



Spatial and Perceptual Evaluation of Architectural Façade Projections and Pedestrian Walkability within Bhaktapur's Traditional Streetscape

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Abstract

Balconies, overhangs, windows, colonnades, architectural trims, oriels, and brick cornices are characterized by closely spaced building with projecting elements that define Bhaktapur's ancient streets. The façade projection influence both the pedestrian walking experience and the spatial character of streets. This study examines how architectural façade projections affect pedestrian walkability in four major traditional streets of Bhaktapur. The study examines how architectural façade projections affect pedestrian walkability and compares observed physical streetscape characteristics with pedestrian perception in four major traditional streets of Bhaktapur. The study investigates how façade projections influence important walkability characteristics such as imageability, enclosure, transparency, street interface, and pedestrian infrastructure. The study uses a mixed-method approach. Serial Vision analysis is used to observe physical streetscape characteristics, while pedestrian perception surveys are conducted to understand people's experiences. The Relative Importance Index (RII) approach is used to analyze and rank pedestrian responses based on their walking experiences. Physical aspects such as street width and building height are considered alongside human perceptions of comfort, safety, and visual attraction. The findings show that spatial analysis and pedestrian perception produce different results. While Serial Vision analysis identifies Street 4 as the most walkable based on physical attributes (total coverage up to 86.54%), the RII results identify Street 1 as the most walkable based on user perception (RII = 2.03–2.12). Imageability emerges as the most influential attribute in both methods, while transparency is valued more strongly in perception than in spatial analysis. The results shows that pedestrian perception of walkability differ from those of the theoretical method. This divergence suggests that physical observations of streets may not fully reflect how people perceive walking in the space. The study demonstrates that walkability in traditional streets is shaped by the interaction between spatial characteristics and user perception rather than by physical form alone. The findings are important for urban designers, planners, and researchers interested in pedestrian-friendly street design, highlighting the need for integrated approaches that combine spatial analysis and perception-based evaluation.

Keywords: *Pedestrian, Walkability, Architectural Façade Projection, Traditional Streetscape, Perceptual Qualities*

1. Introduction

Bhaktapur is the one of Kathmandu Valley's three major cities, is known for its well-preserved mediaeval streetscapes, ancient squares, and richly decorated architecture. The city's streets are narrow and frequently lined with buildings that feature architectural building projections including bay windows, balconies, overhangs, carved struts, and projecting facades. These features not only establish the city's visual and cultural identity, but they also impact pedestrians' spatial experiences, such as enclosure, visibility, shading, and movement patterns. They perceptually affect a pedestrian's perception of comfort, safety, orientation, and visual interest as they go through the streets, aligning with Lynch's (1981) ideas of legibility and human-scale urban setting. Bhaktapur's traditional human-scale proportions and fine detailing offer a unique interplay between architectural form and pedestrian mobility, yet these traits are under threat from modernization and uncontrolled urban transformation. Southworth (2005) define Walkability is defined as walkability as the extent to which the built environment supports and encourages walking by providing safety, accessibility, connectivity, and visual interest within a reasonable distance (Southworth, 2005). Streetscape refers visual and functional characteristic of street as determined by its physical components, such as building facades, sidewalks, street furniture, trees, signage, lighting, and other elements that work together to create the pedestrian experience and urban identity(Moughtin, 2007).

Walkability is most primary mode of transportation . Before the expansion of automobile use in the nineteenth century, urban settlements were organized to support pedestrian movement. With the growth of automobile-oriented development in the twentieth century, emphasis shifted away from walking and public transport(Ariffin & Zahari, 2013)the advent of transportation technology, such as automobile and superhighway has degraded the pedestrian environment. The aim of the paper is to examine the characteristics or attributes that could promote walking acti perception of the urban walking environment. Findings indicate that the proximity of destinations, good weather condition, safety and well-designed pedestrian facilities can significantly contribute to better perceptions of the walking environment. In recent decades, walking has regained importance as a component of sustainable urban development due to concerns related to pollution, energy consumption, and transportation congestion. Walking contributes to health, accessibility, and everyday mobility (Fonseca et al., 2022). In traditional neighbourhoods, buildings are positioned close to the street and incorporate openings such as windows and balconies that overlook the street, creating "eyes on the street" which supports safety and social interaction(Jacobs, 1961.). Face-to-face interaction within neighborhoods contributes to social cohesion and supports the formation of safe and active public environments . Scholars including Oscar Newman, William Whyte, and Jan Gehl have demonstrated that the built environment influences social behaviour through observable spatial conditions. Whyte emphasized that activities such as walking, sitting, and interaction contribute to active street life, while active building frontages strengthen the relationship between interior and exterior spaces. In contrast, inactive frontages reduce pedestrian engagement(Singh, 2016). According to Jan Gehl (2010)emphasized the importance of designing at the pedestrian scale and introduced the concept of "soft edges," where transparent facades and active ground-level elements support pedestrian interaction and engagement.

