Research Paper

A comparative analysis of assessing the quality of the urban pedestrian environment in Dhaka using syntactic and statistical methods

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ABSTRACT

Urban pedestrian environments rank among the most frequent public spaces, playing a vital role in enhancing urban liveability. In Dhaka, the rapid growth seen over recent decades has resulted in the city's streetscape increasingly losing its lively, mixed-use essence, shifting mainly towards being just traffic routes. This research underscores the pressing need to evaluate the quality of Dhaka's pedestrian environment and streetscape to protect its distinctive character before further decline occurs. A mixed method approach is adopted here, such as syntactic analysis, questionnaire surveys, and physical observations, especially focusing on two selected roads in Dhaka. Techniques like Space Syntax and SPSS statistical analysis are employed to quantify spatial data and evaluate user perceptions accordingly regarding current streetscape features with a direct observation for validating the results. Through this integrated approach, the relationship between spatial configuration and spatial quality is closely examined. The findings reveal that combining these methodologies offers a novel and effective avenue for obtaining thorough and trustworthy results when measuring the quality of urban public spaces. Moreover, it shows that interactions between the physical environment and user perceptions significantly influence urban streetscape quality, presenting crucial insights for reimagining Dhaka as a more pedestrian-friendly city.

1. Introduction

Urban pedestrian environments comprise several dimensions, including physical, historical, cultural, morphological, perceptual, social, functional, and temporal aspects [1]. These dimensions blend both technical and social elements. The objective of urban design is to tackle challenges in design and development by improving the form and characteristics of public spaces. This endeavor necessitates both theoretical and practical considerations at varying scales to foster distinct qualities within the built environment [2]. As a result, urban pedestrian environments are assessed through a range of principles that relate to their functions and structural morphology. The principles of urban design include multiple parameters that shift depending on the specific context of place and time. Such parameters, often referred to as the quality of urban public space, continuity and enclosure, character, ease of movement, legibility, diversity, and adaptability [3,4], are interpreted in various ways across different research studies. Scholars identify that the principles of urban public spaces encompass character, continuity, quality, connections, legibility, adaptability, diversity, sustainability and many more. In recent years, urban pedestrian environments have been examined from multiple dimensions, emphasising principles centred on the quality of public space [5–14]. Quality urban public spaces demonstrate a rich diversity of users, alongside attributes like accessibility, legibility, safety and security, liveability, comfort, and a sense of place attachment. Evaluating the quality of urban public spaces is intricately linked to individual well-being [15]. Sape syntax, a framework created by Hillier and Hanson in 1980, thoroughly investigates the connection between pedestrian movement and spatial configuration. This approach employs quantitative data to elucidate a successful, high-quality urban environment, concentrating on urban morphology and the human spatial experience [16–18]. Space syntax uses

morphological analysis for assessing spatial quality, incorporating axial, segmental, and visual graphic evaluations. Axial analysis, in particular, scrutinises integration, connectivity, intelligibility, and synergy metrics to gauge public space quality [19,20]. Frequently referenced metrics in the literature encompass spatial integration, connectivity values, synergy, and comprehensibility parameters [21]. The quality indicators criteria, established as a cornerstone for urban studies in 1980, seek to improve the liveability of urban public spaces by pinpointing the characteristics that contribute to their success [22]. The quality indicators relevant to the urban pedestrian environment define successful urban spaces by their accessibility and connections, comfort and image, activities and uses, as well as sociability and safety. The quality of these areas is evaluated with the impact analysis of pedestrian movement and its surrounding socio-cultural settings. In Dhaka, the lack of public amenities has neglected street activities in public spaces from the users' point of view. Furthermore, car traffic and parking have slowly seized space along streets and in squares originally belonging to pedestrians. In addition, conventional planning often does not consider the consequences of roadway connectivity for the public's accessibility.The dwindling pedestrian spaces in urban environments pose significant dangers and discomforts to the public. In addition, to the aforementioned quality indications, management or control of the urban public or street space is another indicator included in the majority of literature and can be considered a crucial success factor. This indicator has a direct connection to Dhaka city's urban planning and management. This research addresses the current condition of the pedestrian environment of Dhaka, and at the end, it will summarise how the urban and streetscape quality in particular is monitored and controlled. Later on, these markers will be used to gauge the standard of streetscape for a quality pedestrian environment, Fig. 1.

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Nomenclature:			
CBD	Central Business District	*Likert*	The scale used to measure survey participants
DCC	Dhaka City Corporation	*PPS*	Project for Public Spaces
DIT	Department of Information Technology	*SPSS*	Statistics software analysis
		VGA	Visibility graph analysis

2. Literature review

2.1 Streetscape quality indicators in urban settings

Urban design literature identifies several indices of urban quality, with Jane Jacobs' seminal work 'The Death and Life of Great American Cities' (1961) laying the groundwork. Jacobs emphasised safety, community interaction, diverse land use, and a blend of elements, highlighting four key conditions for urban vitality: mixed-use zoning, varied building ages, compact block structures, and sufficient population density. Her work pioneered the study of urban liveability, showing how human activity influences and reflects the built environment [23]. Expanding on this, Jacobs and Appleyard's 'Urban Design Manifesto' (1987) proposed seven principles for enhancing urban spaces, including liveability, public engagement, and addressing modern challenges like poor living conditions and a loss of urban identity. Furthering this discourse, Francis Tibbalds and the Urban Design Group [24] outlined eight interconnected aspects of urban quality (public spaces and special places; activity and mixed-use; visual richness; urban management; cleanliness and safety; structure, legibility and identity; human scale and compactness; moving about and pedestrian friendliness) in a report that critiqued the Prince of Wales' A Vision of Britain (1998), emphasising the need for accessible urban design principles. Florida (2002), known for coining the term "creative economy and creative class,'identifies six key aspects of place quality: diversity, social interaction, authenticity, lifestyle, identity, and creativity. He outlines three dimensions of place quality: 'What's there' (the creative environment), 'Who's there' (the residents and community), and 'What's going on' (vibrant street life, arts, and outdoor activities). These elements together create a dynamic and appealing city for the creative class, making it a hub for creative endeavours [9]. The Project for Public Spaces (PPS) highlights street quality as a key indicator of urban quality, outlining eleven aspects of exemplary streets. These include notable destinations, local identity, active edge uses, amenities for comfort, effective management, seasonal adaptability, catering to diverse users, efficient traffic and pedestrian flow, a blend of uses, and preserving neighbourhood character [22, 25]. Jacobs (2010) adds nine criteria, emphasising walkability, comfort, architectural harmony, greenery, and well-defined spaces. He also stresses the importance of elements like accessibility, density, visual contrast, and unique design features to enhance the street experience.The aforementioned urban and street quality indicators were ranked according to the Carmona et al. urban design dimension after being mentioned in the various urban design literature by Lynch [26], Appleyard [27], Tibbalds et al. [24], Parfect and Power [28], Montgomery [23], Florida [29], and Trip [9]. These indications were then filtered, sorted, and arranged as follows using a content analysis process.

