

Evaluating the parameter of visibility adopted for CPTED for user safety in public open space of Haat Bazar: Isovist and VGA

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Abstract

Public open spaces (POS) are an indispensable part of a well-functioning city that humanize urban areas. However, whether an individual will utilize the space, or shy away from it, depends on the individual's perception of an area in terms of safety. The driving force that governs the safety of users in urban POS is the parameter of visibility. Enhanced visibility reduces the fear of crime through natural surveillance, which is one of seven first-generation CPTED Concepts. This study aimed to explore the effectiveness of Isovist and Visibility Graph Analysis (VGA) in evaluating the parameter of visibility for user safety in the public open space of Haat bazaar. For this purpose, Dilli Haat INA and Dilli Haat Janakpuri were identified as the most suitable study areas. These case study sites were analyzed under three main heads- 1. Archival review of crime records and architectural case studies to help identify the area of interest, 2. Layout study using Isovist and VGA tools for analysis, and 3. Surveys conducted in regular summer, regular winter, and in the festive season for each of the sites. The comparative analysis of the outputs from these three heads showed that Isovist and VGA can be used as a way of evaluating the visibility based on real-time vision and human-based vision respectively. Although this paper is limited to only one typology of POS, this exploratory research has achieved new insights into visibility as a parameter of user safety for CPTED.

Highlights/ Relevance: The role of security in Maslow's hierarchy of needs and SDG targets 11.7, 16.1, 16.5 underline exigency of CPTED in POS. The use of Isovist and VGA for evaluating visibility based on real-time and human-based vision respectively may motivate formation of a toolkit for urban designers to design defensible spaces.

Keywords: CPTED, Haat bazar, User safety, Isovist, Visibility graph analysis (VGA).

1. Introduction

Public open spaces (POS) are an indispensable part of a well-functioning city that humanize the urban areas. However, whether an individual will utilize the space, or shy away from it, depends on the individual's perception of an area in terms of safety. Every 51 minutes, there is a case of female harassment in a POS of India (Bhattacharyya, 2016). As per the National Crime Records Bureau, there was a stark 19.7% increase in cases of crime against females, reaching 0.406 million as of 2019 within 3 years (NCRB, 2016; NCRB, 2019). Cases of crime and the fright of harassment hinder a female's access to the POS and subsequently, their right to the city, setting about an emotion of detachment (Beebeejaun, 2017; Bhattacharyya, 2016; Harvey, 2012; Koskela, 1997; Mahadevia, Mishra, et al., 2016; Mehta, 2014). As per India's National Crime Records Bureau (NCRB), the national capital Delhi has a rate of 1,306 IPC crimes every 1 lakh population in 2017. The national capital stands on top of the crime rate chart for abductions and kidnappings with a crime rate of 32. This study primarily explored the POS of Haat bazaar in Delhi, though the crimes can occur at any location- be it a built or an open space.

Aim, objectives and scope

The aim of the study was to explore the effectiveness of Isovist and Visibility Graph Analysis (VGA) in evaluating the parameter of visibility of CPTED for user safety in the public open space of Haat bazaar.

The specific objectives of the study include:

1. To study the public spaces of urban Haat bazaars of Delhi.
2. To analyze the data on the safety of users in Haat Bazaars of Delhi.
3. To explore the parameter of visibility to promote safety of users in Haat bazaars.
4. To explore the effectiveness of Isovist and VGA as a way of evaluating the visibility.

The scope of the study is limited to the Public Open Spaces of urban Haat bazaars of Delhi. As this study was part of academic dissertation with time schedule, the survey sample size was confined to only 5% of the total footfall.

2. Literature review

Out of 37 literatures reviewed, the following 6 key literatures were found most relevant to the objective of the study, yet not implicating it.

Table 1. Review of literature

TITLE OF PUBLICATION	RESEARCH QUESTION	RESEARCH METHODOLOGY	MAJOR FINDINGS OF THE STUDY
A Digital Image of the City: 3-D isovists and a tribute to Kevin Lynch. Morello, R. et.al.	Can implementation of the Isovist analysis in third dimension, provide a more precise model to urban designers for exploring their design?	TESTS USED - 1. 2-D Isovistfields- Image Processing with Matlab 2. 3-D Isovistfields with DEMs (Digital Elevation Models) 3. Iso-visibility-matrix 4. Lynch's five visual elements	The implementation of the Isovist analysis considering the third dimension, could provide a more precise model, where the distinction of high vs. low buildings might open up stimulating architectural arguments for planning studies.
Isovist and Visibility Graph Analysis (VGA): Strategies to evaluate visibility along movement pattern for safe space. Othman, F. et. al.	How can visual analysis techniques of Isovist be used to promote safe space?	Strategies to analyse and evaluate the visibility on movement pattern evaluated: 1. GIS 2. Isovist 3. DEM 4. Point cloud from LiDAR 5. View dome tool 6. Statistical data comparison	Suggested methods allow the extracting of important spatial and topological information with 2D and 3D environment.
Feeling good and feeling safe in the landscape: a 'syntactic' approach. Julienne H., et.al.	How space syntax can be adapted to understand circumstances in which people feel motivated to explore their local landscape and the spatial factors that may deter people from incorporating walking into their everyday routines?	Literature study of previous works in the field	Three ways in which space syntax methods may be applied to the study of natural landscapes: ' <i>assigning attributes to spatial units</i> ' (or the nodes in the graph based representation), ' <i>assigning attributes to the relationships between spatial units</i> ' (or the edges in the graph) and the use of <i>multi-layered graphs</i> .
Using space syntax to analyse stress ratings of open public spaces Martin K., et.al.	How selected properties commonly used in space syntax research relate to users' ratings of stress and spatial qualities in open public spaces.	1. Set of syntactical properties is extracted from previous literature study, associated with health and stress 2. The resulting sample of 22 POS is described with street network characteristics including global and local integration, connectivity & isovist properties measuring total area, perimeter, vertices number and density, openness and roundness. 3. Combining above data with city dwellers' ratings of the sample regarding to stress perception and urban design qualities	A weak relation can be found between the vertices density of an OPS's isovist and participants' ratings of safety. Overall, the results indicate that line-based measures such as global and city wide integration may be valid measures to analyse stress perception in outdoor spaces
Making isovists syntactic: isovist integration analysis. Alasdair, T. et.al.	How syntactic analysis of isovists complements existing space syntax methodology by allowing the automatic generation of integration values from 3D CAD models?	Using case studies stages involve taking isovists over a grid of locations, then constructing the relationship graph by testing isovist intersections, and inlay using a standard graph analysis program to find mean depth values for the graph.	This paper has described a new method for syntactic analysis of isovists that complements existing space syntax methodology by allowing the automatic generation of integration values from 3D CAD models and proved that in future isovist can well surpass axial integration.
Behavioural Mapping of Crime Hotspots in Delhi: A Spatial Analysis. Gupta, R	Can the spatial distribution of crime can be used to identify areas that are at a higher risk of crime?	The study used crime data from the Delhi Police to identify crime hotspots, then analyzed using Space syntax integration, GIS and GPS techniques to identify the spatial patterns of crime.	The space syntax analysis found that crime hotspots are concentrated in areas with low integration.

