

**AN INTEGRATED FRAMEWORK FOR CROWD
MANAGEMENT
A CASE OF BANKE BIHARI TEMPLE, VRINDAVAN**

*A Thesis Project
submitted in partial fulfillment of the requirements for
the award of the degree of*

Bachelor of Planning

By

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May, 2026

DECLARATION

I **HARSHITA SONI**, Scholar No **2211002133** hereby declare that the thesis titled An Integrated Framework for Crowd Management A Case of Banke Bihari Temple, Vrindavan submitted by me in partial fulfilment for the award of degree of Bachelor of Planning, at Maulana Azad National Institute of Technology, Bhopal, India, is a record of Bonafide work carried out by me. The matter/result embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.



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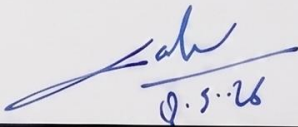
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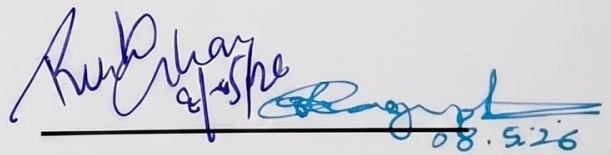


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ABSTRACT(ENGLISH)

This study addresses the challenges of crowd management in the Banke Bihari Temple precinct, Vrindavan, a high-density religious environment experiencing intense and fluctuating pedestrian movement. The existing conditions are characterized by congestion, inefficient circulation, and safety concerns arising from the mismatch between high footfall and limited spatial capacity.

The research adopts a planning-oriented approach integrating spatial analysis, behavioural understanding, and management assessment. Primary surveys, movement mapping, and observational studies were conducted to analyze pedestrian flow patterns, congestion points, and user behaviour. Secondary data and case studies further informed the analysis.

Based on the findings, an integrated spatial behavioural technological framework is developed, focusing on circulation restructuring, congestion redistribution, and regulated inflow management. The proposal introduces a multi-scalar system including peripheral parking, pedestrian prioritization, holding areas, and controlled entry mechanisms.

The proposed framework enhances safety, improves movement efficiency, and ensures inclusivity while maintaining the cultural and spatial character of the precinct. The study demonstrates the role of planning in addressing complex crowd dynamics and provides a replicable model for similar high-density religious environments.

सारांश

यह अध्ययन वृंदावन स्थित बांके बिहारी मंदिर परिसर में भीड़ प्रबंधन की समस्याओं का विश्लेषण करता है, जहाँ अत्यधिक और परिवर्तनीय पैदल यात्री गतिविधि पाई जाती है। वर्तमान स्थिति में भीड़भाड़, असंगठित आवागमन तथा सुरक्षा संबंधी समस्याएँ प्रमुख रूप से देखी जाती हैं, जिनका मुख्य कारण अधिक फुटफॉल और सीमित स्थान क्षमता के बीच असंतुलन है।

अध्ययन में स्थानिक विश्लेषण, व्यवहारिक अध्ययन तथा प्रबंधन प्रणाली का समेकित दृष्टिकोण अपनाया गया है। प्राथमिक सर्वेक्षण, मूवमेंट मैपिंग तथा अवलोकन के माध्यम से भीड़ के पैटर्न, जाम के बिंदु तथा उपयोगकर्ता व्यवहार का विश्लेषण किया गया है।

अध्ययन के आधार पर एक समेकित स्थानिक-व्यवहारिक-तकनीकी ढांचा प्रस्तावित किया गया है, जिसमें आवागमन का पुनर्गठन, भीड़ का वितरण तथा नियंत्रित प्रवेश प्रणाली शामिल है।

यह प्रस्ताव सुरक्षा, गतिशीलता और उपयोगकर्ता अनुभव को बेहतर बनाते हुए क्षेत्र की सांस्कृतिक पहचान को बनाए रखता है। यह अध्ययन उच्च घनत्व वाले धार्मिक स्थलों के लिए एक उपयोगी योजना मॉडल प्रस्तुत करता है।

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION.....	1
1.1. Background of the Study	1
1.2. Crowd Management in Heritage Temple Precincts.....	2
1.3. Need for an Integrated Spatial Behavioural Technological Framework	3
1.4. Study Area Profile: Banke Bihari Temple, Vrindavan	4
1.5. Problem Identification and Critical Issues	6
1.6. Aim and Objectives of the Study	7
1.7. Research Questions	8
1.8. Scope of the Study.....	9
1.9. Limitations of the Study	9
1.10. Methodology.....	10
1.11. Expected Outcome and Planning Significance	11
1.12. Chapter Summary	11

CHAPTER 2

LITERATURE REVIEW.....	13
2.1. Introduction to the Literature Review	13
2.2. Conceptual Understanding of Crowd and Crowd Management	17
2.3. Carrying Capacity and Density Threshold Theories	18
2.4. Behavioural Dimensions of Religious Crowds	18
2.5. Large-Scale Religious Gathering Case Studies	19
2.6. Technology-Driven Crowd Monitoring Systems.....	19
2.7. Indian Policy and Planning Guidelines	20
2.8. Synthesis of Reviewed Literature.....	20
2.9. Methodology (Objective-wise)	20

CHAPTER 3

ANALYSIS AND FINDINGS.....	22
3.1 Introduction.....	22
3.2 Study Area Context and Significance.....	22
3.3 Study Area Delineation and Spatial Extent	24
3.4 Connectivity and Regional Linkages	25

3.5	Land Use Pattern and Activity Distribution	28
3.6	Spatial Structure and Built Form Analysis	30
3.7	Key Spatial Observations	32
3.8	Temple-Centric Movement and Radial Flow Pattern	32
3.9	Movement Pattern Analysis	33
3.10	Circulation Characteristics and Flow Behaviour	34
3.11	Congestion Analysis	34
3.12	Bottleneck Identification and Analysis	35
3.13	Street Characteristics and Their Impact	36
3.14	Temporal Variation and User Perception Analysis	36
3.15	Synthesis of Temporal and Perception Analysis	41
3.16	Identification of Planning Issues	42
3.16.1	Mobility-Related Issues	44
3.16.2	Congestion-Related Issues	47
3.16.3	Management-Related Issues	49
3.16.4	Land Use and Encroachment Issues	52
3.17	Cause–Effect Relationship Analysis	55
3.18	Impact Analysis on Users and System Performance	58
3.19	Interpretation of Findings	61
CHAPTER 4		
PLANNING FRAMEWORK AND STRATEGY FORMULATION		65
4.1	Introduction	65
4.2	Need for a Planning-Led Framework	65
4.3	Planning Approach and Conceptual Basis	67
4.4	Derivation of Strategies from Analysis	68
4.5	Structuring of the Planning Framework	69
4.6	Mobility and Circulation Structuring	70
4.7	Congestion Redistribution and Density Management	71
4.8	Land Use Structuring and Spatial Regulation	72
4.9	Integration of Behavioural and Management Dimensions	73
4.10	Multi-Scalar Structuring of the Framework	74
4.11	Spatial Translation of Strategies Across Scales	76

4.12	Synthesis of the Integrated Framework	77
4.13	Transition to Spatial Proposals	78
4.14	Chapter summary	79
CHAPTER 5		
DESIGN PRINCIPLES AND INTERVENTION APPROACH.....		80
5.1	Introduction.....	80
5.2	Conceptual Basis of Design Intervention.....	81
5.3	Principle of Movement Continuity	82
5.4	Principle of Spatial Hierarchy	83
5.5	Principle of Activity Segregation	83
5.6	Principle of Safety and Emergency Accessibility	84
5.7	Principle of Inclusivity and Universal Accessibility	85
5.8	Principle of Minimal and Context-Sensitive Intervention.....	86
5.9	Principle of Distributed Load and Decentralization.....	87
5.10	Transition to Intervention Approach	87
5.11	Structuring of Intervention Approach	88
5.12	Spatial Interventions and Reorganization of Circulation	89
5.13	Functional Interventions and Activity Organization	90
5.14	Management and Regulatory Interventions.....	91
5.15	Technological Support and Adaptive Systems	92
5.16	Multi-Scalar Application of Interventions.....	92
5.17	Chapter summary	92
CHAPTER 6		
PROPOSAL: INTEGRATED CROWD AND MOBILITY		
MANAGEMENT PLAN		94
6.1	Introduction.....	94
6.2	Overall Structure of the Proposed System	94
6.3	Vehicular Circulation and Parking Strategy	95
6.4	Traffic Volume and Vehicular Load Estimation	98
6.5	Transition from Vehicular to Pedestrian Movement	98
6.6	Pedestrian Circulation and Crowd Management Strategy.....	99
6.7	Pedestrian Volume Estimation	101
6.8	Holding Area Planning and Capacity Quantification	101

6.9	Queue Management and Controlled Entry System.....	102
6.10	Operational Dynamics under Normal and Peak Conditions	103
6.11	System Efficiency and Capacity Justification.....	108
6.12	Junction Improvement and Micro-Level Flow Optimization	108
6.13	Emergency Evacuation Strategy and Risk Mitigation	111
6.14	Phased Implementation Strategy	113
6.15	Institutional Framework and Operational Management	114
6.16	Implementing Agencies and Operational Framework	115
6.17	Design of Holding Areas and Support Spaces	116
6.18	Use of Technology in Crowd Management	118
6.19	Overall System Feasibility and Planning Justification	119
CHAPTER 7		
CONCLUSION		120
7.1	Summary of the Study.....	120
7.2	Key Contributions of the Proposal	120
7.3	Planning Significance and Applicability.....	121
7.4	Implementation Potential and Limitations	122
7.5	Final Reflection	122
REFERENCES.....		124

List of Tables

Table 1.1: Footfall and Carrying Capacity Assessment of Vrindavan and Banke Bihari Temple	7
Table 2.1: Summary of Selected Research Papers	14
Table 6.1: Area Distribution Table	117
Table 6.2: Capacity Calculation Table	117

List of Figures

Figure 1.1: Source: Maps of India, Google Maps & Primary Photograph	4
Figure 1.2: High Footfall	5
Figure 1.3: Narrow Streets	5
Figure 3.1: Site Context Map	23
Figure 3.2: Study Area Delineation Map	24
Figure 3.3: Connectivity Analysis Map	27
Figure 3.4: Land Use Map	29
Figure 3.5: Streer Characteristics Map	31
Figure 3.6: Temporal Peak Crowd Distribution.....	37
Figure 3.7: Waiting Time Graph	38
Figure 3.8: Congested Area Chart.....	39
Figure 3.9: Public Opinion Crowd Management Chart	40
Figure 3.10: Priority Improvement Chart	41
Figure 6.1: proposed vehicular circulation and access management map	96
Figure 6.2: Pedestrian Circulation and Crowd Flow Management Plan	100
Figure 6.3: Pedestrian and Vehicular System – Normal Day Scenario.....	104
Figure 6.4: Pedestrian and Vehicular System – Peak Day / Festival Scenario	106
Figure 6.5: Junction Improvement Plan and Critical Nodes.....	110
Figure 6.6: Emergency Evacuation and Assembly Plan	112
Figure 6.7: Holding Area	116

CHAPTER 1

INTRODUCTION

1.1. Background of the Study

Rapid urbanization and the increasing scale of religious tourism in India have intensified challenges related to crowd management, particularly within historic temple precincts. Uttar Pradesh, as the most visited state in the country, records exceptionally high religious tourist footfall, with recent estimates indicating over 130 crore annual tourist visits, a significant proportion of which are pilgrimage oriented. Within this broader context, the Mathura–Vrindavan pilgrimage circuit alone attracts approximately 7–8 crore devotees annually, accounting for nearly 6 % of the total visitor footfall in Uttar Pradesh. Religious destinations such as Vrindavan therefore experience sustained and intense pressure on infrastructure that was originally developed for much smaller populations. In such contexts, crowd management is not merely an operational concern but a critical urban planning issue that intersects with public safety, heritage conservation, accessibility, and quality of experience. The absence of structured planning responses to crowd dynamics often leads to congestion, safety hazards, and the degradation of both the physical environment and the spiritual experience of devotees.

Temple precincts in India typically evolve organically over centuries, characterized by narrow streets, mixed land uses, and a high dependence on pedestrian movement. While these attributes contribute to the cultural and spatial identity of such places, they also pose serious challenges when subjected to contemporary crowd volumes. In Vrindavan, where pilgrimage activity forms a substantial share of the state’s religious tourism, this mismatch between carrying capacity and footfall becomes particularly evident during peak religious events and festivals. Such periods witness severe congestion, bottlenecks, and uncontrolled crowd surges, increasing the risk of stampedes and safety-related incidents. These conditions underline the urgent need for systematic planning approaches that can respond to both the scale and temporal variability of pilgrimage-driven crowds.

In recent years, crowd-related incidents at major religious destinations have drawn attention to the limitations of conventional crowd control measures, which largely rely on temporary barricading and manual policing. These reactive approaches often fail to

address underlying spatial inefficiencies and behavioural patterns that shape crowd movement. From an urban planning perspective, there is a growing need to adopt proactive and integrated frameworks that combine spatial restructuring, behavioural understanding, and technological support systems. Situated within this context, the present study seeks to contribute to the discourse on sustainable and context-sensitive crowd management strategies for high-density heritage religious precincts, with specific reference to the Banke Bihari Temple precinct in Vrindavan.

1.2. Crowd Management in Heritage Temple Precincts

Crowd management refers to the planning, design, and regulation of spaces to safely and efficiently accommodate large numbers of people while minimizing risks and discomfort. In heritage temple precincts, crowd management assumes added complexity due to spatial constraints, cultural sensitivities, and the need to preserve historic character. Unlike modern public spaces, these precincts are often characterized by narrow access routes, irregular street networks, and intense land-use mixing, which significantly influence pedestrian movement and crowd behaviour.

One of the key challenges in managing crowds in temple precincts is the concept of carrying capacity. Physical carrying capacity is determined by the size and configuration of spaces, while psychological and social carrying capacities relate to comfort levels and perceived safety of users. In many Indian religious towns, the carrying capacity of streets and temple interiors is frequently exceeded during peak periods, leading to congestion and heightened stress levels among devotees. This situation is further aggravated by informal vending, encroachments, and lack of designated pedestrian movement systems.

Behavioural aspects play a crucial role in shaping crowd dynamics within religious settings. Devotional urgency, emotional intensity, group movement patterns, and lack of directional clarity often result in erratic crowd behaviour. Vulnerable user groups such as children, elderly persons, and persons with disabilities are disproportionately affected under such conditions. Traditional crowd control measures rarely account for these behavioural dimensions, focusing instead on physical barriers and crowd dispersal techniques.

From a planning standpoint, effective crowd management in heritage precincts requires a holistic understanding of spatial form, user behaviour, and temporal variations in

footfall. International and national case studies increasingly emphasize the importance of integrated approaches that go beyond physical design solutions. This study builds upon these perspectives by proposing a framework that aligns spatial planning interventions with behavioural insights and technological tools to achieve safer and more inclusive crowd management outcomes.

1.3. Need for an Integrated Spatial Behavioural Technological Framework

Conventional crowd management strategies in religious precincts often adopt a fragmented approach, addressing spatial design, crowd control, and technology as separate components. However, such isolated interventions have limited effectiveness in complex environments like temple precincts, where crowd movement is influenced by a combination of physical constraints, human behaviour, and management practices. This highlights the need for an integrated spatial behavioural technological framework that can respond dynamically to varying crowd conditions.

Spatial planning forms the foundation of effective crowd management by organizing movement networks, defining entry and exit systems, and reducing physical bottlenecks. However, spatial interventions alone cannot fully account for behavioural patterns such as sudden surges, congregation at focal points, and non-linear movement typical of religious crowds. Understanding behavioural responses to space, signage, waiting time, and perceived proximity to the deity is therefore essential for designing effective circulation systems.

Technological interventions have emerged as powerful tools in supporting crowd management through real-time monitoring, data-driven decision-making, and regulated access systems. Technologies such as artificial intelligence-based crowd monitoring, e-ticketing, and digital queue management can help control footfall, predict congestion, and improve response mechanisms. When integrated with spatial design and behavioural insights, technology can significantly enhance safety, efficiency, and user experience.

This study advocates for a planning-led integrated framework that aligns spatial restructuring with behavioural understanding and technological support. Such a framework is particularly relevant for heritage temple precincts, where permanent physical alterations must be sensitive to cultural values, and where effective

management can reduce reliance on intrusive control measures. The framework proposed through this research aims to offer a scalable and replicable model for crowd management in similar high-density religious settings.

1.4. Study Area Profile: Banke Bihari Temple, Vrindavan

Vrindavan is one of the most significant religious towns in India, closely associated with the life and legends of Lord Krishna. Located in the Mathura district of Uttar Pradesh, *Figure 1.1*. The town forms an important node within the Braj region and attracts pilgrims and tourists throughout the year. Among its many temples, the Banke Bihari Temple holds exceptional religious prominence and serves as a major pilgrimage destination. The temple precinct functions as both a sacred space and a highly active urban area, accommodating religious activities, tourism-related functions, residential uses, and informal economic activities within a compact spatial setting.

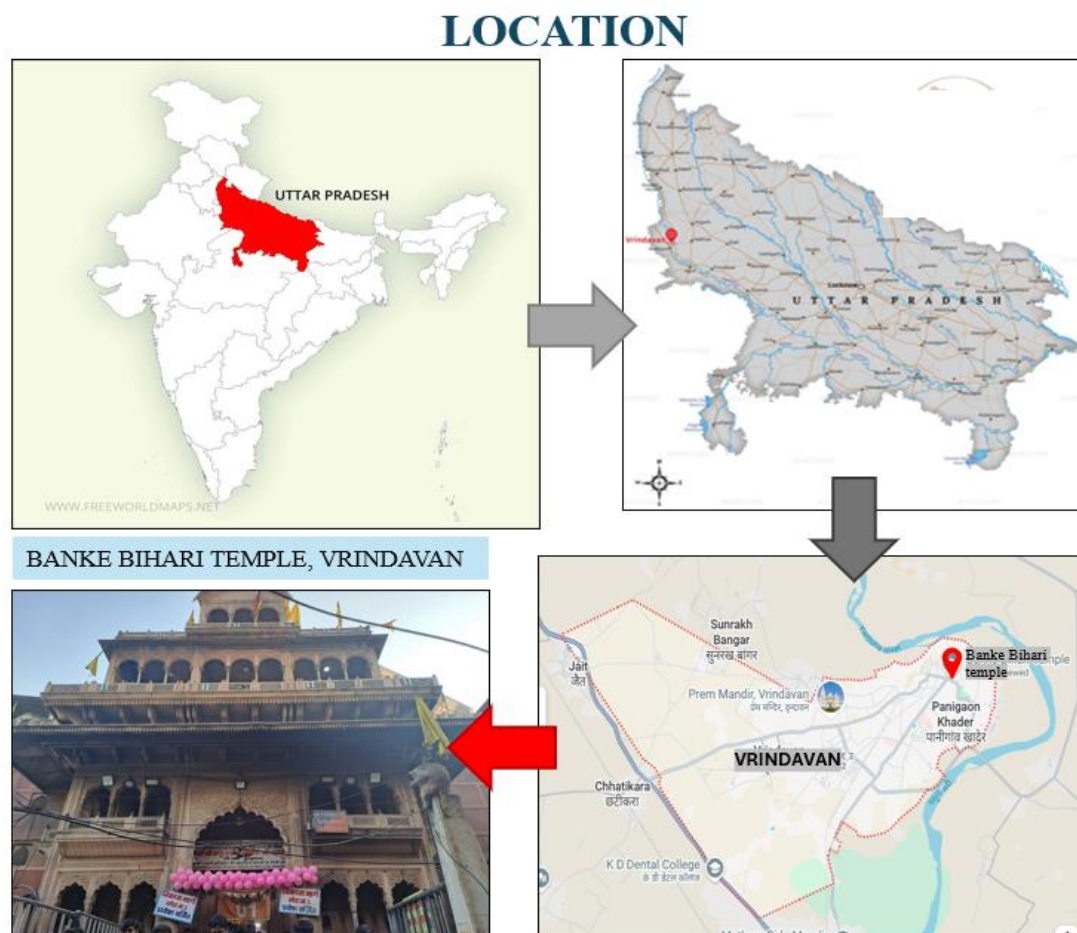


Figure 1.1: Source: Maps of India, Google Maps & Primary Photograph

Source: Maps of India, Google Maps & Primary Photograph

The Banke Bihari Temple is situated within the historic core of Vrindavan, characterized by a dense and organically evolved urban fabric. The surrounding street

network comprises narrow, irregular lanes with limited right-of-way, originally designed for pedestrian and animal movement rather than contemporary crowd volumes. These streets serve multiple functions, including pedestrian circulation, vending, service access, and social interaction, which significantly influence crowd movement patterns. The lack of hierarchical road structure and inadequate connectivity further intensify congestion, particularly during peak pilgrimage periods.



Figure 1.3: Narrow Streets

Source: News Article

Figure 1.2: High Footfall

Source: News Article

The temple attracts a diverse range of users, including daily devotees, tourists, priests, local residents, vendors, and service providers. Footfall increases substantially during festivals such as Janmashtami, Holi, and weekends, often exceeding the physical carrying capacity of the precinct, *Figure 1.2*. The temple's limited internal space and the absence of clearly segregated entry and exit points result in overlapping pedestrian flows, leading to congestion and unsafe conditions, *Figure 1.3*. Additionally, the precinct lacks dedicated infrastructure for elderly devotees, children, and persons with disabilities, making navigation through crowded spaces physically challenging and emotionally distressing for vulnerable groups.

The religious importance of the temple, combined with its spatial constraints and unregulated crowd movement, makes the Banke Bihari Temple precinct a critical case for examining crowd management from a planning perspective. The study area presents an opportunity to explore how integrated planning interventions can enhance safety, accessibility, and overall experience without compromising the cultural and spiritual essence of the place.

1.5. Problem Identification and Critical Issues

The primary challenge within the Banke Bihari Temple precinct arises from the imbalance between extremely high footfall and limited spatial carrying capacity. The narrow streets leading to the temple act as major bottlenecks, especially during peak hours and festivals, restricting smooth pedestrian movement and emergency access. Poor connectivity and the absence of alternative circulation routes exacerbate congestion, resulting in overcrowding and prolonged waiting times for devotees, *Table 1.1*.

Another significant issue is the lack of a well-defined entry and exit system within the temple precinct. Overlapping movement of incoming and outgoing devotees creates conflicting pedestrian flows, increasing the risk of crowd pressure and panic situations. Temporary barricading and manual crowd control measures are often employed during peak periods; however, these solutions are reactive in nature and fail to address the root causes of congestion. The absence of permanent, planning-based circulation strategies limits the effectiveness of such measures.

Behavioural aspects further compound spatial challenges within the precinct. Devotional urgency, emotional intensity, and collective movement patterns often lead to sudden surges, particularly near the sanctum and darshan points. Inadequate signage, lack of directional clarity, and inconsistent crowd regulation contribute to confusion and stress among devotees. Vulnerable user groups, including elderly persons, children, and persons with disabilities, face disproportionate difficulties navigating through dense crowds, highlighting the lack of inclusive planning interventions.

The critical nature of these issues was evident during the stampede incident that occurred in August 2022 during Janmashtami celebrations, when overcrowding within the temple premises resulted in fatalities and injuries. This incident underscores the serious safety implications of inadequate crowd management and highlights the urgent need for a systematic and integrated planning approach. In addition to safety concerns, unregulated vending activities and informal encroachments along access routes further reduce effective street width and disrupt pedestrian movement, intensifying conflicts between devotees, locals, and economic activities.