After addressing nine indicators, each case study will specifically examine planning and management, and at the end, it will summarise how the urban and streetscape quality in particular is monitored and controlled. Later on, these markers will be used to gauge the streetscape standard for a quality pedestrian environment in this study. More information on many indicators of urban quality in general and streetscape quality, in particular, is explored in the urban design literature cited in the sections. Legibility gives travellers a sense of orientation and spatial awareness through physical features that serve as reference points (Ewing, 2006). A study by Yeung and Savage (1996) on Singapore's Orchard Road found that the clear readability of a street greatly enhances people's emotional security while navigating it. Considering this, legibility can be seen as a key indicator of urban quality, especially when evaluating the coherence and wayfinding of urban spaces like streets. Carmona et al. (2010) note that Lynch (1981) downplayed the importance of legibility as a key indicator of urban quality, viewing it as just one type of "feeling'in the overall city experience. Lynch (1984) also acknowledged that for most people, wayfinding was a secondary concern. Kaplan and Kaplan (1982) further proposed that coherence, legibility, complexity, and mystery are informational characteristics of environments that influence people's preferences for certain physical settings.

Accessibility is the ability of individuals to reach desired goods, services, and activities, considering not just physical distance but also convenience and availability [30]. Handy and Clifton [31] highlight that accessibility depends on both land-use patterns and transportation system efficiency, reflecting how easily people can access essential activities. This concept emphasizes the connection between urban design, infrastructure, and daily life. According to Litman, a key factor is pedestrian access to public transport, which affects transportation choices and active travel, shaped largely by community design.

Accessibility can be assessed by the number of options available within a given time and space, with travel time and land-use separation impacting accessibility. Connectivity measures the links between road segments, with well-connected networks featuring short, direct routes, numerous intersections, and minimal dead ends [32]. Street connectedness is typically measured by the number of intersections per land area, indicating the ease and directness of routes between homes and nearby destinations. High street connectivity, often seen in grid layouts, provides multiple route options for efficient navigation, while low connectivity, characterised by cul-de-sacs and fewer intersections, limits direct travel [33]. This concept is vital in urban planning as it impacts transportation efficiency and accessibility. Creating urban spaces that support diverse activities is key to fostering vibrant communities. Urban theorists like Jane Jacobs (2010), David Montgomery (2007), and Jan Gehl (2010) emphasise the importance of designing streets that promote social interaction and relaxation. Tarbatt (2012) views diversity as a spectrum within a community's economic and physical landscape, measured by factors such as land use, housing types, urban form, and architectural variety. These elements enhance the inclusivity and vitality of urban spaces. Florida (2002) highlights that diversity is a major factor in residential choices, with people often seeking environments that reflect racial, ethnic, and other forms of diversity [5].

The concept of liveability has evolved to include traits of sustainable communities and effective traffic management (Bosselmann, 2008). Since Appleyard and Lintell's (1972) study, liveability has been a key focus in urban planning, particularly concerning streets that have become unsafe due to traffic. They defined a liveable street as one where neighbours frequently interact in outdoor spaces, fostering a sense of community. It also refers to a place residents care for and consider their own. Measuring liveability requires examining personal perceptions, with research highlighting well-lit streets, pleasant outdoor areas, walkable destinations, and a healthy integration of human activity and nature [34]. Jan Gehl emphasises that active public spaces promote safety, as the presence of more people signals security and encourages exploration. This creates more 'eyes on the street,' with nearby residents observing street activity. Hillier's research further connects layout design to crime, finding that traditional street patterns have lower crime rates than modern hierarchical layouts. He suggests enhancing safety by connecting buildings, controlling access points, and maximising visibility. Place attachment refers to the "positive bond"formed between individuals and places [35]. Research shows that place attachment is a common global phenomenon, with most people feeling strongly connected to where they live. It can be categorised into three types: functional, emotional, and social attachment [36, 37].

2.2 Understanding the syntactic and statistical relationship relevant to the quality pedestrian environment

Quality of well-being in urban areas is a subset of the broader concept of quality, reflecting how well urban spaces meet people's needs [10, 23]. This concept covers a range of social, economic, and physical parameters, including urban ecological balance, availability of resources, physical environment, infrastructure, and level of comfort and happiness, contributing to resilient cities [38]. The quality of well-being concept assesses individuals' satisfaction, neighbourhood indicators, and relationships with the urban environment that satisfies the state of existence [13]. Many scholars evaluate the quality of urban public spaces using concepts such as sociability, legibility, connectivity and access, uses and activities, safety and security, comfort, place attachment, and livability, Tabel 1. Consequently, quality of well-being studies utilises both objective approaches, based on measurable indicators, and subjective approaches, based on users' perceptions [23,24]. Users' perception parameters were supported by on-site observations and surveys, that assessed space quality using the space syntax method.

Instead of representing spaces in a linear sequence, the space syntax approach examines the factors that impact human movement, uncovering social structures and spatial organisation. This method emphasises topological relationships by articulating spatial connections in terms of steps and spaces instead of numerical measurements [17]. Hillier conceptualised spaces as voids, employing graphs to illustrate movement paths and to highlight the association between social relationships and spatial environments. Following the creation of axial maps, these connections were analysed using the Depth Map X software. Essential concepts for evaluating the quality of urban public spaces through space syntax analysis include connectivity (the degree of visible areas

that enhances environmental perception, sense of place, and accessibility), integration (regions exhibiting high visual and mobility accessibility), and intelligibility (the clarity of spatial experience, which reaches its peak when the scattergram slope is at 45 degrees). Areas characterised by high levels of integration tend to exhibit vibrant social interactions and robust urbanisation [39]. High integration observed on axial maps correlates with appealing locales, influenced by factors like street activity, population density, and building quality. The researcher of this study utilised existing literature to define the criteria for high-quality urban public spaces, which are characterised by spatial arrangements that foster pedestrian-friendly environments within the cityscape. The central argument posits that for a community to be sustainable for its inhabitants, it must first ensure a liveable atmosphere. This viewpoint is consistent with the notion that the quality of public spaces plays a crucial role in determining urban liveability and sustainability [39]. Accordingly, the study aims to investigate the impact of quality streetscapes on the urban pedestrian experience, seeking to identify the essential criteria and key characteristics that contribute to the effectiveness of public spaces from the users' standpoint.