Urban design research has identified key perceptual attributes relevant to walkability, including imageability, enclosure, transparency, human scale, complexity, legibility, connection, and coherence. (Ewing & Handy, 2009). Among these, imageability, enclosure, and transparency have been operationalised and are directly relevant to pedestrian experience. Perception is a cognitive process through which individuals observe, interpret, and assign meaning to their environment. Perception varies among individuals and is shaped by experience and context (Youssef, 2015).Visual perception influences how pedestrians understand and respond to urban space. Lynch , Cullen , and Appleyard emphasise the importance of understanding the city from

the pedestrian point of view through imageability, sequential experience, and visual continuity (Al Mushayt et al., 2021). The term facade refers to the visible exterior of a building and includes architectural elements such as openings, materials, colour, surface articulation, and decorative features (Cucuzzella et al., 2022). In traditional settings such as Bhaktapur, façade composition reflects local craftsmanship and contributes to architectural continuity and identity. These facade elements also define the relationship between the building and the street. The street–building interface defines the transition between public space and private space. Elements such as entrances, windows, plinths, balconies, and awnings determine the degree of interaction between the building interior and the street. A well-articulated street interface supports social interaction, enhances safety, and strengthens the sense of place (Koralage et al., 2023).

In *The Concise Townscape*, Gordon Cullen introduces the concept of serial vision, which describes how urban space is experienced sequentially as a series of views during movement. The visual experience changes through variations in enclosure, alignment, projection, and spatial sequence. This sequential experience contributes to the quality and memorability of urban space (Guy, 2022). Serial Vision provides a method for analysing the visual and spatial experience of streets and is particularly relevant for examining facade projections within a continuous streetscape. This study examines how architectural facade projections influence pedestrian walkability and analyses the relationship between observed streetscape characteristics and pedestrian perception in selected traditional streets of Bhaktapur. It focuses on identifying and documenting different types of facade projections and evaluating their influence on key walkability attributes, including imageability, enclosure, transparency, street interface, and pedestrian infrastructure. The study further examines the relationship between spatial parameters and perceptual responses of pedestrians through a combined visual–spatial and perception-based analysis. Based on these findings, the study also considers how façade projections can be managed to enhance walkability while maintaining the historic and architectural character of the streets. The results aim to inform context-sensitive urban design strategies for improving pedestrian experience in traditional urban environments.

2. Materials and Methods

2.1 Study Area

The study area is located within the historic center of Bhaktapur and focuses on some important streets around Taumadhi Square, Sukuldhoka, Golmadhi Street, and Dattatraya Square. These locations form part of the traditional urban setting of the city and represent its cultural and architectural character. The streets are lined with buildings that display elements of Newari architecture, such as slanted roofs, brick façades, and finely carved wooden windows. The presence of temples, heritage structures, cafés, restaurants, and souvenir shops makes these spaces lively and socially active. These features attract both local residents and visitors, creating vibrant public environments with different levels of pedestrian movement and commercial activities.

Each of the selected streets has distinct spatial and visual characteristics that shape the pedestrian experience. Taumadhi Street is known for its active environment, with tourist-related activities and well-preserved traditional buildings. Sukuldhoka Street serves mainly as a local market area with many different types of shops, although the street itself is relatively narrow. Golmadhi Street is wider compared to other streets and shows visible attempts to restore traditional Newari architectural features following the earthquake. Dattatraya Square, which is listed as a UNESCO World Heritage site, has strong cultural and religious importance and is recognized for its detailed wooden windows and the historic Dattatraya Temple. The variety of physical settings and activities across these streets makes them suitable for examining how architectural elements, street proportions, and surrounding activities affect pedestrian perception and walkability.

2.2 Research Approach

The study approaches a mixed-methods research approach within a case study method, focusing on selected traditional street sections in Bhaktapur's historic area. Both qualitative and quantitative methodologies are used to examine the impact of architectural façade projections on pedestrian walkability. Quantitative method is conducted using Gordon Cullen's Serial Vision approach, which evaluates pedestrians' sequential visual and spatial experiences by documenting key perspectives, changes in enclosure, rhythm, light and shadow, and visual continuity throughout walking paths. Key spatial and perceptual walkability characteristics are discovered and evaluated through a review of the literature and field observations.

The subjective perception of local and visitors regarding how they perceive building façade projection while walking on traditional street is surveyed through Likert scale method. The survey has been taken for 114 respondents. So, by using W.G. Cochran (1953) to estimate proportion. The overall research method adopted in this study is illustrated in Figure 1 Research method. The Relative Importance Index (RII) method is then used to determine the relative relevance of these characteristics, and each street segment is ranked accordingly. The combination of Serial Vision analysis and weighted spatial and perceptual evaluation provides a thorough understanding of how architectural façade projections affect pedestrian walkability in Bhaktapur's traditional streetscapes