From an urban planning perspective, these challenges indicate the absence of a comprehensive crowd management framework that integrates spatial design,

behavioural understanding, and technological support. Addressing these issues requires moving beyond temporary crowd control measures toward long-term planning interventions that enhance circulation efficiency, safety, accessibility, and user experience within the temple precinct.

Table 1.1: Footfall and Carrying Capacity Assessment of Vrindavan and Banke Bihari Temple

Scale	Location	Estimated Footfall	Available Effective Area	Adopted Planning Standard	Calculated Carrying Capacity
Annual	Vrindavan Town	5–6 crore/year	Approx. 5 sq km active tourist zone	2.5 sq m/person (mixed pedestrian areas)	~20–22 lakh persons at a time
Monthly (Average)	Vrindavan Town	40–50 lakh/month	Approx. 5 sq km active tourist zone	2.5 sq m/person	Capacity exceeded during weekends
Festival Peak	Vrindavan Town	15–20 lakh/day	Reduced effective width due to encroachments	3 sq m/person (safe movement)	~12–14 lakh persons
Daily (Average)	Banke Bihari Temple	30,000–50,000/day	Approx. 2,500 sq m usable area	1.5 sq m/person (religious assembly)	~1,600 persons at a time
Peak Day	Banke Bihari Temple	1–2 lakh/day	Same internal space	2 sq m/person (safe darshan)	~1,250 persons at a time
Peak Festival Day	Banke Bihari Temple	4–5 lakh/day	Circulation severely constrained	3 sq m/person (safety norm)	~800–900 persons at a time
Temple Precinct Streets	Banke Bihari Precinct	—	Approx. 10,000 sq m effective area	2.5 sq m/person	~4,000 persons

Source: Author

1.6. Aim and Objectives of the Study

The aim of this study is to develop an integrated spatial–behavioural–technological framework for crowd management in the Banke Bihari Temple precinct, Vrindavan, with the objective of enhancing safety, operational efficiency, inclusivity, and overall user experience. The study seeks to address the requirements of multiple stakeholders, including devotees, local residents, vendors, priests, and vulnerable user groups, while preserving the religious and cultural significance of the temple precinct. Through a planning-led approach, the research aims to demonstrate how coordinated spatial,

behavioural, and technological interventions can mitigate crowd-related risks and improve the functionality of high-density heritage temple precincts.

Objectives of the Study

1. To analyze the existing spatial configuration and circulation network of the Banke Bihari Temple precinct and assess their influence on pedestrian movement and congestion patterns.
2. To examine crowd behaviour during peak and non-peak periods in order to identify temporal variations and behavioural factors contributing to unsafe crowd conditions.
3. To evaluate the effectiveness of existing crowd management measures and supporting infrastructure within the temple precinct.
4. To develop a technology-assisted crowd management framework integrating spatial planning strategies, behavioural insights, and management tools.
5. To propose planning and design interventions that enhance safety, accessibility, and comfort, particularly for children, elderly devotees, and persons with disabilities.

1.7. Research Questions

The study is guided by a set of research questions that structure the inquiry and inform the planning approach adopted.

1. How does the existing spatial layout and circulation network of the Banke Bihari Temple precinct influence crowd movement, congestion, and safety?
2. How does crowd behaviour vary under different temporal conditions, such as daily routines, weekends, and major festivals, and in what ways do these variations affect overall crowd dynamics within the precinct?
3. To what extent are the existing crowd management measures adequate in addressing issues of safety, accessibility, and user experience in the Banke Bihari Temple precinct?
4. How can integrated planning interventions contribute to improved crowd management outcomes in the temple precinct?

5. In what ways can spatial restructuring, when informed by an understanding of crowd behaviour, help reduce congestion and conflict points within the precinct?
6. How can technological tools, such as artificial intelligence–based monitoring systems and e-ticketing mechanisms, support regulated access and enable real-time crowd management in the Banke Bihari Temple precinct?

1.8. Scope of the Study

The scope of the study encompasses the Banke Bihari Temple and its surrounding precinct, including adjacent streets and access routes that directly influence crowd movement and congregation. The research focuses primarily on pedestrian circulation systems, spatial configuration, and crowd behaviour within the study area. It considers both physical and non-physical dimensions of crowd management, including spatial design, behavioural patterns, and the role of technology in regulating footfall and movement.

The study addresses the needs and experiences of diverse user groups, including daily devotees, tourists, local residents, vendors, priests, and vulnerable populations such as elderly persons and persons with disabilities. While the research emphasizes planning interventions, it also considers management and policy-related aspects that influence crowd control practices. The framework developed through the study is intended to be context-specific to the Banke Bihari Temple precinct while offering insights that may be applicable to similar heritage religious settings.

1.9. Limitations of the Study

The study is subject to certain limitations that may influence the extent and generalization of its findings. Time constraints may restrict the duration and frequency of field observations, limiting the ability to capture crowd behaviour across all seasonal and festival variations. Access to real-time crowd data and official records related to footfall and management practices may also be limited, necessitating reliance on observational methods and secondary data sources.

Additionally, crowd behaviour in religious settings is influenced by emotional, cultural, and situational factors that can vary significantly across events and time periods. As a result, behavioural observations made during the study period may not fully represent all crowd scenarios. Despite these limitations, the study aims to provide a robust

planning-based framework grounded in systematic analysis and contextual understanding.

1.10. Methodology

The study adopts a planning-oriented, qualitative and analytical methodology to understand crowd dynamics and propose integrated crowd management interventions for the Banke Bihari Temple precinct. The research methodology is structured to systematically analyze spatial conditions, behavioural patterns, and management mechanisms, ensuring that the proposed framework is grounded in both empirical observations and theoretical understanding.

The initial stage of the methodology involves an extensive review of literature related to crowd management, pedestrian planning, carrying capacity, and safety in high-density religious and heritage precincts. This includes academic journals, planning reports, government guidelines, and policy documents relevant to crowd management and religious tourism. The literature review establishes the conceptual foundation for the study and helps identify best practices and gaps in existing approaches.

Primary data collection is carried out through detailed site visits and physical surveys within the temple precinct and surrounding streets. These surveys document existing spatial characteristics such as street widths, access points, entry and exit locations, pedestrian movement patterns, and areas of congestion. Observations are conducted during different time periods, including peak and non-peak hours, to understand temporal variations in crowd intensity and movement behaviour. Movement mapping and crowd flow diagrams are prepared to visually represent pedestrian circulation and identify critical bottlenecks and conflict zones.

Behavioural observation forms a crucial component of the methodology, focusing on how devotees interact with space, signage, queues, and each other. Particular attention is given to the movement of vulnerable user groups such as elderly devotees, children, and persons with disabilities. Observations also examine behavioural triggers such as waiting time, perceived proximity to the sanctum, and emotional responses during darshan, which significantly influence crowd surges and congestion.

Secondary data sources, including news reports, temple-related information, and available footfall data, are analyzed to supplement primary observations and provide contextual understanding of crowd-related incidents and management practices. Case

study analysis of similar religious precincts is undertaken to draw comparative insights and identify planning strategies that can be adapted to the Banke Bihari Temple context. The integration of these methods enables a comprehensive understanding of crowd management challenges and informs the development of a spatial–behavioural–technological planning framework.

1.11. Expected Outcome and Planning Significance

The expected outcome of the study is the formulation of a comprehensive and integrated spatial–behavioural–technological framework for crowd management tailored to the Banke Bihari Temple precinct. The framework proposes planning-led interventions that address circulation efficiency, safety, accessibility, and overall user experience. Key outcomes include the reorganization of pedestrian movement through clearly defined and separate entry and exit systems, reduction of overlapping flows, and identification of designated routes for smooth crowd dispersal.

The study emphasizes the inclusion of technological tools such as artificial intelligence–based crowd monitoring systems and e-ticketing mechanisms to regulate footfall and support real-time management. These interventions aim to enhance predictive capacity, reduce overcrowding, and improve response during peak periods. Special focus is placed on inclusive planning measures, including designated spaces and circulation routes for persons with disabilities, elderly devotees, and children, ensuring equitable access and dignified darshan experiences.

From a planning perspective, the study contributes a replicable framework that can guide crowd management strategies in other high-density religious and heritage precincts. The integration of spatial design, behavioural understanding, and technology demonstrates how planning interventions can move beyond temporary crowd control measures toward sustainable, long-term solutions. The outcomes of the study are intended to support informed decision-making by planners, local authorities, and temple management bodies.

1.12. Chapter Summary

The Banke Bihari Temple precinct represents a complex urban and religious environment where intense crowd pressure intersects with spatial constraints and cultural significance. This study highlights the limitations of conventional, reactive crowd control measures and emphasizes the need for a proactive, integrated planning

approach. By examining spatial configuration, crowd behaviour, and management practices, the research establishes the foundation for a comprehensive crowd management framework suited to heritage religious settings.

The proposed spatial behavioural technological framework demonstrates how planning-led interventions can enhance safety, accessibility, and user experience while respecting the religious and cultural essence of the temple precinct. The study reinforces the role of urban and regional planning in addressing crowd-related challenges and contributes to the broader discourse on sustainable management of high-footfall religious destinations. Through its integrated approach, the research aims to offer meaningful planning solutions that balance devotion, safety, and urban functionality.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction to the Literature Review

The purpose of this chapter is to examine existing academic research, policy guidelines, theoretical frameworks, and international case studies related to crowd management in high-density environments, with particular emphasis on religious settings. The review establishes the conceptual foundation for the study by synthesizing knowledge from urban planning, disaster management, behavioural science, transportation studies, and technology-driven crowd modelling.

Crowd management has evolved as a multidisciplinary field. Earlier approaches treated crowd control primarily as a policing or administrative task. However, contemporary research recognizes that crowd behaviour emerges from the interaction between spatial configuration, psychological triggers, density thresholds, and management systems. In religious environments, these factors become more complex due to emotional intensity, symbolic focal points, ritual timing, and group-based movement patterns.

The literature reviewed for this study includes Indian and international research papers focusing on mass religious gatherings, pedestrian flow modelling, scheduling systems, risk assessment frameworks, and technology-enabled crowd monitoring systems. These studies collectively provide theoretical grounding and highlight research gaps relevant to permanently congested temple precincts such as the Banke Bihari Temple.

To systematically analyze the selected research papers, a structured review matrix was prepared summarizing the authors, year of publication, study area, methodology, key findings, and relevance to the present research. This matrix facilitates comparative understanding of theoretical approaches, methodological tools, and identified gaps. The summary of the selected literature is presented in, *Table 2.1* .

Table 2.1: Summary of Selected Research Papers

S. No	Title	Author (s)	Journal	Indian/International	Definition/Focus	Aim of Study	Tools & Techniques	Key Conclusion
1	Carrying Capacity Assessment – Sabarimala	Illiyas et al.	IJRT P (2021)	Indian	Physical and effective carrying capacity for religious mass gathering	Define safe density limits and identify bottlenecks	GIS mapping; density calculations; PCC formula; throughput analysis	Effective capacity lower than physical due to bottlenecks
2	Crowd Management – Kumbh Mela 2019	Kanaujiya & Tiwari	NAS L (2022)	Indian	Surveillance and integrated crowd control planning	Evaluate ICT-based safety strategies	ICCC; CCTV; drones; GIS; unidirectional flow system	Technology improved real-time crowd safety
3	Religious Tourism Planning – Vrindavan	Kiran Shinde	JPRT LE (2012)	Indian	Governance gaps and infrastructure stress in pilgrimage towns	Examine policy and planning failures	Interviews; stakeholder analysis; land-use review	Infrastructure stress due to fragmented governance
4	Hajj Pilgrim Scheduling Model	Haase et al.	Operations Research (2019)	International	Optimization-based crowd scheduling model	Prevent unsafe density peaks	Mixed Integer Programming; flow simulation	Scheduling smooths crowd waves and reduces congestion
5	Digital Twin Crowd Safety Framework	Krishnakumari et al.	TRR (2023)	International	AI-based predictive crowd management framework	Forecast congestion proactively	XGBoost; Bowtie risk model; Digital Twin platform	Predictive analytics enables preventive crowd control

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VRINDAVAN

6	Pedestrian Social Group Behaviour	Moussaïd et al.	PLoS ONE (2010)	International	Impact of social group behavior on pedestrian congestion	Analyze density-speed and group formations	Video tracking ; Social Force Model	Groups reduce walking speed and influence congestion
7	Cellular Automata Mixed Flow Model	Zhang & Chang	TRR (2011)	International	Vehicular – pedestrian mixed flow simulation	Model congestion conflicts	Cellular Automata model	Mixed conflicts reduce system capacity
8	Pedestrian Flow in Mixed Traffic	Kotkar et al.	JUPD (2010)	Indian	Pedestrian behavior under heterogeneous traffic	Study speed-density-flow relationships	Videography; statistical modeling	Indian pedestrian patterns differ from Western norms
9	Heterogeneous Traffic Modeling	Arasan & Koshy	JTE (2005)	Indian	Non-lane-based traffic modeling	Simulate mixed vehicle movement	Microscopic simulation	Accurate representation of Indian traffic
10	Modeling Heterogeneous Traffic	Khan & Maini	TRR (1998)	International	Review of heterogeneous traffic models	Evaluate modeling approaches	Macroscopic & microscopic review	Micro models better for mixed flow
11	Multimodal Big Data Mobility	Lemondé et al.	ETR (2021)	International	Big-data multimodal transport analytics	Improve urban mobility planning	Smart card data; ML; GIS	Data integration improves planning coordination
12	Floating Population Spatial Model	Dong & Jiang	MFSR (2019)	International	Spatial clustering of migration patterns	Analyze floating population mobility	Moran's I; spatial regression	Economic imbalance drives migration

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								clustering
13	Floating Population Modeling	Li et al.	Chinese Geog Sci (2012)	International	GIS-based migration origin-destination study	Study migration dynamics	Spatial regression models	Social networks influence migration flow
14	Geographies of Pilgrimage	Scriven	Geography Compass (2014)	International	Pilgrimage mobility theory	Interpret pilgrimage movement	Conceptual framework	Movement and belief shape sacred space
15	Mobility & Centring in Pilgrimage	Bajc et al.	Mobilities (2007)	International	Pilgrimage centre dynamics	Study religious attractors	Complexity theory	Centres act as mobility hubs
16	ICT Crowd Management – Hajj	Alshalani et al.	ICCI T (2020)	International	GPS-based pilgrim tracking system	Enhance safety monitoring	Mobile app; geofencing alerts	Real-time monitoring improves safety
17	Faith & Tourism Planning	Woodward	Tourism Planning (2004)	International	Planning challenges in sacred towns	Manage congestion & tourism pressure	Comparative case study	Holistic planning required
18	Wearable AI Crowd Monitoring	Ragab	Alex Engg Journal (2025)	International	Real-time emotional and fatigue monitoring	Predict crowd behavior using AI	Deep learning ensemble; optimization algorithms	AI improves behavioral detection accuracy
19	Pedestrian Behavior & Space Syntax	Yıldırım & Çelik	FAR (2023)	International	Spatial configuration impact on movement	Link urban design and density	Space Syntax; Visibility Graph Analysis	Spatial integration influences pedestrian density

20	Religious Tourism Impacts – Ambubachi	Talukdar & Malakar	IJRC MS (2025)	Indian	Socio-economic and environmental impact study	Assess tourism effects on local community	Survey; SPSS; paired t-test	Moderate economic benefits observed
21	Stakeholder Salience – Mazu Pilgrimage	Lin	Annals of Tourism Research (2021)	International	Stakeholder ranking using Fuzzy AHP	Identify key actors in pilgrimage management	Fuzzy AHP; MCDM modeling	Temples and pilgrims most influential stakeholders

Source: Used Multiple Research Papers

The tabulated synthesis highlights the predominance of event-based crowd management studies and technology-intensive international models. It also reveals limited research focusing specifically on permanent temple precincts within dense historic urban fabrics. These observations directly inform the direction of the present study.

2.2. Conceptual Understanding of Crowd and Crowd Management

Crowds are not merely large collections of individuals; they represent dynamic systems in which movement patterns are shaped by density, spatial geometry, social interaction, and psychological stimuli. In high-density conditions, individual autonomy decreases and collective movement behaviour emerges. Research in pedestrian dynamics suggests that as density increases, walking speed reduces, personal space shrinks, and the probability of physical contact rises. When density exceeds critical thresholds, shockwave effects and compression forces can develop, leading to crush incidents.

Crowd management differs from crowd control. Crowd control typically refers to reactive measures implemented during emergencies, often involving barricading or dispersal by authorities. In contrast, crowd management is a proactive planning process that anticipates movement patterns, regulates inflow, ensures adequate circulation, and prevents dangerous density accumulation. Effective crowd management therefore requires understanding of carrying capacity, flow rates, and behavioural triggers.

Religious crowds present unique challenges. Devotees are often emotionally motivated and may prioritize spiritual proximity over personal safety considerations. Ritual events

such as aarti, darshan openings, or symbolic moments can trigger synchronized forward movement. Unlike spectators in stadiums who disperse after events, temple devotees often move cyclically, pausing and regrouping near sacred focal points. This cyclical congregation behaviour must be accounted for in planning frameworks.

2.3. Carrying Capacity and Density Threshold Theories

Carrying capacity refers to the maximum number of individuals that a space can safely accommodate without compromising safety, comfort, and mobility. In pedestrian planning, carrying capacity is closely linked to density levels measured in persons per square meter. International research identifies that densities above 4–5 persons per square meter significantly increase risk of crowd turbulence and crush incidents. At such densities, individual movement becomes involuntary and crowd pressure can transmit as force waves.

Fruin's Level of Service (LOS) model, commonly used in pedestrian planning, categorizes movement conditions from free flow (LOS A) to extreme congestion (LOS F). At lower density levels, pedestrians can choose speed and direction freely. At higher levels, movement becomes restricted and physical contact unavoidable. In religious precincts, density often fluctuates rapidly between moderate and critical levels due to ritual timing and inflow surges.

Carrying capacity in temple precincts is not only a function of built area but also of effective circulation width. Encroachments, informal vending, temporary barricades, and structural elements reduce usable space. Therefore, theoretical capacity calculations must consider net usable width rather than gross street width.

This theoretical understanding reinforces the importance of spatial mapping and density analysis in evaluating the Banke Bihari Temple precinct.

2.4. Behavioural Dimensions of Religious Crowds

Behavioural studies emphasize that crowd dynamics are influenced by psychological states, social grouping, and environmental cues. Research shows that a significant proportion of pedestrians move in social groups rather than as isolated individuals. Group movement increases lateral space occupation and reduces flow efficiency. In Indian temple contexts, family groups, elderly companions, and devotional clusters dominate visitor composition, thereby influencing congestion patterns.

Emotional intensity further amplifies behavioural unpredictability. In religious settings, symbolic proximity to the deity acts as a psychological attractor. As individuals approach the sanctum, walking speed may increase temporarily despite high density. Sudden halts near darshan points create backflow compression. This pattern results in density gradients where pressure accumulates near focal nodes.

Behavioural contagion theory suggests that anxiety or urgency can spread rapidly within crowds. If one section begins pushing, others may follow reflexively, even without full awareness of the trigger. Therefore, crowd safety planning must address not only spatial geometry but also communication strategies, signage clarity, and psychological reassurance mechanisms.

2.5. Large-Scale Religious Gathering Case Studies

Research on the **Kumbh Mela** provides valuable insights into mass gathering management. The Kumbh Mela involves temporary city planning with sector divisions, crowd zoning, traffic diversion, and coordinated multi-agency governance. Holding areas and staggered bathing schedules are used to regulate peak surges. However, the spatial flexibility available in temporary open grounds differs significantly from permanent temple precincts embedded within dense built environments.

Similarly, the **Hajj** pilgrimage demonstrates advanced scheduling models and unidirectional movement systems. Time-slot allocation and route segregation have significantly reduced fatal crowd incidents in recent years. Simulation-based planning ensures that inflow does not exceed route capacity.

Although these events operate at a much larger scale, their principles—zoning, unidirectional circulation, holding areas, and regulated inflow—are conceptually transferable to temple precincts.

2.6. Technology-Driven Crowd Monitoring Systems

Recent literature emphasizes digital integration in crowd management. Digital Twin models simulate real-time crowd movement using sensor data, CCTV feeds, and predictive algorithms. Machine learning techniques analyze historical patterns to forecast peak density periods. These systems enable proactive deployment of security personnel and dynamic route adjustments.

However, such advanced infrastructure requires financial investment and technological capacity that may not be fully feasible in mid-tier Indian temple towns. Therefore, scalable adaptations such as GIS-based density mapping, CCTV-supported monitoring, and simplified digital queue systems may offer practical alternatives.

Technology alone cannot solve spatial inefficiencies, but when integrated with planning interventions, it enhances responsiveness and predictive capacity.

2.7. Indian Policy and Planning Guidelines

National disaster management guidelines for mass gatherings emphasize preparedness, evacuation planning, and coordination among agencies. Urban planning principles advocate hierarchical circulation networks, pedestrian prioritization, and emergency corridors. However, these frameworks often lack micro-level application strategies for historic temple cores.

There exists a policy gap between macro-level guidelines and precinct-level design interventions. Most guidelines are event-oriented rather than addressing permanently congested religious zones. This gap strengthens the relevance of developing a context-specific integrated framework for the Banke Bihari Temple.

2.8. Synthesis of Reviewed Literature

The literature collectively reveals recurring themes: proactive planning, capacity assessment, zoning, inflow regulation, behavioural understanding, and technology integration. However, most studies address these components independently. Few studies integrate spatial redesign, behavioural modelling, and feasible technology tools into a unified framework applicable to compact, heritage temple precincts in India. This synthesis identifies the research gap that the present study seeks to address.

2.9. Methodology (Objective-wise)

The methodology is structured to be practical and achievable within a 1.5-month timeline while remaining academically robust.

For Objective 1, spatial configuration analysis will involve preparation of detailed base maps using GIS. Road widths, bottlenecks, congregation nodes, and entry–exit systems will be mapped through field surveys and satellite imagery analysis. Pedestrian density zones will be identified through observational counts during peak and non-peak hours.

This approach aligns with capacity assessment principles emphasized in Kumbh Mela research.

For Objective 2, behavioural study will include structured observation, time-lapse photography (where permitted), and behavioural mapping of congregation patterns. Short interviews with devotees and vendors will provide qualitative behavioural insights. The methodology is supported by social group movement findings, which emphasize the impact of group dynamics on flow.

For Objective 3, evaluation of existing measures will involve stakeholder consultation with temple management and local authorities. Incident history and festival management strategies will be reviewed to assess operational adequacy.

For Objective 4, a simplified technology-assisted framework will be developed conceptually. This will include regulated time-slot darshan allocation (adapted from Hajj scheduling concepts), CCTV-supported monitoring zones, GIS-based density mapping, and defined holding plazas. Advanced AI modelling will not be implemented but referenced conceptually based on Digital Twin principles.

For Objective 5, spatial design proposals will include unidirectional circulation loops, pedestrian-only corridors, designated emergency lanes, holding areas, signage systems, and inclusive infrastructure interventions.

CHAPTER 3

ANALYSIS AND FINDINGS

3.1 Introduction

The analysis of the Banke Bihari Temple precinct is undertaken to understand the spatial, functional, and behavioural characteristics that influence crowd movement and congestion within a high-density religious environment. The temple is one of the most significant pilgrimage destinations in India, attracting thousands of devotees daily and experiencing extreme surges during festivals and peak seasons.

