.2020)

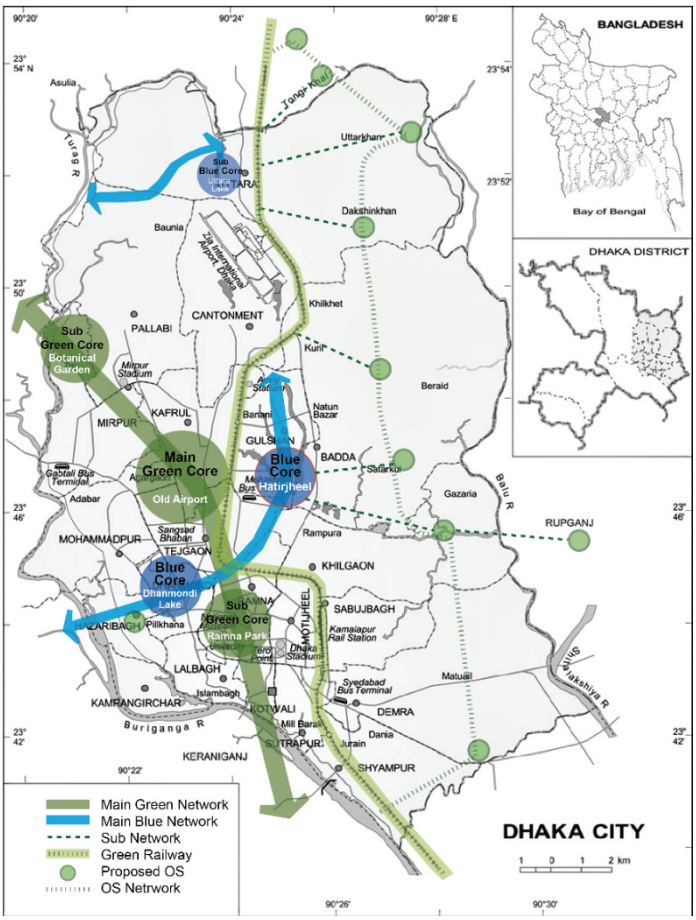

Fig. 2. The Hatirjheel lake was a part of the green-blue network of integrated Dhaka city (Nilufar, 2015)

dense residential neighbourhoods. Four heavy vehicular bridges and four pedestrian bridges were also designed to serve the surrounding residential communities (Architecture Master Prize, 2016). Although the whole site consisted of heavy infrastructures, the anticipated use of this waterfront might get impacted by numerous spatial and non-spatial site factors such as accessibility, connectivity, control, and choice. This study will investigate these potential spatial factors to enhance accessibility and to make the waterfront more vibrant. Also, the user groups would be the beneficiary if the management and operation process succeeds in the project's integrated planning and construction process.

This research aimed to explore the potential relationship between the surrounding neighbourhoods' spatial organization and the site-specific accessibility factors of the study area's connecting roads. The investigation could possibly lead to some suggestions for future sustainable use. In short, the objectives of the research were identified as the following:

- To assess the connectivity of the Hatirjheel waterfront as a responsive public open space.
- To compare the global and local integration values of the urban grid.
- To outline the multi-scalar relationship from neighbourhood to urban activities.
- To analyse the spatial configuration of the area and the peripheral roads.
- To suggest immediate measures to be adopted and implemented to optimize the existing connectivity and use.

MATERIAL AND METHODS

This research was structured with several steps to achieve the mentioned research objectives, such as identifying the study area and describing the syntactic methodology, followed by spatial analysis, discussion on results, key findings, case studies worldwide in similar situations, and several recommendations.

Study area profile

The research covered the entire Hatirjheel waterfront area, including the adjacent Begunbari canal, focusing on 13 roads connected to the Hatirjheel Link (Circular) Road. These roads acted as the primary accessing line to enter the public open areas. Table 1 illustrates the labels of the roads with their locations indicated in Figure 3.