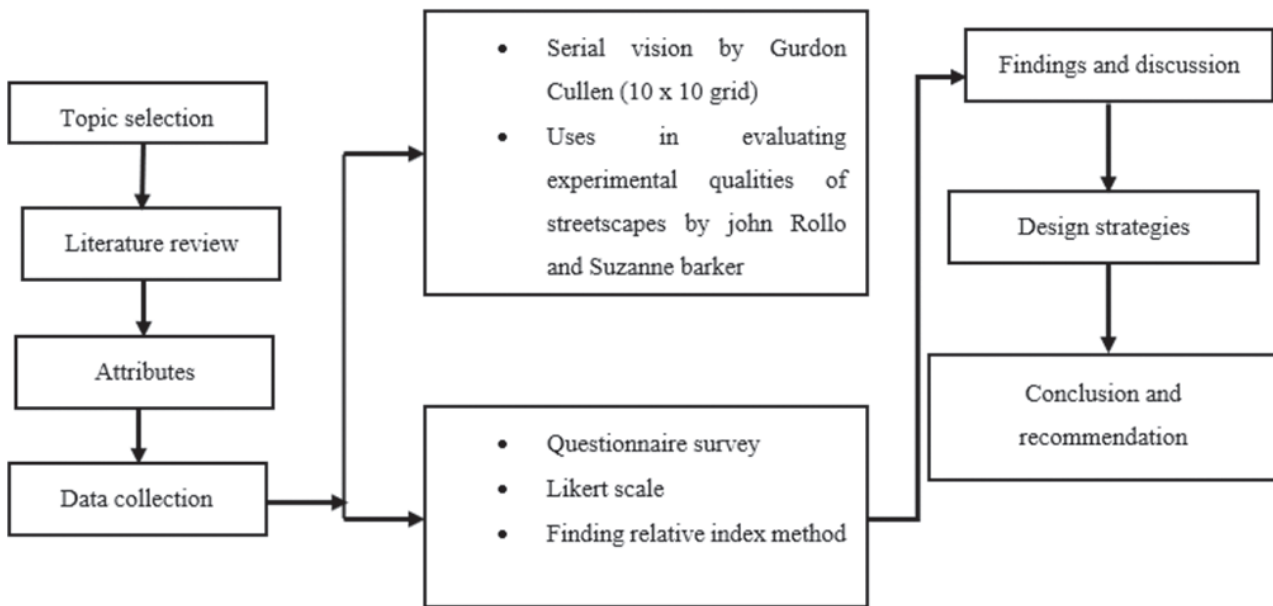


Figure 1: Research approach

2.3 Analytical Framework

The attributes that extracted from literature are used for further analysis. It is based on the flowchart, the conceptual framework groups urban attributes into two main types: objective and subjective. Together, these objective and subjective attributes explain both the physical form of the street and the way people perceive and interact with it. These factors are imageability, enclosure, transparency, street interface and pedestrian infrastructure. The classification of these attributes is shown in Figure 2 Attributes extracted from literature review. The spatial distribution of these attributes is analysed using grid-based mapping, while perception is analysed using the Relative Importance Index (RII). Finally, the results from Serial Vision analysis and the RII-based perception analysis are compared to examine the relationship between observed

spatial characteristics and pedestrian perception of walkability.