Unlike conventional urban areas, the temple precinct functions as a , where movement is largely purpose-driven and directed towards a central focal point. This results in unique crowd dynamics, where spatial constraints, behavioural tendencies, and management systems interact to shape movement patterns.

This chapter presents a detailed analysis of the study area based on field observations, spatial mapping, and interpretation of crowd behaviour. The analysis focuses on understanding how the physical structure of the precinct, combined with land use patterns and connectivity, influences pedestrian flow and congestion.

The findings derived in this chapter establish a critical foundation for identifying planning issues and developing an integrated crowd management framework in subsequent stages of the study.

3.2 Study Area Context and Significance

The Banke Bihari Temple precinct is located in Vrindavan, a major pilgrimage town in the Mathura district of Uttar Pradesh. Vrindavan forms an integral part of the Braj region and holds immense religious significance associated with Lord Krishna, attracting pilgrims from across the country and beyond.

The study area lies within the historic core of the city, characterized by dense built fabric, narrow streets, and mixed land use. The temple acts as a major attractor, generating continuous pedestrian inflow and functioning as a central activity node within the urban structure.

The significance of the site is not only religious but also spatial and functional. The concentration of activities, combined with limited infrastructure capacity, creates a unique environment where crowd management becomes a critical planning concern.

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The high intensity of pedestrian movement, particularly during peak hours and festivals, results in congestion, inefficiency, and potential safety risks.

Understanding the context and significance of the study area is essential for analyzing the spatial and behavioural factors that influence crowd dynamics within the precinct.



Figure 3.1: Site Context Map
Source: Google Earth

The site context map illustrates the location of the temple precinct within the broader urban structure of Vrindavan, *Figure 3.1*. It highlights the dense built fabric surrounding the temple and its proximity to significant natural and urban features, including the Yamuna River.

The map reflects the centrality of the temple within the urban fabric and its role as a major activity node. The surrounding area is characterized by high-density development, which limits the availability of open spaces and restricts movement capacity.

Inference:

The location of the temple within a dense historic core significantly constrains spatial expansion and limits the scope for large-scale infrastructure interventions. This

necessitates planning solutions that optimize existing space rather than relying on expansion.

3.3 Study Area Delineation and Spatial Extent

The delineation of the study area is based on pedestrian movement patterns, accessibility, and the extent of influence of the temple as a central attractor. The study defines two levels of spatial analysis: the primary study area and the extended influence area.

The primary study area, covering a radius of approximately 1–1.5 km, represents the walkable catchment zone where pedestrian movement is most intense. This zone captures the core area of congestion and includes the temple precinct along with surrounding streets and activity zones.

The extended influence area, extending up to 3 km, includes major access routes, entry points, and areas that contribute to pilgrim inflow. This broader scale helps in understanding the regional connectivity and the sources of crowd inflow into the core area, *Figure 3.2*.



Figure 3.2: Study Area Delineation Map

Source: Author

The temple is treated as the central node within this spatial framework, with movement patterns radiating inward from the periphery towards the core. This delineation allows for a comprehensive analysis of both localized congestion and larger-scale movement dynamics.

The study area delineation map visually represents the spatial extent of analysis, distinguishing between the primary study area and the extended influence area. The map highlights the temple as the central node and illustrates the radial nature of movement towards it.

The primary study area captures zones of high pedestrian density and congestion, while the extended area includes major routes that influence crowd inflow. This dual-scale approach provides a comprehensive understanding of both local and regional movement patterns.

Inference:

The delineation clearly indicates that congestion within the temple precinct is not an isolated issue but is influenced by larger connectivity patterns and inflow from surrounding areas.

3.4 Connectivity and Regional Linkages

The connectivity of the temple precinct plays a crucial role in shaping movement patterns and influencing crowd inflow. The analysis reveals that the precinct is well connected to surrounding towns and cities through a network of roads and railways.

Major sources of inflow include nearby bus stands, railway stations, and other pilgrimage sites within the region. These nodes act as entry points from where pedestrians move towards the temple, contributing to the overall crowd volume.

The movement pattern is largely radial, with all major routes converging towards the temple. This creates a centralized system where the majority of pedestrian flow is directed towards a single point, leading to high concentration and congestion.

Within the core area, movement is predominantly pedestrian-based, with limited vehicular access. The transition from vehicular to pedestrian movement occurs at the periphery, where pilgrims enter the walkable zone. This connectivity structure highlights the importance of managing inflow at multiple levels, including regional entry points and local circulation routes.

Connectivity Analysis Map

The connectivity map illustrates the regional linkages of the temple precinct, highlighting major access routes, entry points, and sources of pilgrim inflow. It shows how movement is directed from surrounding areas towards the temple, *Figure 3.3*.

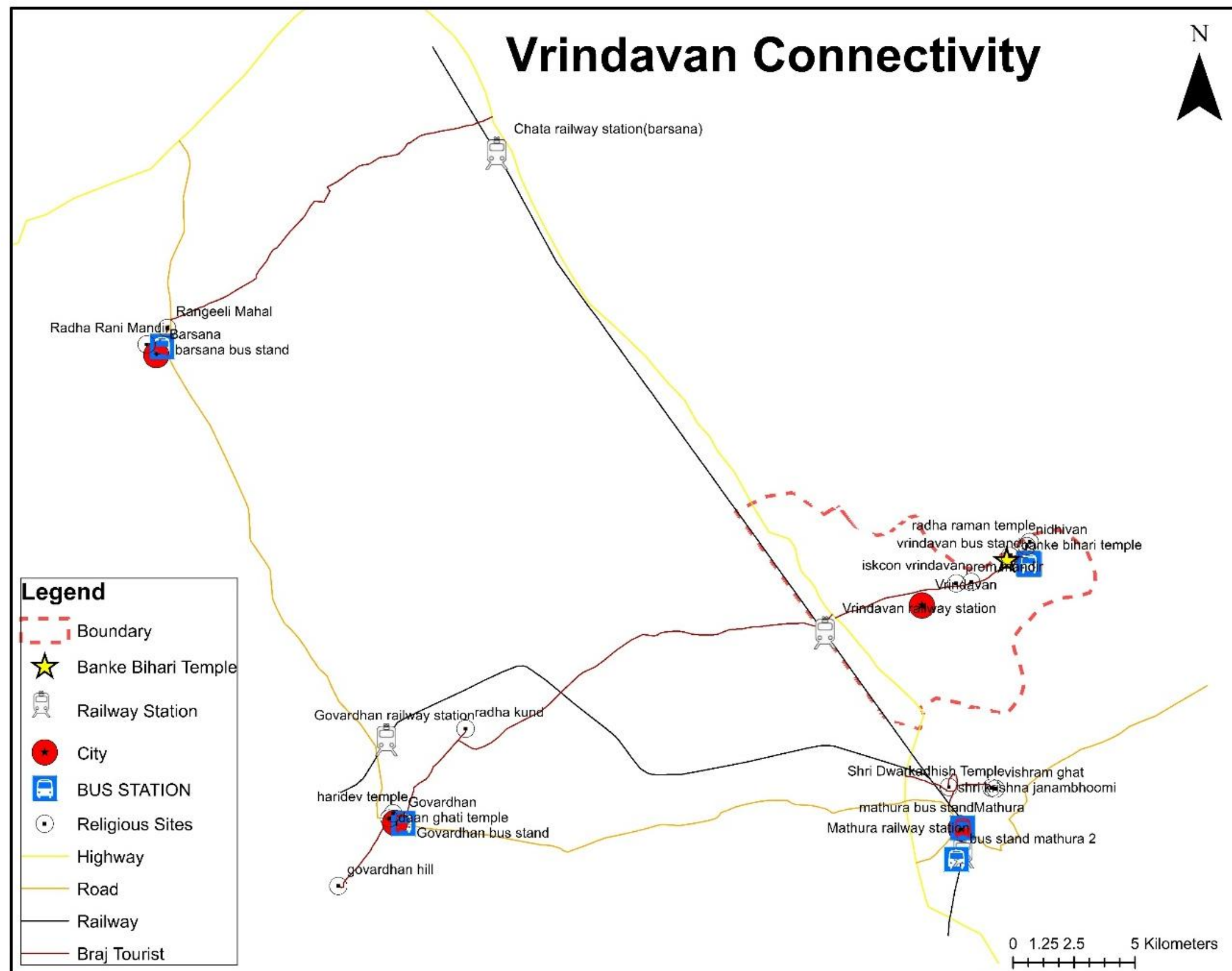


Figure 3.3: Connectivity Analysis Map

Source: Author

The map also indicates the concentration of movement along specific corridors, which contribute to increased pressure on certain routes within the core area.

Inference:

The strong regional connectivity, while beneficial for accessibility, results in concentrated inflow towards the temple, necessitating effective distribution and management of movement within the precinct.

3.5 Land Use Pattern and Activity Distribution

The land use pattern within the temple precinct is predominantly mixed, with a strong concentration of commercial and religious activities near the temple core. Shops selling prasad, food items, and religious goods line the streets, creating a vibrant but highly congested environment.

The intensity of commercial activity is highest near the temple and gradually decreases towards the periphery, where residential land use becomes more dominant. This gradient in land use directly influences the distribution of crowd density within the precinct.

A critical issue observed is the spillover of commercial activities onto the streets. Vendors and shopkeepers often extend their operations into pedestrian pathways, reducing the effective width available for movement.

The interaction between stationary activities (such as shopping and waiting) and moving pedestrians creates conflicts that disrupt flow continuity. These conflicts are particularly pronounced in narrow streets, where even minor obstructions can lead to significant congestion.

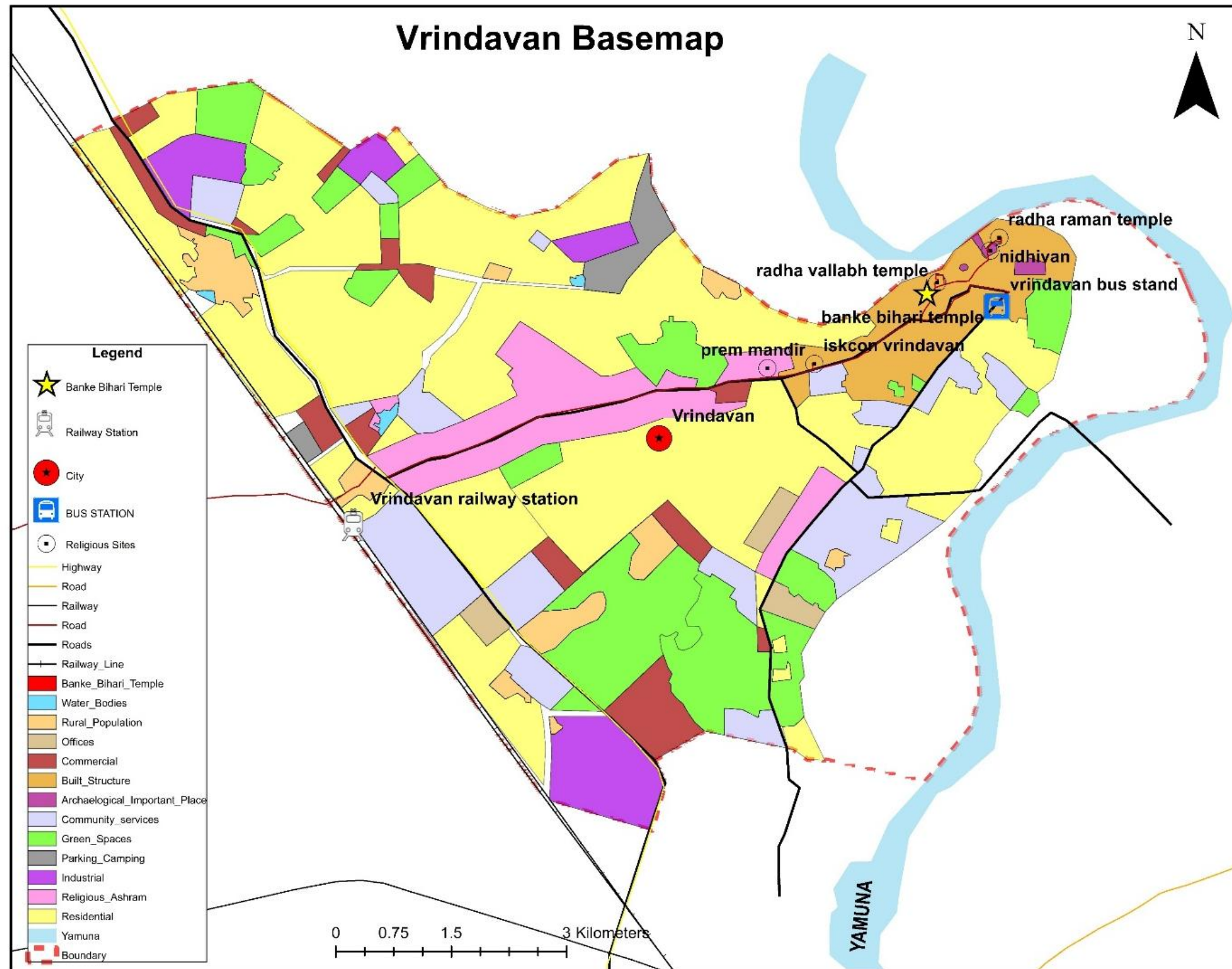


Figure 3.4: Land Use Map
Source: Mathura Vrindavan Development Authority

The land use map highlights the distribution of commercial, residential, and religious activities within the precinct. It shows a high concentration of commercial activities near the temple core, with residential areas located further away, *Figure 3.4*.

The map also reflects the mixed-use nature of the area, where multiple activities coexist within limited space, leading to increased interaction and conflict.

Inference:

The concentration of commercial activities near the temple contributes significantly to congestion by attracting pedestrians and reducing effective movement space.

3.6 Spatial Structure and Built Form Analysis

The spatial structure of the temple precinct is characterized by a dense and compact built form, with limited open spaces and a highly irregular street network. Buildings are closely spaced, creating a continuous urban fabric that restricts movement and limits visibility.

The street network consists of narrow streets with varying widths, often ranging between 1.5 m and 3 m. These streets are not designed to accommodate large volumes of pedestrian traffic, particularly during peak periods.

The irregular geometry of the street network creates multiple junctions and turning points, which act as potential conflict zones. These areas experience reduced movement efficiency due to changes in direction and interaction between pedestrians.

The lack of open spaces within the precinct further exacerbates congestion, as there are limited areas for crowd dispersal or temporary holding.

Street Characteristics Map

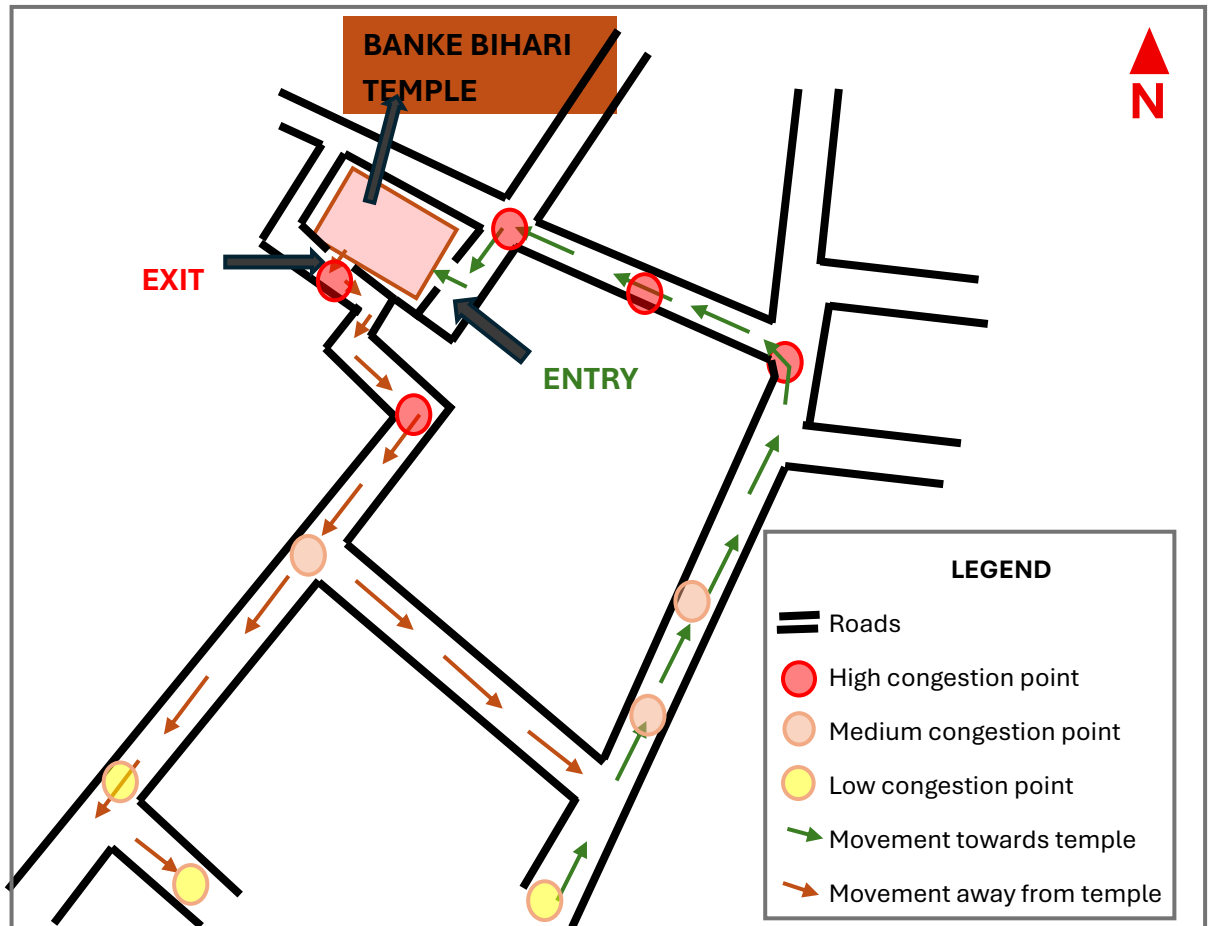


Figure 3.5: Streer Characteristics Map

Source: Author

The street characteristics map illustrates the variation in street widths and their impact on movement capacity. It highlights the narrow and irregular nature of the street network within the precinct, *Figure 3.5*.

The map clearly shows that most streets fall within the lower width range, indicating limited capacity to accommodate high pedestrian volumes.

Inference:

The constrained street network is a primary factor contributing to congestion, as it limits the ability of the system to handle peak crowd conditions.

3.7 Key Spatial Observations

The spatial analysis of the temple precinct reveals several critical observations. The area is characterized by a dense built fabric, narrow streets, and mixed land use, all of which contribute to high levels of congestion.

Movement within the precinct is highly centralized and directed towards the temple, resulting in uneven distribution of crowd density. The lack of hierarchy in the street network and absence of organized circulation further intensify congestion.

Commercial activities, while essential to the local economy, significantly impact movement by reducing effective space and creating obstructions. The interaction between different activities within limited space leads to conflicts and inefficiencies.

These observations highlight the need for integrated planning interventions that address both spatial and functional aspects of the precinct.

3.8 Temple-Centric Movement and Radial Flow Pattern

One of the most significant findings of the analysis is that movement within the precinct is highly centralized around the Banke Bihari Temple. The temple acts as a dominant attractor, influencing movement patterns across the entire study area.

Pedestrian movement is largely radial, with individuals approaching the temple from multiple directions. This results in a continuous inflow of people converging towards a single point, leading to high-density conditions at the core.

Such a movement pattern creates an imbalance in spatial distribution, with excessive pressure on the central area and relatively lower density in peripheral zones. The lack of alternative routes or distributed activity nodes further intensifies this concentration.

The temple-centric nature of movement also makes the system highly sensitive to fluctuations in inflow. During peak hours or festivals, even a slight increase in the number of visitors can lead to exponential growth in congestion levels.

This finding highlights the need for planning strategies that can decentralize movement, distribute crowd load, and reduce dependency on a single focal point.

3.9 Movement Pattern Analysis

The movement pattern within the Banke Bihari Temple precinct is predominantly pedestrian-oriented, especially within the core area where vehicular access is either restricted or functionally negligible. The analysis of movement patterns reveals that pedestrian flow is not random but highly structured around the temple as the primary destination.

The street network, composed of narrow and interconnected streets, acts as the main conduit for movement. These streets guide pedestrian flow toward the temple through multiple entry paths, resulting in a system where movement is continuously directed inward. This creates a condition of sustained inflow throughout the day, with varying intensities depending on time and occasion.

A key characteristic of movement within the precinct is its temple-centric convergence. Unlike grid-based urban systems where movement disperses across multiple routes, the movement here is focused and directional. This results in a high degree of crowd concentration at specific nodes, particularly near the temple entrance.

Additionally, the lack of a clearly defined circulation hierarchy contributes to inefficiencies. All streets, regardless of their width or capacity, tend to function equally as access routes, leading to uneven distribution of pedestrian load. As a result, even smaller streets experience significant pressure during peak hours.

The pedestrian movement map, refer to figure 3.5 illustrates the directional flow of people within the temple precinct. It highlights the convergence of multiple movement streams toward the temple, reinforcing its role as the central attractor.

The map also indicates the dominance of pedestrian movement within the core area, with minimal vehicular interference. However, the concentration of movement along narrow and irregular streets creates conditions of high density and restricted flow. The absence of clearly defined primary and secondary circulation routes further contributes to uneven distribution of movement.

Inference:

The movement pattern is highly centralized and lacks hierarchy, resulting in excessive pressure on specific routes and nodes. This indicates the need for structured circulation planning to distribute pedestrian flow more efficiently.

3.10 Circulation Characteristics and Flow Behaviour

The circulation system within the precinct is characterized by a combination of partial organization and significant irregularities. While certain efforts have been made to segregate entry and exit routes, these measures are not consistently implemented across the entire area.

In many locations, entry and exit flows overlap, leading to bidirectional movement within narrow spaces. This creates friction between pedestrians, reducing movement speed and increasing the likelihood of congestion.

Another important observation is the absence of continuous flow. Movement is frequently interrupted by stopping behaviour, particularly near commercial areas and temple entry points. These interruptions create localized clusters of people, which disrupt the overall circulation system.

Furthermore, the irregular geometry of streets, including sudden turns and varying widths, leads to unpredictable movement patterns. Pedestrians are often forced to adjust their direction and speed, resulting in inefficient flow.

These characteristics highlight the need for a well-defined and continuous circulation system that can guide movement in an organized manner.

3.11 Congestion Analysis

Congestion within the temple precinct is a result of the interaction between high pedestrian inflow and limited spatial capacity. The analysis identifies several key areas where congestion is most severe.

The temple entrance is the most critical congestion point, experiencing the highest density of pedestrians. This is due to the convergence of multiple movement streams into a single entry point, combined with stopping behaviour associated with darshan.

Adjacent streets and junctions also function as bottlenecks, particularly where street widths are narrow or where commercial activities occupy significant space. These areas experience high levels of crowd accumulation, especially during peak hours.

The intensity of congestion decreases with increasing distance from the temple, indicating a strong spatial gradient in crowd density. However, even peripheral areas experience congestion during periods of high inflow.

The analysis demonstrates that congestion is not uniformly distributed but concentrated at specific nodes and along key movement corridors.

The congestion map, refer to figure 3.5, identifies critical zones within the precinct where crowd density is highest. The temple entrance emerges as the primary congestion node, followed by adjacent narrow streets and junctions.

