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Impact of Streetscape Attributes on Walkability and Urban Pedestrian Experience, A Case of Swayambhu Marg

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Abstract

Walkability refers to how friendly and accessible an area is for walking. It encompasses a range of physical and environmental factors such as Pedestrian Infrastructure Robustness, Comfort, Safety and Functionality, that influence whether people are likely to choose walking as mode of transport. The urban pedestrian experience describes how individuals perceive and interact with the urban environment while walking. A positive pedestrian experience encourages walking, fosters community engagement and enhances overall quality of life in urban settings. The research analyzes degree of perceived walkability on micro scale i.e. in streetscape attributes. The study utilizes multifaceted approach, combining objective study i.e. observation, Pedestrian Environment Data Scan with subjective study survey was conducted along with cognitive testing. Due to inadequate sidewalks and inconsistent streetscape elements the pedestrians experience is often fragmented in case of Swayambhu Marg. The results show that the street has lower functionality score indicating that components of functionality should be prioritized to improve walkability in the street. These findings offer actionable insights for designers and urban planners to improve walkability and enhance pedestrian experience in urban areas.

Keywords: *Walkability, Pedestrian Experience, Streetscape, PEDS, Cognitive Testing*

1. Introduction

Walkability is a concept that examines the experience of walking. Many studies have been conducted due to benefits of walkability to analyze how the streetscape affects the overall walking experience (Banger et al., 2024).

Micro scale variables play a crucial role in defining walkability because they provide a higher level of detail at the street level, representing complementary characteristics to the built environment (Roper et al., 2024). The streetscape attributes are essential in representing how walkable the urban environment is, especially in the urban Global South context where the condition of pedestrian infrastructure sometimes acts as a barrier to walking. Comfortable built environment will not necessarily compel a person to walk if safety conditions (a higher-order need) are not acceptable (Larranaga et al., 2019).

Due to unmanaged urban growth and development, and increasing number of vehicles in Kathmandu, vibrant and pedestrian-friendly streets and the unique streetscape, including streets in planned and informally developed areas, are changing at a high rate. On streets of all kinds, it has disfigured the physical form, reduced social interaction, increased accidents, and lowered pedestrian comfort (Limbu & Shahi, n.d.). Therefore, to effectively tackle these issues and enhance walkability, comprehensive studies on the different elements of pedestrian -oriented design are essential.

One of the dimensions of walkability that has been overlooked is the subjective component or "perceived walkability". Perceived walkability, i.e. how convenient people find it to walk (in an area or to destinations), has only received limited attention. It is only in recent years, studies have established that walking duration and frequency, are not only affected by objective attributes, but also by the subjective nature of an environment, as well as perceived suitability and convenience for walking (van der Vlugt et al., 2019).

While several studies have examined walkability in the context of Kathmandu, most have focused on objective assessments of physical infrastructure. For instance, Limbu & Shahi (n.d.) explored impacts of pedestrian traffic on urban form in historic core of Kathmandu, while Bhattarai (2020) evaluated walkability in commercial streets based on sidewalk conditions, land use and pedestrian counts. Similarly, Shrestha & Bajracharya (2022) applied Pedestrian Environment Data Scan to assess walkability in institutional areas like Pulchowk. However, integration of user perception and translating findings into design level interventions have not been addressed. This study addresses this gap by combining PEDS with structured user surveys and cognitive testing using 3D visualizations. Conducted in Swayambhu Marg, the study adds a crucial layer of insight by aligning pedestrian experience with physical design, providing holistic approach to walkability assessment in urban street of Kathmandu.

1.1 Objectives

The research aims to explore relation between streetscape attributes and perceived walkability and their overall experience. It seeks to develop quantifiable methods for translating subjective impression of streetscape into measurable data, helping to access how pedestrian friendly the street is.

The study investigates: How do micro-scale streetscape attributes affect perceives walkability in dense urban environments like Swayambhu Marg, and how can these insights inform context- sensitive design interventions?"

1.2 Literature Review

This study is based on Alfonzo's Hierarchy of walking needs, which suggests that safety, comfort and accessibility are prioritized by pedestrians. Integration of both objective audits and subjective ratings aligns with this layered model of walkability. Some researchers have built micro scale walkability scores by summing up various factors. Each factor represents subjective social experiences, emotions, or behavior patterns. These factors are therefore accompanied with perception elements to measure their importance(Guzman et al., 2022).

1.2.1 Pedestrian Infrastructure Robustness (PIR)

The quality of pedestrian infrastructure refers to the characteristics and condition (e.g., area, width, marking, surfaces) that makes it is physically possible to walk from a point to another (Jabbari et al., 2023).

1.2.2 Comfort

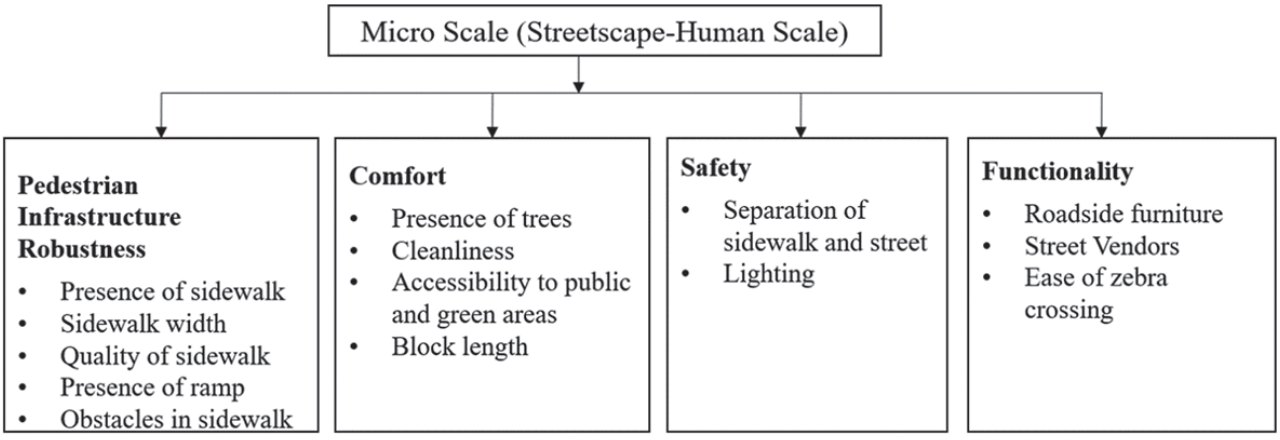
Comfort is the physical and psychological comfort experienced while walking. The layout of pedestrian routes, presence of amenities (benches or shade), and the overall attractiveness of the environment; all contribute to comfort. (Guzman et al., 2022).

1.2.3 Safety

Safety is complex concept that emphasizes the protection of individuals from harm or danger in various contexts, particularly within urban environments. One of the primary concern for pedestrians is safety, which encompasses not only the crime rates but also the perception of safety while walking (Alfonzo, 2005).

1.2.4 Functionality

Functionality, in the context of walkability, refers to how well the streetscape supports pedestrian movement and activity. It includes various factors that determine how well street furniture, sidewalks, paths and urban spaces encourage walking as a mode of transport (Guzman et al., 2022).