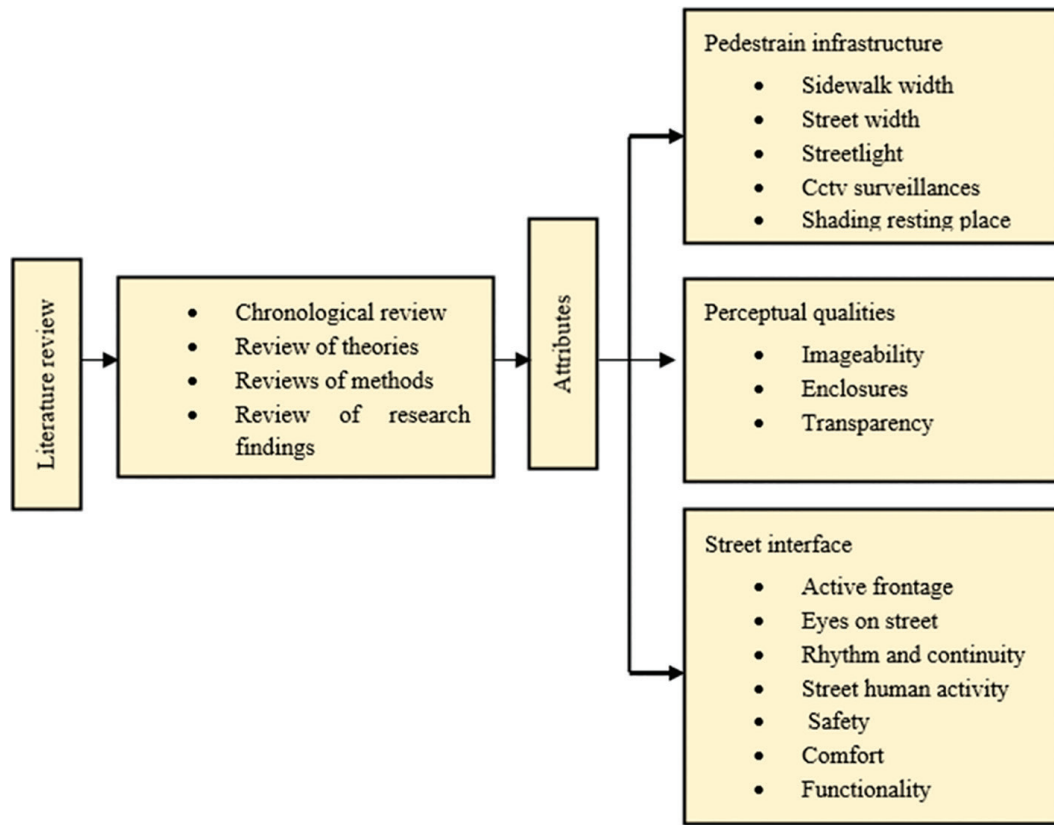


Figure 2: Analytic frame

The four observation streets selected for analysis are Street 1 – Taumadhi Street, Street 2 – Sukuldhoka Street, Street 3 – Golmadhi Street, and Street 4 – Dattatraya Street. These streets were selected for analysis because they represent different spatial and functional conditions within the traditional urban setting of Bhaktapur.



Figure 3: Street 1



Figure 4: Street 2



Figure 5: Street 3



Figure 6: Street 4



..... 1 Taumadhi street 2. Sukuldhoka street 3. Golmadhi street 4. Dattrataya Sqaure

Figure 7: Observation street

Color mapping was used to measure different physical features related to attributes such as imageability, enclosure, transparency, street interface, and human scale shown **Table 1**. A 10×10 grid was applied, and the presence of these features was calculated in percentage form. The results are shown in Figure 6, which indicates how strongly each attribute is present at each location. The table presents attributes across different streets, including facade elements such as bay windows, decorative windows, lattice windows, wooden carved cornices, brick carved cornices, tiki jhya, toran, and other traditional architectural features that contribute to imageability. Mapping the coverage refers to calculating the total coverage of each attribute within the study area. The mapping helps to visually represent how different urban design qualities are distributed along the street.

Table 1: Attributes in different spots

Attributes	Street's
Imageability	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p><i>Street 1</i></p> <p>Bay windows, decorative windows, lattice window, wooden craved cornices, tudals, brick carved cornices, cement wash cornices, jhingati tiles</p> </div> <div style="text-align: center;">  <p><i>Street 2</i></p> <p>Bay window, tiki jhya ,brick carved conices, tiki jhya ,toran</p> </div> </div>



Street 3

Bay windows varieties (circular, rectangular, slanted), tiki jhya, wooden craved cornices , brick carved cornices, prajapati tiles,