3. Methodology

An evaluative research approach was adopted for conducting the study. Dilli Haat INA and Dilli Haat Janakpuri were identified as most suitable sites for conducting this study. These case study sites were analyzed under three main heads- 1. Archival review of crime records and architectural case studies to help to identify the area of interest, 2. Surveys conducted in regular summer, regular winter, and in the festive season for each of these sites and 3. Layout study using Isovist and VGA tools for analysis. The outputs from these three heads were compared to test the reliability of the methods used and the results obtained. Further critical evaluation and analysis was done to draw conclusions and suggest future scope of the research.

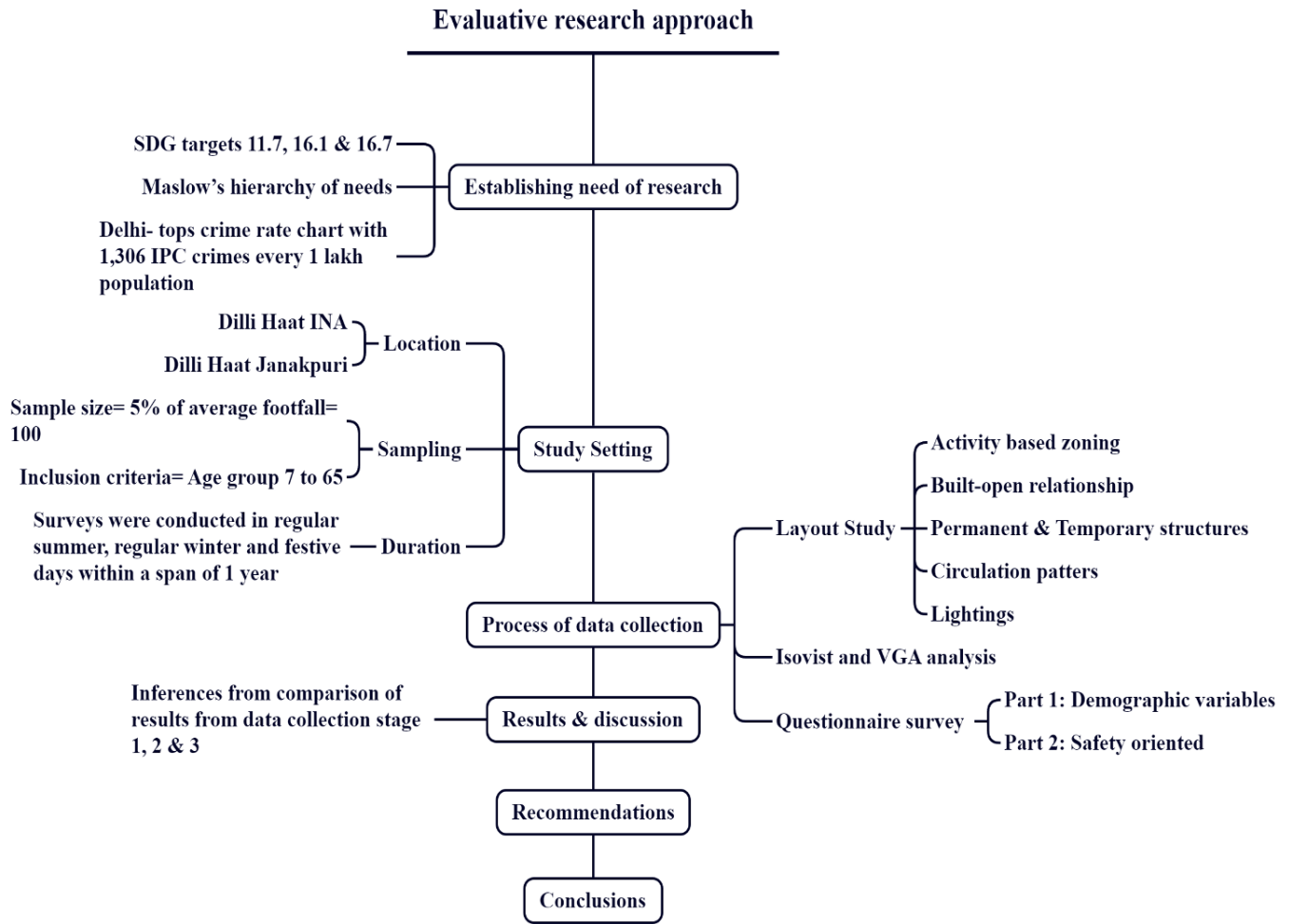


Figure 1. Schematic representation

3.1. Technologies used

3.1.1. Crime prevention through environmental design (CPTED)

CPTED, which stands for Crime Prevention Through Environmental Design, is a way of using the design and layout of our surroundings to stop criminal behavior. Seven key CPTED concepts include: territoriality, surveillance (informal and formal), access control, image/maintenance, activity programme support, target hardening and geographical juxtaposition. Some researchers, like Fisher and Nasar (1992), talk about three types of things in CPTED: places where you can see everything, places where people can hide, and ways for people to get away. Taylor and Harrell (1996) say that people are more afraid of crime in places where criminals can hide easily but it's hard for others to see or escape from. Through optimizing the visibility of spaces, it becomes possible to deter criminal activities.