The map clearly illustrates the spatial distribution of congestion, showing a gradual reduction in intensity as distance from the temple increases. It also highlights the relationship between street width and congestion levels, with narrower streets experiencing higher density.

Inference:

Congestion is strongly linked to spatial constraints and movement convergence. Addressing these issues requires both spatial interventions and improved circulation management.

3.12 Bottleneck Identification and Analysis

Bottlenecks are critical points within the circulation system where movement is significantly restricted due to limited space or conflicting flows. The analysis identifies several types of bottlenecks within the temple precinct.

The most prominent bottlenecks are located near the temple entrance, where converging movement creates extreme pressure on limited space. These areas experience high density and reduced movement speed, often leading to crowd accumulation.

Junctions within the street network also act as bottlenecks, particularly where multiple गलियाँ intersect. The irregular geometry of these junctions creates confusion in movement direction, resulting in delays and conflicts.

Another major source of bottlenecks is commercial encroachment. Vendors and shops occupying portions of the street reduce the effective width available for movement, creating localized restrictions.

Temporary bottlenecks are also observed during peak hours, when crowd volume exceeds the capacity of available space. These bottlenecks are dynamic and shift based on movement patterns and crowd behaviour.

3.13 Street Characteristics and Their Impact

The physical characteristics of streets play a crucial role in determining movement efficiency. The streets within the precinct are narrow, irregular, and highly constrained, with widths ranging from 1.5 m to 3 m.

Such limited widths are insufficient to accommodate the high volume of pedestrians, particularly during peak periods. The situation is further aggravated by encroachments, which reduce the effective width even further.

The lack of dedicated pedestrian pathways means that all movement occurs within the same shared space, increasing the likelihood of conflicts. Additionally, the absence of clear signage or guidance systems makes navigation difficult, especially for first-time visitors.

These conditions collectively contribute to inefficient movement and increased congestion, highlighting the need for spatial reorganization and improved infrastructure.

3.14 Temporal Variation and User Perception Analysis

The analysis of temporal variation and user perception provides critical insights into the dynamic nature of crowd conditions within the Banke Bihari Temple precinct. Unlike static spatial conditions, crowd intensity fluctuates significantly over time, influenced by daily routines, religious practices, and seasonal events.

The findings presented in this section are based on primary survey data collected from over 90 respondents, including visitors and local shopkeepers. The analysis highlights variations in crowd density, waiting time, congestion perception, and effectiveness of existing management systems.

Temporal Crowd Distribution (Time of Day)

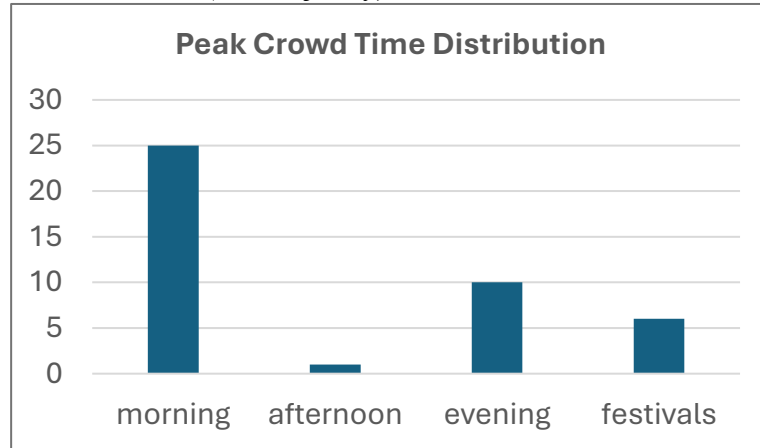


Figure 3.6: Temporal Peak Crowd Distribution
Source: Primary Survey

The temporal distribution chart illustrates the variation in crowd intensity across different times of the day. The data indicates that the highest concentration of visitors is observed during the morning hours, corresponding to peak darshan timings, *Figure 3.6*.

This pattern can be attributed to religious practices, where devotees prefer early morning visits for spiritual significance. As a result, a large number of people arrive within a limited time window, leading to a sharp increase in crowd density.

Although the inflow of visitors continues throughout the day, the intensity gradually reduces after the morning peak. However, intermittent surges may still occur depending on specific rituals or events.

Inference:

The concentration of crowd during specific time periods creates peak pressure on infrastructure, indicating the need for time-based crowd management strategies.

Waiting Time Experienced by Visitors

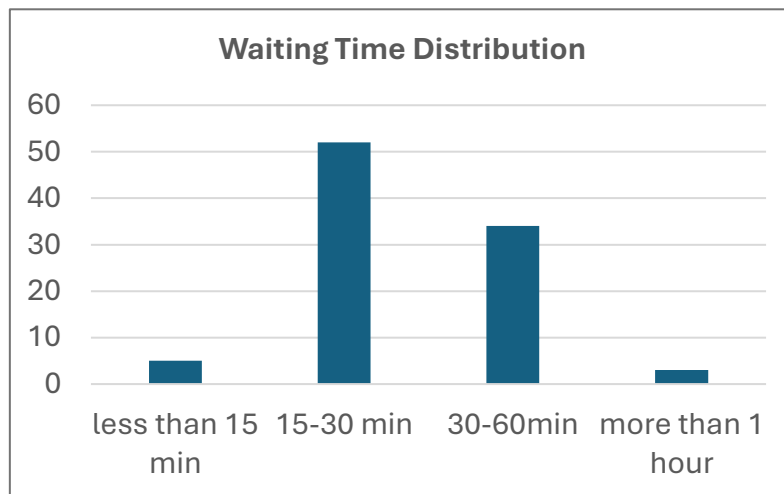


Figure 3.7: Waiting Time Graph

Source: Primary Survey

The waiting time chart reflects the duration that visitors spend in queues before accessing the temple. The majority of respondents reported waiting times ranging between 15 to 30 minutes, indicating moderate to high crowd pressure, *Figure 3.7*.

This waiting time is a direct indicator of congestion levels within the precinct. Longer waiting durations suggest inefficiencies in movement and queue management, particularly during peak hours.

The presence of waiting time also reflects the imbalance between pedestrian inflow and the capacity of the system to process visitors efficiently.

Inference:

Waiting time can be used as a measurable indicator of crowd management efficiency and highlights the need for improved queue organization and flow regulation.

Perception of Most Congested Areas

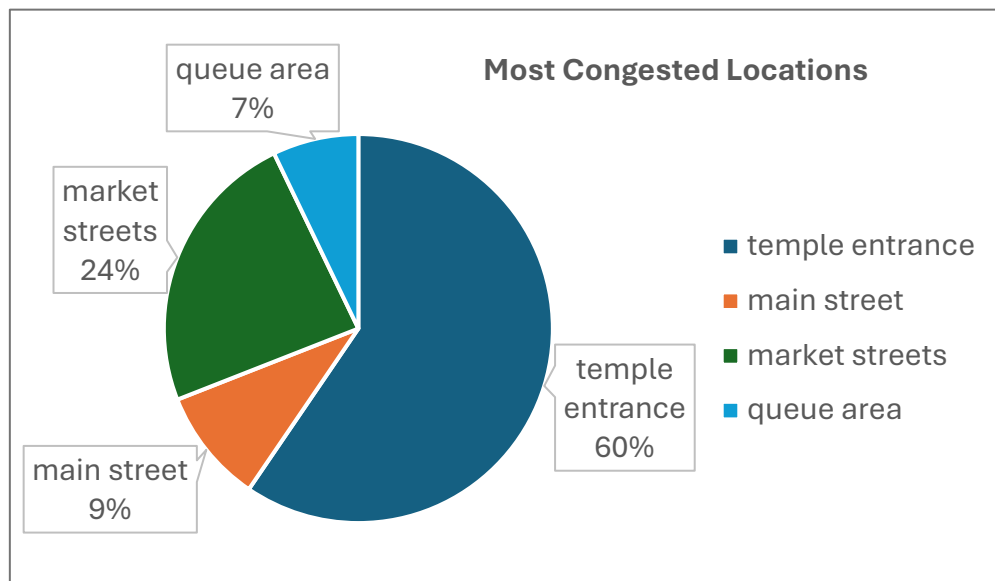


Figure 3.8: Congested Area Chart

Source: Primary Survey

The perception-based analysis identifies the temple entrance as the most congested area within the precinct. A significant proportion of respondents also highlighted surrounding market streets as zones of high crowd density, *Figure 3.8*.

This perception aligns closely with spatial and movement analysis, which identified these areas as critical congestion nodes. The convergence of movement near the temple and the presence of commercial activities in adjacent streets contribute to high density.

The consistency between user perception and spatial findings strengthens the validity of the analysis.

Inference:

Congestion is not only physically measurable but also strongly perceived by users, reinforcing the need to address key hotspots within the precinct.

Public Opinion on Existing Crowd Management

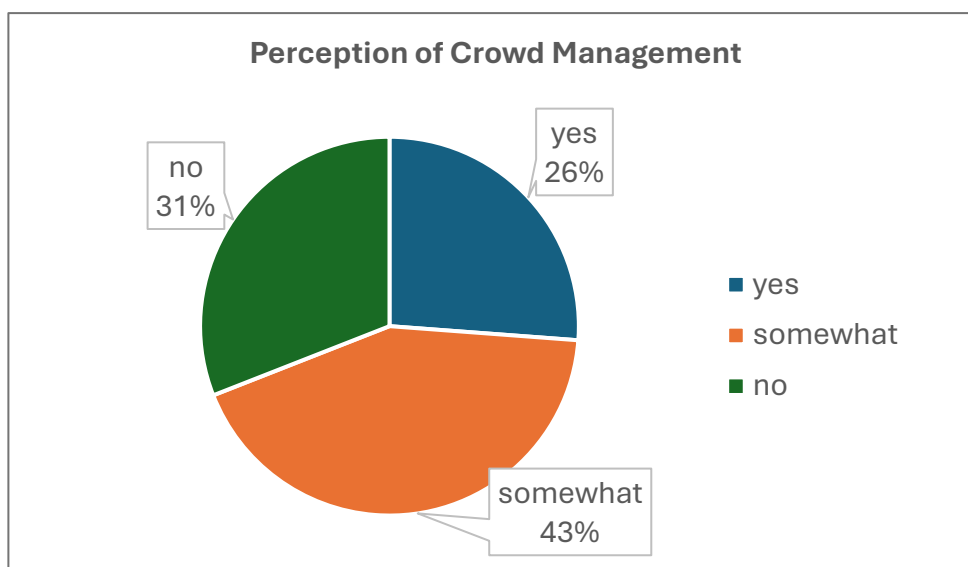


Figure 3.9: Public Opinion Crowd Management Chart

Source: Primary Survey

The chart representing public opinion on existing crowd management systems indicates a mixed response. While some respondents consider the system to be somewhat effective, a large proportion finds it inadequate in handling peak crowd conditions, *Figure 3.9*.

This reflects the limitations of current management practices, which may be partially functional but lack the capacity to handle high-density situations effectively.

The perception of inadequacy suggests gaps in planning, coordination, and implementation of crowd control measures.

Inference:

Existing management systems require improvement and integration with spatial planning to effectively manage crowd conditions.

Priority Needs Identified by Users

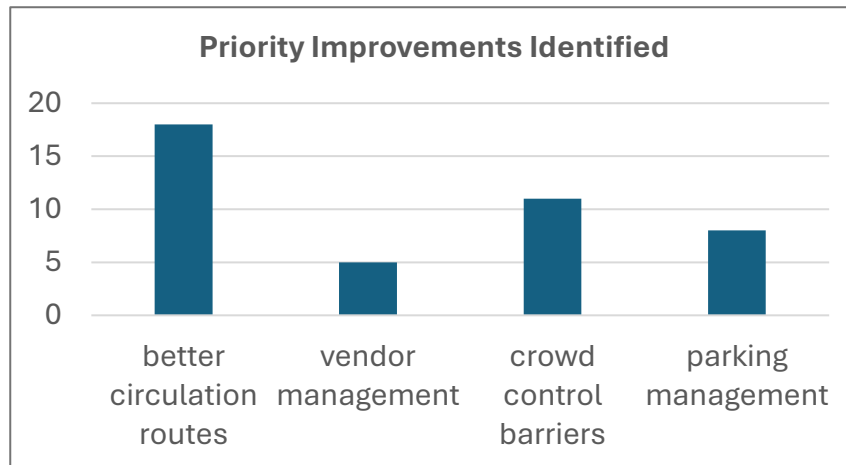


Figure 3.10: Priority Improvement Chart

Source: Primary Survey

The priority needs chart highlights the key concerns of users regarding crowd management within the precinct. The most frequently identified needs include better circulation management, improved crowd control measures, and regulation of vendors and parking, Figure 3.10.

These responses indicate that users are aware of the underlying issues affecting movement and safety. The emphasis on circulation and regulation reflects the importance of spatial organization in improving overall conditions.

The identification of these needs provides valuable input for developing planning strategies and interventions.

Inference:

User-driven insights play a crucial role in shaping effective and context-sensitive planning solutions.

3.15 Synthesis of Temporal and Perception Analysis

The combined analysis of temporal variation and user perception reveals that crowd conditions within the precinct are highly dynamic and influenced by both time and spatial factors.

Peak crowd conditions during morning hours, combined with high-density zones near the temple entrance, create critical pressure points within the system. The presence of waiting time and user dissatisfaction further indicates inefficiencies in existing management practices.

The alignment between observed conditions and user perception strengthens the reliability of the findings and highlights the need for integrated interventions that address both spatial and behavioural aspects.

Overall, the analysis demonstrates that effective crowd management requires not only physical improvements but also time-based strategies and user-oriented planning approaches.

3.16 Identification of Planning Issues

The identification of planning issues within the Banke Bihari Temple precinct emerges as a critical outcome of the detailed spatial, behavioural, and perceptual analysis conducted in the previous sections. The precinct represents a unique urban condition where religious significance, high pedestrian inflow, and historic spatial constraints converge to create a highly complex and dynamic environment. Unlike conventional urban areas where movement patterns are relatively distributed and predictable, the temple precinct functions as an intensely focused activity zone, where the majority of movement is directed towards a single focal point. This inherent characteristic plays a fundamental role in shaping the nature and intensity of planning issues observed within the area.

One of the most significant aspects of the identified issues is their interconnected nature. The challenges observed within the precinct cannot be categorized as isolated problems; rather, they exist as part of a larger system of interdependent factors. Mobility constraints, congestion, land use conflicts, and management inefficiencies are not independent conditions but are closely linked to one another, with each issue reinforcing and amplifying the others. For instance, limited street width not only restricts movement but also intensifies the impact of encroachments, which in turn contributes to congestion and affects overall circulation efficiency. Similarly, unregulated pedestrian behaviour, such as stopping or moving in groups, interacts with spatial limitations to create localized pressure zones that eventually develop into larger bottlenecks.

The analysis reveals that the precinct operates under conditions of continuous spatial stress. The existing urban fabric, which evolved organically over time, was not designed to accommodate the current scale of pedestrian movement. However, the temple's growing importance as a major pilgrimage destination has led to a significant increase

in footfall, particularly during peak hours and festival periods. This has resulted in a mismatch between the demand placed on the space and its capacity to accommodate that demand. The consequence of this mismatch is visible in the form of congestion, inefficient movement, and reduced safety levels across the precinct.

Another important dimension of the identified issues is their temporal variability. The intensity and manifestation of these problems are not constant but fluctuate throughout the day and across different periods. During peak hours, the system experiences extreme pressure, with crowd density reaching levels that significantly restrict movement. In contrast, during non-peak hours, the same spatial environment may function relatively efficiently. This variation highlights the dynamic nature of the problem and underscores the need for solutions that are adaptable and responsive to changing conditions.

Furthermore, the analysis indicates that the issues within the precinct are not solely physical but also behavioural and perceptual. The way people move, interact, and respond to the environment plays a crucial role in shaping crowd dynamics. For example, the tendency of visitors to move towards the temple in a converging manner, combined with stopping behaviour for darshan or purchasing goods, creates interruptions in flow that contribute to congestion. Similarly, user perception of congestion and discomfort influences behaviour, which in turn affects movement patterns and overall system performance.

The lack of an integrated planning and management framework further exacerbates these issues. Current interventions, where present, tend to address specific problems in isolation rather than considering the system as a whole. This fragmented approach results in limited effectiveness, as improvements in one area may be offset by issues in another. For example, partial segregation of entry and exit routes may improve movement in certain sections but fails to address congestion at junctions or within narrow streets.

The identification of planning issues in this context therefore requires a holistic understanding of the system, taking into account the interaction between spatial, behavioural, and managerial factors. It is not sufficient to focus solely on physical constraints or management deficiencies; rather, the analysis must consider how these elements work together to produce the observed conditions.

In summary, the planning issues within the temple precinct can be understood as the outcome of a complex interplay between high pedestrian demand, limited spatial capacity, unregulated land use activities, and insufficient management systems. These issues are dynamic, interconnected, and context-specific, requiring a comprehensive and integrated approach for effective resolution. The detailed examination of these issues in the following sections aims to provide a deeper understanding of their nature, causes, and implications, thereby forming the basis for developing appropriate planning strategies in subsequent chapters.

3.16.1 Mobility-Related Issues

Mobility within the Banke Bihari Temple precinct represents one of the most critical dimensions of the overall planning problem, as it directly influences accessibility, user experience, and the efficiency of movement across the area. The analysis of mobility conditions reveals that pedestrian movement within the precinct is not only constrained by physical limitations but is also significantly affected by behavioural patterns and the absence of structured circulation systems. These factors combine to create a highly inefficient mobility environment, particularly during peak hours when the volume of pedestrians exceeds the functional capacity of the available space.

At the most fundamental level, mobility within the precinct is restricted by the narrow width of streets, which typically range between 1.5 meters and 3 meters. While such dimensions may be adequate for low-intensity pedestrian movement, they become severely inadequate in conditions of high density. As the number of pedestrians increases, the available space per individual decreases, leading to a reduction in walking speed and an increase in physical interaction between users. This interaction often manifests as friction, where individuals are forced to adjust their movement continuously in response to others, resulting in slow and irregular flow patterns. The constrained spatial environment does not allow for flexibility in movement, meaning that even minor disruptions can have a significant impact on overall mobility.

In addition to physical constraints, the absence of a hierarchical circulation system further contributes to mobility inefficiencies. In a well-organized urban environment, movement is typically distributed across a network of primary, secondary, and tertiary routes, each designed to accommodate different volumes and types of traffic. However, in the temple precinct, such differentiation is largely absent. All streets, regardless of

their width or capacity, tend to function as access routes to the temple. This lack of hierarchy results in uneven distribution of pedestrian flow, where smaller and less capable गलियाँ are subjected to the same level of demand as relatively wider streets. Consequently, these गलियाँ experience high levels of congestion, which further restricts movement and reduces overall efficiency.

Another significant factor affecting mobility is the nature of pedestrian behaviour within the precinct. Unlike purely functional movement observed in other urban areas, movement in the temple precinct is influenced by religious practices, social interactions, and commercial activities. Visitors often move in groups, which occupy larger space and reduce the effective capacity of the street. Group movement also tends to be slower and less flexible, as individuals adjust their pace to maintain cohesion. Additionally, pedestrians frequently stop for various reasons, including purchasing goods, interacting with vendors, or performing religious rituals. These stopping behaviours create localized interruptions in flow, which can quickly escalate into larger disruptions in a constrained environment.

The lack of designated spaces for such activities further exacerbates the problem. In the absence of clearly defined zones for waiting, shopping, or resting, these activities spill over into circulation areas, directly interfering with movement. This overlap between static and dynamic activities creates a condition where the same space is required to accommodate both movement and non-movement functions simultaneously. As a result, the efficiency of mobility is significantly compromised.

Wayfinding and navigation also present challenges within the precinct. The absence of clear signage and directional guidance systems makes it difficult for visitors, particularly first-time pilgrims, to navigate the area efficiently. In many cases, individuals rely on following the crowd or using informal cues, which can lead to confusion and unnecessary movement. This lack of clarity not only increases travel time but also contributes to congestion, as people may stop or change direction unexpectedly.

The issue of mobility is further complicated by the interaction between entry and exit flows. Although some degree of segregation exists in certain areas, it is neither consistent nor effectively enforced. As a result, pedestrians moving in opposite directions often share the same limited space, leading to bidirectional flow conditions.

In narrow streets, such conditions create significant friction, as individuals must constantly negotiate space with others moving in the opposite direction. This reduces movement speed and increases the likelihood of congestion, particularly in areas where space is already constrained.

Another important aspect of mobility within the precinct is the lack of continuity in movement. Ideally, pedestrian flow should be smooth and uninterrupted, allowing individuals to move efficiently from one point to another. However, in the temple precinct, movement is frequently interrupted by a variety of factors, including bottlenecks, encroachments, and behavioural disruptions. These interruptions create a stop-and-go pattern of movement, which is highly inefficient and contributes to overall congestion.

The cumulative effect of these factors is a mobility system that is highly constrained, inefficient, and vulnerable to disruption. Under normal conditions, the system may function at a basic level, albeit with reduced efficiency. However, during peak periods, when pedestrian volume increases significantly, the system becomes overwhelmed, leading to severe congestion and restricted movement. This highlights the need for interventions that address not only the physical constraints of the environment but also the behavioural and organizational aspects of mobility.

From a broader perspective, the mobility issues within the precinct can be understood as a result of the mismatch between demand and capacity. The demand for movement, driven by the high number of visitors and the temple-centric nature of the area, far exceeds the capacity of the existing infrastructure. This imbalance is further exacerbated by the lack of planning and management mechanisms to regulate and distribute movement effectively.

In conclusion, mobility within the temple precinct is influenced by a complex interplay of spatial, behavioural, and organizational factors. The narrow street network, absence of hierarchical circulation, unregulated pedestrian behaviour, and lack of guidance systems collectively contribute to inefficient movement conditions. These issues are not only physical but also systemic, requiring integrated solutions that address multiple dimensions simultaneously. Improving mobility within the precinct is therefore essential not only for enhancing accessibility and user experience but also for reducing congestion and improving overall system performance.

3.16.2 Congestion-Related Issues

Congestion within the Banke Bihari Temple precinct represents the most visible and critical manifestation of the underlying spatial and systemic inefficiencies identified in the study. It is not merely a physical condition characterized by high crowd density, but rather a complex phenomenon resulting from the continuous interaction between movement patterns, spatial constraints, behavioural tendencies, and management limitations. The analysis indicates that congestion in the precinct is both spatially concentrated and temporally variable, making it a dynamic challenge that requires careful interpretation.

At the core of the congestion problem lies the temple itself, which acts as the primary focal point of movement. The temple attracts a continuous inflow of pedestrians from multiple directions, resulting in a converging movement pattern that concentrates crowd density within a limited area. This convergence is particularly intense near the temple entrance, where all incoming flows merge into a single access point. The limited capacity of this entry zone, combined with the high volume of visitors, leads to the formation of extremely dense crowd conditions, especially during peak hours.

The situation is further complicated by behavioural factors associated with religious practices. Visitors tend to slow down or stop near the entrance for darshan, prayers, or other rituals, which interrupts the continuity of movement. These interruptions create localized clusters of people, which quickly expand as more individuals arrive. In a constrained spatial environment, such clusters can rapidly evolve into severe congestion zones, where movement becomes highly restricted and difficult to manage.

Beyond the immediate vicinity of the temple, congestion extends into the surrounding street network, particularly in narrow streets and at junctions. These areas function as secondary congestion zones, where the effects of high inflow and limited capacity are compounded by spatial irregularities and movement conflicts. Junctions, in particular, play a critical role in shaping congestion patterns, as they represent points where multiple movement streams intersect. The lack of clear directional guidance in these areas often leads to confusion and overlapping flows, which further reduce movement efficiency.