Table 1. Name of the primary access road of Hatirjheel waterfront

Code	Access road's name
1	Karwan Bazar Road
2	Sat Rasta-Moghbazar Road
3	Hatirjheel Link Road
4	AUST Link Road
5	Love Road
6	Hatirjheel-Gulshan-Tejgaon Link Road
7	Bir Uttam Mir Shawkat Sarak
8	Pragati Sarani
9	Generator Lane
10	Mahanagar Middle Road-2
11	Mahanagar Housing Road
12	Modhubag Road
13	Mouchak-Moghbazar Road

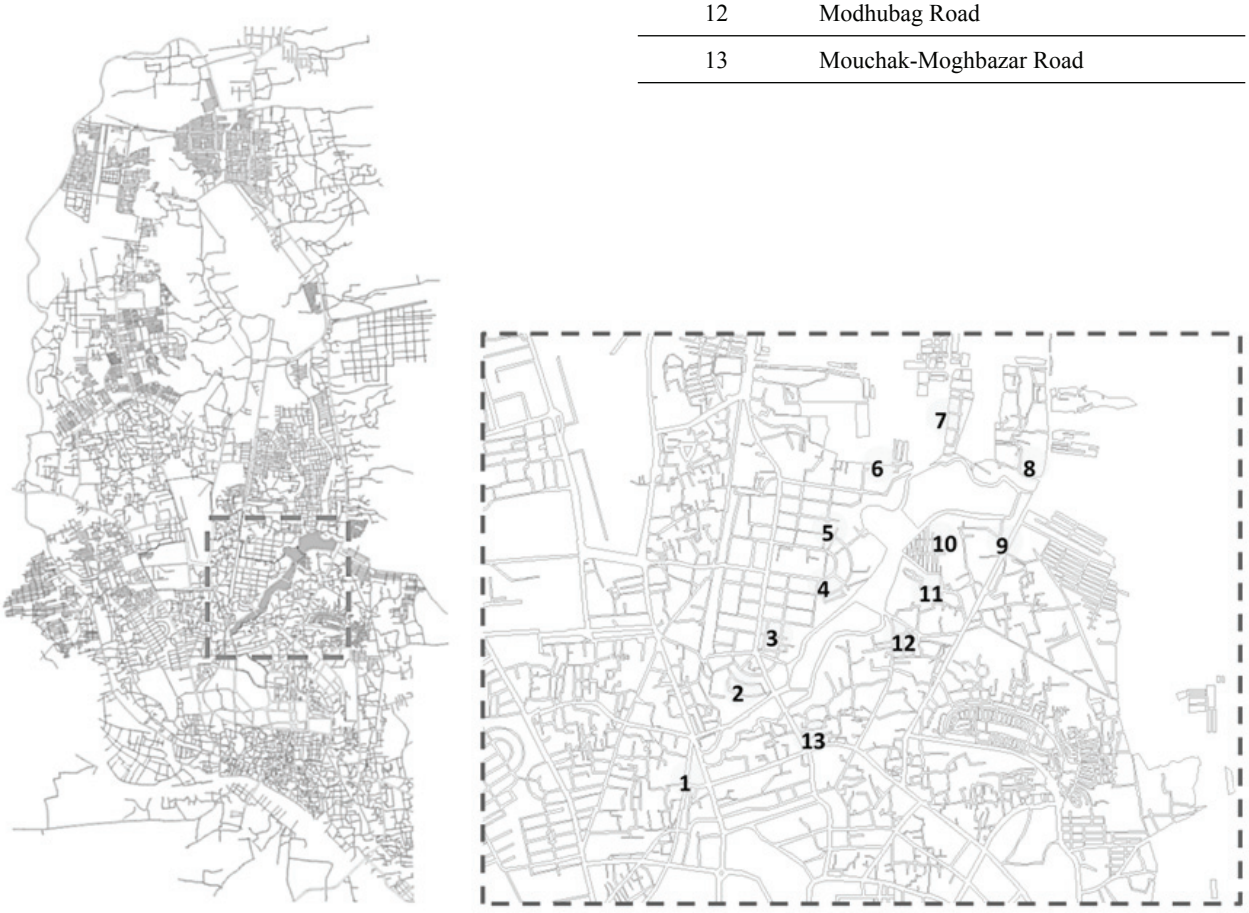

Fig. 3. The study area's location with major access roads (based on Dhaka city map, 2014)