Space Syntax

Space syntax is an analytical framework rooted in architectural and urban studies that aims to comprehend the relationships between spatial configurations and human behavior within the built environment. This approach is built on the idea that the layout and connectivity of spaces influence how people interact with and perceive their surroundings. By quantifying the connectivity and accessibility of different spaces, space syntax can help optimize visibility patterns, circulation, and spatial organization, thereby significantly enhancing user safety within the built environment.

The selection of the Isovist/VGA tool was done based on the following comparative analysis.

ANALYSING THE PUBLIC OPEN SPACE FOR SAFETY					
TOOLS ▶	Convex Space	Axial Space	View Dome Tool	Point cloud from LiDAR	Isovist/ VGA
FACTORS ▼					
3 Dimensional Space Analysis	✗	✓	✓	✓	✗
Can Be used at Designing Phase for exploration of various options	✓	✓	✓	✗	✓
Autocad files can be imported	✓	✓	✓	✗	✓
Appropriate for exterior spaces	✗	✓	✓	✓	✓
360 degree field of view	✓	✗	✓	✓	✓
Type of analysis	✗ Link analysis	⚠ Linear Visibility	✓ Visibility	✗ Model Generation	✓ Visibility
Open Source Software	✓	✓	✗	✓	✓

Table 2. Selection of tool

Isovists, a tool of space syntax represents a specific point's location within an enclosed polygonal space and the three-dimensional volume of space visible from that point.. There has been a historical focus on analyzing isovists in two dimensions, particularly the horizontal plane (Benedikt, 1979; Weitkamp, 2011).

The integration of Isovist analysis into Geographic Information Systems (GIS) having abundant availability of geo-referenced data and visualization tools enhances visibility analysis from a human perspective. This integration involves utilizing undirected graphs to connect

all visible points within a human-scale grid creating a robust framework to tackle crucial challenges concerning the interplay between the built environment and human behavior, particularly in terms of safety considerations.

3.2. Process of data collection

The survey was conducted at 2 locations- 1. Delhi haat INA- located in Kidwai nagar, opposite INA market, New Delhi with a site area of 6 acres and 2. Delhi haat Janakpuri located in Lal Sai Mandir Marg, Virender Nagar, Janakpuri, New Delhi with a site area of 8 acres. Average daily footfall in Dilli Haat INA and Janakpuri is 3000 and 1000 respectively as per Delhi tourism records for the year 2021. 5% of the average footfall of the two Haats i.e., 100 was taken as the sample size. Only visitors within the age group of 7 to 65 years were surveyed as per the inclusion criteria. Duration of the data collection was for one year. The surveys were conducted in summer, winter and in festive days.

Questionnaire and Space syntax were used for data collection.

The questionnaire consisted of 14 questions. Part 1 dealt with demographic variables such as name, age, education etc. and Part 2 dealt with safety of the people using the POS of Haats. Likert Scale was used to measure the survey responses in the form of a number of ratings, which was further analyzed as bar & pie charts. Likert scale helped to measure the safety of the people in the haat. A score of 5 is given for highest safety and a score of 1 is given for lowest safety.

Isovist- a type of space syntax and VGA- a GIS based tool, were used as tools to analyze why people perceive places differently, why certain places are more meaningful, and some can easily be forgotten i.e. human perception in built environment. It is one of the most popular way analyzing the field of view from a particular point in a built environment.

4. Findings and Discussion

4.1. Dilli Haat INA

4.1.1. Layout study

Constructed in 1993 under Delhi Tourism and Municipal Corporation of Delhi, Dilli Haat INA situated in Kidwai Nagar, opposite INA market, New Delhi is a popular tourist destination and one of the most visited shopping complexes in South Delhi. Covering a site area of 6 acres, it has approximately 12% ground coverage and a built-up area of 3190 sq.m. The figures below represent the layout study under various heads as per figure 1.