Variables identified based on literature review that guided further research:

Figure 1: Streetscape Variables (Alfonzo, 2005) (Guzman et al., 2022) (Jabbari et al., 2023)

2. Materials and Methods

1.1 Study Area

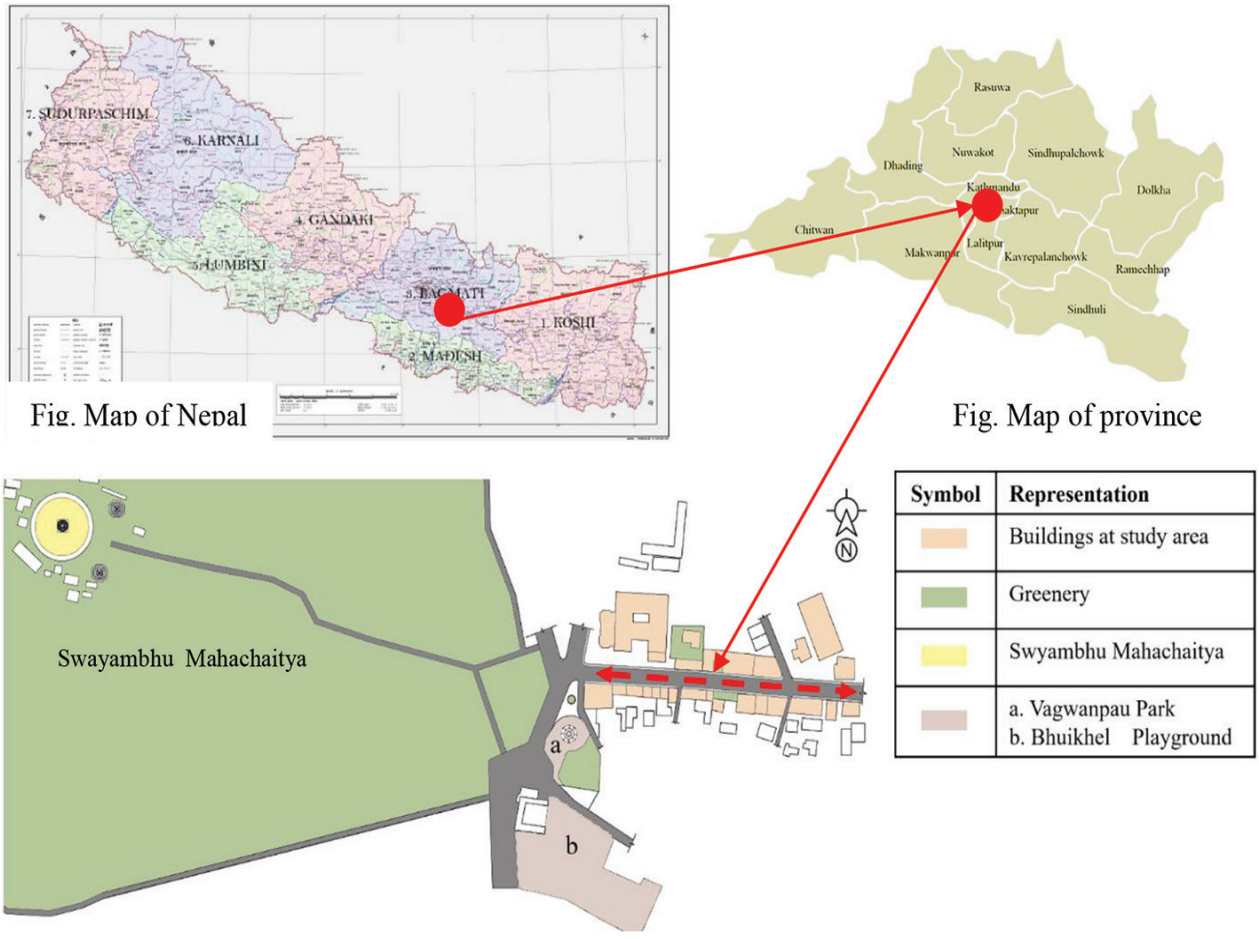


Figure 2: Location Map -Swayambhu Marg and its Surroundings

Swayambhu Marg serves as the main route connecting Bijeshwori to western entrance of the Swayambhu Mahachaitya. The road facilitates pilgrimage activities, is a key route for tourists visiting the stupa exploring World Heritage Site and it contributes to the local economy. While Swayambhu's historical and cultural context draws foot traffic, the lack of urban design interventions addressing the relationship between building massing and streetscape detracts from its walkability. Streetscape and pedestrian movement play a crucial role in shaping perceived walkability. However due to inadequate sidewalks and inconsistent streetscape elements, the pedestrian experience is often fragmented. To address these issues and promote walkability, it is imperative to conduct in depth study of aspects of pedestrian friendly design in Swayambhu Marg. The street stretch that has been selected is 200m as shown in figure 2. The existing width of street is 8m with average width of sidewalk of 1.2m.

2.2 Study Method

The study focuses on the physical aspects of the environment and relies on objective parameters for data collection and analysis. Therefore, it adopts qualitative techniques to derive its findings.

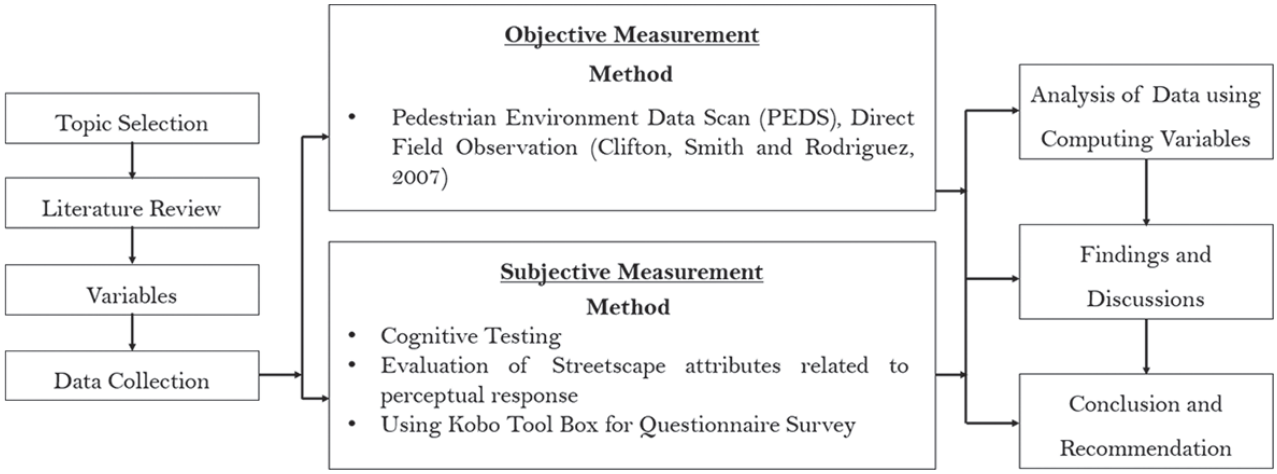


Figure 3: Research Method

The observational study was conducted through Pedestrian Environment Data Scan (PEDS). The advantage of this instrument is that it allows auditors to collect data on micro-scale environmental characteristics, such as pedestrian facilities (i.e. path materials and types of pedestrian facilities), road attributes (i.e. the condition of roads and curb cut availability) (Wimbardana et al., 2018). To minimize bias and ensure consistency, a pilot assessment was first conducted to familiarize with the tool and calibrate scoring based on clear criteria defined in PEDS manual. The observations were carefully documented using standardized checklist format to maintain uniformity across all points.

To gather subjective data, a structured questionnaire was developed. The respondents included pedestrians actively using the study area. During the survey, cognitive testing was also conducted. This involved assessing participants' preferences of 3D images of streetscapes- a method well suited to uncover unconscious perceptions. These preferences were then quantified as percentages, allowing comparison across interface types. In addition, the responses were triangulated with Likert scale ratings collected via questionnaire, enabling the study to examine whether visual preferences aligned with reported satisfaction levels for related attributes. This approach analysis helped ensure a deeper understanding for user perceptions beyond direct questioning.