The spatial configuration of the precinct significantly contributes to the intensity and distribution of congestion. The narrow width of streets limits the number of pedestrians

that can move simultaneously, while the irregular layout creates multiple points of friction where movement slows down. Additionally, commercial encroachments reduce the effective width of streets, further constraining movement and creating localized bottlenecks. These bottlenecks act as barriers within the circulation system, causing upstream accumulation of pedestrians and increasing overall density.

Temporal variation is another critical dimension of congestion within the precinct. The analysis of crowd patterns indicates that congestion is not constant throughout the day but varies significantly depending on time and activity. Peak congestion is observed during morning hours, when a large number of devotees visit the temple simultaneously. During these periods, the capacity of the existing infrastructure is exceeded, leading to extreme crowd density and restricted movement. Festivals and special occasions further amplify this condition, resulting in sudden and substantial increases in footfall.

An important characteristic of congestion in the precinct is its self-reinforcing nature. As crowd density increases, movement speed decreases, leading to longer travel times and increased accumulation of pedestrians within the same space. This creates a feedback loop where congestion intensifies over time, even without a significant increase in inflow. In such conditions, the system becomes highly sensitive to minor disruptions, which can trigger rapid escalation of congestion levels.

The psychological dimension of congestion also plays a significant role in shaping crowd behaviour. High-density environments often create a sense of discomfort and urgency among users, which may lead to erratic movement patterns such as pushing, sudden changes in direction, or attempts to bypass queues. These behaviours further disrupt the flow of movement and contribute to the formation of additional congestion points. The perception of congestion, therefore, is not only a result of physical conditions but also influences the way individuals interact with the environment and with each other.

Another important aspect of congestion is its impact on accessibility and circulation efficiency. High levels of congestion reduce the ability of pedestrians to move freely, resulting in increased travel time and reduced accessibility to the temple and surrounding areas. This not only affects the experience of visitors but also impacts the functioning of commercial activities within the precinct. Vendors and shopkeepers may

experience both positive and negative effects, as high footfall increases potential customers but excessive congestion can limit accessibility and movement.

The absence of a structured circulation system further exacerbates congestion within the precinct. Without clearly defined routes and movement patterns, pedestrians tend to move in an uncoordinated manner, resulting in overlapping flows and increased friction. The lack of segregation between entry and exit routes is particularly problematic, as it creates bidirectional movement within limited space. This condition significantly reduces movement efficiency and increases the likelihood of congestion.

From a systemic perspective, congestion within the precinct can be understood as a symptom of deeper planning deficiencies. The combination of high demand, limited capacity, unregulated activities, and inadequate management creates a condition where congestion becomes inevitable. Addressing this issue requires not only localized interventions but also a broader rethinking of how space, movement, and activities are organized within the precinct.

In conclusion, congestion within the Banke Bihari Temple precinct is a multi-dimensional problem that arises from the interaction of spatial, behavioural, and temporal factors. It is characterized by concentration at specific nodes, variation across time, and a tendency to intensify under pressure. The analysis highlights the need for integrated strategies that address both the causes and effects of congestion, with a focus on improving circulation efficiency, optimizing space utilization, and enhancing overall system performance.

3.16.3 Management-Related Issues

The effectiveness of crowd management within the Banke Bihari Temple precinct plays a decisive role in determining how efficiently the space functions under conditions of high pedestrian inflow. While spatial constraints and behavioural patterns significantly influence movement dynamics, it is ultimately the management system that has the potential to regulate, guide, and optimize these conditions. However, the analysis indicates that the existing management framework within the precinct is limited in its scope, fragmented in its implementation, and largely reactive in its approach.

One of the most fundamental issues identified is the absence of an integrated and coordinated crowd management system. The current approach appears to rely on isolated measures, such as partial entry–exit segregation and on-ground personnel

deployment, rather than a comprehensive strategy that addresses the precinct as a unified system. This lack of integration results in inconsistencies in how crowd control measures are applied across different areas. While certain zones may exhibit some level of organization, others remain unregulated, leading to uneven performance of the overall system.

A key limitation of the existing management approach is its reactive nature. Interventions are typically implemented in response to congestion after it has already developed, rather than being designed to prevent such conditions from occurring in the first place. This reactive mode of operation reduces the effectiveness of management efforts, as it becomes increasingly difficult to control crowd behaviour once density reaches critical levels. Preventive strategies, such as regulating inflow, guiding movement, and distributing crowd load, are largely absent or insufficiently developed.

Queue management within the precinct represents another critical area of concern. The absence of clearly defined and organized queuing systems leads to inefficient use of space and contributes significantly to congestion. In many instances, queues form in an unstructured manner, extending into circulation areas and interfering with pedestrian movement. This overlap between waiting and movement spaces creates additional friction within the system, further reducing efficiency. Moreover, the lack of designated holding areas means that excess crowd is not effectively contained or managed, leading to spillover into already congested zones.

The issue of entry and exit management further highlights the limitations of the current system. Although some degree of segregation is observed, it is neither consistent nor adequately enforced. As a result, entry and exit flows often intersect, creating bidirectional movement conditions that significantly reduce efficiency and increase congestion. The absence of clearly marked and continuously maintained routes contributes to confusion among visitors, particularly those unfamiliar with the area, leading to uncoordinated movement patterns.

Another significant gap in the management framework is the lack of technological integration. In contemporary crowd management practices, technology plays a crucial role in monitoring, analyzing, and controlling crowd conditions in real time. However, within the temple precinct, such systems are either absent or minimally utilized. The lack of surveillance tools, data collection mechanisms, and real-time monitoring limits

the ability of authorities to assess crowd density, identify emerging bottlenecks, and respond proactively to changing conditions. This absence of data-driven decision-making results in a reliance on manual observation and reactive intervention, which is insufficient in high-density environments.

Coordination among different stakeholders is also a critical issue affecting the effectiveness of crowd management. The precinct involves multiple actors, including local authorities, temple administration, law enforcement agencies, and vendors. The absence of a clearly defined and coordinated framework for collaboration among these stakeholders leads to fragmented implementation of management measures. This fragmentation not only reduces efficiency but also creates gaps in coverage, where certain areas remain unmanaged or poorly regulated.

The management of commercial activities further illustrates the challenges associated with the current system. Vendors and shopkeepers play an important role in the local economy; however, the lack of regulation and enforcement allows commercial activities to spill over into pedestrian pathways. This encroachment reduces effective movement space and contributes to congestion. The absence of clear guidelines and designated zones for commercial activities indicates a gap in the integration of land use management within the broader crowd management framework.

Behavioural management is another dimension that remains largely unaddressed. Crowd behaviour, including stopping, grouping, and directional changes, has a significant impact on movement dynamics. However, there are limited measures in place to guide or regulate such behaviour. The absence of signage, announcements, or visual cues means that pedestrians rely on their own judgment or follow others, resulting in uncoordinated and often inefficient movement patterns. Effective crowd management requires not only physical and operational interventions but also strategies to influence and guide user behaviour.

The temporal variability of crowd conditions further complicates management efforts. The system is required to handle varying levels of demand throughout the day, with peak periods placing extreme pressure on infrastructure and management resources. However, the current system does not appear to adapt dynamically to these changes. The lack of flexible and responsive strategies means that the same measures are applied regardless of crowd intensity, reducing their effectiveness during peak conditions.

From a broader perspective, the management issues within the precinct can be understood as a reflection of the absence of a holistic planning approach. The current system focuses on addressing immediate problems rather than developing long-term solutions that integrate spatial, behavioural, and technological components. This results in a cycle where congestion is managed temporarily but not resolved, leading to recurring challenges.

In conclusion, the management-related issues within the Banke Bihari Temple precinct are characterized by a lack of integration, coordination, and proactivity. The existing system is insufficient to handle the complexity and scale of crowd conditions, particularly during peak periods. Addressing these issues requires a shift from reactive control measures to a comprehensive and integrated management framework that incorporates spatial planning, behavioural guidance, and technological support. Such an approach is essential for improving efficiency, enhancing safety, and ensuring a better experience for users within the precinct.

3.16.4 Land Use and Encroachment Issues

The land use pattern within the Banke Bihari Temple precinct plays a crucial role in shaping the spatial dynamics of movement and significantly contributes to the formation and intensification of congestion. Unlike planned urban areas where land uses are organized and segregated based on function, the temple precinct exhibits a predominantly mixed-use character, where commercial, religious, and residential activities coexist within a highly constrained spatial framework. While this mixed-use environment contributes to the vibrancy and economic vitality of the area, it also creates a complex set of challenges related to movement, space utilization, and overall spatial efficiency.

One of the defining characteristics of the precinct is the high concentration of commercial activities in close proximity to the temple. Shops selling prasad, food items, religious artifacts, and other goods line the streets leading to the temple, creating a continuous commercial edge that attracts a large number of pedestrians. These activities are not only essential to the functioning of the precinct but also serve as an integral part of the pilgrimage experience. However, their spatial organization and interaction with pedestrian movement significantly influence the efficiency of circulation within the area.

A major issue observed in this context is the phenomenon of commercial spillover and encroachment. Vendors and shopkeepers frequently extend their activities beyond the confines of their designated spaces, occupying portions of the street that are intended for pedestrian movement. This encroachment reduces the effective width of the सड़क, which is already limited, thereby further constraining movement capacity. In many instances, the usable width of the street is significantly less than its physical width due to such encroachments, creating narrow passageways that are insufficient to accommodate the volume of pedestrians.

The impact of encroachment is particularly pronounced in areas where street widths are already minimal. In such locations, even a small reduction in available space can lead to a substantial decrease in movement efficiency. Pedestrians are forced to navigate through tight spaces, often adjusting their path and speed to avoid obstacles, which results in irregular and fragmented movement patterns. These conditions contribute to the formation of localized bottlenecks, which can quickly escalate into larger congestion zones under high-density conditions.

In addition to reducing physical space, commercial activities also influence pedestrian behaviour in ways that contribute to congestion. Shops and vendors act as points of attraction, where pedestrians tend to stop, gather, and engage in activities such as purchasing goods or interacting with sellers. This stopping behaviour interrupts the continuity of movement and creates clusters of people within circulation areas. In a constrained environment, such clusters can significantly disrupt flow, as they reduce the available space for moving pedestrians and create points of friction within the system.

The interaction between static and dynamic activities further complicates the situation. Static activities, such as shopping and waiting, require individuals to remain in a fixed location for a certain period of time, while dynamic activities involve continuous movement. When these two types of activities occur within the same space, conflicts arise, as moving pedestrians must navigate around stationary individuals. This interaction leads to frequent interruptions in flow and reduces overall efficiency of movement.

Another important dimension of land use-related issues is the lack of regulation and control over commercial activities. The absence of clearly defined boundaries and

designated zones for vendors allows for unregulated expansion of activities into pedestrian spaces. This lack of control not only affects movement but also creates challenges in maintaining order and organization within the precinct. The situation is further complicated by the informal nature of many commercial activities, which makes it difficult to enforce regulations without affecting livelihoods.

The mixed-use nature of the precinct also results in a high degree of spatial overlap between different functions. Residential areas, commercial establishments, and religious spaces are often located in close proximity, leading to a continuous interaction between various activities. While this overlap contributes to the vibrancy of the area, it also creates challenges in managing space effectively. For instance, residents, shopkeepers, and visitors all use the same सड़क network, resulting in increased competition for limited space.

The temporal dimension of land use further influences crowd dynamics within the precinct. Commercial activity tends to peak during certain hours, coinciding with periods of high pedestrian inflow. This overlap intensifies congestion, as both movement and commercial interactions increase simultaneously. During festival periods, the scale of commercial activity expands further, with temporary vendors and additional stalls occupying even more space, thereby exacerbating existing issues.

From a broader perspective, the land use pattern within the precinct reflects a tension between economic activity and spatial efficiency. On one hand, commercial activities are essential for supporting the local economy and enhancing the visitor experience. On the other hand, their unregulated expansion into circulation spaces significantly reduces the efficiency of movement and contributes to congestion. Balancing these competing demands represents a key challenge in the planning and management of the precinct.

The absence of a structured approach to organizing land use activities indicates a gap in the integration of spatial planning and crowd management. Effective management of the precinct requires not only controlling pedestrian movement but also regulating the activities that influence that movement. This includes defining clear zones for commercial activities, ensuring that pedestrian pathways remain unobstructed, and creating designated spaces for activities that currently spill over into circulation areas.

In conclusion, land use and encroachment issues within the Banke Bihari Temple precinct are a significant contributor to congestion and movement inefficiency. The mixed-use character of the area, combined with unregulated commercial activities and encroachments, creates a complex environment where space is used intensively but inefficiently. Addressing these issues requires a careful balance between maintaining the economic and cultural vitality of the precinct and ensuring efficient and safe movement for users. This highlights the need for integrated planning strategies that align land use management with crowd management objectives.

3.17 Cause–Effect Relationship Analysis

The complex set of issues identified within the Banke Bihari Temple precinct can be more effectively understood through a detailed cause–effect relationship analysis. This approach allows for the identification of underlying mechanisms that generate congestion and inefficiencies, rather than merely describing their visible manifestations. By examining the sequence of interactions between spatial constraints, pedestrian behaviour, land use patterns, and management practices, it becomes possible to trace the origin of problems and understand how they evolve within the system.

At the most fundamental level, the root cause of the issues within the precinct lies in the limited spatial capacity of the built environment. The narrow and irregular street network, combined with dense built form, creates a constrained physical framework within which all movement and activities must occur. This limited capacity is further reduced by encroachments and unregulated use of space, resulting in a significant gap between the available space and the demand placed upon it. The reduction in effective street width directly impacts the ability of pedestrians to move freely, setting the stage for further complications.

When high volumes of pedestrians enter this constrained environment, the system begins to experience stress. The temple, acting as the primary focal point, generates a continuous inflow of visitors from multiple directions. This inflow is not evenly distributed but converges towards a single node, resulting in a rapid increase in density near the temple and along key access routes. The mismatch between high inflow and limited capacity leads to the formation of initial pressure zones, where movement becomes slower and less efficient.

As density increases, the relationship between pedestrian flow and movement speed becomes critical. Higher density results in reduced personal space, which forces individuals to adjust their speed and direction in response to surrounding conditions. This leads to a gradual decline in movement efficiency, as pedestrians are no longer able to maintain a consistent pace. The reduction in speed causes people to remain within the same space for longer durations, further increasing density and intensifying the problem.

At this stage, behavioural factors begin to play a significant role in shaping the system. Pedestrians do not move uniformly; their behaviour is influenced by a variety of factors, including religious practices, social interactions, and individual preferences. Stopping behaviour, in particular, has a pronounced impact on flow dynamics. When individuals stop for activities such as darshan or purchasing goods, they create localized disruptions that interrupt the continuity of movement. In a constrained environment, these disruptions can quickly propagate, leading to the formation of bottlenecks.

Bottlenecks represent a critical stage in the cause–effect chain, where the capacity of a specific location is exceeded by the volume of pedestrians attempting to pass through it. These points of restriction can occur due to physical constraints, such as narrow streets or encroachments, or due to behavioural factors, such as stopping or merging flows. Once a bottleneck forms, it creates a barrier within the circulation system, causing pedestrians to accumulate upstream. This accumulation increases density and further reduces movement speed, reinforcing the conditions that led to the bottleneck in the first place.

The interaction between multiple bottlenecks within the precinct creates a network of congestion points that affect the overall performance of the system. Congestion is no longer confined to a single location but spreads across adjacent areas, creating a cascading effect. For instance, congestion near the temple entrance can extend into surrounding streets, affecting movement even in areas that are not directly connected to the primary node. This interconnected nature of congestion highlights the importance of understanding the system as a whole rather than focusing on individual problem areas.

Management deficiencies further amplify the effects of these conditions. The absence of structured circulation systems and effective crowd control measures allows

congestion to develop and persist. Without mechanisms to regulate inflow, guide movement, and distribute crowd load, the system lacks the ability to respond to increasing pressure. This results in a situation where congestion becomes self-sustaining, as there are no interventions to break the cycle of accumulation and reduced movement.

The temporal dimension adds another layer of complexity to the cause–effect relationship. During peak periods, the inflow of pedestrians increases significantly, placing additional stress on the system. Under these conditions, the threshold at which bottlenecks form is reached more quickly, and the intensity of congestion increases. The system becomes highly sensitive to even minor disruptions, which can trigger rapid escalation of crowd density. Conversely, during non-peak periods, the same system may function relatively efficiently, indicating that the issues are not constant but dependent on the interaction between demand and capacity.

Another important aspect of the cause–effect relationship is the feedback loop that characterizes congestion. As movement slows down due to increased density, more people accumulate within the same space, which further reduces speed and increases density. This positive feedback loop creates a self-reinforcing cycle, where congestion intensifies over time without external intervention. Breaking this cycle requires targeted strategies that address both the causes and the effects of congestion simultaneously.

The role of land use and commercial activities in this chain cannot be overlooked. Encroachments and spillover of activities into pedestrian pathways reduce the effective width of streets, creating initial constraints that contribute to bottleneck formation. At the same time, commercial activities attract pedestrians and encourage stopping behaviour, which further disrupts movement. This dual role of land use as both a cause and a catalyst for congestion highlights the need for integrated planning approaches that consider the interaction between movement and activity.

From a systemic perspective, the cause–effect relationship within the precinct can be visualized as a continuous cycle, where each factor influences and is influenced by others. Spatial constraints lead to reduced capacity, which interacts with high inflow to increase density. Increased density reduces movement speed, leading to accumulation and bottlenecks. Bottlenecks create congestion, which is further intensified by

behavioural and management factors. This cycle continues unless interventions are introduced to disrupt the sequence and restore balance within the system.

In conclusion, the cause–effect analysis reveals that congestion and inefficiency within the Banke Bihari Temple precinct are the result of a complex and dynamic interplay between multiple factors. The issues cannot be attributed to a single cause but emerge from the interaction of spatial, behavioural, and managerial elements. Understanding this relationship is essential for developing effective planning strategies, as it highlights the need for integrated interventions that address the root causes of the problem rather than merely its symptoms.

3.18 Impact Analysis on Users and System Performance

The planning issues identified within the Banke Bihari Temple precinct have far-reaching implications that extend beyond spatial inefficiency and congestion. These impacts are experienced at multiple levels, affecting not only the physical movement of pedestrians but also their comfort, safety, perception, and overall experience of the place. At the same time, these issues influence the functioning of the precinct as a whole, impacting its economic activity, operational efficiency, and long-term sustainability. A comprehensive understanding of these impacts is essential for evaluating the severity of the problem and for informing appropriate planning interventions.

At the most immediate level, the impact of congestion and restricted mobility is reflected in the reduced efficiency of pedestrian movement. As crowd density increases, the speed of movement decreases, resulting in longer travel times and delays. Visitors are required to spend more time navigating through the precinct, particularly during peak hours when congestion is most severe. This not only affects accessibility to the temple but also reduces the efficiency of circulation within the surrounding areas. The inability to move freely creates a sense of frustration among users, particularly those who are unfamiliar with the area or who are visiting under time constraints.

The impact on user comfort is equally significant. High-density conditions lead to a reduction in personal space, forcing individuals into close physical proximity with others. This lack of space creates physical discomfort, particularly in hot or humid conditions where ventilation may be limited. The continuous need to adjust movement in response to surrounding individuals adds to this discomfort, making the experience

physically demanding. Over time, such conditions can lead to fatigue, especially for elderly visitors or those accompanied by children.

In addition to physical discomfort, the psychological impact of congestion must also be considered. Dense crowd conditions often create a sense of stress and anxiety, as individuals become aware of the limited space and restricted movement. This psychological pressure can influence behaviour, leading to impatience, urgency, or even panic in extreme cases. Such behavioural responses can further disrupt movement patterns and contribute to the escalation of congestion. The perception of overcrowding, therefore, is not only a consequence of physical conditions but also a factor that influences how individuals interact with the environment.

Safety represents one of the most critical dimensions of impact within the precinct. High-density conditions, combined with restricted movement and lack of clear evacuation routes, significantly increase the risk of crowd-related incidents. In situations where crowd density exceeds safe limits, even minor disturbances can lead to dangerous situations such as pushing, falling, or stampedes. The absence of adequate emergency access and management systems further exacerbates these risks, making it difficult to respond effectively in critical situations. The potential for such incidents highlights the urgency of addressing crowd management issues within the precinct.

The impact on user experience extends beyond movement and safety to include the overall perception of the site. For many visitors, the temple precinct represents a place of spiritual significance and cultural importance. However, the presence of congestion, long waiting times, and lack of organization can detract from this experience, reducing the sense of comfort and satisfaction. Visitors may associate their experience with stress and inconvenience rather than the intended spiritual or cultural value. This has implications not only for individual satisfaction but also for the broader perception of the site as a destination.

From an operational perspective, the identified issues also affect the functioning of the precinct. Congestion and inefficient movement disrupt the flow of people, making it difficult to manage large volumes of visitors effectively. This places additional pressure on management systems, which are already limited in their capacity. The lack of organization in movement and activities creates challenges in implementing control

measures, as authorities must constantly respond to changing conditions rather than operating within a structured framework.

The impact on economic activity within the precinct is complex and multifaceted. On one hand, high footfall increases the potential for commercial transactions, benefiting vendors and shopkeepers. On the other hand, excessive congestion can limit accessibility to shops, as pedestrians may find it difficult to navigate through crowded areas. In such cases, the benefits of high footfall may be offset by reduced efficiency of movement and decreased willingness of visitors to engage in commercial activities. The balance between economic activity and spatial efficiency is therefore a critical consideration in the planning of the precinct.

Another important dimension of impact is related to inclusivity and accessibility. The current conditions within the precinct make it difficult for certain groups, such as elderly individuals, children, and persons with disabilities, to navigate the space comfortably and safely. The lack of organized pathways, high crowd density, and physical obstructions create barriers to access, limiting the ability of these groups to participate fully in the experience. This raises important concerns regarding equity and inclusivity in the design and management of the precinct.

The cumulative impact of these issues also affects the long-term sustainability of the precinct. Continuous exposure to high levels of congestion and inefficiency can lead to degradation of the physical environment, as well as reduced quality of experience for visitors. Over time, this may affect the reputation of the site and its ability to function effectively as a major pilgrimage destination. Addressing these impacts is therefore not only a matter of improving current conditions but also of ensuring the long-term viability of the precinct.

Furthermore, the interaction between different types of impacts creates a compounded effect that intensifies the overall problem. For instance, reduced mobility leads to increased congestion, which in turn affects comfort and safety. Similarly, negative user experiences can influence behaviour, which further disrupts movement and exacerbates congestion. This interconnected nature of impacts highlights the need for integrated solutions that address multiple dimensions simultaneously.

In conclusion, the impacts of the identified planning issues within the Banke Bihari Temple precinct are extensive and multi-dimensional, affecting both users and the

overall functioning of the system. These impacts are not limited to physical movement but extend to comfort, safety, perception, and economic activity. Understanding these effects provides a comprehensive perspective on the severity of the problem and reinforces the need for holistic and integrated planning interventions aimed at improving mobility, enhancing safety, and ensuring a better experience for all users.

3.19 Interpretation of Findings

The comprehensive analysis of the Banke Bihari Temple precinct reveals that the challenges of crowd management within the area are not merely operational issues but are deeply rooted in the spatial structure, behavioural patterns, and organizational framework of the precinct. The interpretation of findings goes beyond identifying individual problems and seeks to understand the systemic nature of these issues, highlighting the underlying relationships that define how the precinct functions under conditions of high pedestrian density.