3. Method

This study adopted two methods: the space syntax method and survey through questionnaire and observation, to understand the current state of the pedestrian environment in Dhaka. As one of the data collection methods, the provision of 'Depth Map' in 'space syntax' is used as a technique for data presentation and analysis to measure spatial data. Another quantitative survey method is SPSS statistical analysis, which is obtained from user perceptions of the current physical characteristics of the streetscape. The questionnaire survey results also helped to interpret the quality indicators to validate the observational data.
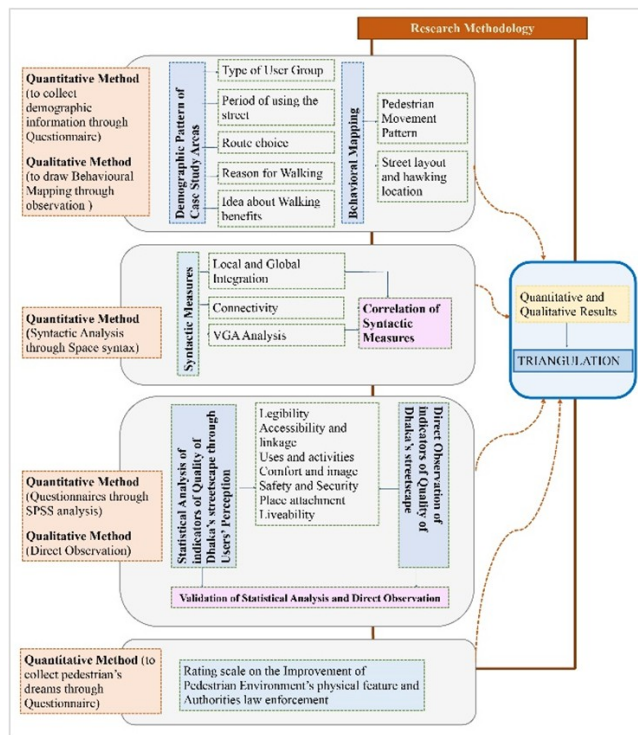

Figure 1. A methodological framework formulated for this research.

The space syntax method constituted the foundational phase of the investigation, utilising axial, segment, and visual graph analyses to scrutinise urban environments [21]. The literature frequently references values related to spatial integration and connectivity, along with measures of intelligibility [16, 27, 28]. Specifically, axial analysis is recognised for its efficiency in appraising public spaces, generating values associated with integration, connectivity, and intelligibility, which reveal the dynamics between human movement and urban morphology. This analysis yields valuable insights into urban morphology, net depth, and the intelligibility of urban locales, all vital for comprehending environmental perception, navigational orientation, and social foresight. Integration and connectivity values were obtained from the longest visible

street lines exhibiting minimal connections, while the intelligibility value was calculated through the correlation of these metrics. Other quantitative methods were employed for the analysis of numerical data in this study. The quantitative component was documented and analysed through a questionnaire survey, utilising the Statistical Package for the Social Sciences (SPSS) and Excel, based on eight major themes derived from extant literature. In the questionnaire, a 5-point Likert scale was adopted to gauge respondents' attitudes towards specific questions or statements. The statistical approach focused on ascertaining the effects of dependent and independent variables. Statistically significant relationships were established by an alpha level for each identified theme. The analytical unit for this investigation encompasses two groups: the users and the phenomenon of the streetscape within a real-life public context. To illustrate the quantitative data about the physical features of public places concerning the quality development of the streetscape, correlation coefficient analysis, frequency distribution, median, and totals were employed. Physical evidence was gathered onsite to supplement the perception data derived from the questionnaire survey analysis. Basic tools and techniques, such as hand-drawn plans, sketch maps, and digital photography notes, were utilised for data documentation to reinforce specific findings from the perception analysis.

3.1 Selection of sample size and respondents

This research employed Convenience Sampling, focusing on accessibility and ease of availability [40, 41]. As a non-probability sampling method, it was chosen for its practicality, without strict guidelines for participant selection. Chua [42] notes that inferential statistics generalise findings from the sample to the broader population. In Convenience Sampling, participants are gathered based on availability [43], without formal inclusion criteria. This approach was used in the study as the quality indicators of the streetscape varied, and the opinions of street users reflected the unique characteristics of the area, including activity patterns and pedestrian environment features. Dhaka Metropolitan City has a population of around 20 million (Bangladesh Bureau of Statistics, 2021). To determine the sample size for this research, published tables were used as recommended by Creswell [40], applying Yamane's (1967) formula and Krejcie and Morgan's [44] sample table. The sample size for this study was set at 400 respondents, representing the population and aimed at yielding accurate results. The research focuses on evaluating the quality of the physical environments in two street corridors in Dhaka. Given the city's large, diverse population, a specific number of participants were selected using Convenience Sampling to streamline data collection. Pedestrians and passengers regularly using the study areas were chosen to provide varied perspectives. The 400 respondents, equally distributed between the two sites, participated in the survey between 9 AM and 5 PM. Only individuals aged 18 or older were included to ensure they could objectively assess the streetscape's visual quality. This approach ensured the research was conducted efficiently and in line with the study's goals.