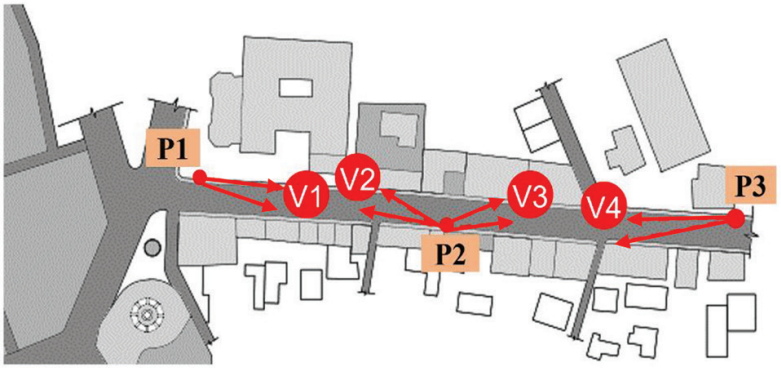


Figure 4: Observation Points and Directions

Figure 5: View from Observation point 1 towards V1

Figure 6: View from Observation point 2 towards V2

Figure 7: View from Observation point 2 towards V3

Figure 8: View from Observation point 3 towards V4

2.2 Observation Points and Findings

Three observation points (P1, P2 and P3) were selected for the study, with four viewing directions (V1, V2, V3 and V4) considered at each location for analysis. P1 and P3 were positioned at the end of street viewing towards the street while P2 viewing at both direction from center of the street. This setup was chosen to enable a comprehensive examination of the street segment from all perspectives. At each of the four viewing directions, 17 individuals were surveyed totaling 68 participants. As the survey was conducted with pedestrians there was no particular proportion size; the sample of 68 respondents was derived using 90% confidence level and 10% margin of error based on W.G. Cochram (1935) formula. The purpose of this was to assess people's priorities and perceptions related to specific streetscape attribute at each viewing direction (Sophiya Shrestha, 2025).

The average weight for each attribute was determined by combining the associated variables listed under each category (as outlined in table 1) to create a composite score. The score was calculated by averaging the individual item ratings. Participants were asked to rate each variable in the questionnaire on a scale from 1 (not satisfied) to 5 (very highly satisfied), which was then used to assign a score to each variable. The attribute scores were computed using SPSS by calculating the average of the related variables through compute function.

Table 1: Computing Variable (Average Score at V1)

	Computed Variable (V1)			
Respondents	**PIR**	**Comfort**	**Safety**	**Functionality**
1	3.4	2.25	2.67	4
2	2.8	2.5	2.67	3.67
-	-	-	-	-
17	3.2	2.5	3	3
Total	**47.6**	**57.97**	**55.25**	**37.4**
Mean Score	**2.8**	**3.41**	**3.25**	**2.2**

Table 1 includes data collected from 17 respondents for viewing direction V1. Calculations for each viewing direction were done in same way as for V1. The average score for each attribute was calculated by dividing the total score by the number of respondents. Scores range from 1 to 4, where 1 indicates the lowest level of

satisfaction and suggests that the attribute has minimal positive influence on walkability – highlighting an area in need of improvement. In contrast, a score 4 reflects the highest level of satisfaction and indicates a strong positive contribution to walkability.

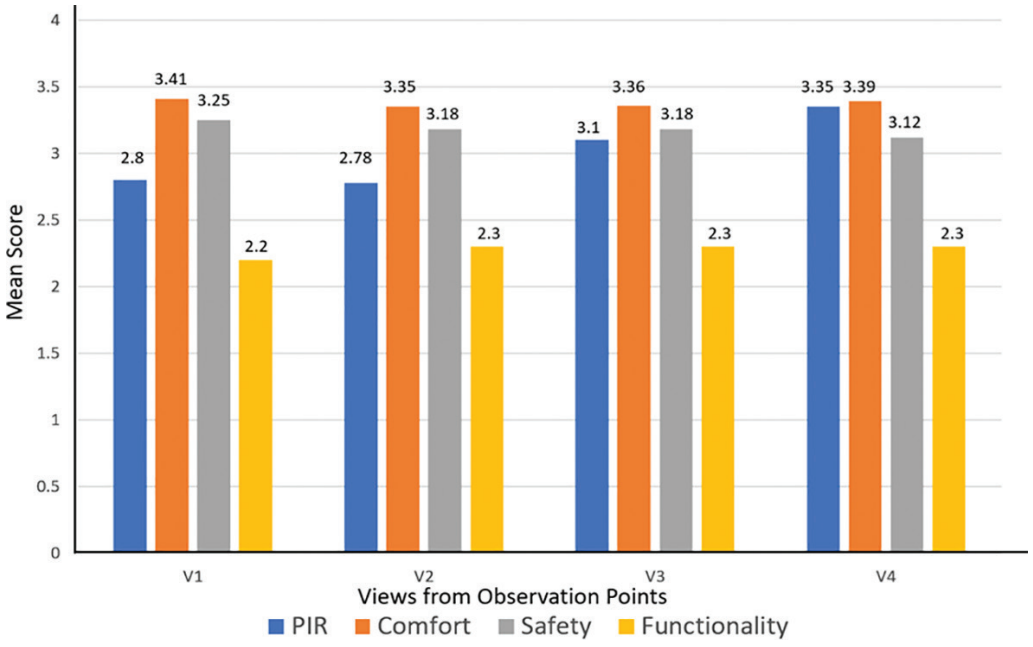


Figure 9: Attributes of Streetscape at Different Views from different Observation Points

Figure 9 presents a chart based on computed scores of individual variables. Walkability is higher at V4 compared to other views specially V1 and V2. However, weightage of all factors is similar in all viewing directions except for Pedestrian Infrastructure Robustness (PIR).

Table 2: Walkability Score

Views	Walkability Score
V1	2.9
V2	2.8
V3	2.98
V4	3.04

Overall walkability was determined by calculation the mean value of all attribute scores i.e. Walkability score= (PIR+ Comfort+ Safety+ Functionality)/4 (Yeager, n.d.).

3. Results and Discussion

The results and discussions are structured around the streetscape attributes observed in each viewing direction at designated observation points. Each attribute has been examined through both subjective (perception based) and objective (observational) approaches, as illustrated in figure 3 and the results have been compared accordingly.

Table 3: PEDS (Section A: Environment): Observation

No.	Variable	Characteristics	Explanation
1	Segment Type	**Low volume road (v/c < 0.6)**	High-volume roads often make crossing the street difficult and unattractive for pedestrians (Clifton et al., 2007). LVR will create more pleasant walking conditions by decreasing noise exposure and air contaminants and reduce vehicle conflicts.
2	Uses in segment	Restaurant/café/ commercial, Recreation	Compact, high-density and mixed land use can encourage walking due to the advantage of shorter trip distances (Hagen & Rynning, 2021). Residents are in close proximity to places to work, shop, and recreate, increasing the potential for walking.
3	Slope	Flat (< 12%)	The steepness of slopes determines degree of accessibility of sidewalks or public spaces, particularly for individuals using a wheelchair. Slopes with an inclination up to 25% or 14° are relatively accessible for general users, but such condition can impose a barrier for elderly or disabled persons (Wimbardana et al., 2018).