One of the most significant interpretations derived from the analysis is that the movement system within the precinct is fundamentally temple-centric and highly concentrated. Unlike conventional urban systems where activities and movement are distributed across multiple nodes, the temple acts as a dominant attractor that concentrates pedestrian flow into a single focal point. This concentration results in uneven distribution of crowd density, with the highest pressure observed near the temple entrance and along primary access routes. The lack of alternative nodes or distributed activity centers further intensifies this condition, making the system highly dependent on a single point of convergence.

This temple-centric movement pattern creates an inherent structural limitation within the system. Even in the absence of external disruptions, the concentration of movement at a single node leads to high density and reduced efficiency. During peak periods, when the volume of visitors increases significantly, this limitation becomes more pronounced, resulting in severe congestion and restricted movement. The interpretation of this pattern suggests that the issue is not only related to the volume of people but also to the way in which movement is organized and directed within the space.

Another critical interpretation is the mismatch between spatial capacity and pedestrian demand. The existing urban fabric, characterized by narrow and irregular streets, is unable to accommodate the scale of movement generated by the temple. The effective

capacity of the space is further reduced by encroachments and overlapping activities, creating a condition where demand consistently exceeds supply. This imbalance is a primary driver of congestion and inefficiency within the precinct.

The analysis also highlights the absence of a hierarchical circulation system, which is essential for efficient movement in high-density environments. In the current condition, all streets function in a similar manner, regardless of their capacity or importance. This lack of differentiation results in inefficient distribution of pedestrian flow, where smaller streets are subjected to the same level of pressure as larger ones. The interpretation suggests that introducing a hierarchy in movement routes could significantly improve the efficiency of circulation by directing flow along appropriate paths.

Behavioural patterns emerge as another key factor influencing the functioning of the precinct. The movement of pedestrians is not purely functional but is shaped by religious practices, social interactions, and individual preferences. Activities such as stopping for darshan, gathering in groups, and engaging with vendors create interruptions in flow that contribute to congestion. These behaviours are intrinsic to the nature of the place and cannot be eliminated; however, they must be understood and accommodated within the planning framework. The interpretation of these patterns indicates that effective crowd management must integrate behavioural considerations with spatial design.

The interaction between land use and movement represents another important dimension of the findings. The concentration of commercial activities near the temple creates zones of high attraction, where pedestrian density increases due to both movement and stationary activities. The spillover of these activities into circulation spaces further reduces effective movement area, creating conflicts between static and dynamic uses. This interaction highlights the need for coordinated planning that aligns land use organization with movement requirements.

Management-related findings reveal that the current system lacks the capacity to respond effectively to the complexity of crowd conditions within the precinct. The absence of a proactive and integrated management framework results in a reliance on reactive measures, which are insufficient for addressing the root causes of congestion. The interpretation suggests that management must evolve from a control-oriented

approach to a planning-oriented approach, where movement is guided and regulated through a combination of spatial design, behavioural strategies, and technological support.

Another significant interpretation is the dynamic nature of crowd conditions within the precinct. The intensity of congestion varies across time, with peak periods experiencing extreme pressure while non-peak periods remain relatively manageable. This temporal variation indicates that the system does not operate under constant conditions but is subject to fluctuations that require adaptive and flexible management strategies. Static solutions are therefore unlikely to be effective, and interventions must be designed to respond to changing conditions.

The analysis also reveals the presence of feedback loops within the system, where congestion reinforces itself over time. As density increases, movement slows down, leading to further accumulation of pedestrians within the same space. This creates a cycle that intensifies congestion and makes it difficult to manage without intervention. The interpretation of this phenomenon emphasizes the importance of breaking these feedback loops through targeted strategies that reduce density and improve flow.

From a broader perspective, the findings indicate that the issues within the precinct are not isolated but are part of a systemic problem that requires integrated solutions. Addressing individual issues in isolation is unlikely to produce significant improvements, as the underlying causes are interconnected. Instead, interventions must consider the system as a whole, addressing spatial, behavioural, and managerial factors simultaneously.

The interpretation also highlights the importance of optimizing existing space rather than relying on expansion. Given the constraints of the historic urban fabric, large-scale physical interventions may not be feasible. Instead, the focus must be on improving the efficiency of space utilization, organizing movement patterns, and regulating activities within the existing framework. This approach aligns with the need for sustainable and context-sensitive planning solutions.

Another key insight is the need to balance efficiency with cultural and economic considerations. The temple precinct is not only a movement space but also a place of religious and commercial activity. Interventions must therefore respect the cultural significance of the site and the economic role of vendors while improving spatial

efficiency. This requires a nuanced approach that integrates multiple objectives rather than prioritizing one at the expense of others.

In conclusion, the interpretation of findings reveals that the challenges of crowd management within the Banke Bihari Temple precinct are deeply rooted in the structural, behavioural, and organizational characteristics of the area. The temple-centric nature of movement, combined with limited spatial capacity and inadequate management systems, creates a complex and dynamic environment where congestion is both inevitable and self-reinforcing. Addressing these challenges requires a comprehensive and integrated approach that rethinks how space, movement, and activities are organized within the precinct. The insights derived from this interpretation form the basis for developing planning strategies and interventions in the subsequent chapter.

CHAPTER 4

PLANNING FRAMEWORK AND STRATEGY FORMULATION

4.1 Introduction

The analysis of the Banke Bihari Temple precinct presented in the previous chapter establishes that the challenges of crowd management within the area are not isolated operational concerns but are deeply embedded within the spatial structure, functional organization, and behavioural dynamics of the precinct. The observed conditions of congestion, restricted mobility, and inefficient movement patterns are the outcome of a complex interaction between high pedestrian inflow, limited spatial capacity, unregulated land use activities, and inadequate management systems. These issues are further intensified by the temple-centric nature of movement, where the majority of pedestrian flow converges toward a single focal point, resulting in uneven distribution of crowd density and excessive pressure on critical nodes.

Given the interconnected nature of these challenges, it becomes evident that isolated interventions addressing individual issues are unlikely to produce meaningful or sustainable improvements. Instead, there is a need for a comprehensive planning framework that can respond to the system as a whole, recognizing the relationships between spatial configuration, user behaviour, and management practices. Such a framework must move beyond reactive crowd control measures and adopt a proactive, planning-led approach that anticipates movement patterns, regulates inflow, organizes space, and enhances overall system efficiency.

This chapter develops a structured planning framework for crowd management within the Banke Bihari Temple precinct, grounded in the findings of the analysis. The framework is designed to translate identified issues into actionable planning strategies that are both context-sensitive and implementable within the constraints of the historic urban fabric. It provides a conceptual and strategic foundation for the subsequent proposal stage, ensuring that design interventions are not arbitrary but are derived from a clear and logical planning rationale.

4.2 Need for a Planning-Led Framework

The need for a planning-led framework arises from the limitations of existing crowd management practices observed within the precinct. Current approaches are largely

reactive, relying on temporary measures such as barricading, manual regulation, and on-ground personnel deployment. While these measures may provide short-term relief during peak periods, they do not address the underlying causes of congestion and inefficiency. As a result, the same issues recur repeatedly, particularly during festivals and high footfall periods, indicating a lack of structural resolution.

The analysis demonstrates that the core of the problem lies in the mismatch between pedestrian demand and spatial capacity. The narrow and irregular street network, combined with encroachments and mixed land use activities, significantly reduces the effective movement space available to pedestrians. At the same time, the continuous and often unregulated inflow of visitors into the precinct leads to conditions where demand consistently exceeds capacity. This imbalance creates a system that operates under constant stress, with congestion emerging as an inevitable outcome rather than an occasional occurrence.

In such a context, effective crowd management cannot be achieved solely through operational control. Instead, it requires a planning approach that reorganizes space, structures movement, and regulates activities in a coordinated manner. The role of planning in this scenario is to create a system where movement is guided rather than forced, where space is optimized rather than expanded, and where behaviour is influenced rather than controlled.

Furthermore, the historic and cultural significance of the precinct imposes additional constraints on the nature of interventions. Large-scale physical restructuring or demolition is neither feasible nor desirable, as it may disrupt the existing urban fabric and cultural identity of the area. Therefore, the framework must focus on optimizing the use of existing space through strategic reorganization, rather than relying on extensive physical alterations.

The need for such a framework is further reinforced by the temporal variability of crowd conditions within the precinct. As observed in the analysis, crowd intensity fluctuates significantly throughout the day and across different periods, with peak hours experiencing extreme pressure while non-peak periods remain relatively manageable. This dynamic nature of the system requires flexible and adaptive strategies that can respond to changing conditions, rather than static solutions that assume uniform demand.

In this context, the planning framework developed in this chapter seeks to address these challenges by integrating spatial, behavioural, and management dimensions into a cohesive system. It aims to provide a structured approach that can guide the development of interventions across multiple scales, ensuring that the proposed solutions are both effective and contextually appropriate.

4.3 Planning Approach and Conceptual Basis

The planning approach adopted in this study is based on the recognition that crowd management within high-density religious precincts is a multi-dimensional problem that cannot be addressed through a single disciplinary lens. Instead, it requires an integrated approach that combines spatial planning, behavioural understanding, and management mechanisms into a unified framework. This approach is particularly relevant in the context of the Banke Bihari Temple precinct, where the interaction between space, movement, and human behaviour plays a critical role in shaping crowd dynamics.

At its core, the approach is grounded in the principle of **system-based planning**, where the precinct is viewed as an interconnected system rather than a collection of isolated components. Within this system, spatial configuration influences movement patterns, movement patterns influence crowd behaviour, and behaviour in turn affects the efficiency of the system. Any intervention within this system must therefore consider its impact on all related components, rather than addressing a single aspect in isolation.

The first dimension of the approach focuses on **spatial organization**, which involves restructuring the circulation network, defining movement hierarchies, and optimizing the use of available space. The objective is to create a clear and efficient movement system that can accommodate high pedestrian volumes without resulting in congestion. This includes the identification of primary and secondary routes, segregation of entry and exit flows, and removal of physical bottlenecks that restrict movement.

The second dimension emphasizes **behavioural integration**, recognizing that pedestrian movement in religious settings is influenced by factors such as devotion, social interaction, and perception of space. Unlike purely functional environments, where movement is directed and predictable, the temple precinct exhibits complex behavioural patterns, including stopping, grouping, and non-linear movement. The

planning approach therefore seeks to guide behaviour through spatial cues, signage, and organization of activities, rather than attempting to control it directly.

The third dimension relates to **management and regulation**, which includes both physical and operational measures to control crowd flow and ensure safety. This involves the use of technology for monitoring and regulation, as well as the development of systems for inflow control and crowd distribution. However, within the context of this study, technology is treated as a supporting tool rather than a primary solution, with emphasis placed on low-cost and implementable strategies that can function within the existing constraints of the precinct.

An important aspect of this approach is its **multi-scalar nature**, which aligns with the study area delineation established in the analysis. The framework operates across three spatial scales: the extended influence area (up to 3 km), the primary study area (1–1.5 km), and the immediate temple precinct. Each scale addresses different aspects of the problem, ranging from inflow management at the regional level to detailed circulation design at the micro level. This ensures that interventions are not limited to the core area but address the broader system that contributes to crowd formation.

The conceptual basis of the framework is therefore rooted in integration, scalability, and context sensitivity. It seeks to balance the need for improved efficiency and safety with the preservation of the cultural and spatial character of the precinct. By aligning spatial, behavioural, and management strategies within a single framework, the approach provides a coherent structure for addressing the complex challenges of crowd management in the Banke Bihari Temple precinct.

4.4 Derivation of Strategies from Analysis

The strategies proposed within the framework are not arbitrary but are directly derived from the findings of the analysis presented in Chapter 3. Each identified issue—whether related to mobility, congestion, land use, or management—has been examined in terms of its underlying causes and systemic relationships. This has enabled the formulation of strategies that address not only the symptoms of the problem but also its root causes.

For instance, the analysis identified that mobility within the precinct is constrained by narrow streets, lack of circulation hierarchy, and overlapping flows. In response, the framework emphasizes the development of structured movement systems that organize pedestrian flow and reduce friction. Similarly, the identification of congestion hotspots,

particularly near the temple entrance and adjacent streets, has informed strategies focused on redistribution of crowd load and creation of holding areas.

Land use and encroachment issues, which significantly reduce effective street width and disrupt movement, have led to the formulation of strategies aimed at regulating commercial activities and defining clear zones for different functions. At the same time, the observed limitations in existing management practices have highlighted the need for improved coordination, monitoring, and behavioural guidance.

A key aspect of this derivation process is the recognition that these issues are interrelated. As a result, the strategies developed within the framework are also interconnected, with each component supporting and reinforcing the others. For example, improving circulation not only enhances mobility but also reduces congestion, while regulating land use contributes to both movement efficiency and safety.

The framework therefore represents a synthesis of analytical insights into a coherent set of planning directions. It provides a logical transition from the identification of problems to the formulation of solutions, ensuring that the subsequent proposal stage is grounded in a clear and evidence-based planning rationale.

4.5 Structuring of the Planning Framework

The formulation of the planning framework for the Banke Bihari Temple precinct is structured around the understanding that the existing condition is not defined by a single dominant issue but by a layered set of interdependent challenges. These challenges, as established in the analysis, operate simultaneously across spatial, functional, and behavioural dimensions, creating a system where inefficiencies are continuously reproduced. The framework therefore does not attempt to isolate or prioritize individual problems but instead seeks to reorganize the entire system through a set of coordinated planning strategies.

At the structural level, the framework is organized as a response to four primary dimensions of the problem: movement inefficiency, congestion concentration, land use conflict, and management limitation. These dimensions are not treated as independent categories but as interconnected components of a single system. The planning framework is therefore designed in a way that each strategy addresses multiple issues simultaneously, ensuring that improvements in one aspect reinforce improvements in others.

The central premise of the framework lies in shifting the functioning of the precinct from an unstructured and reactive system to an organized and anticipatory one. In the existing condition, movement patterns are largely unregulated, activities overlap spatially, and management interventions occur only after congestion has developed. The framework aims to reverse this condition by establishing clear spatial organization, guiding movement patterns, and introducing regulatory mechanisms that operate before critical thresholds are reached.

This restructuring is achieved through a set of coordinated strategies that collectively redefine how space is used, how movement is organized, and how crowd behaviour is influenced. The emphasis is not on increasing capacity through physical expansion, but on improving the efficiency with which existing space is utilized. This approach is particularly relevant in the context of the historic urban fabric, where opportunities for large-scale physical intervention are limited.

4.6 Mobility and Circulation Structuring

The organization of pedestrian movement forms the foundation of the planning framework, as mobility inefficiency is identified as one of the primary contributors to congestion within the precinct. The analysis demonstrates that the absence of a structured circulation system results in overlapping flows, bidirectional conflicts, and uneven distribution of pedestrian load across the street network. In response, the framework introduces a restructured circulation logic that aims to transform the existing unorganized movement patterns into a more controlled and efficient system.

The reorganization of movement is based on the introduction of a hierarchical circulation network, where different routes are assigned specific roles based on their capacity, location, and function. This hierarchy enables the distribution of pedestrian flow across multiple routes, reducing the excessive pressure on certain गलियाँ and improving overall system efficiency. Rather than allowing all streets to function equally as access routes to the temple, the framework distinguishes between primary movement corridors, secondary distribution routes, and localized access paths.

Within this structure, particular emphasis is placed on the segregation of entry and exit flows. The analysis clearly indicates that overlapping bidirectional movement within narrow streets significantly reduces flow efficiency and contributes to congestion. By introducing directional clarity and separating incoming and outgoing movement

wherever feasible, the framework aims to minimize friction between pedestrians and improve the continuity of flow.

At the same time, the framework recognizes that complete segregation may not be possible across the entire precinct due to spatial constraints. Therefore, the approach focuses on achieving maximum possible separation within critical sections, particularly near the temple and along major access routes. In areas where segregation cannot be fully implemented, the framework proposes the use of spatial cues and design elements to guide movement direction and reduce conflicts.

Another critical aspect of mobility restructuring is the reduction of interruptions in movement. The existing condition is characterized by frequent stopping behaviour within circulation paths, caused by commercial activities, informal gathering, and lack of designated waiting spaces. The framework addresses this issue by redefining the relationship between movement and stationary activities, ensuring that circulation routes remain as uninterrupted as possible.

The objective of this strategy is not merely to increase movement speed but to establish a consistent and predictable flow pattern that can accommodate varying levels of pedestrian density. By organizing movement into a structured system, the framework reduces the likelihood of sudden disruptions and creates a more stable and manageable environment.

4.7 Congestion Redistribution and Density Management

While mobility restructuring addresses the efficiency of movement, the issue of congestion requires a parallel focus on the distribution and regulation of crowd density within the precinct. The analysis reveals that congestion is highly concentrated at specific nodes, particularly near the temple entrance and along adjacent streets, where multiple movement streams converge within limited space. This concentration creates conditions where density rapidly exceeds safe thresholds, leading to restricted movement and increased safety risks.

The framework addresses this issue through a strategy of congestion redistribution, which aims to reduce pressure on critical nodes by dispersing crowd load across the system. This is achieved by identifying opportunities to expand the effective functional space of the precinct, not through physical expansion but through spatial reorganization and redistribution of activities.

One of the key approaches within this strategy is the creation of intermediate holding and dispersal spaces within the circulation network. These spaces act as buffers that absorb excess crowd during peak periods, preventing the direct transfer of high-density conditions to the temple entrance. By allowing crowd to accumulate in controlled locations, the framework reduces the intensity of congestion at critical nodes and improves the overall stability of the system.

In addition to spatial redistribution, the framework also emphasizes the regulation of inflow as a means of controlling density. The analysis indicates that the continuous and unregulated entry of pedestrians into the precinct contributes significantly to congestion, particularly during peak hours. By introducing mechanisms to regulate the rate of inflow, the framework aims to align pedestrian entry with the carrying capacity of the system.

This approach reflects a shift from reactive congestion management to proactive density control, where the objective is to prevent the formation of high-density conditions rather than managing them after they occur. The effectiveness of this strategy depends on the integration of spatial and management measures, ensuring that inflow regulation is supported by adequate holding capacity and efficient circulation.

Another important aspect of congestion management is the recognition of temporal variation in crowd intensity. The framework acknowledges that peak conditions are not constant but occur during specific time periods, particularly in the morning and during festivals. As a result, the strategies are designed to be adaptable, allowing for different levels of intervention based on the intensity of crowd conditions. This ensures that the system remains functional and efficient across varying demand scenarios.

4.8 Land Use Structuring and Spatial Regulation

The role of land use in shaping movement dynamics within the precinct is significant, as the interaction between commercial activities and pedestrian circulation directly influences congestion levels and spatial efficiency. The analysis highlights that unregulated commercial spillover and encroachments reduce the effective width of streets and create conflicts between stationary and moving activities. Addressing these issues requires a restructuring of land use organization that aligns with the requirements of movement and crowd management.

The framework approaches land use not as a separate planning component but as an integral part of the circulation system. The objective is to redefine how activities are distributed within space, ensuring that they support rather than disrupt movement. This involves establishing a clearer distinction between areas designated for movement and those intended for stationary activities such as vending, waiting, and social interaction.

Rather than eliminating commercial activities, which are essential to the economic and cultural functioning of the precinct, the framework seeks to regulate and organize them in a manner that minimizes their impact on circulation. This includes the identification of specific zones where vending and commercial activities can be accommodated without obstructing movement routes. By consolidating such activities within defined areas, the framework reduces the tendency for uncontrolled spillover into circulation paths.

The restructuring of land use also considers the spatial hierarchy established within the circulation network. Primary movement corridors are treated as high-priority routes where obstruction must be minimized, while secondary and tertiary spaces may accommodate a higher degree of activity. This differentiated approach allows for a balance between movement efficiency and economic activity, ensuring that the precinct remains functional without compromising its vibrancy.

In addition to regulating commercial activities, the framework also addresses the need for designated spaces for non-movement functions such as waiting and gathering. The absence of such spaces in the existing condition leads to the occupation of circulation paths for these activities, resulting in interruptions in movement. By providing alternative spaces for these functions, the framework reduces pressure on movement routes and improves overall system efficiency.

4.9 Integration of Behavioural and Management Dimensions

A critical aspect of the planning framework is the integration of behavioural understanding and management mechanisms into the spatial strategies. The analysis clearly demonstrates that crowd behaviour within the precinct is influenced by factors such as devotion, social grouping, and perception of proximity to the temple. These behavioural patterns cannot be eliminated, but they can be guided and accommodated through appropriate planning interventions.

The framework recognizes that spatial design alone is insufficient to achieve effective crowd management. Without behavioural guidance and management support, even well-designed circulation systems may fail to function as intended. Therefore, the approach incorporates mechanisms that influence how people move and interact within the space.

This includes the use of visual and spatial cues to guide movement direction, reduce confusion, and improve wayfinding. Clear and intuitive navigation is particularly important in a high-density environment where uncertainty can lead to hesitation and disruption in flow. By improving clarity in movement paths, the framework reduces the likelihood of erratic behaviour and enhances overall efficiency.

Management mechanisms are also integrated into the framework to support the functioning of the system. However, unlike the existing reactive approach, the framework emphasizes proactive management, where interventions are designed to prevent congestion rather than respond to it. This includes the use of monitoring systems to assess crowd conditions and the implementation of regulatory measures to control inflow and distribution.

Importantly, the framework adopts a pragmatic approach to technology, focusing on solutions that are feasible within the context of the precinct. Rather than relying on highly advanced systems, the emphasis is placed on scalable and implementable tools that can enhance management capacity without requiring extensive infrastructure.

The integration of behavioural and management dimensions ensures that the framework operates not only as a spatial plan but as a functional system that can adapt to real-world conditions. This holistic approach is essential for addressing the complexity of crowd dynamics within the temple precinct.

4.10 Multi-Scalar Structuring of the Framework

A critical insight derived from the analysis is that crowd conditions within the Banke Bihari Temple precinct are not generated solely within the immediate temple surroundings but are influenced by a broader system of movement and inflow operating at multiple spatial scales. The delineation of the study area into the extended influence area (up to 3 km), the primary study area (approximately 1–1.5 km), and the immediate temple precinct provides a basis for understanding how different layers of the system contribute to crowd formation and distribution. The planning framework therefore

adopts a multi-scalar approach, where strategies are structured and applied across these three levels in a coordinated manner.

At the level of the extended influence area, the primary concern is the regulation and distribution of inflow into the core precinct. This area functions as the interface between regional connectivity and the pedestrian-dominated environment of the temple precinct. Major access points such as parking areas, drop-off locations, and transit nodes act as entry gateways through which visitors transition into the walkable zone. The framework recognizes that uncontrolled inflow from these points leads to excessive pressure within the core area, particularly during peak periods. Therefore, strategies at this scale focus on managing the rate and distribution of pedestrian entry into the primary study area, ensuring that the volume of incoming visitors is aligned with the capacity of the system.

The extended area also plays a role in dispersing movement before it converges toward the temple. By structuring routes and guiding movement at this scale, it becomes possible to reduce the concentration of pedestrians along specific corridors and achieve a more balanced distribution of flow. This approach reduces the likelihood of congestion forming within the inner areas and enhances the overall efficiency of the system.

At the level of the primary study area, which represents the walkable catchment zone around the temple, the focus shifts from inflow regulation to movement organization and distribution. This area acts as a transitional zone where pedestrian density begins to increase and movement patterns become more directed toward the temple. The framework addresses this condition by introducing a structured circulation system that distributes pedestrian flow across multiple routes, reducing the intensity of convergence toward any single path.