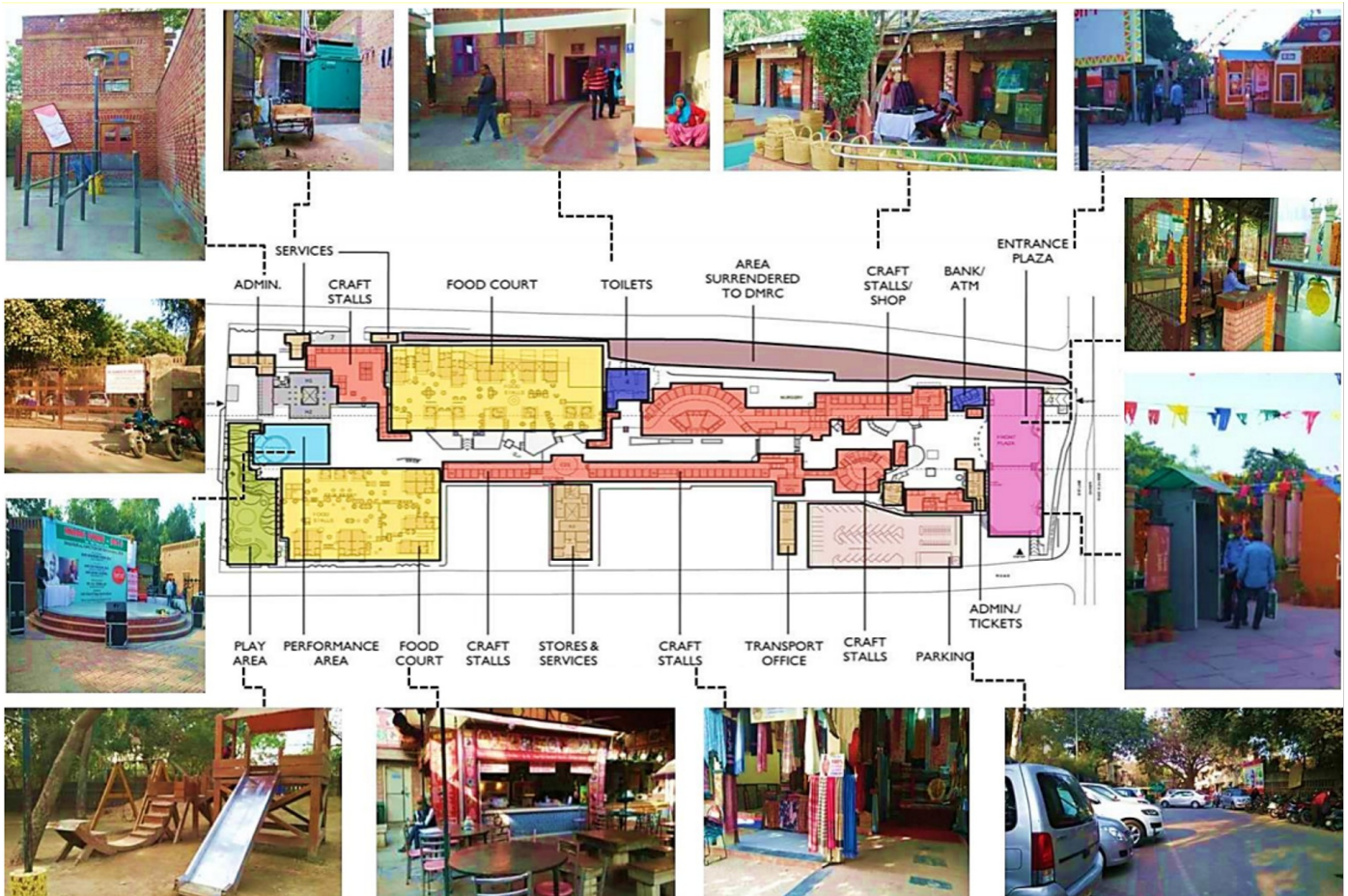


Figure 2. Activity based zoning plan

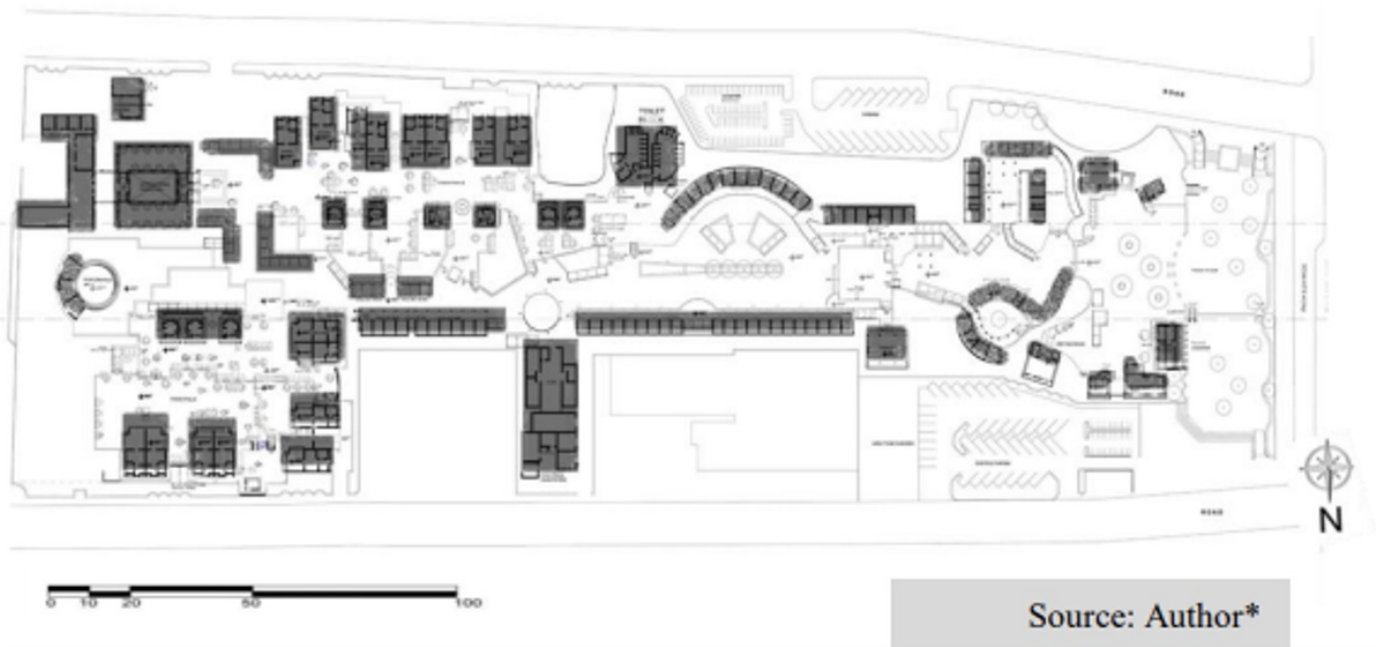


Figure 3. Built-open Relationship



Figure 4. Temporary/ permanent structures

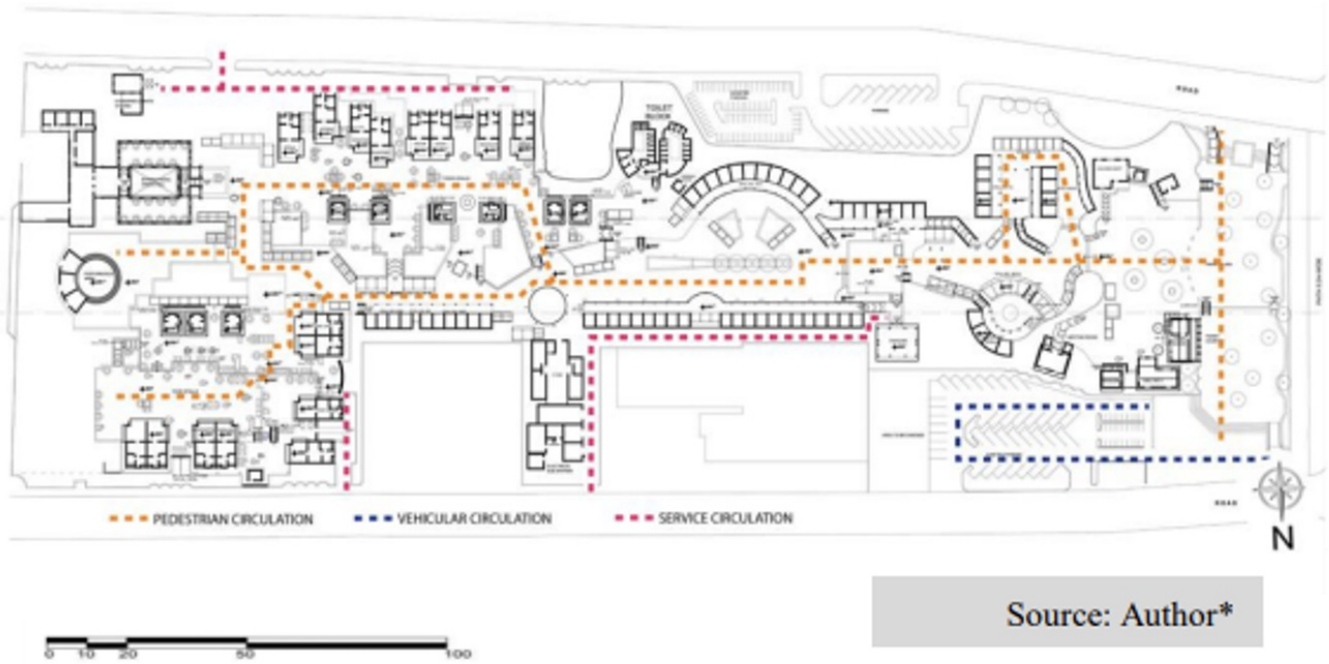


Figure 5. Circulation pattern

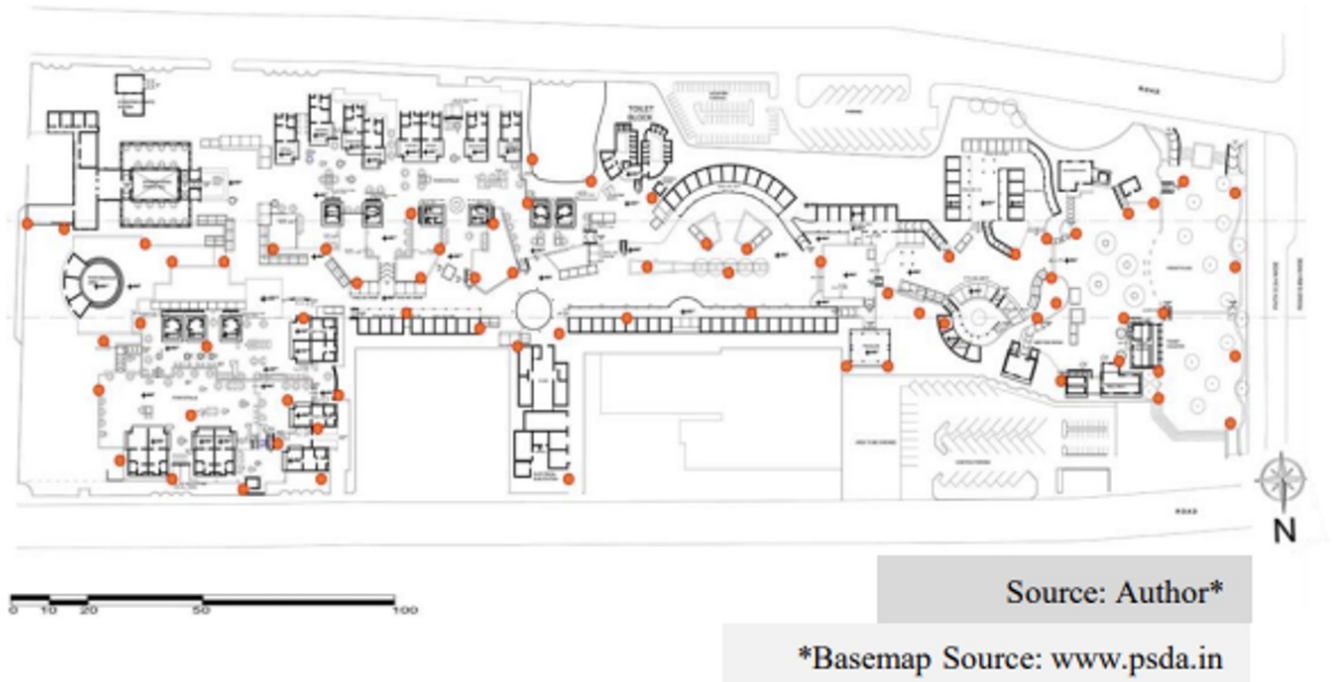


Figure 6. Lighting

4.1.2. Isovist and Visibility Graph Analysis

The Visibility Graph Analysis of the axial map of Dilli Haat INA showed that the street corresponding to the first half of the central spine from entrance had the highest values of visibility but comparatively smaller values of integration to the overall system. This is by virtue of its linear character which supports its function as a shopping street. In comparison, the latter half of the central spine with a nearer value in visibility has very high value of integration as it is well integrated into the network of food zones on both sides. The food zones that flank as networks on both sides of the spine after the roundabout has a medium level of visual connectivity and integration. The lowermost portion of the site has lesser integration levels due to its visual discontinuity. This is visible through in-situ observation. Space syntax tools further reveal the underlying properties of the spatial configuration of Dilli Haat.