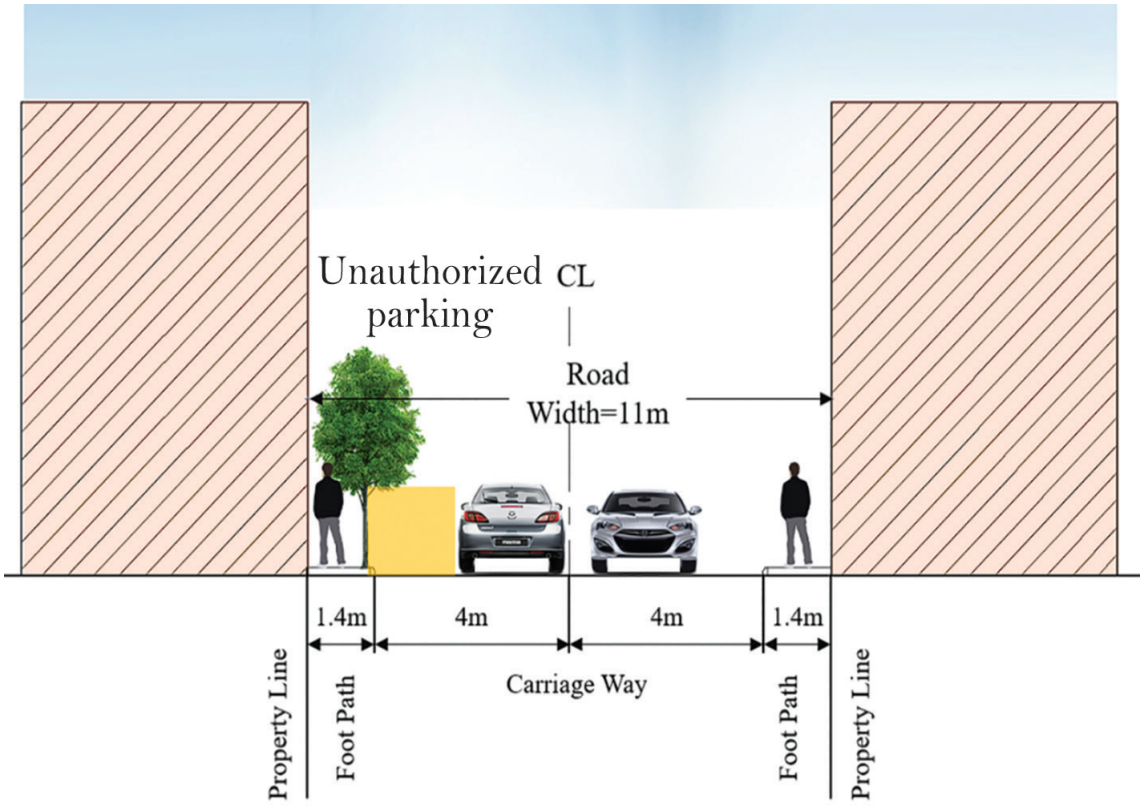


Figure 10: Section at X-X (Existing Street Section)

This stretch of street has two lanes. Each traffic lane is four meters wide making total carriage way 8 meters. The sidewalk is elevated 152mm above street level with the varying width from 1.2 to 1.8 meter along the street stretch. Trees are planted along the sidewalk that is 1.4m, side walk which is not enough for pedestrians and makes the flow congested. Although the lane width is 4m which is sufficient for flow of vehicle, unmanaged parking (marked in yellow in figure above) along the street in no parking area has caused problem for both vehicle and pedestrian flow.

3.1 Pedestrian Infrastructure Robustness

The chart shows that there is good presence and continuity of sidewalk throughout the street. Width of sidewalk at V1 and V2 is not sufficient (in presence of compact buildings with multiple activities. Whereas at V3 it is neutral and at V4 width is sufficient. At existing condition width of sidewalk at V1 is 4' and during special occasions like jatras and festivals it creates congestion and creates problems. As per literature five feet sidewalk accommodates two people walking along, with separate planting strip provided between the curb and sidewalk. The only factor that changes in all four views is width of side walk and its satisfaction level while other factors have similar scores in all viewing direction.

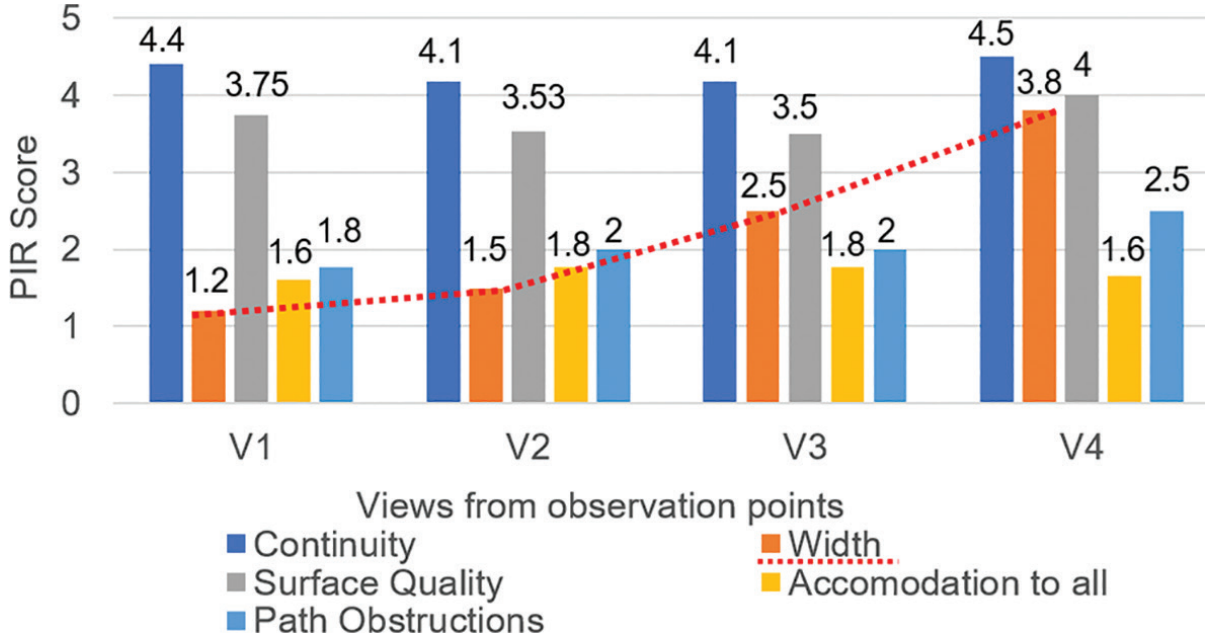


Figure 11: Variables of Pedestrian Infrastructure Robustness at Different Views from Different Observation Point (Perception Study)

Table 4: PEDS (Section B: Pedestrian Infrastructure Robustness): Observation

No.	Variable	Characteristics	Explanation
4	Side Walk Surface Condition/ Maintenance	Good (very few bumps/cracks/holes): as stroller can easily be pushed along the sidewalk without jarring motions to the passenger and/or it needs no repair at this time. (Avg. Score: 3.7)	Attractive paving, wide sidewalks and shading trees along with well-maintained pedestrian facilities greatly encourage walking (Hagen & Rynning, 2021)
5	Accommodation to all	No Curb Cuts. (Avg. Score: 1.7)	 **Figure 12:** No Curb Cuts Studies have shown that a significant majority of pedestrians, including those without disabilities, prefer using curb cuts over traditional curbs. A study in Sarasota, Florida, found that nine out of ten pedestrians chose to use curb cuts when available; 'The curb Effect' (*The Curb-Cut Effect (SSIR)*, n.d.).
6	Path Obstruction	Obstructions severely reduces the pedestrian facility.	 **Figure 13:** Path Obstruction Presence of electric poles -transformer reduces the width of sidewalk impacting walkability.

Cognitive Testing:

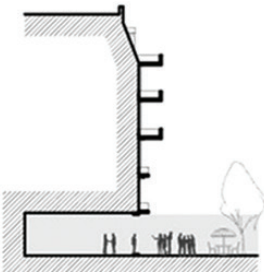


Figure 14: Physical permeability

Figure 15: Ground Interface with Setback

Figure 16: Without Setback

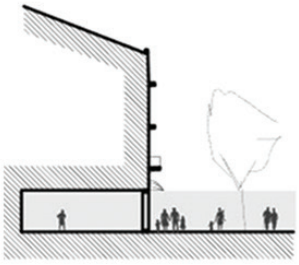


Figure 17: Visual Permeability

Cognitive testing was done to identify preference of respondent's preference of ground interface whether they preferred ground interface with or without setback or with physical or visual permeability.