3.2 Case study

Dhaka is both the largest and busiest city centre of Bangladesh, Fig. 2. It is rich in its traditions and culture and is called the 'city of mosques'. According to the World Bank Report 2010, Dhaka is one of the most densely populated countries in the world. Dhaka city has a large boundary in terms of land size and number of populations. While selecting the specific areas within this municipality area, the survey locations focus on the busiest and most popular areas. Two study areas were chosen as samples, to represent the phenomena in the real-life context of people linked with streetscape quality in the urban spaces of Dhaka city. The areas are known as Mirpur Road [Dhanmondi 27 to New Market] (Case Study 1) and Motijheel Road [Topkhana to Toyenbee Road] (Case Study 2). The main functional activities of the areas are shopping and commercial based. Mirpur Road is located in the naturally grown central retail area and highly integrated location in both the global and local urban context of the city [45]. In addition, Motijheel Road is situated in the heart of the busy city, and being a commercial area has significant importance to the city dwellers [46]. Mirpur Road has become a crucial north-south corridor in Dhaka, connecting key districts like Dhanmondi, Mirpur, and Uttara. As one of the city's major highways, it spans from Dhaka New Market to Mirpur 10 Circle, supporting vital neighbourhoods such as Azimpur, Mohammadpur, and Dhanmondi. The road is heavily used by office workers and students, leading to significant congestion during peak hours. Despite efforts by the Dhaka Metropolitan Police (DMP) and Dhaka City Corporation (DCC) to manage pedestrian traffic, hawkers have returned to the pavements, posing challenges for the road's maintenance. Due to these issues, Mirpur Road was selected as a Case Study area to develop solutions that could later be applied to other city roads. Meanwhile, Motijheel, Dhaka's Central Business District (CBD), serves as another Case Study area due to its central location, dense concentration of

Table 1. Factors/Indicators under investigation for Pedestrian Environment related to Streetscape quality development in Dhaka city.

SN	Urban quality indicator	Components	References (Authors)
01	Ligibility	Creating a sence of direction and aiding navigation along the street.	Donais (2019), Sholihah (2016), Proshansky, Fabian and Kaminoff (1995), Dewar and Watson (1990), Frey (1991), Lynch (1981).
02	Accessibility and linkage	Mobility in and around the area. Accessibility within the community.	Relph (1976), Lynch (1981), Gehl (1987), El-Shimy (2016), Donais (2019)
03	Connectivity	Intensity of connections between road segments.	Hillier (1996), Marshall (2005), Koohsari Sugiyama et. al. (2014), Ozbil et al. (2011), Mohamad and Said (2014)
04	User and activities	Nature of users activity. The Pattern of Users activity. Distinctiveness	Tarbatt (2011), Gehl (1987), Dewar and Watson (1990), Mehta (1007), Montgmery (2007), Gehl (1987), Carmona et al. (2010), Gehl (1987), Shuhana and Norsidah (2008)
05	Livesbility	Physical features of the street	Jacobs (2011), Bosselmann (2008), Lynch (1981), Gehl (1987), Appleyard and Lintell (1972)
06	Creativity	Street festival and creatrivity	Madanipour (2013), Bayliss (2007), Landry (2000).
07	Safety and Security	Safety and security	Gehl (1987), Williams et al. (1995), Shuhana and Norsidah (2008).
08	Comfort and image	Comfortable engironmrntal condition of the street. Aesthesis character of urban places. Street image and transfomation.	Bentley et al. (1985), Prelovskaya (2017), Gehl (2010), Ewing et al. (2006), Herzog and Shier (2000).
09	Place attachment	Sense of place and user friendliness	Shuhana and Norsidah (2008), Shamsuddin (2010)

Table 2. Research methodology and strategy with research design from research objectives to tools.

Research approach	Research method		Data collection technique	Objective of collecting data	Analysis method
Mixed method study	Quantitative Method	Space syntax	Integration value Connectivity value Visibility graph.	Drawing an Axial map of two studied areas to obtain information on spatial characteristics of the urban streetscape on the urban pedestrian environment of Dhaka city.	Depth map analysis
		Questionnaire	Close-ended questions interpreting nominal, ordinal, and interval data.	To emphasise interpretation and significance, as well as how the participants comprehend their situations.	Statistical analysis through SPSS
	Qualitative Method	Observation	Observations conducted while walking or in the field; Mapping of physical features; Mapping of behaviours; Photographs and drawings.	To emphasise on natural settings	Physical mapping; Pedestrian Counts; Walk-by Observations, Behavioural Mapping, Text and Image Analysis

businesses, and the unique challenges it faces with pedestrian traffic and land use, making it a critical area for urban planning and development.

4. Research findings

Among the eight distinct quality indicators of urban public spaces, the criterion for use and activities will be connected to integration values. Meanwhile, aspects of sociability and legibility will relate to both integration and intelligibility values. The indicators of access, linkages, usage, and activation will correspond to the values of connectivity, integration, and intelligibility, Tabel 2. Finally, the elements of comfort and image, place attachment, and the criterion of liveability will be associated with the values of connectivity and intelligibility, as shown by the syntactic and statistical data.

4.1 The impact of spatial characteristics of the urban streetscape on the urban pedestrian environment of Dhaka city

The syntactic analysis for this study focused on how to get a better understanding of the configurational characteristics that influence the urban streetscape and pedestrian environment in Dhaka city. The main goal was to uncover how spatial layout impacts movement patterns and land use. The analysis sought to link concepts such as axial integration, connectivity, control, choice, and visual integration. By employing methods like axial analysis and VGA analysis, the study assessed accessibility patterns within Dhaka. The axial analysis examined the connection between axial properties and movement dynamics, while VGA analysis looked at visual configurations to predict accessible spaces that facilitate movement within a smaller grid. These analyses aimed to shed light on how urban design shapes movement and accessibility in Dhaka's urban environment. In this analysis, Case 1 (Mirpur Road) and Case 2 (Motijheel Road) were scrutinised within a concentrated radius of 5-10 minutes walking distance from the core of the study areas. The aim was to grasp the intricacies of the local spatial structure and investigate spatial measures of accessibility and connectivity through syntactic analysis of these two specific study areas. By focusing on these zones, researchers sought to gain insights into how the