The organization of movement at this scale is particularly important in preventing the formation of bottlenecks before they reach the core precinct. By ensuring that pedestrian flow is evenly distributed and guided along defined routes, the framework reduces the accumulation of crowd in specific locations and maintains a more stable density across the area. This not only improves mobility but also enhances the effectiveness of downstream interventions within the temple precinct.

Within the immediate temple precinct, which represents the most critical and constrained part of the system, the focus is on managing high-density conditions and

ensuring safe and efficient movement within limited space. At this scale, the framework emphasizes detailed spatial interventions that address circulation, congestion, and activity organization at a micro level. The objective is to optimize the use of available space, minimize conflicts between movement and activities, and create a controlled environment where crowd density remains within manageable limits.

The multi-scalar structuring of the framework ensures that interventions at different levels are not isolated but are interconnected and mutually supportive. Strategies implemented at the extended scale reduce pressure on the primary area, while interventions at the primary level improve the functioning of the core precinct. This cascading effect allows the system to operate more efficiently as a whole, rather than relying on isolated improvements within a single area.

4.11 Spatial Translation of Strategies Across Scales

The effectiveness of the planning framework depends on how well the identified strategies are translated across different spatial scales. Each strategy—whether related to mobility, congestion management, land use, or behavioural guidance—operates differently at each level of the system, but together they form a coherent and integrated response.

At the extended influence level, mobility strategies focus on guiding pedestrian movement from entry points toward designated routes, ensuring that the transition into the core area is smooth and organized. Congestion management at this scale is primarily concerned with preventing excessive inflow, which is achieved through the regulation of entry points and the provision of waiting or holding areas where necessary. Land use considerations at this level include the organization of parking, drop-off zones, and support facilities in a manner that does not interfere with pedestrian movement.

At the primary study area level, mobility strategies are translated into the structuring of circulation routes, with emphasis on creating a hierarchy that distributes movement effectively. Congestion management involves the identification of potential bottlenecks and the introduction of spatial measures to reduce their impact. Land use strategies focus on regulating commercial activities along key routes, ensuring that they do not obstruct movement while still supporting the local economy.

Within the temple precinct, the translation of strategies becomes more detailed and precise. Mobility interventions involve the segregation of entry and exit flows,

optimization of route widths, and elimination of unnecessary obstructions. Congestion management is achieved through the creation of controlled movement systems and the introduction of spaces that can accommodate temporary accumulation of crowd without disrupting circulation. Land use regulation focuses on minimizing encroachments and clearly defining zones for different activities, ensuring that movement paths remain unobstructed.

The behavioural and management components of the framework are also adapted across scales. At the extended level, behavioural guidance may involve directional signage and information systems that guide visitors toward appropriate routes. At the primary level, these measures become more specific, providing clear navigation within the circulation network. Within the precinct, behavioural guidance is closely integrated with spatial design, using visual cues and spatial organization to influence movement patterns.

This layered translation ensures that the framework is not limited to a single scale of intervention but operates as a continuous system that manages crowd movement from the point of entry to the temple and back. It reinforces the idea that effective crowd management must address the entire journey of the visitor, rather than focusing solely on the final destination.

4.12 Synthesis of the Integrated Framework

The integration of strategies across spatial scales results in a comprehensive framework that addresses the complexity of crowd dynamics within the Banke Bihari Temple precinct. The framework functions as a coordinated system in which each component contributes to the overall objective of improving mobility, reducing congestion, enhancing safety, and optimizing spatial efficiency.

A key aspect of this synthesis is the recognition that the system must operate in a balanced manner, where no single component is overloaded. In the existing condition, excessive pressure is concentrated at specific nodes, particularly near the temple entrance, leading to system failure in the form of congestion and restricted movement. The framework seeks to redistribute this pressure across space and time, ensuring that the load is shared and managed more effectively.

Another important dimension of the synthesis is the alignment between spatial organization and behavioural patterns. The framework does not attempt to eliminate the inherent characteristics of religious crowds, such as grouping and stopping behaviour,

but instead accommodates them within a structured system. By providing designated spaces for these activities and guiding movement through spatial cues, the framework reduces the negative impact of behaviour on circulation efficiency.

The integration of management mechanisms further strengthens the framework by providing the tools necessary to regulate and monitor crowd conditions. However, the emphasis remains on supporting the spatial system rather than replacing it. Management is positioned as an enabling component that enhances the functioning of the system, rather than acting as a primary control mechanism.

The resulting framework is therefore not a rigid set of rules but a flexible and adaptive system that can respond to varying conditions. It is capable of accommodating daily fluctuations in crowd intensity as well as extreme conditions during festivals, without requiring fundamental changes in structure. This adaptability is essential for ensuring the long-term effectiveness of the framework.

4.13 Transition to Spatial Proposals

The planning framework developed in this chapter establishes a clear and logical basis for the formulation of spatial proposals in the subsequent chapter. It translates the findings of the analysis into a structured set of strategies that define how the precinct should function, how movement should be organized, and how activities should be regulated.

The next stage of the study involves the transformation of these strategies into specific spatial interventions that can be implemented within the study area. This includes the design of circulation networks, identification of intervention zones, organization of land use activities, and integration of management systems within the physical environment.

It is important to note that the proposals will not introduce entirely new systems but will build upon the existing structure of the precinct, enhancing and reorganizing it to improve efficiency and safety. The emphasis will be on minimal yet effective interventions that respect the historic and cultural context while addressing the functional requirements of crowd management.

The framework therefore serves as a guiding structure that ensures consistency and coherence in the proposal stage. It provides the criteria against which interventions can

be evaluated and ensures that all design decisions are aligned with the overall objectives of the study.

4.14 Chapter summary

This chapter establishes an integrated planning framework for crowd management in the Banke Bihari Temple precinct, grounded in a comprehensive understanding of spatial, behavioural, and management-related factors. By adopting a multi-scalar approach and structuring strategies across different levels of the system, the framework addresses the complexity of crowd dynamics in a systematic and coordinated manner.

The framework moves beyond conventional crowd control measures and emphasizes a planning-led approach that organizes space, guides movement, and regulates activities. It recognizes the limitations of the existing urban fabric and focuses on optimizing the use of available space rather than relying on expansion. At the same time, it incorporates behavioural and management dimensions to ensure that the system functions effectively under real-world conditions.

The integration of these components results in a flexible and adaptive system capable of responding to varying levels of demand while maintaining efficiency and safety. The framework provides a strong conceptual and strategic foundation for the development of spatial proposals, ensuring that the subsequent interventions are both logical and implementable.

CHAPTER 5

DESIGN PRINCIPLES AND INTERVENTION APPROACH

5.1 Introduction

The planning framework developed in the previous chapter establishes a comprehensive and integrated approach for addressing crowd management challenges within the Banke Bihari Temple precinct. It identifies the need to reorganize movement systems, regulate spatial use, and integrate behavioural and management mechanisms in order to improve overall efficiency, safety, and user experience. However, the framework in itself remains conceptual unless translated into specific design principles and intervention approaches that can guide the formulation of spatial proposals.

This chapter bridges that gap by converting the strategic directions identified in the framework into a set of planning and design principles that will inform the development of detailed interventions. These principles are not generic guidelines but are directly derived from the spatial, behavioural, and functional characteristics of the study area. They provide a consistent logic that ensures all proposed interventions are aligned with the objectives of the framework and are responsive to the constraints and opportunities of the precinct.

Given the historic and densely built nature of the Banke Bihari Temple precinct, the design approach must be both sensitive and precise. Unlike greenfield developments where large-scale restructuring is possible, the interventions in this context must operate within an already established urban fabric. This requires a focus on optimization rather than expansion, where the objective is to improve the efficiency of existing space through careful reorganization and minimal physical alteration.

The chapter therefore defines a set of design principles that address key aspects such as movement continuity, spatial hierarchy, activity segregation, safety, and inclusivity. These principles are subsequently translated into an intervention approach that categorizes and structures the types of actions required at different scales. Together, they form the basis for the proposal chapter, ensuring that all design decisions are grounded in a coherent and logically derived planning framework.

5.2 Conceptual Basis of Design Intervention

The design intervention approach adopted in this study is rooted in the understanding that spatial form, human behaviour, and functional activities are intrinsically linked within the temple precinct. The inefficiencies observed in the existing condition are not solely the result of inadequate infrastructure but emerge from the interaction between these elements. Therefore, the objective of design is not merely to modify physical space but to reorganize this interaction in a way that enhances system performance.

At the conceptual level, the intervention approach is guided by the principle of **spatial restructuring without displacement**, where the emphasis is on reconfiguring existing elements rather than introducing entirely new systems. This approach acknowledges the limitations imposed by the dense built fabric and the cultural sensitivity of the site, ensuring that interventions remain contextually appropriate and feasible.

Another important aspect of the conceptual basis is the recognition that movement within the precinct is not linear but dynamic and influenced by multiple factors. Unlike formal urban environments where circulation can be strictly controlled, the temple precinct requires a more adaptive approach that accommodates variability in movement patterns. The design interventions must therefore be flexible, allowing for fluctuations in crowd density and behaviour while maintaining overall system stability.

The approach also emphasizes the importance of **predictability in movement**, where the spatial environment provides clear cues that guide users intuitively. In the absence of such cues, pedestrians tend to rely on crowd behaviour, which often leads to unstructured movement and increased congestion. By introducing clarity in spatial organization and navigation, the design aims to reduce uncertainty and improve flow efficiency.

Furthermore, the intervention approach is based on the idea of **distributed pressure management**, where the objective is to prevent excessive concentration of crowd at specific nodes by distributing movement and activities across the precinct. This aligns with the findings of the analysis, which identified the temple entrance and adjacent streets as critical pressure points. By redistributing crowd load, the design reduces the likelihood of system failure and enhances overall safety.

The conceptual basis of the design intervention is therefore not focused on isolated improvements but on creating a cohesive system where space, movement, and activity

function in a coordinated manner. This ensures that the proposed interventions are not only effective in addressing current issues but are also capable of adapting to future variations in demand.

5.3 Principle of Movement Continuity

One of the most fundamental principles guiding the design interventions is the continuity of movement. The analysis of the precinct reveals that disruptions in pedestrian flow are a major contributor to congestion, as they create localized accumulations that propagate through the system. These disruptions are often caused by the overlap of movement and stationary activities, abrupt changes in direction, and the absence of clear circulation paths.

The principle of movement continuity aims to establish a circulation system where pedestrian flow is as uninterrupted as possible. This does not imply increasing speed but ensuring that movement remains consistent and predictable across different sections of the precinct. In a high-density environment, even minor interruptions can have significant impacts on overall flow, making continuity a critical factor in improving efficiency.

Achieving this continuity requires the careful organization of space to minimize conflicts between moving and stationary activities. Circulation routes must be clearly defined and maintained as dedicated movement corridors, free from obstructions and encroachments. At the same time, activities that require stopping, such as waiting or purchasing goods, must be accommodated in separate spaces that do not interfere with movement.

The principle also addresses the issue of directional conflict, where bidirectional movement within narrow streets creates friction and reduces flow efficiency. By guiding movement in a more organized manner and reducing unnecessary cross-movements, the design enhances the continuity of flow and reduces the likelihood of congestion.

Importantly, movement continuity is not achieved solely through physical design but also through behavioural guidance. The spatial environment must provide clear indications of direction and purpose, enabling users to navigate the precinct intuitively. This reduces hesitation and confusion, which are common causes of disruption in high-density conditions.

5.4 Principle of Spatial Hierarchy

The absence of a hierarchical circulation system in the existing condition is identified as a key factor contributing to inefficient movement and uneven distribution of crowd. In the current scenario, all streets function in a similar manner regardless of their capacity or importance, leading to situations where smaller गलियाँ are subjected to the same level of demand as relatively wider routes. This lack of differentiation results in overloading of certain paths and underutilization of others.

The principle of spatial hierarchy addresses this issue by organizing the circulation network into distinct levels based on their function and capacity. This hierarchy enables the distribution of pedestrian flow in a more controlled and efficient manner, ensuring that movement is directed along routes that are best suited to handle it.

At the highest level of the hierarchy are the primary movement corridors, which serve as the main access routes to the temple. These routes are designed to accommodate the highest volume of pedestrians and are therefore prioritized in terms of width, continuity, and obstruction-free movement. Secondary routes function as connectors that distribute movement from the primary corridors to different parts of the precinct, while tertiary routes provide localized access to specific areas.

The establishment of this hierarchy allows for a more organized circulation system, where each route performs a specific role within the network. This not only improves movement efficiency but also enhances the overall readability of the space, making it easier for users to navigate.

The principle of spatial hierarchy also extends to the organization of activities within the precinct. High-intensity activities are directed toward areas that can accommodate them without disrupting movement, while more sensitive or low-intensity activities are located in less congested zones. This alignment between movement and activity ensures that the system functions cohesively.

5.5 Principle of Activity Segregation

The interaction between stationary and moving activities is one of the primary causes of congestion within the precinct. The existing condition is characterized by a high degree of overlap between these activities, with commercial vending, waiting, and

social interactions occurring within circulation paths. This overlap reduces the effective width of streets and creates interruptions in movement, leading to inefficiencies and localized congestion.

The principle of activity segregation seeks to address this issue by clearly defining and separating spaces for different functions. Movement, being the primary requirement of the precinct, is given priority in terms of spatial allocation, ensuring that circulation routes remain unobstructed. Activities that involve stopping or gathering are relocated or reorganized in a manner that does not interfere with these routes.

This does not imply the removal of commercial or social activities, which are integral to the character of the precinct, but rather their reorganization within designated zones. By providing appropriate spaces for these activities, the design reduces their impact on movement while preserving their economic and cultural significance.

The segregation of activities also enhances safety by reducing conflicts between pedestrians engaged in different types of movement. In high-density conditions, such conflicts can lead to sudden disruptions and increase the risk of accidents. By organizing activities in a structured manner, the design creates a more stable and predictable environment.

5.6 Principle of Safety and Emergency Accessibility

Safety emerges as one of the most critical considerations in the design of the Banke Bihari Temple precinct, particularly in light of the high-density conditions and the potential risks associated with uncontrolled crowd movement. The analysis highlights that the existing spatial configuration, combined with limited accessibility and lack of organized circulation, creates conditions where emergency response becomes difficult and evacuation pathways are unclear or obstructed. In such an environment, even minor disturbances can escalate into critical situations due to the inability of the system to absorb or respond effectively to sudden changes in crowd behaviour.

The principle of safety is therefore embedded within the design approach as a fundamental requirement rather than an additional feature. It is addressed through the structuring of space in a manner that ensures both preventive and responsive capacity within the system. Preventive safety is achieved by maintaining crowd density within manageable limits through efficient circulation and distribution of movement, thereby reducing the likelihood of hazardous conditions developing. Responsive safety, on the

other hand, is ensured through the provision of accessible and unobstructed pathways that can facilitate emergency movement when required.

A key aspect of this principle is the incorporation of clear and continuous emergency access routes within the circulation network. These routes must remain free from encroachments and interruptions, allowing for the movement of emergency personnel and services even under high-density conditions. In addition, the design must ensure that these routes are easily identifiable and connected to key nodes within the precinct, enabling efficient response in case of emergencies.

The principle also considers the importance of visibility and spatial awareness in enhancing safety. In densely built environments, limited visibility can contribute to confusion and panic, particularly during peak conditions. By improving visual connectivity and providing clear spatial cues, the design enhances the ability of users to understand their surroundings and navigate safely.

Importantly, safety is not treated as a separate component but is integrated into all aspects of the design, including movement organization, activity distribution, and spatial hierarchy. This ensures that the system inherently supports safe functioning rather than relying solely on external control measures.

5.7 Principle of Inclusivity and Universal Accessibility

The existing conditions within the precinct reveal significant challenges for vulnerable user groups, including elderly individuals, children, and persons with disabilities. High crowd density, uneven movement patterns, and lack of dedicated infrastructure create barriers that limit their ability to navigate the space comfortably and safely. This raises critical concerns regarding inclusivity and equity, as the current environment does not adequately accommodate the needs of all users.

The principle of inclusivity addresses this gap by ensuring that the design interventions create an environment that is accessible and usable for a diverse range of users. This involves not only the provision of physical infrastructure but also the organization of space in a manner that reduces physical and psychological stress.

A central aspect of this principle is the creation of more predictable and less physically demanding movement conditions. By improving circulation efficiency and reducing congestion, the design inherently benefits vulnerable users, who are more affected by

high-density environments. In addition, the provision of designated spaces for rest and waiting allows users to navigate the precinct at their own pace without being forced into continuous movement.

Wayfinding and spatial clarity also play an important role in enhancing inclusivity. Clear and intuitive navigation reduces confusion and anxiety, particularly for first-time visitors or those who may find it difficult to interpret complex spatial environments. By providing easily understandable movement paths and minimizing abrupt changes in direction, the design creates a more user-friendly environment.

Inclusivity is therefore approached not as a set of isolated interventions but as an integral aspect of the overall design strategy, ensuring that improvements in mobility, safety, and organization benefit all users equally.

5.8 Principle of Minimal and Context-Sensitive Intervention

The Banke Bihari Temple precinct is characterized by a historic urban fabric that has evolved organically over time, reflecting cultural, religious, and socio-economic processes. This context imposes significant constraints on the nature of interventions that can be introduced, as large-scale physical restructuring may disrupt the existing character and functioning of the area.

The principle of minimal intervention acknowledges these constraints and emphasizes the need for design solutions that are both effective and sensitive to the existing context. Rather than introducing extensive physical changes, the focus is on optimizing the use of available space through reorganization and refinement of existing elements.

This approach is based on the understanding that many of the issues identified within the precinct arise not from a lack of space but from inefficient use of space. By reorganizing movement patterns, regulating activities, and improving spatial clarity, it is possible to achieve significant improvements without altering the fundamental structure of the precinct.

Context sensitivity also involves respecting the cultural and functional significance of the area. The temple precinct is not merely a physical space but a living environment that supports religious practices, social interactions, and economic activities. Interventions must therefore balance the need for improved efficiency with the preservation of these functions.

The principle ensures that the design remains grounded in the realities of the site, avoiding unrealistic or intrusive solutions and focusing instead on practical and implementable strategies.

5.9 Principle of Distributed Load and Decentralization

A key finding of the analysis is the excessive concentration of crowd at the temple entrance and along specific access routes, resulting from the highly centralized nature of movement within the precinct. This concentration creates critical pressure points where the capacity of the space is exceeded, leading to congestion and safety risks.

The principle of distributed load addresses this issue by promoting the decentralization of crowd movement and activity within the precinct. Rather than allowing all movement to converge directly toward a single node, the design introduces mechanisms that distribute crowd load across multiple routes and spaces.

This distribution is achieved through a combination of spatial organization and behavioural guidance, which together influence how pedestrians move and where they gather. By creating alternative pathways and intermediate spaces, the design reduces the intensity of convergence and allows the system to function more efficiently.

Decentralization does not imply reducing the importance of the temple as the central attractor but rather managing how movement approaches it. By controlling the flow of pedestrians and distributing their presence across space, the design reduces pressure on critical nodes while maintaining the overall functionality of the precinct.

This principle is particularly important in ensuring the stability of the system under peak conditions, as it prevents the formation of extreme density zones that can lead to system failure.

5.10 Transition to Intervention Approach

The design principles established in the preceding sections provide a conceptual and operational foundation for the development of spatial interventions within the Banke Bihari Temple precinct. They define how space should function, how movement should be organized, and how activities should be structured to achieve the objectives of improved mobility, reduced congestion, enhanced safety, and inclusive accessibility.

However, the realization of these principles requires their translation into specific and actionable interventions that can be implemented within the study area. This transition

from principle to intervention involves identifying the types of changes required, the scale at which they should be applied, and the manner in which they interact with each other.

The intervention approach adopted in this study is therefore structured to reflect the multi-scalar nature of the planning framework, ensuring that actions at different levels of the system are coordinated and mutually supportive. It categorizes interventions based on their function and impact, while maintaining a clear connection to the underlying principles.

The approach recognizes that effective transformation of the precinct cannot be achieved through a single type of intervention but requires a combination of spatial, functional, and management measures. These interventions must operate together to create a cohesive system, where each component reinforces the others and contributes to the overall performance of the precinct.

The following sections elaborate on the nature and structure of these interventions, outlining how the principles are translated into practical strategies that form the basis of the proposal.

5.11 Structuring of Intervention Approach

The translation of planning principles into actionable design requires a structured approach that defines not only what interventions are necessary but also how they interact within the overall system. The intervention approach developed in this study is therefore not conceived as a collection of isolated design solutions, but as a coordinated set of actions that collectively reorganize the functioning of the temple precinct.

The need for such structuring arises from the complexity of the issues identified in the analysis. Mobility inefficiencies, congestion, land use conflicts, and management limitations are deeply interconnected, and any intervention addressing one aspect inevitably influences others. For instance, improving circulation without regulating adjacent activities may not yield significant results, while controlling encroachments without reorganizing movement may lead to temporary improvements but not long-term efficiency. Recognizing this interdependence, the intervention approach is designed as an integrated system where different types of interventions operate simultaneously and reinforce each other.

At its core, the approach focuses on redefining the relationship between movement, space, and activity. The existing condition is characterized by an unstructured overlap of these elements, resulting in inefficiencies and conflicts. The intervention strategy aims to reorganize this relationship by assigning clear roles to different spaces, guiding movement through defined pathways, and regulating activities to ensure compatibility with circulation.

The structuring of interventions also reflects the principle of minimal yet effective change. Given the constraints of the historic urban fabric, the approach avoids large-scale physical modifications and instead emphasizes strategic adjustments that can produce significant improvements. These adjustments include the reallocation of space, reorganization of functions, and introduction of guiding elements that influence movement patterns.

5.12 Spatial Interventions and Reorganization of Circulation

Spatial interventions form the primary layer of the intervention approach, as the physical configuration of space directly influences movement behaviour and system performance. The objective of spatial intervention is not to redesign the precinct entirely but to reorganize its existing structure in a manner that enhances efficiency and reduces conflict.

The reorganization of circulation is central to this process. Based on the principle of spatial hierarchy, the intervention approach defines a network of routes with distinct functions, ensuring that pedestrian movement is distributed and guided rather than concentrated and unstructured. Primary routes are reinforced as the main channels of movement, with emphasis on maintaining continuity and minimizing obstructions. Secondary routes are structured to support distribution and provide alternative pathways, reducing dependency on a limited number of corridors.

Within the temple precinct, spatial interventions focus on optimizing the use of available width by eliminating unnecessary obstructions and reorganizing edges. The objective is to maximize effective movement space without requiring physical widening of streets, which may not be feasible. This is achieved through careful alignment of activities and removal or relocation of elements that disrupt flow.

The design also addresses critical nodes such as junctions and entry points, where movement patterns intersect and congestion is most likely to occur. These areas are

restructured to improve clarity of movement and reduce conflicts, ensuring smoother transitions between different parts of the network. By improving the functioning of these nodes, the intervention enhances the performance of the entire system.

In addition to circulation routes, spatial interventions include the identification and development of intermediate spaces that can support the overall functioning of the precinct. These spaces act as buffers that absorb crowd during peak periods, reducing direct pressure on movement corridors and critical nodes. Their integration within the circulation network ensures that they function as part of the system rather than as isolated elements.

5.13 Functional Interventions and Activity Organization

While spatial reorganization provides the physical framework for improved movement, the effectiveness of the system also depends on how activities are distributed within that space. The intervention approach therefore includes a set of functional strategies that regulate and organize activities in alignment with circulation requirements.