Syntactic method

Space syntax is a concept in the fields of urban design, urban planning, building, traffic, and circulation design. This analytical method was initially developed to conceptualize urban grids' morphological logic (Hillier, 1996), to study settlement and housing genotypes (Hillier, Hanson & Graham, 1987; Hillier, Hanson & Peponis, 1987) and to measure spatial configurations (Hillier & Hanson, 1984; Hillier, Penn, Hanson, Grajewski & Xu, 1993). Spatial configuration ranges from the precise relation between two spaces considering a third space to broadly all the relationships among spaces in a system considering everything else in the system (Koohsari, Kaczynski, Mcormack & Sugiyama, 2014). Later space syntax had been widely used to investigate inconsistencies in urban texture (Ratti, 2004), the relationship between urban road configuration and land-use density (Kim & Sohn, 2002), the use of pedestrian and landscape attributes (Foltête & Piombini, 2007) and street pattern and network analysis (Duan & Wang, 2009; Omer & Zafrir-Reuven, 2010). Recently it has been utilized in advanced and multidisciplinary fields to correlate historical research (Griffiths, 2011, 2012; Froy, 2016; Srinurak & Mishima, 2017), to explore the relations between traffic network and the urban environment (Giannopoulou, Roukounis & Stefanis, 2012), to study the space-societal-economic triangular relationship (Mohamed, van Nes, Salheen, Kohlert & Schwander, 2013), to weigh influences on the residential markets in metropolitan cities (Law, Karimi, Penn & Chiaradia, 2013), to assess disaster risk in the organic towns with hilly landscape (Castillo, 2013), to integrate the recreational spaces in towns (Tariq & Nilufar, 2013), to design new cities based on evidence (Karimi & Vaughan, 2014) and even, to predict social crimes in residential zones (Wu et al., 2015).

In space syntax, the urban grids are analyzed based on the configuration of the axial map. The axial map consists of the least set of longest and straightest lines that can be drawn to connect the open spaces in a city (Ahmed, Hasan & Maniruzzaman, 2014). These axial lines encompass every urban block in a city. Each street intersection within these urban grids is inscribed as an intersection of axial lines. Therefore, to record the urban grid structures, axial map analysis could be an appropriate method. According to the space syntax theory, the first-order and second-order measures' relationship (Khan, 2014) can be considered as in Figure 4.

Integration, a static global measure, depicts the mean depth or shallowness of space to every other space in the system in the space syntax theory. Spaces in the system can be categorized from the least integrated to the least isolated (Klarqvist, 1993). Choice (CH), a dynamic global measure, expresses the number of the shortest paths passing through a system, connecting all spaces to all spaces of the system. A higher number of flows through any space indicates a stronger choice (Klarqvist, 1993). Connectivity (CN) is a local syntactic measure. It represents the number of immediate neighbouring roads directly connected

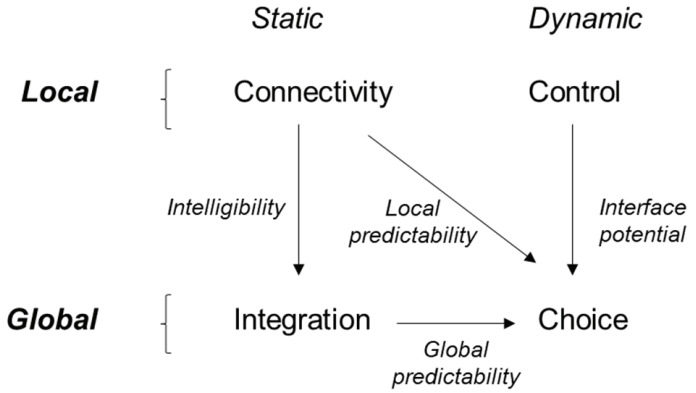

Fig. 4. The relationship between different syntactic orders (adopted from Khan, 2014)