immediate surroundings influence movement patterns and spatial dynamics within these urban environments. In Case 1, the Global Integration (Rn) Map of Mirpur shows that the least integrated roads (in blue) lead to the most integrated ones (in red), indicating the typical separation between spaces in the system. The axial analysis reveals that primary roads like New Market (1.013), Green Road (1.014), and collector roads such as Shahid Jahanara Imam Sharani (0.940) and Elephant Road (0.969) are highly integrated, with values exceeding the city's average global integration (0.677), with the highest being 1.087. Roads near Mirpur Road also show higher integration values, reflecting the street hierarchy. The intersection of key integrated lines, particularly near the Science Laboratory node, suggests that the integration core within the study area is centred around this node. The spatial structure of Mirpur Road is locally significant but lies outside the city's global integration centre. For local integration patterns, a radius of 4 was used, revealing that New Market (2.969), Green Road (2.932), and Elephant Road (2.544) are among the most integrated lines, surpassing the city's mean local integration (1.636). While Mirpur Road connects highly integrated lines, some local roads in the northern (Dhanmondi Road 4, 1.621) and southern Nilkhet areas (Babupara Street, 1.533) are less integrated within the research region, despite having values above the city's mean local integration. The analysis of Motijheel's Global Integration (Rn) Map reveals a distinct pattern where the most integrated roads, shown in red, connect to the least integrated ones, shown in blue. This map illustrates the typical distance between areas within the road network. Key primary roads like DIT Avenue (0.892) and Motijheel Road (0.829), along with collector roads such as Gazi Dastagir Road (0.851) and Dilkusha Road (0.827), stand out as the most integrated, surpassing the city's average integration values. These roads play a crucial role in the area's spatial structure, promoting efficient transportation. The grid-like road network surrounding the study area further enhances connectivity and accessibility, even for roads parallel to major arteries. This highlights the effectiveness of the road network in improving mobility within the area. The global spatial analysis shows a strong correlation between syntactic properties and street hierarchy, particularly evident in the integration values. Notably, major integrated roads like DIT Avenue, Press Club

Road, and Motijheel Road converge near the Dainik Bangla node, indicating that this node is the integration core of the area. The local integration map also highlights DIT Avenue (2.868), Motijheel Road (2.611), and Outer Circular Road (2.788) as the most interconnected routes, with Motijheel Road being especially significant at the Dainik Bangla and Shapla Chatter Node. While some local roads in the northern (Dilkusha) and southern (Aramabag) parts of the area have relatively lower integration levels, they still exceed the city's average local integration value (0.351) due to the complex spatial structure, Fig. 3. The connectivity value for several routes in Case 1 (Mirpur Road). The most connected roads in the study area include Green Road (27), New Market Road (22), Shahid Jahanara Imam Sharani (18), and Elephant Road (15) which are all higher than the city's mean value (4) and maximum value of (46). The connection value of several routes in Case 2 (Motijheel Road) is displayed in Fig. 4. The research region showcases several highly connected roads, notably Outer Circular Road, Motijheel Road, DIT Avenue, and Baitul Mukarram Road, with connectivity values of 23, 17, 15, and 14 respectively. These values notably exceed both the city's average connectivity value of 4 and its maximum value of 46. This suggests that these roads serve as crucial conduits within the region, facilitating significant movement and interaction between various spaces. Their elevated connectivity values emphasize their importance in the overall transportation and accessibility network of the area. The Visual Analysis (VGA) indicates that the lanes on Mirpur Road have poor visual connections with the surrounding streets compared to the main roads. These laneways require more visual syntactic steps (visual step depth), greater distances (metric depth), and higher angular deviations (angular step depth) to be visible from the main streets. This limited visibility can impede pedestrians' ability to engage in social interactions if the areas are not easily seen. Similarly, the analysis of Motijheel Road shows that its alleys also suffer from weak visual linkages to adjacent streets compared to the main roads. The alleys need more visual syntactic steps, longer distances, and greater angular deviations to be visible from the main streets. Poor visibility in these lanes can similarly make it challenging for people to participate in social activities if the locations are not prominent.

4.2 Impact of physical indicators of the pedestrian environment on users' daily activities on the urban streetscape of Dhaka

Sociability and legibility:

This research explored two case study areas with similar features: Case Study 1 (Mirpur Road), a commercial and shopping district, and Case Study 2 (Motijheel Road), a mixed-use area with approximately three thousand hawker shops. In both areas, street hawkers occupy various street levels, though primarily the main street in Case Study 2. The study examined user demographics, frequency of area use, travel modes, and the benefits of urban public space design. A survey of 400 respondents revealed that the majority of pedestrians in both areas were visitors from other parts of the city, with only a smaller portion being residents. Additionally, a significant number of respondents indicated that they walked in these areas out of necessity, with 38% in Case Study 1 and 49% in Case Study 2, while others viewed walking as a practical mode of transportation. The surveys reflect the significance of the users in inducing the perception of legibility through the physical attributes in and around the studied areas. The physical and distinctive features of the areas indicate the average contentment identified by the users. The degree of perception of the users of Case Study 1 and Case Study 2 is between the scale of 1 and 4, which is significant. The results suggest users' dissatisfaction with the components like street signage, attractive building frontage; obstacles in the footpath, and so on. The scale of user perception of the elements is found to be very close in both study areas. Approximately from both case areas 72% of the pedestrians stated that they visit the place frequently for their daily needs despite all the physical and environmental barriers. **Accessibility and linkage:**

The majority of the users perceived that accessibility and linkage are the foremost concerns in supporting a user-friendly streetscape. Users from both study areas have a negative impression of the elements related to the walkability and accessibility of the studied areas. The scale value of the agreement is between 1.5 and 2, which is below average. There are so many barriers, including poor transport facilities, lack of free walkable spaces, enormous traffic congestion, poorly linked spaces to easily move, shortage of parking spaces, walking-distanced public transport, street crossing facility, connection to public plazas, and conflict between pedestrian and carriageway and above all absence of a pleasant street view. Users from both case study areas confirm the statements as the problems in the particular areas. About 62% of users in Case Study 1 expressed the opinion that improper and unlawful bus stops cause extreme traffic jams and that pedestrian connectivity is disrupted during both peak and off-peak hours, Fig. 5. Case Study 2 users reported comparable issues. Nevertheless, the users visit the place frequently for their daily needs,

being hopeless with the current situation. Data indicate that users perceive certain unfavourable features to strongly impact the quality of the areas under examination. This suggests that the potential for improvement in both cases is likely to be very similar. Similarly, other identified problems demonstrate consistent patterns. This underscores the importance of addressing the variables associated with walkability and accessibility issues effectively and comprehensively. By doing so, there's a higher probability of enhancing the quality of the studied areas for the benefit of the city community.
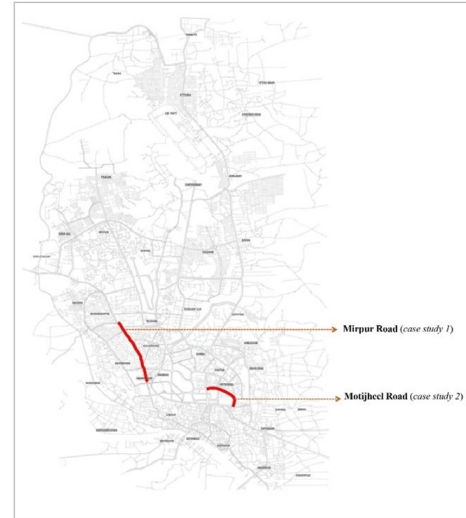

Figure 2. A methodological framework formulated for this research.