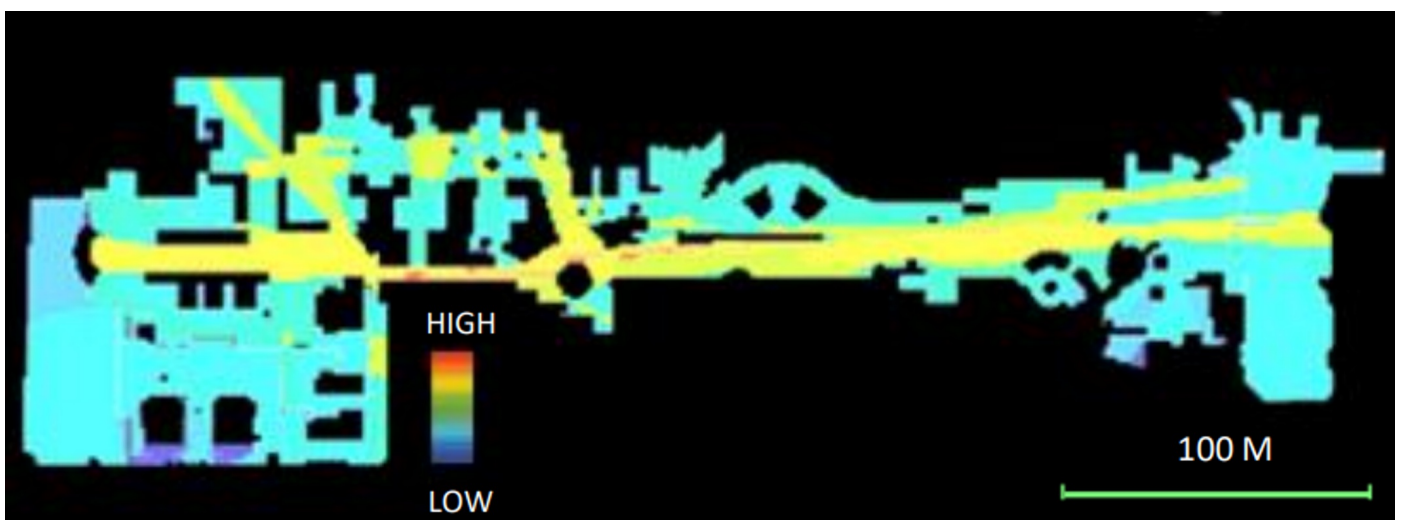


Figure 7. VGA of Dilli Haat INA

4.1.3. Questionnaire survey

A survey was conducted to assess the safety perception of people at the haat. The results showed that people feel most safe in the afternoon (54%) and least safe at 10:30 PM (27%). They also feel safer during 7 PM in summer (51%) than in winter (49%). People feel safer on regular days (56%) than on holidays (44%).

In terms of location, people feel most safe in front of the shops (63%) and least safe in voids and toilets (37%). The public visibility is insufficient for 30% of the people. The night lighting of the haat is neutrally safe and sufficient for 54% of the people, while 27% think it is unsafe. The public toilets of the haat are neutrally safe for 59% of the people, but 40% feel it unsafe. The pedestrian pathways in the haats are safe and clear for 54% of the people.

The survey also found that 86.4% of the people have no idea regarding lost/found provision in the haat. Additionally, 45.5% of the people feel that the haat is unsafe for children. The maximum number of people feel most safe at the entrance (67%) and least safe at the end (33%).

4.2. Dilli Haat Janakpuri

4.2.1. Layout Study

Constructed in 2014 under Delhi Tourism and Municipal Corporation of Delhi, Dilli Haat Janakpuri is situated in Lal Sai Mandir Marg, Virender Nagar, Janakpuri, New Delhi. Covering a site area of 9.6 acres, it has approximately 27.8% ground coverage and a built-up area of 9028 sq.m. The underlying layer that bonded the overall program of formal and informal shops was its “rhythmic heartbeat concept”. The figures below represent the layout study under various heads as per figure 1.