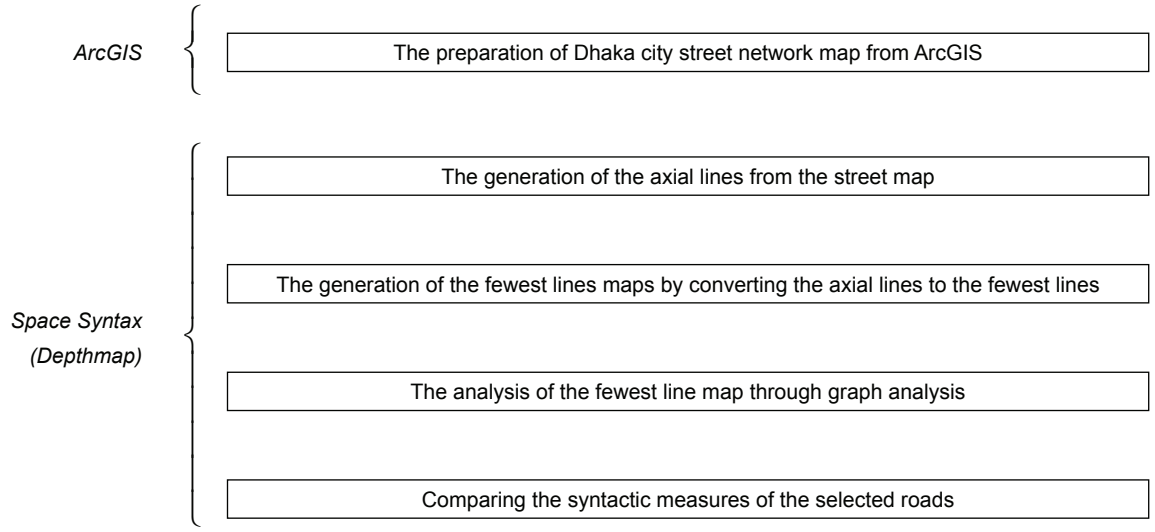

Fig. 5. The syntactic methodology of the spatial analysis

to space. The correlation between connectivity and integration is known as Intelligibility (Tariq & Nilufar, 2013). The control (CV) calculates the extent to which any space controls accessibility to its immediate neighbours considering the number of alternative connections each of these neighbours has (Klarqvist, 1993). The methodology of this research followed the steps in Figure 5.

For spatial analysis, DepthmapX was used, and ArcGIS was used to prepare the 2-D geometric map. The spatial configurations of the selected roads were used to take guidance to identify some findings and suggest further recommendations.

RESULTS AND DISCUSSION

Spatial analysis

In the spatial analysis, the global integration map (HH, $R = n$) showed that the highly integrated lines were situated at the centre with isolated lines dispersing towards the peripheral areas, representing a well-balanced scenario (Fig. 6). The Hatirjheel waterfront area was located alongside the global integration core, possibly generating bustling vehicular traffic. The local integration map (HH, $R = 4$) showed that the integration core was dispersed in different localities with a dispersed set of lines (Fig. 7). The Hatirjheel area was located far from the local integration core, albeit closer to the strongly integrated lines.

Syntactic measures of the selected 13 roads' connectivity had been displayed in Table 2, along with their global and local integration values. The result showed that Karwan Bazar Road (1), Sat Rasta-Moghbazar Road (2), and Mouchak-Moghbazar Road (13) had the highest integration values (Figs. 6, 7). The connectivity values showed a strong relationship between the integration core and the connectivity of those roads. However, several roads like Pragati Sarani and Generator Lane had comparatively lower connectivity values, although being located nearby the local integration core (Figs. 6, 7). Thereby, the potential scope of connecting them more with the local integration core would improve the accessibility of those roads.

The relationship between the global integration (HH, $R = n$) and the local integration (HH, $R = 4$) was reasonably good with the tangent of the slope, $R^2 = 0.301686$ (Fig. 8). The statistics proved that the entire area was relatively well-integrated in both neighbourhood and city scale.

The relationship between the local integration (HH, $R = 4$) and the connectivity was moderate with the tangent of the slope, $R^2 = 0.13955$ (Fig. 9). So, there remained a scope for improvements.