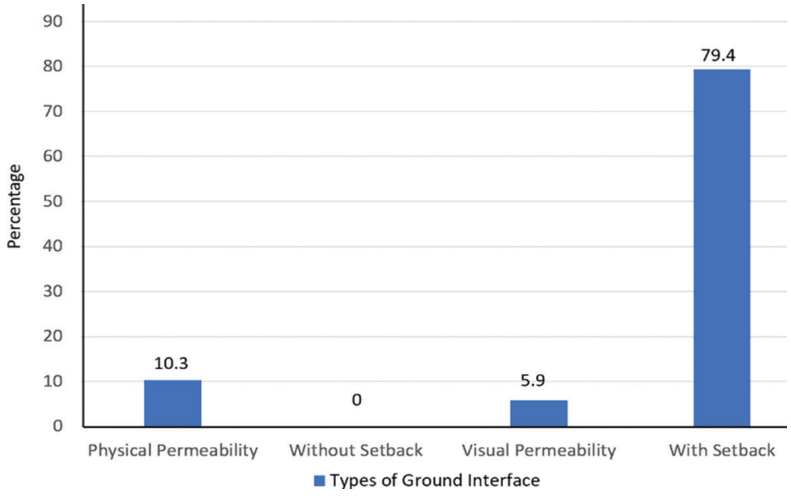


Figure 18: Preference of Ground Interface

Ground interface with setback significantly improves walkability by allowing for better shop visibility and engagement in sidewalk. It also implies that width of side walk is not sufficient for comfortable walking. While walking people feel safer if there is distance maintained from others. Visual permeability is necessary to uplift walkability. Glass in façade or ground level improves aesthetic but it can create barrier when overemphasized. Respondents prefer design elements that could balance both usability and transparency. Presence of cafes or shops with permeable designs, combined with setbacks, promotes interaction and leisure, increasing street's appeal.

3.2 Comfort

The chart shows that greenery has the lowest score reflecting dissatisfaction with quality and amount of greenery present on the street. Removal of trees during sidewalk reconstruction and insufficient replantation efforts contribute to this low score. There is no problem of solid waste but air pollution is significant problem caused by vehicles and nearby construction site. Greenery is seen as critical for improving air quality, reducing urban heat, and enhancing street aesthetics. While accessibility to public space and shorter block length has increased its walkability.

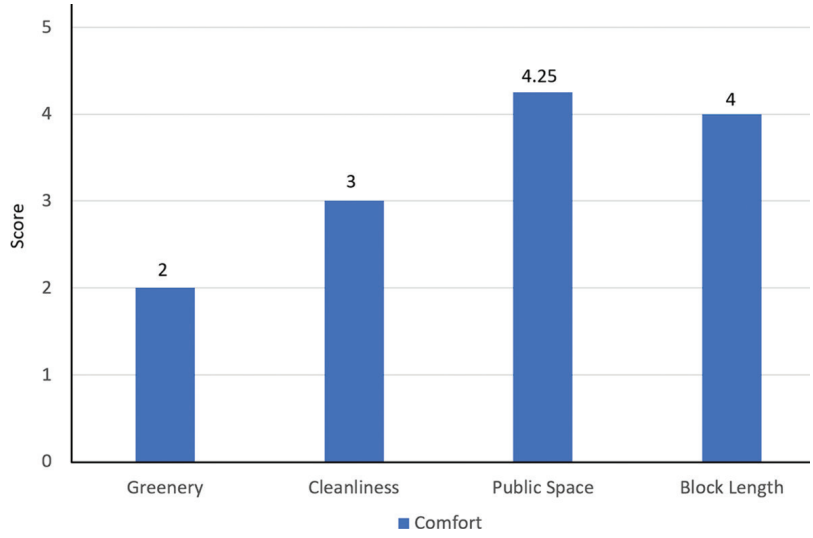


Figure 19: Comfort Level along Whole Street Stretch

Table 5: PEDS (Section C: Comfort): Observation

No.	Variable	Characteristics	Explanation
7	Number of trees Shading Path	less than 25% is covered	Trees minimize rigid appearance of asphalt and concrete surfaces creating human scale and welcoming environment which would otherwise feel cold and overwhelming.

3.3 Safety

Safety in the street has decreased due to lack of separation between sidewalk and street and insufficient street lighting for pedestrians. Whereas there is no problem of vehicles encroaching sidewalk.

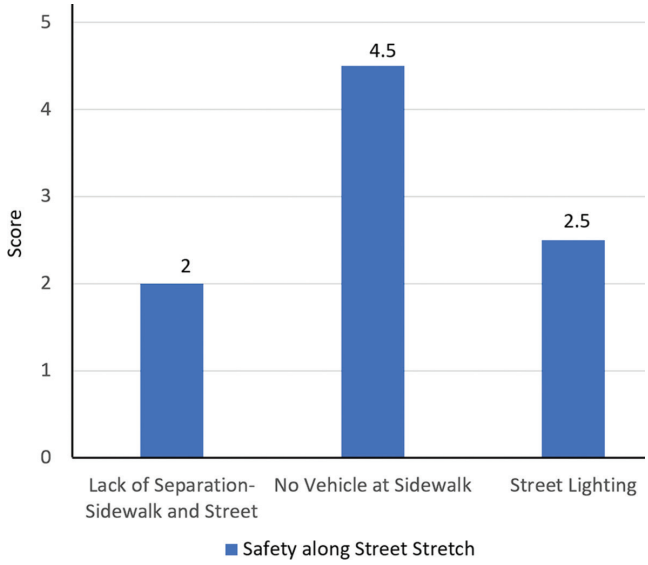


Figure 20: Safety Level along Whole Street Stretch

Table 6: PEDS (Section D: Safety): Observation

No.	Variable	Characteristics	Explanation
8	Roadway/ Path Lighting	• **Road oriented lighting** • Lacks Pedestrian-scale lighting	Certain neglected sidewalks, leaving these areas dimly lit. In urban environments where there are no buffers, pedestrians face heightened risks. Research shows that many pedestrian injuries occur when individuals are walking along road edges without sufficient separation from traffic (Wimbardana et al., 2018).
9	Separation of sidewalk and street	**No buffer** (Avg.Score: 2)	

Figure 21: Lacks Proper Separation

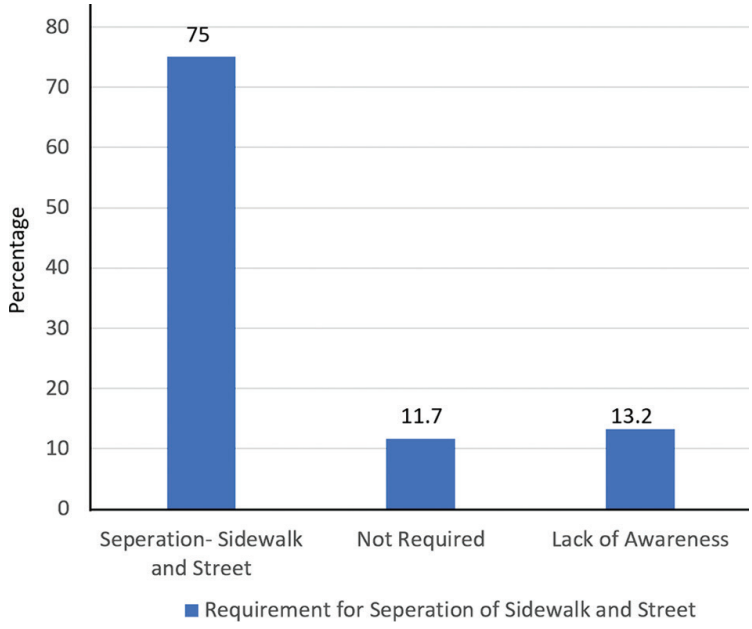


Figure 22: Pedestrian Perception Regarding Requirement of Separation Between Sidewalk and Street (Perception Study)

There were various opinions about the requirement for proper separation of sidewalk and street. 31 respondents chose to support requirement for separation. As per literature, LVR enhances the pedestrian experience by reducing noise, air pollution, and conflicts with vehicles. However, the existing problem is that on the Low Volume Road, vehicles travel at high speed making it difficult to control and leading to vehicles entering the sidewalk causing frequent accidents and also harm to nearby shops. 8 respondents mentioned that separation is not necessary, as railings or bars used for separation makes people lean or sit on it creating congestion. 9 respondents also stated that separation is not required because they were unaware of safety measures while walking on the street, preferring to cross wherever they wanted without walking the extra distance to proper crossings.