Uses and activities:

People are more likely to interact actively with their surroundings when a place has a variety of purposes and activities. People typically assess a place based on what it has to offer, how many activities it offers, and how well-kept the physical environment is. To identify the issues and problems of the urban streetscape in the urban public spaces of Dhaka city, a questionnaire, and direct observation were involved as data collection techniques. According to the users' perception, most of the respondents agreed that for both study areas, there are no specific pedestrian activities on weekdays and not even on weekends. However, the footpath is always busy with buying and selling activities by the street vendors. People are not happy that there are no public spaces that improve the community, interaction, economic viability, or the city's image because there is no prominent visual appeal in the surrounding neighbourhoods. People from the two studied areas agreed that there are diverse modes of operation, however, the eateries are not the right place to serve the nearby public. The route to the restaurants is also full of detours. abrupt crack in the sidewalk without proper pedestrian crossing facilities. So, it is important to have changes in diversity in land use. Both study areas exhibit a variety of activities. Although Case 1 is primarily a shopping district and Case 2 is a mixed-use area, both share similar street activities, particularly street hawking, in the urban public spaces of Dhaka city. The street hawkers in these areas operate in four categories based on a field survey: Permanent, Semi-Permanent, Semi-Mobile, and Mobile. The encroachment of pathways by hawkers and peddlers has made walking uncomfortable for many pedestrians, highlighting the poor maintenance of the walkable environment. In almost every researched region, hawkers of all types are present. In Case 1, permanent street vendors dominate, making up more than half (58.9%) of the total, followed by semi-permanent vendors (20.3%). Semi-mobile (12.9%) and mobile (7.9%) vendors are fewer in number and are typically found near entrances and exits. In Case 2, the majority of permanent hawkers (54.1%) are on the sidewalks, but there is also a relatively high proportion of mobile hawkers (24.3%).

Comfort and image:

Users' experience of comfort with the quality development of the urban pedestrian environment included those relating to hygiene, lighting, maintenance, and noise control. Users from both study areas have a negative impression of the elements related to the comfort of the studied areas. The scale value of the agreement is between 1 and 2, which is below average. Respondents agreed on so many barriers, like insufficient night light, busy and chaotic areas, unhygienic food and environment, open wastages on the road, poor maintenance systems and so on. All these statements discourage pedestrians not to walking on the footpath and enjoying the streetscape of that respective
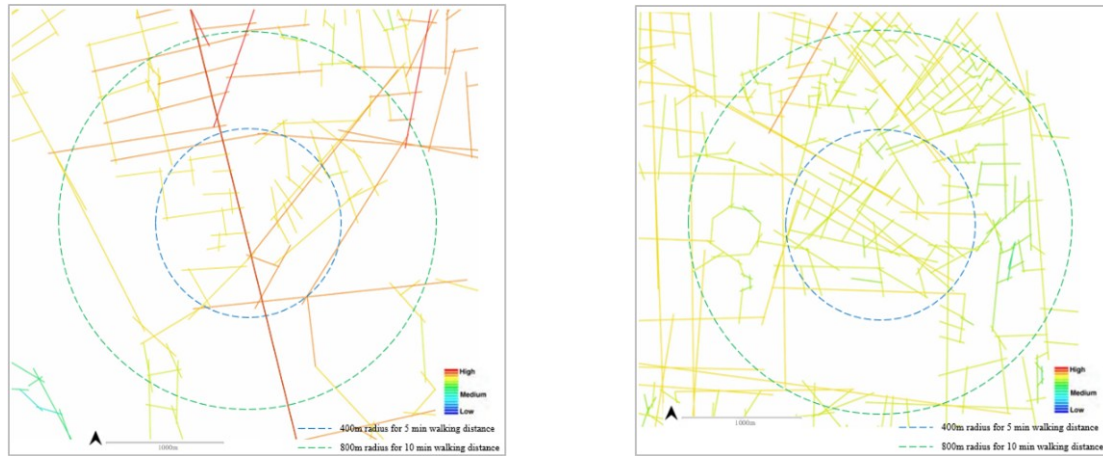
Figure 3. The global integration (R = n) of distinct roads within Case Study 1 (Mirpur Road) [left] and Case Study 2 (Motijheel Road) [right].
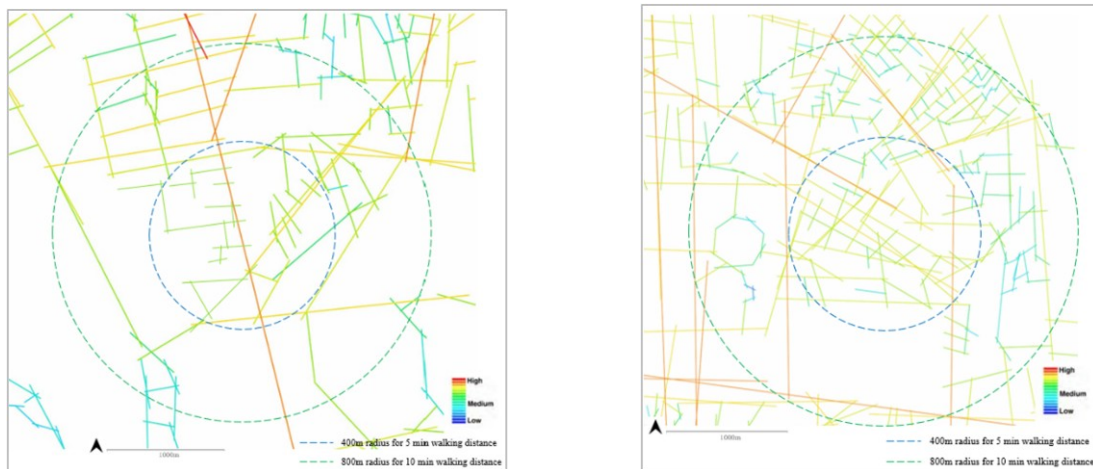
Figure 4. Integrating various roads locally (R=4) within Case Study 1 (Mirpur Road) [left] and Case Study 2 (Motijheel Road) [right].