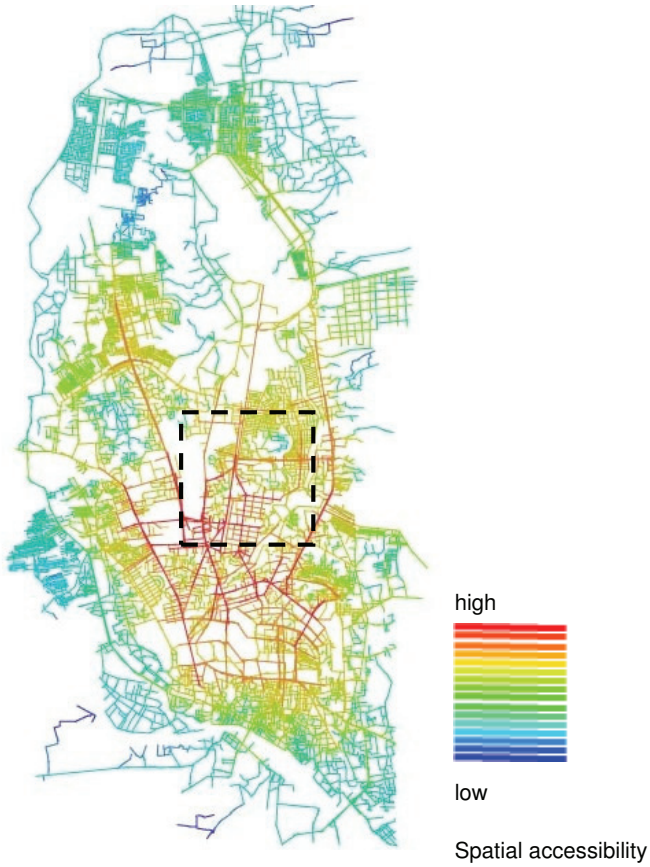

Fig. 6. The axial map with global integration (HH), $R = n$

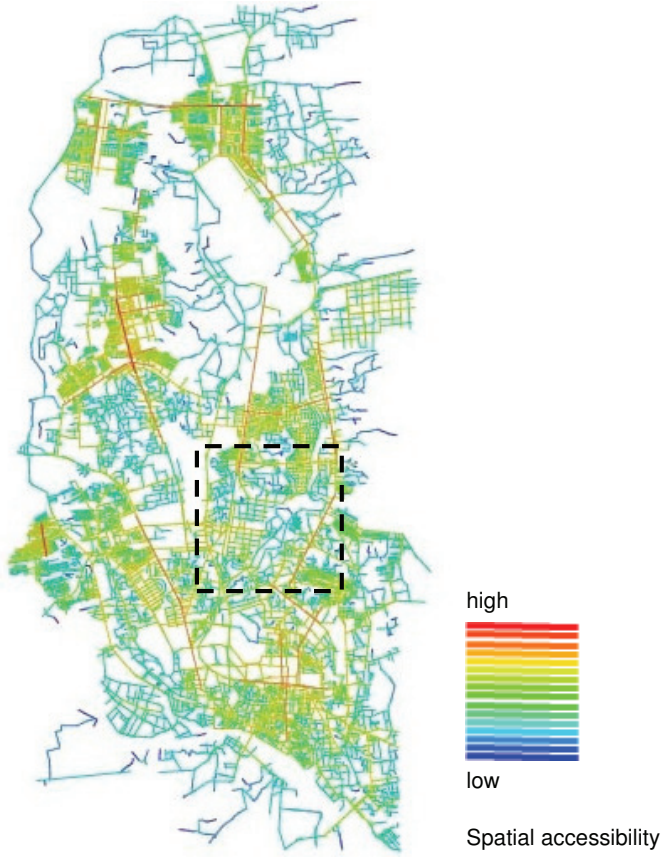

Fig. 7. The axial map with local integration (HH4), $R = 4$

Table 2. Different syntactic measures of the significant accessible roads of the Hatirjheel waterfront development project

Code	Access road's name	Global integration (HH, $R = n$)	Local integration (HH, $R = 4$)	Connectivity
1	Karwan Bazar Road	1.06264	3.01574	37
2	Sat Rasta-Moghbazar Road	1.03037	2.65121	19
3	Hatirjheel Link Road	1.00281	2.3494	09
4	AUST Link Road	0.84609	1.58986	03
5	Love Road	0.80575	1.4425	04
6	Hatirjheel-Gulshan-Tejgaon Link Road	0.828948	1.75584	03
7	Bir Uttam Mir Shawkat Sarak	0.786788	1.5005	05
8	Pragati Sarani	0.811843	1.69548	03
9	Generator Lane	0.773052	1.73026	02
10	Mahanagar Middle Road-2	0.734906	1.52286	05
11	Mahanagar Housing Road	0.772525	1.72706	08
12	Modhubag Road	0.861593	2.23031	11
13	Mouchak-Moghbazar Road	1.03037	2.65121	19