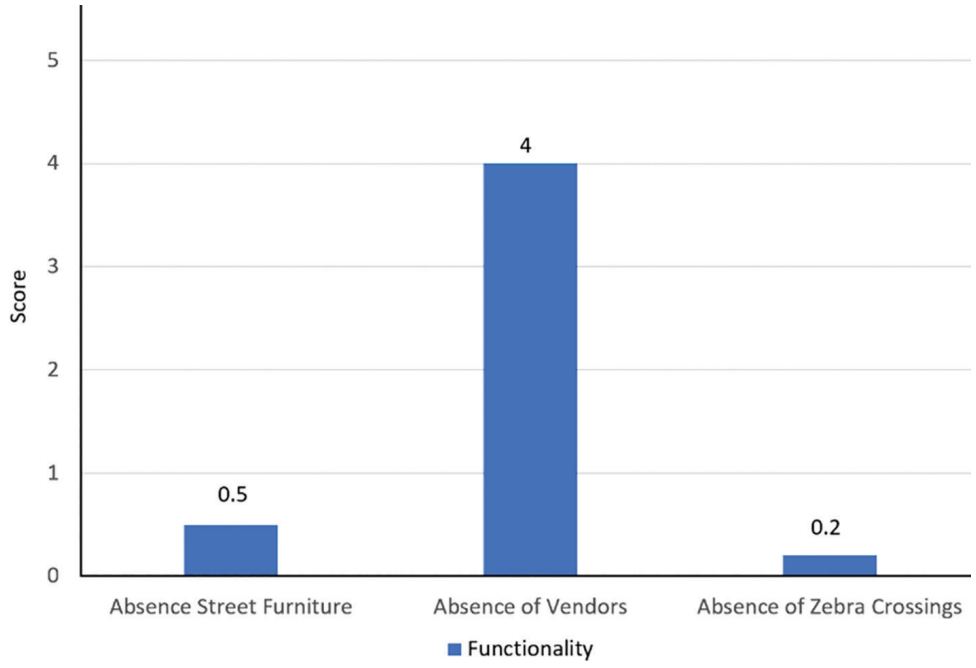


Figure 23: Functionality along Whole Street Stretch

3.4 Functionality

Lack of amenities on the street (street furniture, trash cans) and no zebra crossing has decreased walkability. The absence of zebra crossings has been particularly problematic for tourists who have to walk long distances in search of crossing to safely cross the road. However, the issues of street vendors have recently been solved on the street which has improved overall functionality of the street.

Table 7: PEDS (Section E: Functionality): Observation

No.	Variable	Characteristics	Explanation
10	Amenities	None (Benches, Garbage cans, Vending Machines)	Kora: Performed going around Swayambhu hill spinning prayer wheels as mind calming meditative exercise. Being culturally important area flow of old people is high for this purpose. So, street seating is required as these people sit in the plinths of shops due to lack of street furniture. But the concern is that street furniture might cause congestion due to sidewalk width. Dynamic interplay between areas designed for relaxation and spaces that facilitate movement (Van 't Hoff et al., 2016).
11	Crosswalk	None within study area	Without designated crosswalk, pedestrian cross at random points, making it harder for drivers to anticipate and react. Major problem for tourists finding harder to cross the road.

4. Design Intervention

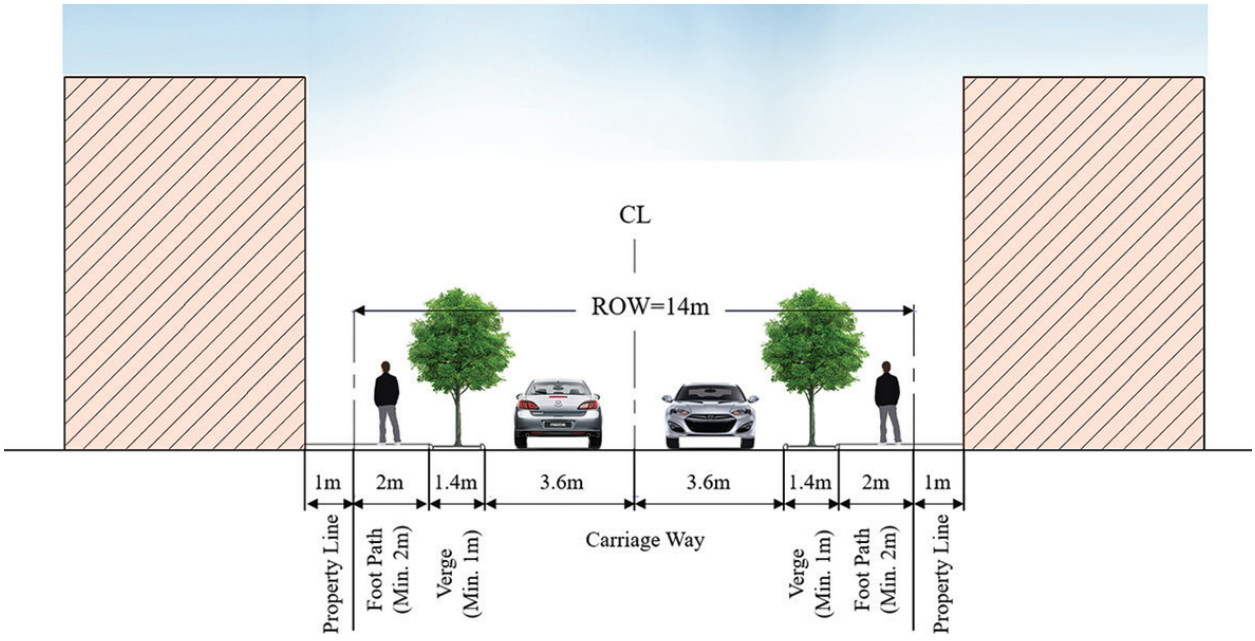


Figure 24: Street Section-15m ROW

ROW for Swayambhu Marg is 14m (*THE MAZE - Kathmandu ROW Map*, n.d.). It accommodates carriage way of 7.5m with two lanes, sidewalk of 2m and verge of 1.4m at both side of street and if possible providing transitional space to create comfortable walking environment and enhancing street level activity. 3.6m with of lane is provided as per standard for this type of street and it also prevents the problem of over speeding. 2m of sidewalk is the minimum requirement considering the flow the people. The verge provided separates vehicular lane form side walk as well as provides sense of enclosure to sidewalk. Verge can also be designed to accommodate street furniture in certain spaces along with trees.

As provided by the standard, the required distance between the crossing is 100-200m if the area is mix use with 300-1000 people per hour. So, in the existing street, a crossing is necessary to be provided nearer to the intersection where flow of people is high and next crossing shall be provided at distance of 115m in the study stretch.