area. The disorder, commotion, and disarray in the surrounding region make it impossible for people to move about. The hawkers as well as the customers are not concerned about the cleanliness of the areas due to lack of enforcement. There is a Mobile court authority (started in 2017) that has taken action against selling open, back-dated, and unhygienic food on the street. However, so many hawkers sell unhygienic food on the street. There is insecurity among users at night. The lighting system for business is not adequate because the hawkers use only 3 to 5 watts of energy-saving bulbs. There are no proper regulations for street lights from the city corporation and due to lack of maintenance, so many street lights are not working. The studied areas have no aesthetic elements to engage pedestrians while walking except for ubiquitous advertisements. So many roads in the studied areas are in poor condition which should be repaired. There is in need to disperse the availability of proper maintenance. According to RAJUK instructions (2008: 57), a plantation is a must for making the city liveable as well as for the city's beautification. However, there is a lack of plantation and landscape found in the areas, thus it couldn't provide breathing space for the public.

Safety and security:
It is revealed that the majority of users said that when using the footpaths, security and safety should come first. The components of the safety and security of the researched areas are perceived negatively by users from both study areas. The agreement's scale value, which falls below average, is between 1.5 and 2 (See Fig. 4). Security issues come in a plethora of forms, such as victimisation, threats, and criminality. These locations are the scene of numerous anti-social acts at night. Users verifying the statements as issues in the specific areas are those from both case study areas. Pedestrians tend to feel fear when they are approached by strangers, particularly when the stranger crosses their boundaries. Women are being harassed on the streets. There is a lack of eagerness to walk around alone especially when night falls because of many petty crimes and sudden attacks in the vicinity. Sometimes the hawkers are also threatened

by the local leaders and gangs.

Place attachment:
To critically assess whether respondents feel attached to the studied areas, the quality indicators of 'place attachment' were analysed, focusing on user-friendliness, culture, attraction, and curiosity. In both areas, user-friendliness was found to be lacking, with no significant attractions or representation of Bangladeshi culture. These issues contributed to an unpleasant pedestrian environment. However, all respondents agreed that their attachment to the area could be enhanced by physical interactions with the street, emphasizing the importance of physical features such as old shops, popular stores, and street pavements.

Liveability:
The surveys highlight the significance of physical characteristics in shaping users' perceptions of liveability in the studied areas, as well as the challenges they've identified. Users' perception levels for both Case Study 1 and Case Study 2 fall between 1 and 2 on the scale, indicating an average rating. The results reflect dissatisfaction with elements such as the width of the footpaths, street shelters, paving, and an overall unfriendly environment. The perception scale for these elements is consistent across both study areas. Despite 82% of respondents expressing that they do not enjoy walking in these areas, they continue to visit frequently to meet their daily needs, despite the physical and environmental obstacles.

5. Discussion

The study's findings underscore the imperative for improving the current streetscape scenario to unlock its full potential. By addressing all identified significant indicators, there exists an opportunity to establish a high-quality streetscape at the street level, thereby significantly enhancing the quality of public space and overall quality of life in the city centre. Consequently, the
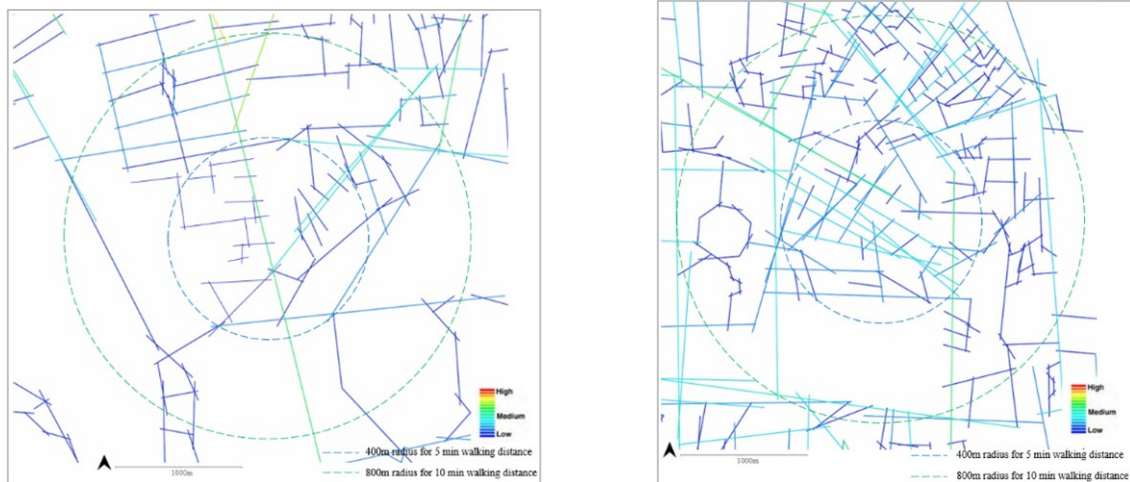
Figure 5. Connectivity of different roads within Case 1 (Mirpur Road) [left] and Case Study 2 (Motijheel Road) [right].

Table 3. Evaluation of the analysis.