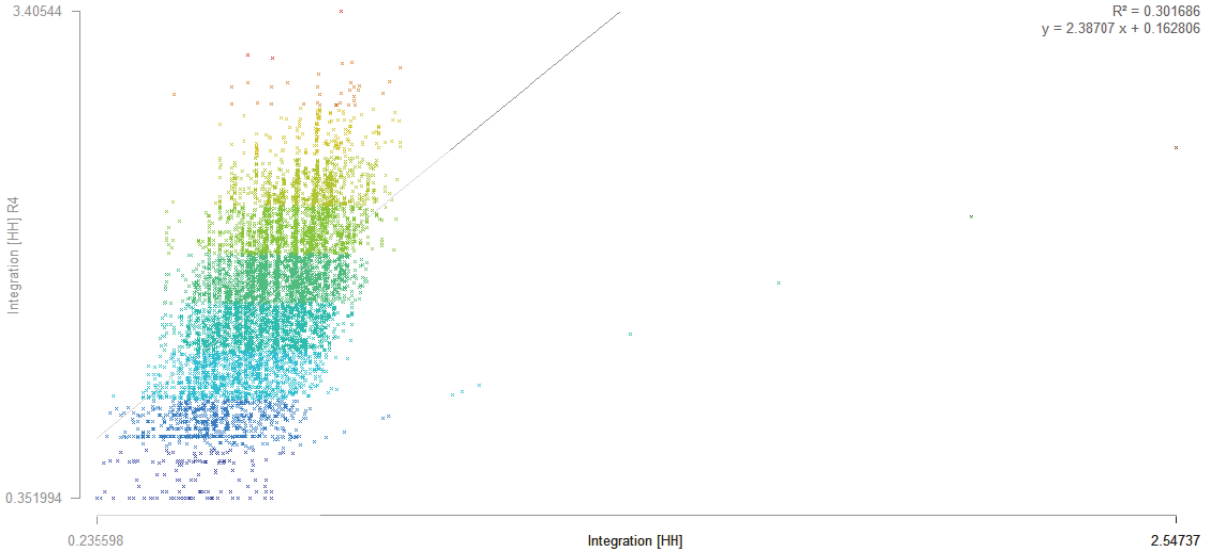

Fig. 8. The correlation between global integration (HH, $R = n$) and local integration (HH, $R = 4$)