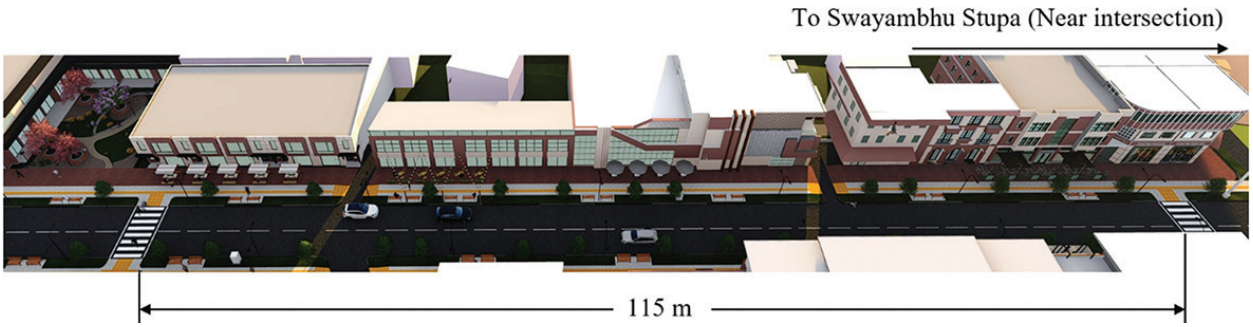


Figure 25: Required Distance Between Crossing to Increase Walkability

Figure 26: Detail View from Observation Point P1 towards V1

Figure 27: Front View of Treated Blank Wall

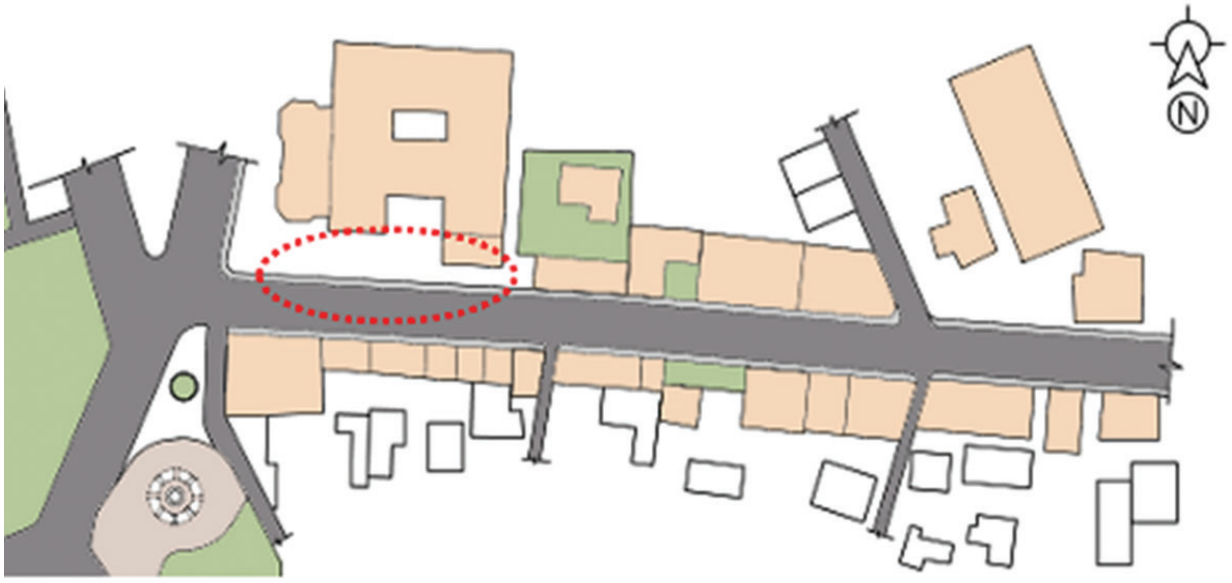


Figure 28: Key Map

The area being place that is culturally important, preference for paving material is sandstone as it harmonizes with surrounding context. It also withstands wear from environmental exposure, daily use making it suitable for high- traffic communal areas. Timely cleaning, sealing and maintenance ensure its longevity. Flooring material has been kept different in side walk and transition areas so as to differentiate public boundary from private.

Sidewalk Zoning:

1. **Frontage Zone:** It extends as part of the building, either by entrances or sidewalk cafes. Both building structure and the street facing building façade is frontage zone. Providing through frontage zone or transition space may not be possible. So, Ground floor of the building can be pushed inside i.e. certain

setback at ground floor can be left to create frontage zone providing activities that would make sidewalk engaging.

2. **Pedestrian Through Zone:** It is an accessible route that is parallel to the street. It must be at least six feet for existing context for people to walk comfortably. Sidewalks shall be designed that are sufficiently wide to accommodate a range of pedestrian users safely, but not so board to be vacant. The needs of people with strollers, wheel chair users shall be considered. However, a sidewalk must be wider if it is also intended to support activities such as sitting.