Figure 8. Activity based zoning plan

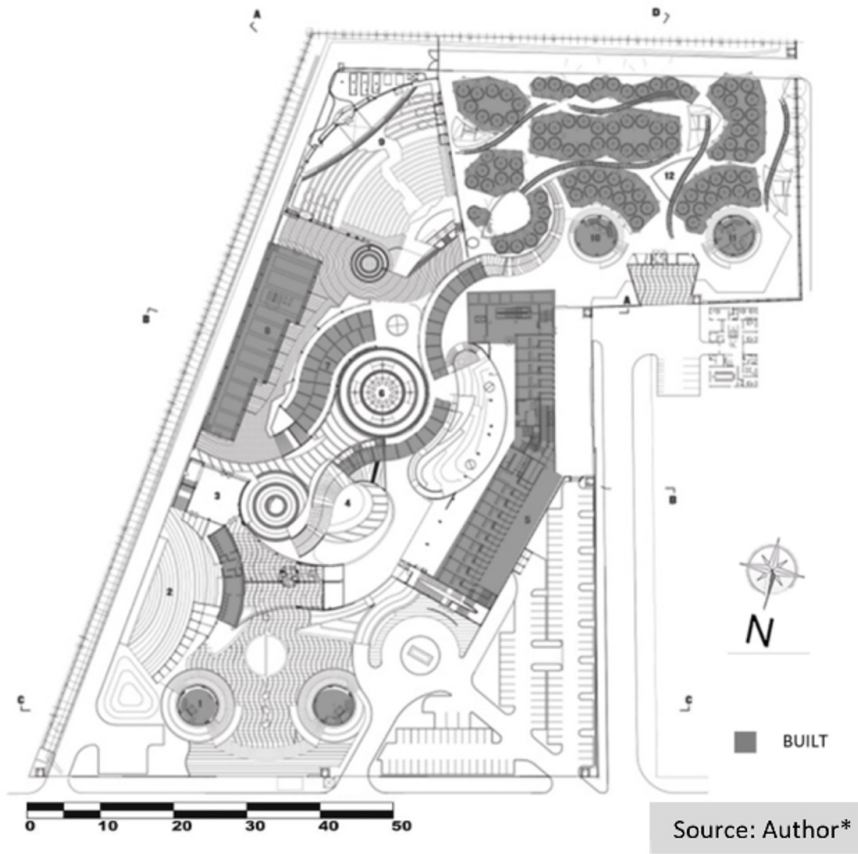


Figure 9. Built-open Relationship

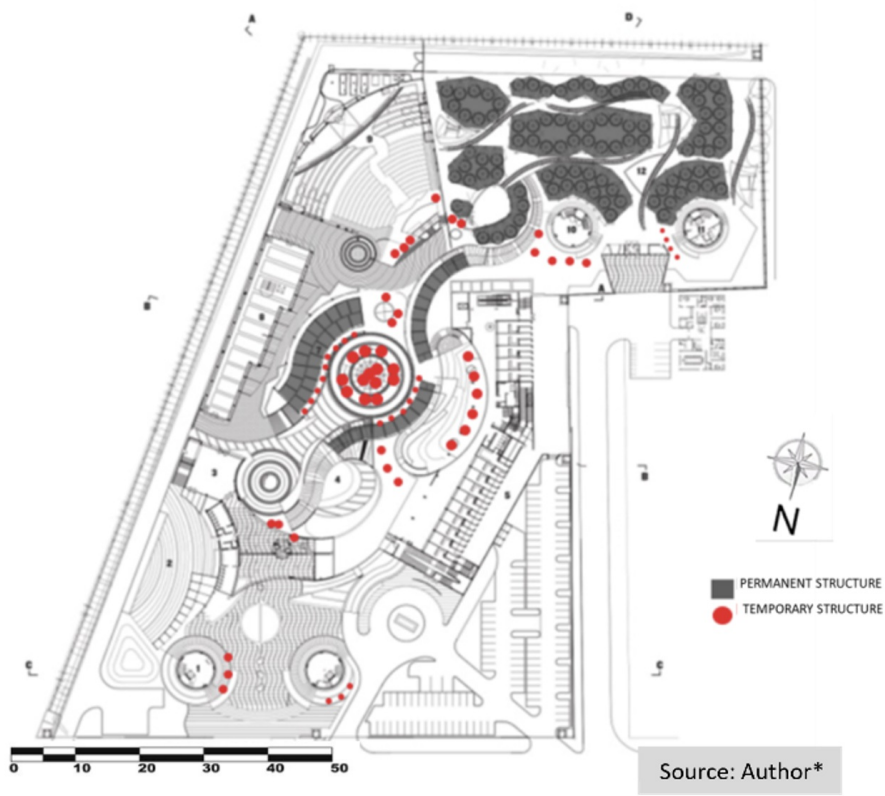


Figure 10. Temporary/ permanent structures



Figure 11. Circulation pattern

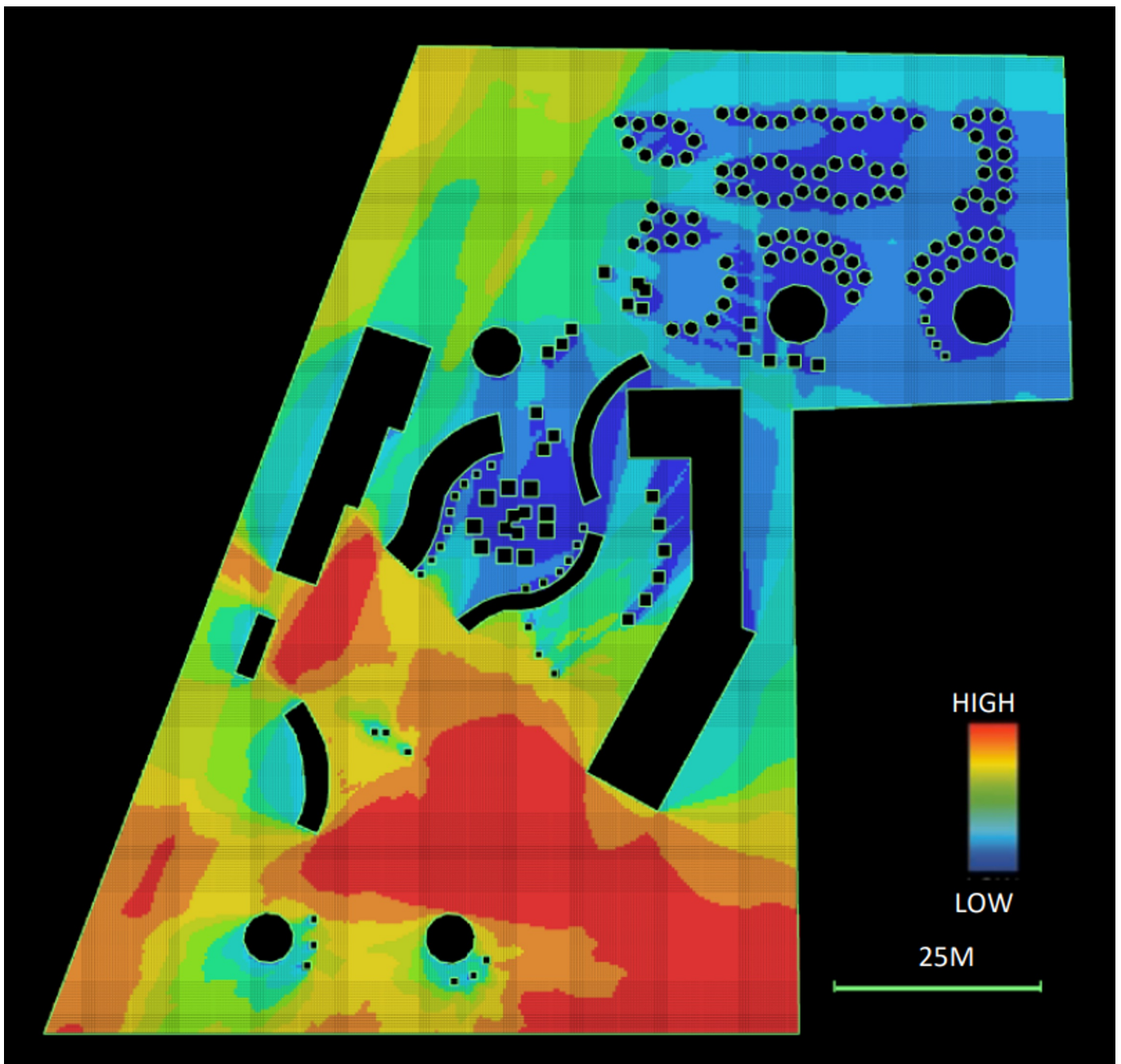


*Basemap Source: www.archohm.com

Figure 12. Lighting

4.2.2. Isovist and Visibility Graph Analysis

The visibility analysis of the Dilli Haat Janakpuri plan shows that the street corresponding to the entrance has the high values of visual connectivity and integration to the overall system. In comparison, the latter half of the central spine with lower visibility value poorly connected to the network of food zones. The rear end of the haat has the lowest values of visibility. The canopy structures further lower the visual connectivity values. The toilets have lesser integration levels due to their visual discontinuity. This is visible through insitu observation. Space syntax tools further reveals how urban spaces and their configurations can translate into positive public value.

**Figure 13.** VGA of Dilli Haat Janakpuri

4.2.3. Survey

The results showed that people feel most safe from morning to evening (63%) and least safe during late hours after 6:30 PM (37%). They also feel safer during 7 PM in summer (51%) than in winter (49%). People feel safer on festive days (56%) than on regular days (44%).