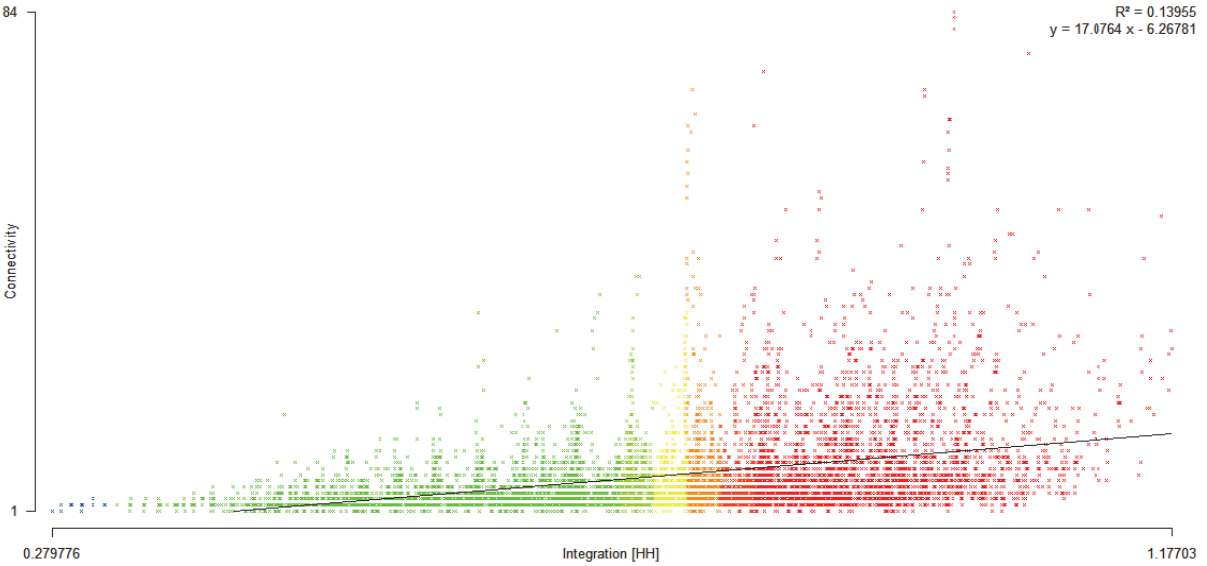

Fig. 9. The correlation between local integration (HH, $R = 4$) and connectivity

Findings

The Hatirjheel Link road was segregated to some extent from the major roads with high connectivity measures. Though several access roads were close to the highly integrated axial lines, they were under-utilized and situated far from the global integration core. The focus should be given to pedestrian connectivity, a local measurement that should be designed from the local integration and neighbourhood (local) activity pattern. Moreover, some recreational facilities to the Hatirjheel waterfront area were located across high vehicular traffic roads, evidently identified in the global integration measures. It was suggested that high vehicular roads should not be directly connected to the public urban open spaces. Instead, pedestrian roads with high integration roads should be preferred. For instance, in this particular case, the Hatirjheel waterfront area was seldom connected to one of Dhaka city's highest integrated roads – Pragati Sarani (8) (Fig. 10). More pedestrian connectivity could be developed between these roads and the local integration core.

The recreational facilities, established during the recent restoration, lacked robust connectivity with highly integrated roads, and weakly integrated roads surrounded those spaces (Fig. 11). Incorporating these recreational spaces with integrated roads could indirectly enhance their land use. Generally, commercial land use grows more on the edges of the highly integrated roads. However, in this case, most of the Hatirjheel Link Road's (3) edges were not commercially developed yet. The barren facades and unused pocket spaces could create potential crime zones. The possible reason could be that the restored area was not close to the local integration core. As a result, pedestrians' movement was superseded by heavy vehicular movements, hence not attracting the walking consumers from the surrounding neighbourhoods to use it frequently.

Cases around the world in similar situations

The design and implementation of public spaces regarding openness and accessibility are global concerns among researchers, planners, and urban designers. Wei (2017) emphasized the accessibility of public spaces as a spatial and socio-economic process and changes in access as a significant criterion to allocate the parks efficiently. Feng et al. (2019) also analysed the internal relationships between the urban park accessibility and the location of neighbourhood residents. Several

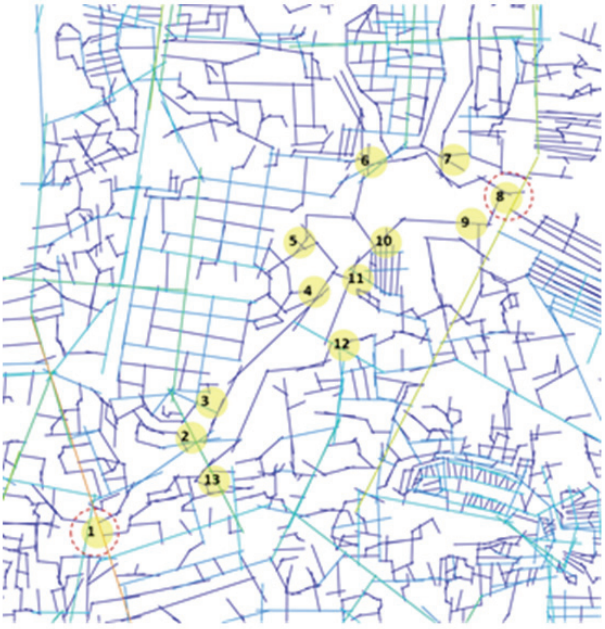

Fig. 10. The weaker connectivity to the nearest highly integrated roads

Fig. 11. Major findings between the connectivity with the recreational spaces

studies also addressed the post-design evaluation and discussed the relationship between accessibility and the effectiveness of public spaces. A comparative case study (Pedersen, Weisner & Johansson, 2019) showed that an urban wetland integrated with the residential area in Helsingborg was more socially responsive than two other less integrated wetlands in Hässleholm and Staffanstorp. Urban wetlands can act as vital public spaces in dense metropolitan areas. Though human access and interference in urban wetlands are often considered a threat to ecological restoration in some countries, recent studies proved that openness to the public in London Wetland Park did not restrain the collaborative existence of people and environmental resources. In China, the optimization of Haizhu Wetland Park as a public place even accelerated the ecological restoration, economic benefit, and social interaction (Lv & Guan, 2019). In Singapore, Bishan-Ang Mo Kio Park was bisected by the Kallang River, separating the park from two adjacent residential communities. The park had later been restored by providing more pedestrian access and opening it to the surrounding residential communities, resulting in an increased sharing of landscape resources (An, Chen & Li, 2020).