Parameters	Syntactic analysis	Statistical Analysis
Evaluating factors	This approach is evaluated exclusively through assumptions concerning individual behaviour concerning physical characteristics. In the context of Space Syntax, urban mobility predominantly hinges on morphological factors.	The quality indicators are appraised based on individuals' perceptions of physical phenomena' societal and cultural effects. Quality indicators pertinent to the pedestrian environment offer insights into the living conditions of the city integrating the human aspect.
Measuring scale	Calculations in Space Syntax depend on quantitative measurements.	The statistical technique illustrates the practical application of these concepts.
The periphery of study areas	The information obtained from this approach is affected by the extent of the study areas.	The outcomes resulting from this method remain unaffected by the dimension of the site.
Data acquisition	Syntactic and statistical assessments seldom intersect. However, the benefits of using Space Syntax prove it as a primary method due to its ability to deliver rapid data and quantify findings numerically before experiencing space.	
Emerging findings	The effects of physical indicators pertinent to pedestrian environments, gathered through surveys and observations when combined with Space Syntax, offer a more thorough understanding of user demographics and variations in quality criteria. These include distinction in usage patterns between day and night and aspects of safety security – elements that Space Syntax alone may not adequately address. Research conducted through direct observation with users provides a clear representation of the area's current state. As a result, this methodology not only aids in evaluating the quality of spaces but also yields essential insights regarding potential enhancement.	

study highlights the importance of recommending practical and policy-based ideas aimed at implementing improvements. These recommendations can serve as a roadmap for local authorities and urban planners to initiate targeted interventions that not only enhance the physical environment but also contribute to fostering a vibrant and inclusive urban realm for residents and visitors alike.

- The syntactic analysis, questionnaire and observation data of pedestrian environment relevant to the streetscape of Dhaka mostly verify each other.

- The overall movement in the study area is notably higher near major arterial and secondary roads, thanks to strong connectivity with various attractors such as offices, bus stops, institutions, shopping centres, and food outlets. However, movement decreases significantly in areas deeper within residential zones. Footpaths along major roads like Mirpur Road and Motijheel Road are particularly busy, serving as key walking routes for many pedestrians.

- The axial characteristics and VGA properties have been analysed separately to better understand the accessibility conditions. The axial analysis reveals that the Mirpur site is more globally integrated within the city's spatial structure, making it a more integral part of the urban system. Main roads like Mirpur Road and connecting roads such as Shahid Jahanara Imam Sharani, Science Laboratory, Elephant Road, and Nilkhet-Katbon Road have achieved higher integration values, indicating better accessibility. In contrast, the Motijheel area remains outside the city's global core, holding local significance. As a result, primary arterial roads like DIT Avenue, Motijheel Road, and Circular Road have seen increased integration values. A moderate correlation

between global integration and connectivity has been found in both areas, suggesting a moderate level of ïntelligibility,ör the ability to understand the grid from a local scale to a broader context that influences movement. Other streets intersect more integrated lines at deeper levels, contributing to a more comprehensible system.

- The statistical analysis of streetscape quality indicators reveals that both studied areas are in poor condition. Users expressed dissatisfaction with the current state of physical features, citing a lack of attractive qualities, clear signage, wayfinding, safety, and other essential elements. Similar issues were observed across other quality indicators. These concerns were also confirmed by direct observation surveys. Consequently, it is believed that enhancing these conditions could contribute to creating a more liveable city community in Dhaka.

5.1 Comparing the syntactic and statistical analysis

The overall results reveal that the quality of urban public spaces is assessed as an average based on statistical metrics, however, it is rated below average when evaluated using the Space Syntax method. This leads to several overarching conclusions regarding the study, Tabel 3.

5.2 Rationale for result analysis

Interpretation requires more than just data analysis; it demands conceptual and critical thinking to uncover and distil key insights from the complexity and nuances of the findings [47]. Carmona et al. (2010) argue that inclusive urban design aims to create better spaces for all potential users of the built environment. The goal of making Dhaka a liveable city by 2035 should focus on enhancing street-level activities and the experiences of street users.

Street activities in Dhaka primarily revolve around street hawking, and while public spaces should meet users' needs, these spaces lack appeal beyond serving daily necessities. Syntactic and statistical analysis confirmed that the elements supporting public space activities failed to satisfy users in both case studies. This highlights the impact of streetscape on the Üses and Activitiesöf public spaces, addressing the research objectives. The findings align with Appleyard's (1981) 'Liveable Streets' theory, which links increased movement to the decline of street liveability. People need familiarity to navigate pedestrian environments and believe the government should enhance these spaces with distinct features. This aligns with theories suggesting that physical barriers and interruptions along pedestrian paths are perceived as unpleasant and time-consuming [48–51]. Similarly, user perceptions of public space activities support findings from studies on Switzerland's streetscapes [52] and walkability [53] Illegal Street parking, disorganised street stalls, traffic congestion, and a lack of pleasant walkable spaces act as barriers, reducing accessibility and connectivity. Providing adequate space for pedestrians through proper guidelines can create successful public spaces. This aligns with PPS [22], which states that a place's accessibility is determined by its visual and physical connections to its surroundings. Previous literature by Jacobs (1961) and Whyte (1964) suggests that activities attracting pedestrians to urban spaces can enhance safety. The findings indicate that poor lighting, lack of security personnel, and unwelcoming features along walkways contribute to pedestrians' anxiety and fear of victimisation. Additionally, observations and user perceptions show a lack of appealing imagery that could invigorate the area and its users. These issues are also supported by the research of Gehl (1987), Bentley et al. (1992), and Marcus and Francis (1998). The explanation provided indicates that spatial configuration alone is not a strong predictor of pedestrian environments. This suggests that other factors, like physical indicators, significantly impact pedestrian behaviour, emphasising the importance of considering elements beyond spatial layout when analysing movement patterns.

6. Conclusion

Walkability serves as an exceptionally effective way to intimately experience a city and its neighbourhoods, and this is also a crucial measure of urban liveability. This research has uncovered some interesting findings. The outcomes hold significant implications, leading the author to advocate for further studies aimed at establishing a more comprehensive database, which would enhance peoples' grasp of pedestrian-friendly streetscapes in public areas. This study deepens comprehension by validating the distinctive characteristics of urban streetscapes that accommodate foot traffic and are vital for promoting lively urban public interactions. It also reaffirms earlier research regarding the multifunctional nature of streets in Asia. Additionally, the study adds to the expanding evidence that underscores the importance of accessible urban streetscapes in the urban experience. While these findings contribute to resolving the query of which methodology proves to be more effective in assessing quality, they may also offer insights into the selection and application of approaches for subsequent research.

Authors' contribution

All authors contributed equally to the preparation of this article.

Declaration of competing interest

The authors declare no conflicts of interest.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data that support the findings of this study are available from the corresponding author upon reasonable request. The data that support the findings of this study are available from the corresponding author upon reasonable request. The data that support the findings of this study are available from the corresponding author upon reasonable request.

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