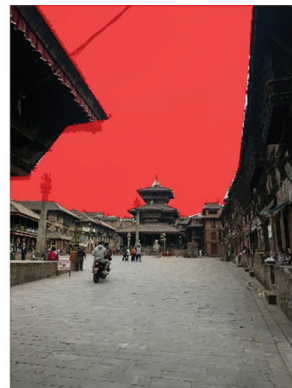
Street 4

Decorative window,brick craved cornices,

Enclosure



Street 1



Street 2



Street 3



Street 4

Transparency



Street 1



Street 2



Street 3



Street 4

Street Interface



Street 1



Street 2



Street 3



Street 4

Pedestrian infrastructure



Street 1



Street 2



Street 3



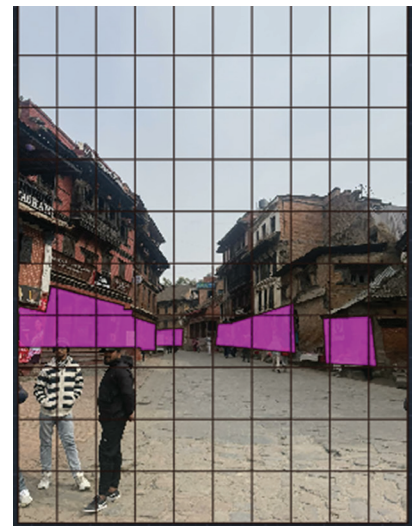
Street 4



Imageability coverage :25%



Enclosure coverage:20%



Transparency coverage: 5%

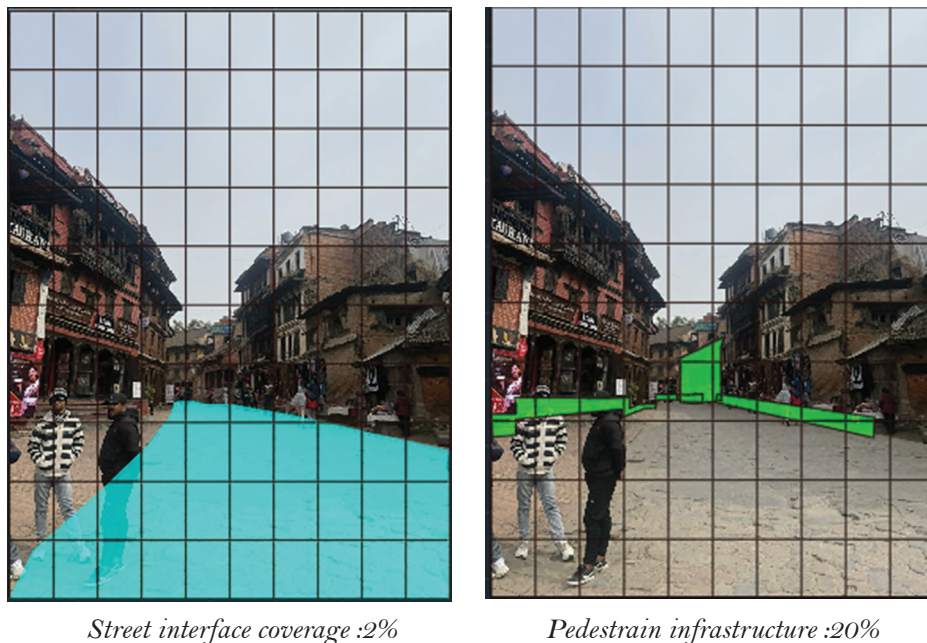


Figure 7: Observation street 1

Table 2: Summary of mapping

Attributes	Street 1	Street 2	Street 3	Street 4
Imageability	25%	15%	18%	35.00%
Enclosure	20%	10%	15%	25%
Transparency	5.00%	8.60%	8.50%	2.60%
Street interface	2.00%	8.50%	3.50%	3.94%
Pedestrian Infrastructure	20%	10.40%	13.90%	20%
Total	72%	52.50%	59%	86.54%

The results are summarized in Table 2, which shows that Street 4 has the highest coverage at 86.54%, indicating that it has the strongest presence of walkability-related physical attributes. In comparison, Street 2 has the lowest coverage at 52.50%, showing that it is less walkable than the other streets. Street 1 and Street 3 show moderate levels of attribute coverage. The figure7 above presents the mapping of urban design qualities at Observation Street 1 as a sample, and similarly all the other attributes were mapped and analyzed using the same method as demonstrated above.

Table 3: Frequency table of different scale by people at street 1

STREET 1					
Attributes	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Imageability	15	10	4	1	0
Enclosure	6	12	8	4	0
Transparency	12	13	6	1	1
Street interface	13	12	5	2	0
Pedestrian infrastructure	11	10	7	3	1

Similarly all the other street's table frequency were analyzed using the same as demonstrate above.

Analysis of Likert scale was conducted to understand pedestrian perception. A total of 114 respondents were asked to rate their level of agreement from strongly agree to strongly disagree using a scale from 1 to 5 based on the survey statements. This five-point Likert scale was used to collect the data. Such a scale is commonly used to understand people's attitudes, perceptions, and opinions about a specific subject. The statements were based on the attributes introduced by Gordon Cullen in his 1961 work *Townscape*, which explains the Serial Vision method. These attributes were used in the form of statements to understand how people perceive an area while walking through it. The frequency distribution of responses for each attribute is presented in **Table 3**, and similarly all the other street frequency tables were analyzed using the same method as demonstrated above.

Table 4: Calculating relative importance index

Attributes	Relative importance index			
	Street 1	Street 2	Street 3	Street 4
Imageability	0.45	0.3	0.3	0.352
Enclosure	0.46	0.4	0.45	0.46
Transparency	0.39	0.45	0.37	0.4
Street interface	0.37	0.45	0.4	0.39
Pedestrian infrastructure	0.45	0.35	0.44	0.44
Total coverage	2.12	1.95	1.96	2.042

The Relative Importance Index (RII) was calculated to determine the relative importance of each attribute. The RII values for different walkability attributes across the four streets are presented in **Table 4**. The attributes analyzed include imageability, enclosure, transparency, street interface, and pedestrian infrastructure. The results show that Street 1 has the highest total value at 2.12, which indicates that it is perceived as the most walkable street. In comparison, Street 2 has the lowest value at 1.95, showing that it is less walkable than the other streets based on pedestrian perception. Street 3 and Street 4 show moderate values. The comparison between spatial analysis and perception-based analysis shows that the two methods produce different results in identifying walkability. The mapping results (**Table 2**) identify Street 4 as the most walkable based on physical attributes, while the RII results (**Table 4**) identify Street 1 as the most walkable based on pedestrian perception. This difference indicates that physical observations of streets do not always fully reflect how people perceive walking in the space. While some streets perform strongly in terms of spatial characteristics, they may not be perceived as equally walkable by users.

The analysis shows that both spatial characteristics and pedestrian perception play important roles in understanding walkability. The results suggest that objective and subjective attributes need to be considered together in evaluating pedestrian environments, particularly in traditional urban streets where visual character and user experience are closely linked.