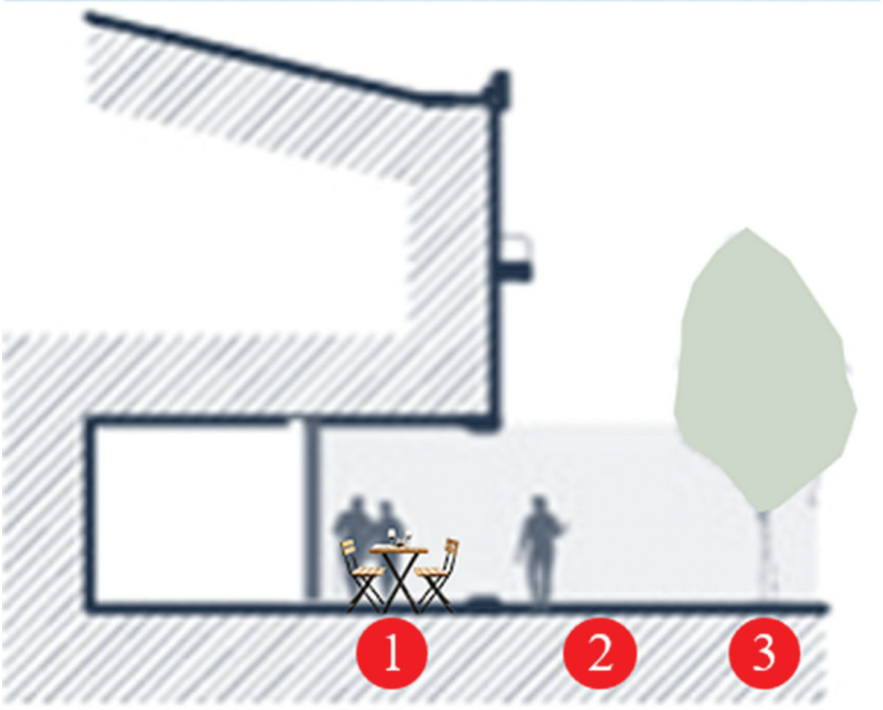


Figure 29: Sidewalk Zoning

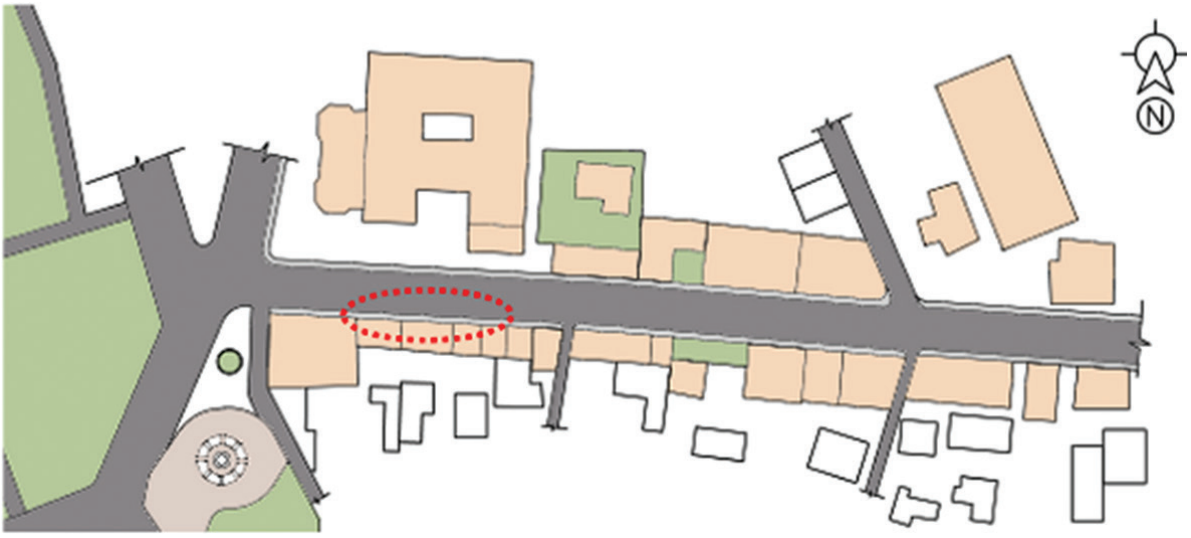


Figure 30: Key Map

3. **Street Furniture/Curb Zone:** Curb zone in which facilities and street furniture such as utility poles, lighting, benches, tree pits etc can be mounted. Trees and other landscape element in this zone contribute in creating appealing sidewalks and streets, used to separate vehicular traffics from pedestrians and provide shade in summer. A buffer zone between vehicular lane and sidewalk has been associated with increasing walkability. Separating pedestrians form vehicles offer improved conditions for all, especially people with impaired vision or hearing

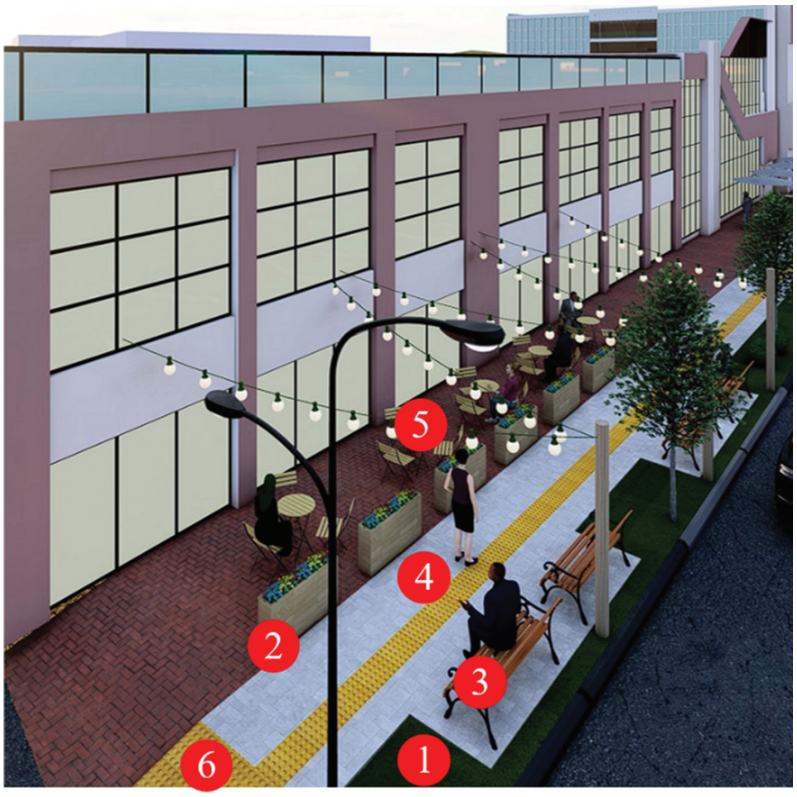


Figure 31: Streetscape Detail

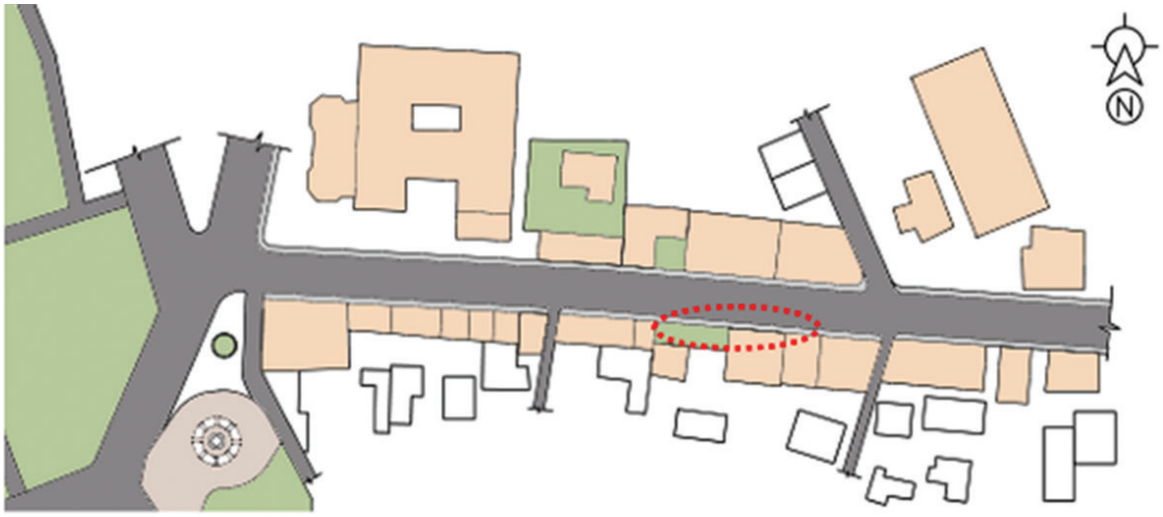


Figure 32: Key Map

1. Textured transition to provide cues between sidewalk, planting areas and the street. Proper separation of sidewalk and street preventing accidents.
2. Night Lighting to create safer, more visible streets after darkness.
3. Street Furniture for seating focusing old age people.
4. Wider Sidewalk minimum of 6' sidewalk provide space for conversation and circulation.
5. Degree of Enclosure introducing the elements that creates place and increases human scale and vibrancy.
6. Directional Curb cuts & Dec table Warning increasing accessibility to impaired vision and differentially able people.

5. Conclusions

This research emphasizes the importance of streetscape features in influencing walkability and shaping the urban pedestrian experience. The result highlights the necessity of a comprehensive approach that blends physical design factors with users; perceptual responses when evaluating walkability. By aligning measurable spatial characteristics with pedestrian preferences, urban planners and designers can cultivate streets that are not only functional but also inclusive and safe. Enhancing the quality of streetscapes contributes more than just ease of movement – it supports community identity, comfort and overall urban livability.

The research consists of two distinct sections. The initial section involves research phase where walkability score in existing scenario of Swayambhu Marg was quantified accessing the responses of pedestrian (perception or subjective study) and through observation using pedestrian environment data scan measure (objective study). Then the findings form these studies were used to create design interventions. While microscale (streetscape level) traits influence walkability, human scale design, active frontages, pedestrian comfort and safety are more directly engaged with walking environment.

The recommendations provided in design interventions are based on people's perception, observations, literature and from given standards. This street section is designed to accommodate both vehicular traffic and pedestrians offering solutions for street in this particular context.

Limitations and Ethical Considerations

This study was conducted with informed consent from all participants. The purpose of the research was clearly explained and anonymity of the respondents was maintained during both the survey and cognitive testing phases.

Further research could include a follow up survey to assess the quantifiable impact of the proposed design interventions – specifically, the extent of improvement in walkability score after implementation. However, assessing the post intervention impact on walkability score was beyond the scope of this study. Also, confidence intervals and error bars were not included in the current visual analysis but are recommended for future studies to enhance statistical reliability. Data collection was limited to a single season (collection was done at month of March), potentially affecting perception due to weather and generalizability is limited to similar sense cultural urban contexts.

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