In terms of location, people feel most safe in front of the shops (63%) and least safe in front of the voids and empty spaces and toilets (37%). The public visibility of the entire haat is safe for 63% of the people. However, 59% of the people feel that the night lighting of the haat is not sufficient in terms of safety of women and children. The public toilets of the haat are not safe for 59% of the people. The pedestrian pathways in the haats are safe and clear for 45% of the people.

The survey also found that 86.4% of the people have no idea regarding lost/found provision in the haat. Additionally, 40% of the people feel that the haat is safe for children and 27% feels that it is not safe. The maximum number of people feel most safe at the entrance (67%) and least safe at the end (33%).

4.3. Implications

These findings suggest that there are some safety concerns at the haat, especially for women and children.

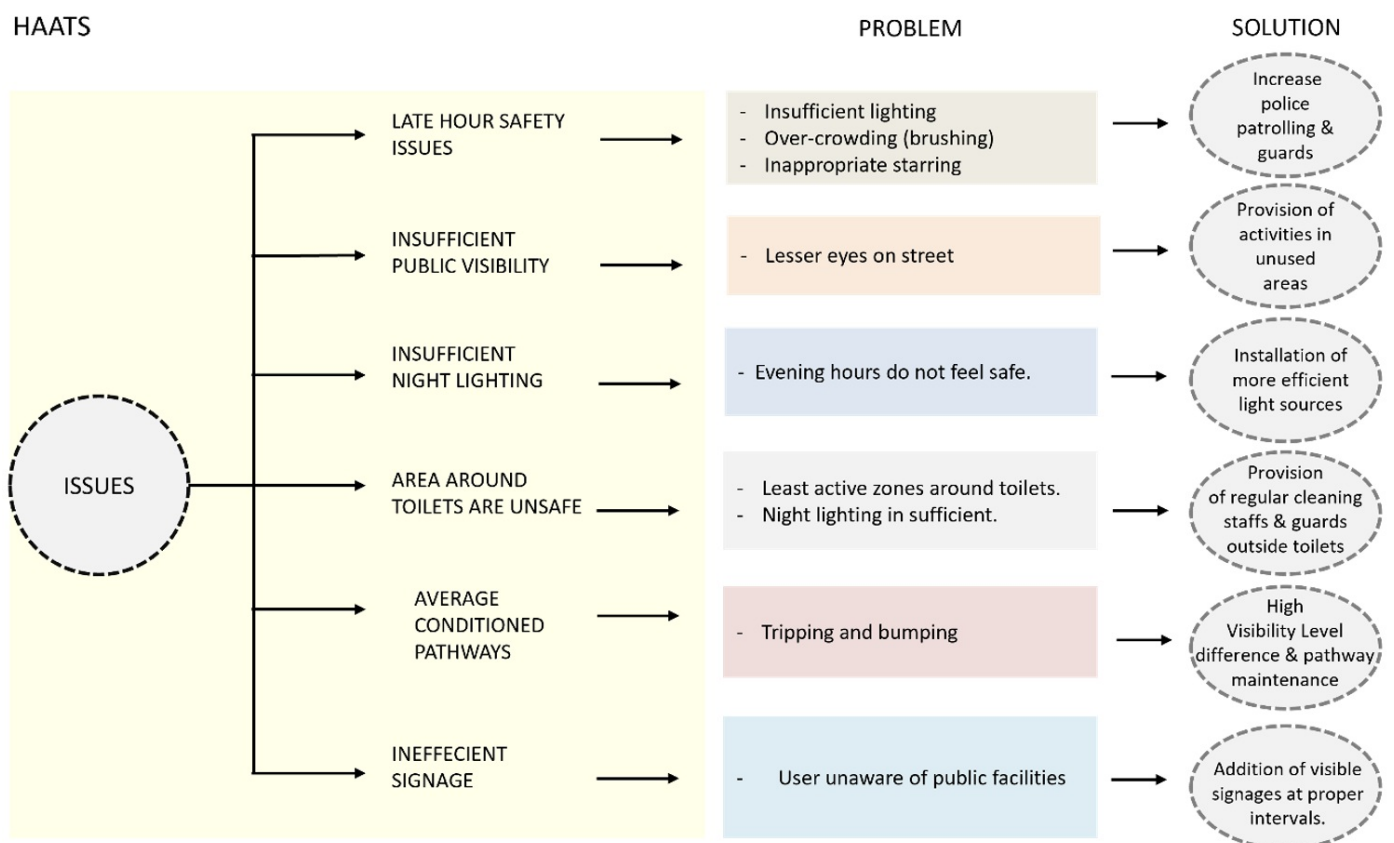


Figure 14. Findings & implications

The study highlighted several key issues identified at Dilli Haat along with their corresponding problems and potential solutions. Late-hour safety concerns, encompassing insufficient lighting, over-crowding leading to brushing incidents, and inappropriate behavior, pose serious threats to visitors' well-being. Another issue pertains to the lack of public visibility, resulting in fewer observers on the streets, which could potentially contribute to security problems.

Furthermore, safety concerns extend to the areas surrounding the toilets, often regarded as inactive zones and lacking proper night lighting. Ineffective signage further compounds the problems, with users often being unaware of the location of essential public facilities.

To enhance the overall safety, visibility, accessibility and for providing a more secure and enjoyable experience for visitors of the POS, the following recommendations are made.

5. Recommendations

- Increase the number of guards and police patrolling in POS
- Usage of performances to engage more public
- Provision of performance areas in front of eateries,
- Closure of the rear entrance
- Provision of slot wise entry to limit the crowd,
- Installation of CCTV cameras and loudspeakers,
- Installation of Fog lights, Radiating and Moving lights
- Provision of regular cleaning staff and stationed guards around the toilets
- Well-placed Signages at appropriate intervals throughout the premises.

6. Conclusions

The comparative analysis of the outputs from these layout study, VGA analysis and questionnaire surveys showed that Isovist and VGA can be used as a way of evaluating the visibility based on real-time vision and human-based vision respectively. Although this paper is limited to only one typology of POS, this exploratory research has achieved new insights into visibility as a parameter of user safety for CPTED.

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