RECOMMENDATIONS

Urban open spaces act as an essential element to serve the recreational necessity of the urban population. Due to high land prices and scarce land, it is nearly non-realistic to create a new open space in Dhaka city. Hence the existing open spaces should be protected and well-utilized. In order to optimize the utilization of these limited resources, policy-makers need to plan accordingly. From the previous discussion on the case of the Hatirjheel waterfront area, this research recommended that,

- More pedestrian roads should be developed with the local integration core, and vehicular roads with heavy traffic load should be placed near the global integration core.
- More connectivity should be developed with roads with high integration by joining the isolated ends.
- Optimum use of the recreational spaces could be ensured by linking them with highly locally integrated roads.
- The land use of the surrounding edges of the globally integrated roads should be grown with urban commercial activities.
- Locally integrated roadsides should support more local commercial activities to prevent potential crime zones.

CONCLUSIONS

This research identified the Hatirjheel waterfront as one of the most significant public open spaces in Dhaka city and assessed its accessibility measures in the post-design evaluation phase. It is incredibly challenging to produce new public open spaces in Dhaka for land scarcity due to the high density of buildings, the predominance of wetlands, and a densely growing population. So, the existing open spaces need to be utilized in optimum-scale, possibly with significant additions and alterations on a micro-scale. The Hatirjheel lake was designed as a part of the city's green-blue core infrastructure network by connecting the peripheral riverine networks and several massive urban forests, wetlands, and the old airport. Therefore, proper utilization of this open space should be made essential. Any disorder or under-utilization of it will hamper the growth of other corresponding infrastructures. The recommendations, discussed in this research by analysing several theoretical bases and practical situations, could resolve the constraints hindering the maximum use of the open space. This model could be later successfully followed for the public open spaces in a similar context.

Acknowledgements

This research was part of the author's coursework on the Urban Morphology-I course with technical and resource support from the Department of Architecture, Bangladesh University of Engineering and Technology (BUET), Dhaka.

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OPTYMALIZACJA KONFIGURACJI PRZESTRZENNYCH MIEJSKIEJ PRZESTRZENI OTWARTEJ: ANALIZA SYNTAKTYCZNA ODTWORZONEGO JEZIORA HATIRJHEEL, DHAKA

STRESZCZENIE

W związku z gwałtowną urbanizacją rola terenów otwartych nabiera coraz większego znaczenia – zarówno w życiu codziennym, jak i społecznym mieszkańców. To znaczenie jest jeszcze większe dla gęsto zaludnionego miasta Dhaka, które w przeszłości doświadczyło licznych migracji. Niestety mieszkańcy Dhaki mają dostęp tylko do kilku miejskich obiektów rekreacyjnych, w szczególności publicznych terenów otwartych. Ze względu na nielegalne zajmowanie, słabe utrzymanie i sztywną politykę te ograniczone liczbowo tereny stopniowo ulegają niszczeniu i wkrótce mogą zaniknąć całkowicie. Jezioro Hatirjheel w Dhace niedawno odtworzono, aby stało się istotnym łącznikiem w zielono-niebieskiej infrastrukturze miasta. Dostępność to znaczący parametr przestrzeni, pozwalający ocenić szanse na potencjalny sukces. W badaniu przeanalizowano, w jaki sposób dostępność polepszyłaby wieloczynnikową relację między dzielnicami a aktywnościami miejskimi. Za pomocą wielu analiz syntaktycznych poszukiwano również potencjału jeziora Hatirjheel jako miejskiej otwartej przestrzeni, która przyspieszy lokalną i globalną aktywność. Możliwe negatywne efekty braku aktywności na tych otwartych przestrzeniach zostały zbadane zarówno teoretycznie, jak i praktycznie. Na koniec analizując te okoliczności, zasugerowano kilka zaleceń w celu poprawy obecnych warunków i uzyskania optymalnych korzyści z istniejących terenów otwartych.

Słowa kluczowe: urbanistyka wodna, syntaktyka przestrzeni, dostępność, integracja lokalna, integracja globalna