3. Results and Discussion

3.1 Spatial Analysis using Serial Vision Method

The findings presented in this section were analysed using the Serial Vision method introduced by Gordon Cullen (1961). The analysis is based on the color mapping approach explained earlier in the Observation and

Analysis section. The results of this analysis are discussed below. The coverage of different urban design attributes observed in four streets is presented in Figure 8. The attributes include imageability, enclosure, transparency, street interface, and pedestrian infrastructure. The bar diagram helps to understand how strongly these qualities appear in each street.

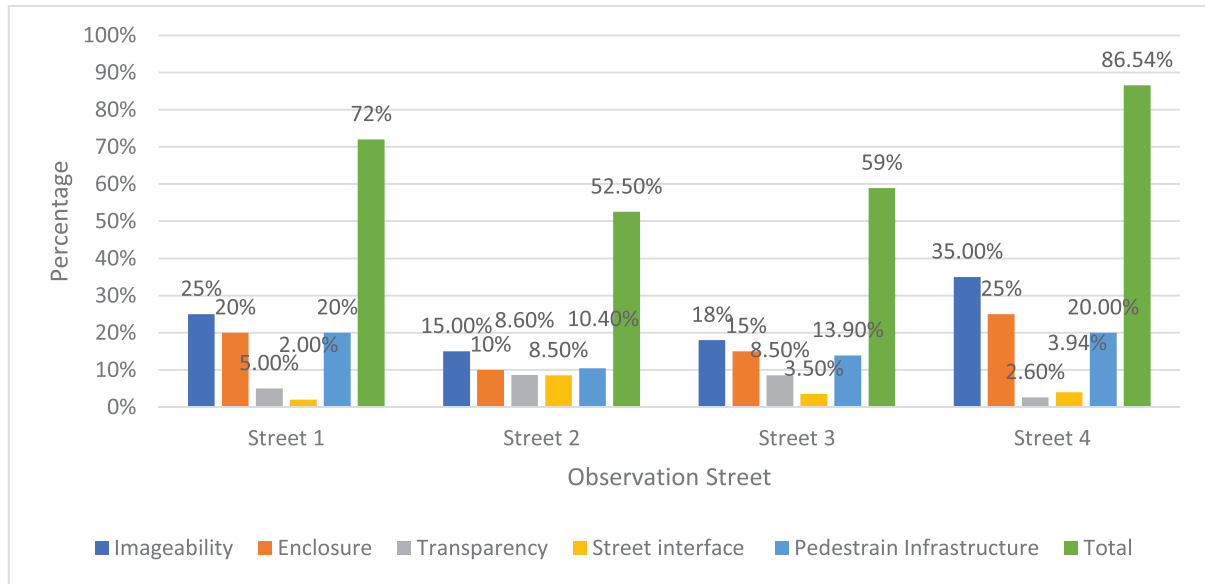


Figure 8: Different attributes and their coverage

A comparison across the streets shows that Street 4 has the strongest overall presence of urban design qualities, with a total coverage of 86.54%, followed by Street 1 (72%), Street 3 (59%), and Street 2 (52.50%). In Street 4, imageability (35%) and enclosure (25%) are clearly visible, indicating a strong visual character and a well-defined spatial form. This aligns with Cullen's (1961) concept of Serial Vision, where spatial sequence and enclosure contribute to a strong townscape experience. Pedestrian infrastructure in Street 4 is also relatively high (20%), supporting pedestrian movement. Street 1 also demonstrates a relatively strong presence of urban design attributes, particularly imageability (25%) and pedestrian infrastructure (20%). However, transparency (5%) and street interface (2%) appear weaker compared to other attributes, suggesting limited interaction between buildings and the street. This contrasts with Gehl's (2010) emphasis on active edges and visual connection at street level. Street 3 presents a moderate level of urban design qualities, with imageability (18%), enclosure (15%), and pedestrian infrastructure (13.90%) showing a balanced presence. Transparency (8.50%) and street interface (3.50%) are present but less dominant. Street 2 shows the lowest overall presence of the observed attributes, with total coverage of 52.50%. Although some elements of imageability (15%) and enclosure (10%) are present, transparency (8.60%), street interface (8.50%), and pedestrian infrastructure (10.40%) are relatively limited. This suggests that the street environment provides fewer spatial qualities that support pedestrian experience, which is consistent with Moughtin's (2007) discussion of streetscape quality requiring integration of multiple elements. The Serial Vision analysis shows that Street 4 performs best in terms of physical attributes, followed by Street 1, while Street 2 shows the weakest performance.

3.2 Perception-Based Analysis using Likert Scale and RII

Further data were analysed using the Likert scale method based on respondents' perceptions. The results of

the Relative Importance Index (RII) are presented in **Figure 9** and **Figure 10** .

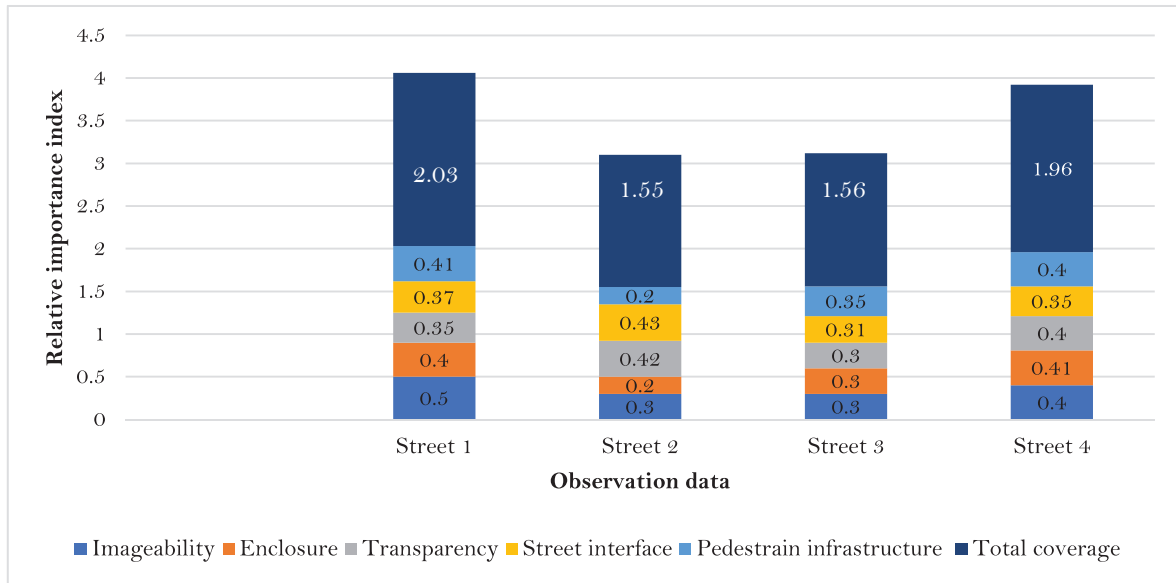


Figure 9: Different attributes calculated by RII

The RII values indicate that Street 1 has the highest total value (2.03–2.12), followed by Street 4 (1.96–2.024), while Street 2 (1.95) and Street 3 (1.56–1.96) show lower values. This indicates that Street 1 is perceived as the most walkable street. In terms of individual attributes, imageability shows the highest value in Street 1 (0.5) and remains high in Street 4 (0.4), indicating strong visual identity. This supports Lynch’s (1981) concept of imageability, where recognizable elements contribute to the legibility of urban space. Enclosure shows relatively balanced values across the streets, with Street 4 (0.41) and Street 1 (0.4) slightly higher. Transparency shows higher values in Street 2 (0.42) and Street 4 (0.4), indicating that pedestrians value visual connection and street-level activity. Street interface shows generally lower values, with Street 2 (0.43) slightly higher than others. Pedestrian infrastructure shows moderate values, with Street 1 (0.41) and Street 4 (0.4) performing better. These results indicate that Street 1 and Street 4 perform better in terms of perceived urban design qualities, while Street 2 and Street 3 perform relatively lower. This suggests that pedestrian perception is influenced not only by physical attributes but also by experiential qualities, as discussed by Gehl (2010).

3.3 Integrated Analysis of Spatial and Perceptual Walkability

The comparison between Serial Vision and RII results is presented in Figure 10, and Figure 11. The findings show that the two methods produce different results in identifying the most walkable street. According to Serial Vision analysis, Street 4 is identified as the most walkable street, while the RII results identify Street 1 as the most walkable. This difference reflects the distinct nature of the two approaches. Serial Vision focuses on spatial form, sequence, and visual structure (Cullen, 1961), while RII reflects pedestrian perception and experience.

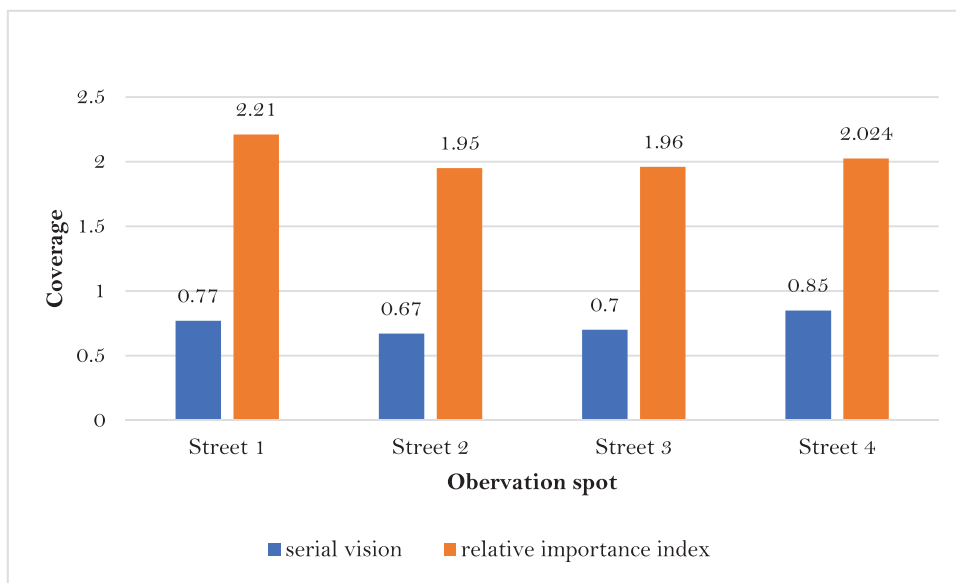


Figure 10: Comparison of findings

Table 4: Comparison table of serial vision and RII

Description	Spot with maximum values	
	Serial vision method	Relative importance index
Imageability	93%(1)	1.5(1)
Enclosure	70%(2)	1.31(4)
Transparency	24%(4)	1.47(2)
Street interface	17.94%(5)	1.16(5)
Pedestrian infrastructure	64%(3)	1.36(3)

A comparison of attributes shows both similarities and differences. Imageability ranks highest in both methods, with Street 4 showing the highest physical value (93%) and Street 1 showing the highest perceptual value (1.5). This confirms that visual character is a dominant factor in both spatial analysis and perception, consistent with Lynch (1981) and Ewing and Handy (2009). For enclosure, both methods indicate strong performance in Street 4 (70% in Serial Vision and 1.31 in RII), showing partial agreement. However, for transparency and street interface, both methods identify Street 2 as the highest performing street (24% and 17.94% in Serial Vision; 1.47 and 1.16 in RII), indicating agreement in terms of visual connection and interaction. Pedestrian infrastructure shows variation, with Serial Vision identifying Street 4 (64%) and RII identifying Street 1 (1.36) as higher. This indicates that while physical infrastructure may be stronger in one location, perceived comfort and usability may differ. The comparison also shows that while Street 4 performs better in terms of physical attributes, Street 1 is preferred by pedestrians. This may be influenced by factors such as comfort, activity level, and reduced vehicular disturbance, which are not fully captured through spatial analysis.

The results show a clear divergence between objective spatial analysis and subjective perception. This divergence extends beyond existing urban design studies, which often evaluate walkability primarily through physical attributes or expert-based assessment (Ewing & Handy, 2009; Moughtin, 2007). While these

approaches emphasize measurable spatial qualities, the findings of this study show that pedestrian perception does not always correspond directly with these physical indicators. This finding also refines Lynch's (1981) concept of imageability by demonstrating that although imageability remains the strongest common factor, other attributes such as transparency and street interface play a more significant role in perception than is typically captured in spatial analysis. Similarly, while Cullen's (1961) Serial Vision explains spatial sequence and enclosure, the results indicate that enclosure is not always perceived as a dominant factor by pedestrians, suggesting a limitation when applied independently. Furthermore, the higher perceptual importance of transparency supports Gehl's (2010) emphasis on active edges and street-level interaction. However, the relatively low performance of street interface in both methods indicates that such interaction is not fully developed in the study area. This suggests that even in historically rich environments, visual character alone is not sufficient to ensure a high-quality pedestrian experience.

Therefore, this study contributes to existing scholarship by demonstrating that walkability in traditional streets is shaped by the interaction between physical attributes and user perception rather than by spatial form alone. The integration of Serial Vision analysis and perception-based evaluation provides a more comprehensive approach that captures both measurable characteristics and experiential qualities of the street environment.

4. Conclusions

The study employed a mixed-method approach combining Serial Vision analysis and perception-based evaluation using the Relative Importance Index (RII) to examine the influence of architectural facade projections on pedestrian walkability in Bhaktapur's traditional streets. This approach enabled the assessment of both physical street characteristics and pedestrian perception.

The findings show that imageability is the most influential attribute in both methods, with strong physical presence (up to 93%) and high perceptual value (up to 1.5). This highlights the importance of visual character and architectural detailing in shaping pedestrian experience in historic streets. Pedestrian infrastructure shows moderate importance, while enclosure, although physically strong (up to 70%), is less significant in perception. In contrast, transparency is valued more by pedestrians, indicating the importance of visual connection and street-level activity. Street interface shows the lowest performance in both methods, suggesting limited interaction between buildings and the street. A key finding is the divergence between spatial analysis and perception. While Street 4 performs best in terms of physical attributes (86.54%), Street 1 is perceived as the most walkable (RII \approx 2.03–2.12). This indicates that walkability cannot be fully explained through physical attributes alone but is shaped by the interaction between spatial form and user experience.

From a practical perspective, improving walkability in traditional streets requires not only preserving architectural character but also strengthening street interface, transparency, and pedestrian infrastructure. The study demonstrates that combining Serial Vision and perception-based methods provides a more comprehensive framework that can be applied in other historic urban contexts. However, the analysis is limited to four streets and 114 respondents, and does not include behavioural or movement-based analysis. Future research can expand the sample size, include additional methods such as GIS and pedestrian movement studies, and examine design strategies for improving weaker attributes.

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