The primary objective of functional intervention is to eliminate conflicts between movement and stationary activities. In the existing condition, commercial vending, waiting, and social interactions frequently occur within circulation paths, leading to interruptions in flow and reduction in effective space. The intervention approach addresses this issue by defining clear zones for different functions, ensuring that activities are accommodated without obstructing movement.

Commercial activities, which are integral to the local economy and cultural environment, are reorganized rather than removed. The approach identifies appropriate locations where such activities can be concentrated, allowing them to function efficiently while minimizing their impact on circulation. This reorganization not only improves movement but also enhances the overall order and readability of the space.

The provision of designated spaces for waiting and gathering is another important aspect of functional intervention. In the absence of such spaces, these activities spill over into circulation routes, creating disruptions in movement. By allocating specific areas for these functions, the design reduces pressure on movement corridors and creates a more organized environment.

Functional interventions also consider the temporal variation in activities, recognizing that the intensity and nature of use change throughout the day and during different events. The organization of space is therefore designed to be flexible, allowing it to accommodate varying levels of activity without compromising overall efficiency.

5.14 Management and Regulatory Interventions

The effectiveness of spatial and functional interventions is significantly enhanced when supported by appropriate management and regulatory mechanisms. The intervention approach therefore incorporates a set of measures that guide and control the functioning of the system, ensuring that the intended organization of space and movement is maintained over time.

A key aspect of management intervention is the regulation of inflow into the precinct. As identified in the analysis, uncontrolled entry of pedestrians contributes to excessive crowd density and system overload. By introducing mechanisms to manage the rate of inflow, the approach aligns the number of visitors with the carrying capacity of the space, reducing the likelihood of congestion.

Management interventions also include the implementation of monitoring systems that provide real-time information on crowd conditions. While advanced technological solutions may not be fully feasible, the use of basic surveillance and observation systems can significantly improve the ability to respond to changing conditions. These systems enable authorities to identify emerging congestion points and take timely action to prevent escalation.

Another important dimension is the enforcement of spatial organization, particularly with respect to encroachments and activity zones. Without effective regulation, even well-designed spaces may revert to unstructured conditions. The intervention approach therefore emphasizes the need for consistent management practices that maintain the integrity of the spatial system.

Behavioural guidance is also integrated into management interventions, using signage, announcements, and visual cues to influence how people move and interact within the space. By improving clarity and reducing uncertainty, these measures enhance the effectiveness of spatial design and contribute to overall system stability.

5.15 Technological Support and Adaptive Systems

While the framework does not rely heavily on advanced technological infrastructure, it recognizes the potential of technology as a supporting tool in enhancing the effectiveness of crowd management. The intervention approach therefore incorporates scalable technological measures that can be integrated within the existing context.

These measures focus primarily on monitoring, information dissemination, and inflow regulation. Simple digital systems for managing entry, such as time-based access or queue management, can help distribute crowd over time and reduce peak pressure. Similarly, surveillance systems can provide valuable data on crowd density and movement patterns, enabling more informed decision-making.

The use of technology is approached in a pragmatic manner, ensuring that it complements rather than replaces spatial and management strategies. The emphasis remains on creating a robust physical system that can function independently, with technology acting as an enhancement that improves responsiveness and adaptability.

5.16 Multi-Scalar Application of Interventions

The intervention approach is closely aligned with the multi-scalar framework established in the previous chapter, ensuring that actions at different levels of the system are coordinated and mutually supportive. At the extended influence level, interventions focus on managing inflow and organizing entry points, reducing pressure on the inner areas. At the primary study area level, the emphasis is on structuring circulation and distributing movement across the network. Within the temple precinct, detailed spatial and functional interventions address high-density conditions and optimize the use of limited space.

This multi-scalar application ensures that the system functions cohesively, with each level supporting the others. It prevents the concentration of interventions within a single area and instead distributes them across the system, enhancing overall effectiveness.

5.17 Chapter summary

This chapter establishes a comprehensive set of design principles and intervention approaches that translate the planning framework into actionable strategies. By defining how space, movement, and activities should be organized, it provides a clear and consistent basis for the development of spatial proposals.

The intervention approach emphasizes integration, context sensitivity, and practicality, ensuring that proposed solutions are both effective and implementable within the constraints of the precinct. It recognizes the complexity of the system and addresses it through coordinated actions across multiple dimensions and scales.

The chapter therefore forms a critical link between the conceptual framework and the proposal stage, ensuring that the subsequent design interventions are grounded in a strong planning rationale. The next chapter builds upon this foundation to develop detailed proposals that operationalize these strategies within the study area.

CHAPTER 6

PROPOSAL: INTEGRATED CROWD AND MOBILITY MANAGEMENT PLAN

6.1 Introduction

The Banke Bihari Temple precinct functions as a high-intensity religious core within the urban structure of Vrindavan, attracting significant daily and peak-period footfall. The analysis conducted in earlier chapters establishes that the existing system is unable to accommodate the scale and variability of demand, resulting in severe congestion, inefficient movement, and compromised safety conditions. The primary issues arise from the uncontrolled inflow of visitors, lack of structured circulation, unregulated land use activities, and absence of a coordinated management framework.

The proposal developed in this chapter builds upon the integrated spatial–behavioural–technological framework established earlier and translates it into a set of implementable planning interventions. The approach focuses on reorganizing movement systems, regulating vehicular and pedestrian flows, optimizing the use of space, and introducing structured management mechanisms. The proposal is designed to operate across two spatial scales: the 3 km influence area, which governs vehicular movement and inflow, and the 1.2 km core precinct, where pedestrian circulation and crowd management are the primary focus.

A key objective of the proposal is to ensure that the system functions effectively under both normal and peak conditions. Unlike conventional approaches that address only extreme scenarios, the proposed system is designed to operate continuously, adapting to variations in crowd intensity while maintaining efficiency and safety. The interventions are therefore structured to regulate inflow, distribute movement, and prevent the formation of critical congestion points.

6.2 Overall Structure of the Proposed System

The proposed system is structured as a **controlled and phased movement network**, where vehicular and pedestrian flows are clearly separated and organized across different spatial levels. The core principle guiding this structure is the reduction of conflict between movement types and the regulation of crowd entry into the precinct.

At the city level (3 km influence area), vehicular movement is organized through a peripheral system of parking and controlled entry points. Visitors arriving by private vehicles, buses, or intermediate transport modes are intercepted before entering the congested core area. This reduces vehicular pressure within the precinct and ensures that the inner area functions primarily as a pedestrian zone.

Within the 1.2 km core area, movement is predominantly pedestrian-based, with a structured circulation system that guides visitors toward the temple through designated routes. The system incorporates holding areas, directional movement paths, and activity regulation zones to ensure smooth flow and prevent congestion buildup.

The integration of these two levels creates a layered system where inflow is controlled at the outer level and movement is organized at the inner level. This ensures that the pressure on the temple precinct is managed proactively rather than reactively.

6.3 Vehicular Circulation and Parking Strategy

The vehicular circulation strategy is designed to minimize the entry of vehicles into the core precinct and to manage traffic at the level of the 3 km influence area. The proposal introduces a system of peripheral parking nodes that intercept incoming vehicles and convert vehicular movement into pedestrian or intermediate transport-based movement before reaching the temple.

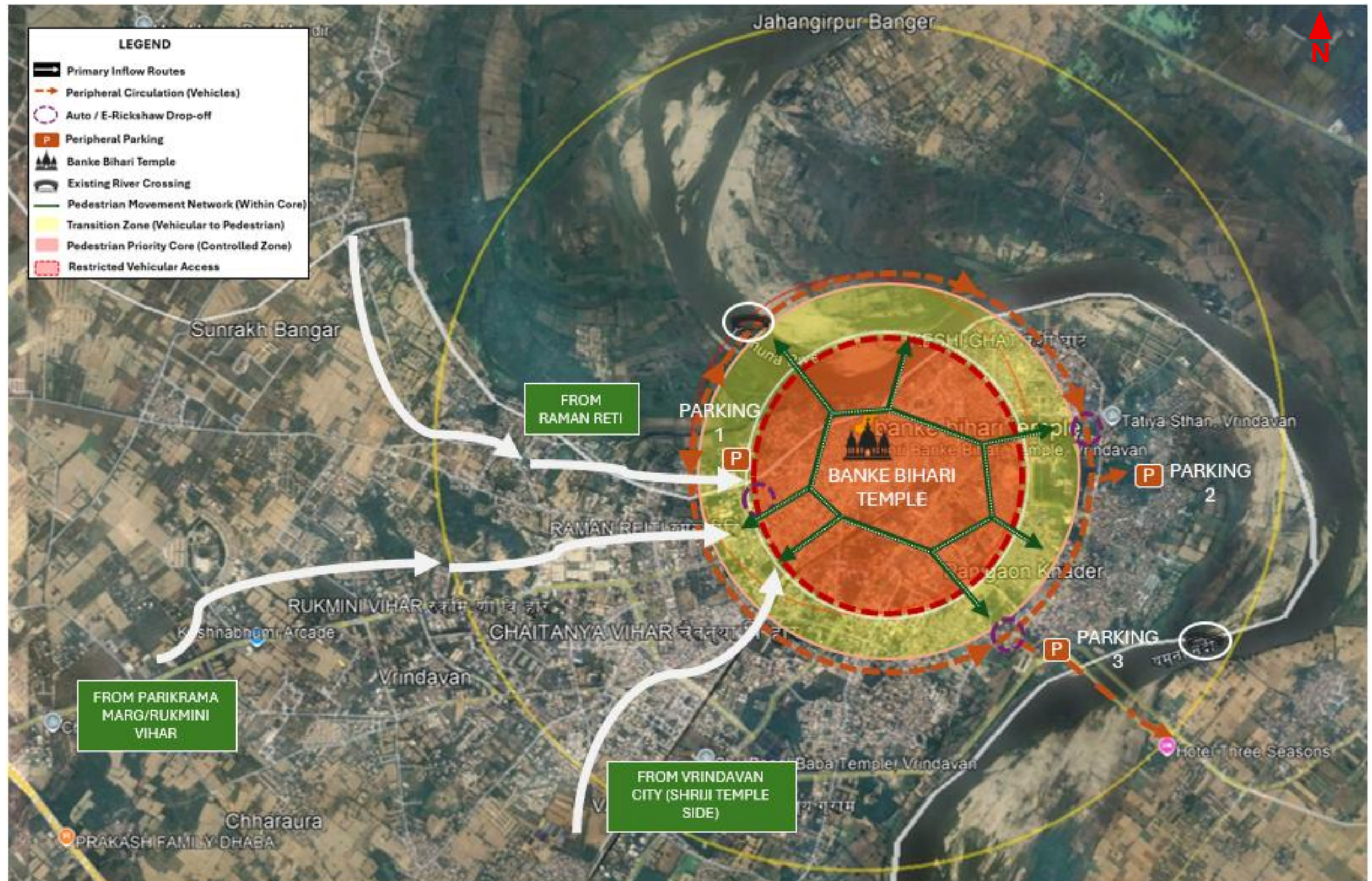


Figure 6.1: proposed vehicular circulation and access management map

Source: Author

The vehicular movement within the influence area is organized through designated routes that direct incoming traffic toward identified parking zones. Through traffic is diverted away from the core, ensuring that only essential and regulated movement occurs within the inner areas. This reduces congestion not only within the precinct but also along the approach roads leading to the temple.

The proposal identifies three major parking locations strategically distributed around the precinct, each designed to cater to a specific segment of incoming traffic. These parking nodes are located along major access routes, ensuring ease of access while preventing unnecessary penetration of vehicles into the core area, *Figure 6.1*.

Parking 1, located near Keli Kunj Vrindavan, has an available area of approximately 15,915 square meters. Based on standard planning norms, where an average car parking space including circulation requires approximately 25 square meters and a two-wheeler requires approximately 3 square meters, the site can accommodate a mixed parking capacity. Assuming a balanced allocation, this parking area can accommodate approximately 450–500 cars along with 1,000–1,200 two-wheelers. This parking node primarily serves visitors approaching from nearby local areas and acts as an initial interception point.

Parking 2, located near Bhanumati Road and in proximity to Shree Shree Uma Peeth, is the largest of the three sites, with an area of approximately 54,425 square meters. This site functions as the primary parking hub for the precinct. Based on the same planning standards, it has the capacity to accommodate approximately 1,800–2,000 cars, 3,000–3,500 two-wheelers, and designated spaces for approximately 150–200 buses. This parking node is intended to handle the bulk of incoming traffic, particularly during peak periods and festivals, where large volumes of visitors arrive simultaneously.

Parking 3, located near the Yamuna Expressway Road, covers an area of approximately 19,433 square meters. This site serves as a regional-level parking facility for visitors arriving from long-distance routes. It can accommodate approximately 600–700 cars, 1,200–1,500 two-wheelers, and a limited number of buses. Its location along a major access corridor allows for early interception of vehicles, reducing traffic load on inner roads.

The combined capacity of these three parking nodes ensures that a significant proportion of incoming vehicles can be accommodated outside the core precinct. This reduces vehicular congestion within the inner areas and enables the transformation of the precinct into a predominantly pedestrian environment.

6.4 Traffic Volume and Vehicular Load Estimation

The estimation of vehicular load is based on the observed footfall and typical mode share patterns in religious tourism contexts. On a normal day, the temple attracts approximately 30,000 to 50,000 visitors. Assuming that approximately 40% of visitors arrive by private vehicles and two-wheelers, the estimated vehicular load ranges between 8,000 to 10,000 vehicles per day, including cars, two-wheelers, and intermediate transport.

During peak days and festivals, when footfall reaches 1–2 lakh visitors or more, the vehicular load increases significantly. Under such conditions, the estimated number of vehicles can range between 20,000 to 25,000 per day. Without regulation, this level of traffic would overwhelm the existing road network and result in severe congestion.

The proposed parking system is designed to absorb this load by distributing vehicles across multiple nodes. During normal conditions, Parking 1 and Parking 3 handle a majority of local and regional traffic, while Parking 2 operates at moderate capacity. During peak conditions, Parking 2 functions as the primary hub, with additional load distributed to the other parking areas.

The introduction of this structured parking system reduces the need for vehicles to circulate within the precinct in search of parking, thereby reducing unnecessary traffic movement and improving overall efficiency.

6.5 Transition from Vehicular to Pedestrian Movement

A critical component of the proposal is the transition from vehicular to pedestrian movement, which occurs at the parking nodes and designated entry points to the core precinct. This transition is essential for reducing congestion within the inner area and ensuring that the precinct functions as a safe and efficient pedestrian environment.

Visitors arriving at parking areas are directed toward designated pedestrian routes or intermediate transport systems such as e-rickshaws or shuttle services, depending on

the distance from the temple. This structured transition ensures that movement toward the temple is organized and controlled, rather than random and unregulated.

The design of entry points into the pedestrian zone is therefore crucial, as these locations act as filters that regulate inflow. By controlling the rate at which pedestrians enter the core area, the system prevents excessive accumulation within the precinct and maintains manageable density levels.

6.6 Pedestrian Circulation and Crowd Management Strategy

Following the regulation of vehicular inflow at the city level, the inner precinct is structured as a **pedestrian-priority zone**, ensuring that the movement system within the 1.2 km core operates efficiently under high-density conditions, *Figure 6.2*. The proposal establishes a controlled pedestrian network that guides visitors toward the temple through organized and segregated routes, thereby reducing conflicts, improving flow continuity, and enhancing safety.

The core area within a radius of approximately 300–400 meters from the temple is designated as a **car-free pedestrian priority zone**. This zone accommodates the highest concentration of movement and is therefore designed to support high-capacity pedestrian flow through clearly defined corridors.

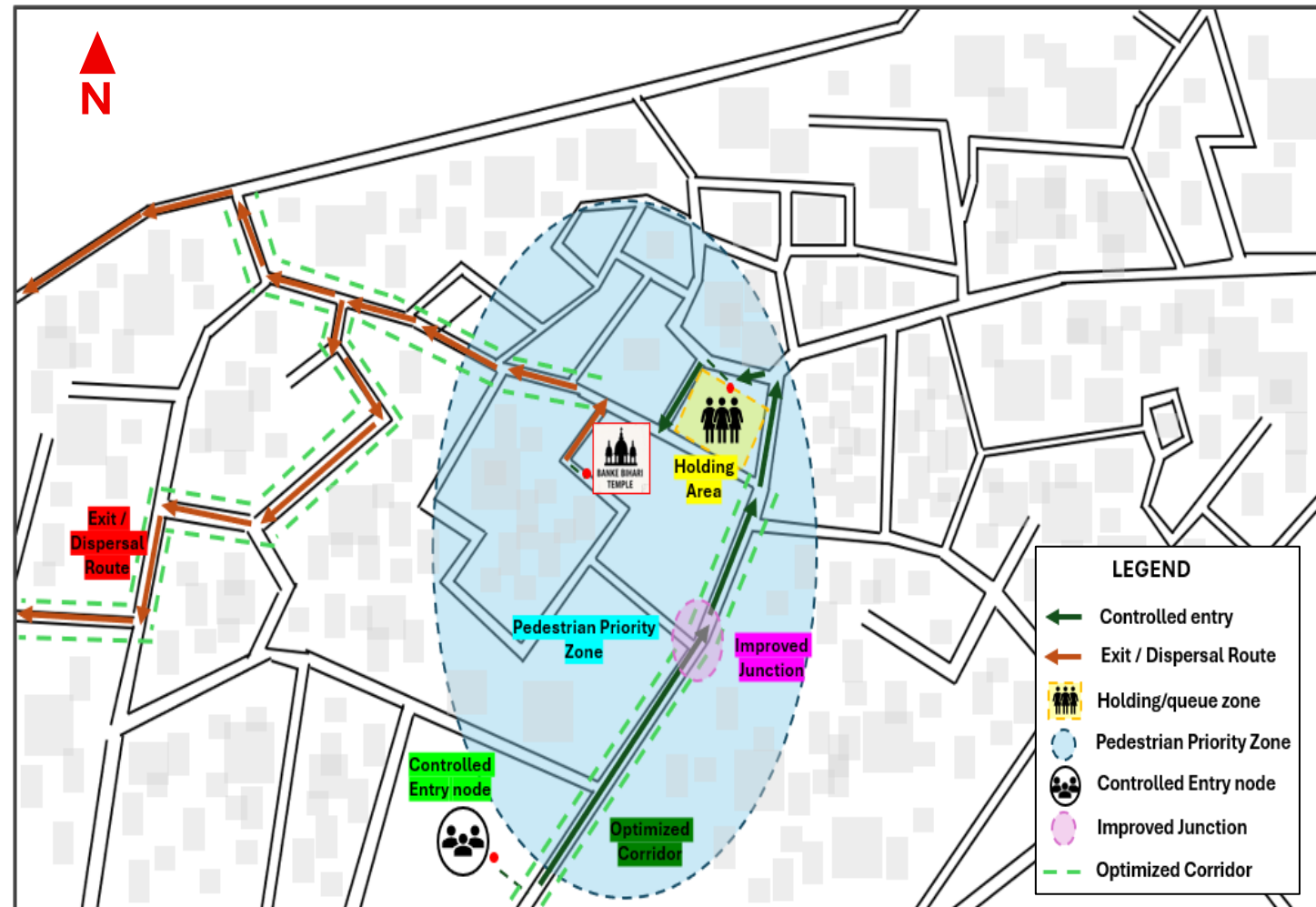


Figure 6.2: Pedestrian Circulation and Crowd Flow Management Plan

Source: Author

The circulation system follows a **radial movement pattern**, where pedestrians approach the temple from multiple directions but are guided through structured entry routes. These routes are further organized into **entry and exit paths**, ensuring that opposing flows do not intersect within critical areas. This segregation significantly reduces friction between pedestrians and improves overall movement efficiency.

The primary pedestrian corridors within the precinct are designed with an effective width ranging between 6 to 10 meters, as indicated in your proposal sheet. Based on standard pedestrian flow capacity, such corridors can accommodate approximately 6,000 to 10,000 persons per hour under controlled conditions. This capacity ensures that the system can handle both normal and peak inflow scenarios without resulting in excessive congestion.

6.7 Pedestrian Volume Estimation

The estimation of pedestrian load is based on observed footfall patterns presented in earlier chapters. On a normal day, the temple receives approximately 30,000 to 50,000 visitors. Assuming that these visitors are distributed over an active period of 8 to 10 hours, the average pedestrian inflow can be estimated at approximately 3,000 to 5,000 persons per hour.

During peak periods such as weekends and festivals, the footfall increases significantly, reaching approximately 1–2 lakh visitors per day, and in extreme cases up to 4–5 lakh. Under such conditions, peak hourly inflow may reach approximately 15,000 to 25,000 persons per hour, depending on the intensity of the event.

The existing system is unable to handle such volumes due to lack of structured circulation and insufficient space. The proposed system, however, distributes this load across multiple corridors and incorporates holding mechanisms, ensuring that the effective density within the core remains within manageable limits.

6.8 Holding Area Planning and Capacity Quantification

One of the most critical components of the proposal is the introduction of a holding area near Banke Bihari Gate 2, with an available area of approximately 1,853 square meters. This space functions as a controlled buffer zone where crowd can be temporarily accommodated before entering the temple, thereby preventing excessive accumulation within the core area.

The capacity of the holding area is calculated based on standard crowd density norms. For standing crowds in religious contexts, a space requirement of 0.5 to 0.75 square meters per person is considered appropriate, depending on the level of comfort and crowd intensity.

Based on this standard:

- At 0.75 sqm/person (moderate density) → capacity $\approx$ 2,400 persons
- At 0.5 sqm/person (high-density condition) → capacity $\approx$ 3,700 persons

This indicates that the holding area can accommodate approximately 2,500 to 3,500 persons at a time, depending on crowd conditions.

This is slightly more precise than your sheet estimate (3,000–5,000) , and you can confidently defend this in viva as scientifically derived.

The role of this holding area is not merely to store crowd but to regulate inflow into the temple in a controlled manner. Visitors are released in batches based on the available capacity within the temple and surrounding circulation space. This ensures that the internal density does not exceed safe limits, thereby reducing the risk of congestion and crowd-related hazards.

6.9 Queue Management and Controlled Entry System

The proposal incorporates a structured queue management system integrated with the holding area and entry nodes. The queue system is designed in a zig-zag configuration, allowing for efficient use of space while accommodating large numbers of people.

The queue system serves multiple functions. It organizes waiting crowd in a controlled manner, reduces random movement, and distributes waiting time more evenly. By providing shaded pathways and clearly defined routes, the system enhances comfort and reduces stress among visitors.

Controlled entry nodes, as shown in the map, are equipped with basic regulation mechanisms such as barricading, security checks, and flow control gates. These nodes act as checkpoints where the rate of inflow is adjusted based on real-time crowd conditions. The number of entry nodes, typically 3 to 4, ensures that inflow is distributed rather than concentrated at a single point.

Exit routes are designed separately from entry paths, ensuring that outgoing movement does not interfere with incoming flow. These routes are aligned with major dispersal corridors, enabling rapid evacuation and reducing congestion within the core.

6.10 Operational Dynamics under Normal and Peak Conditions

The proposed system is designed not as a static spatial arrangement but as a dynamic operational framework that responds to variations in crowd intensity. The distinction between normal day and peak day scenarios is therefore not merely representational but reflects a fundamental shift in how the system functions. While the physical infrastructure remains constant, the mode of operation changes in response to demand, ensuring both efficiency and safety across different conditions.

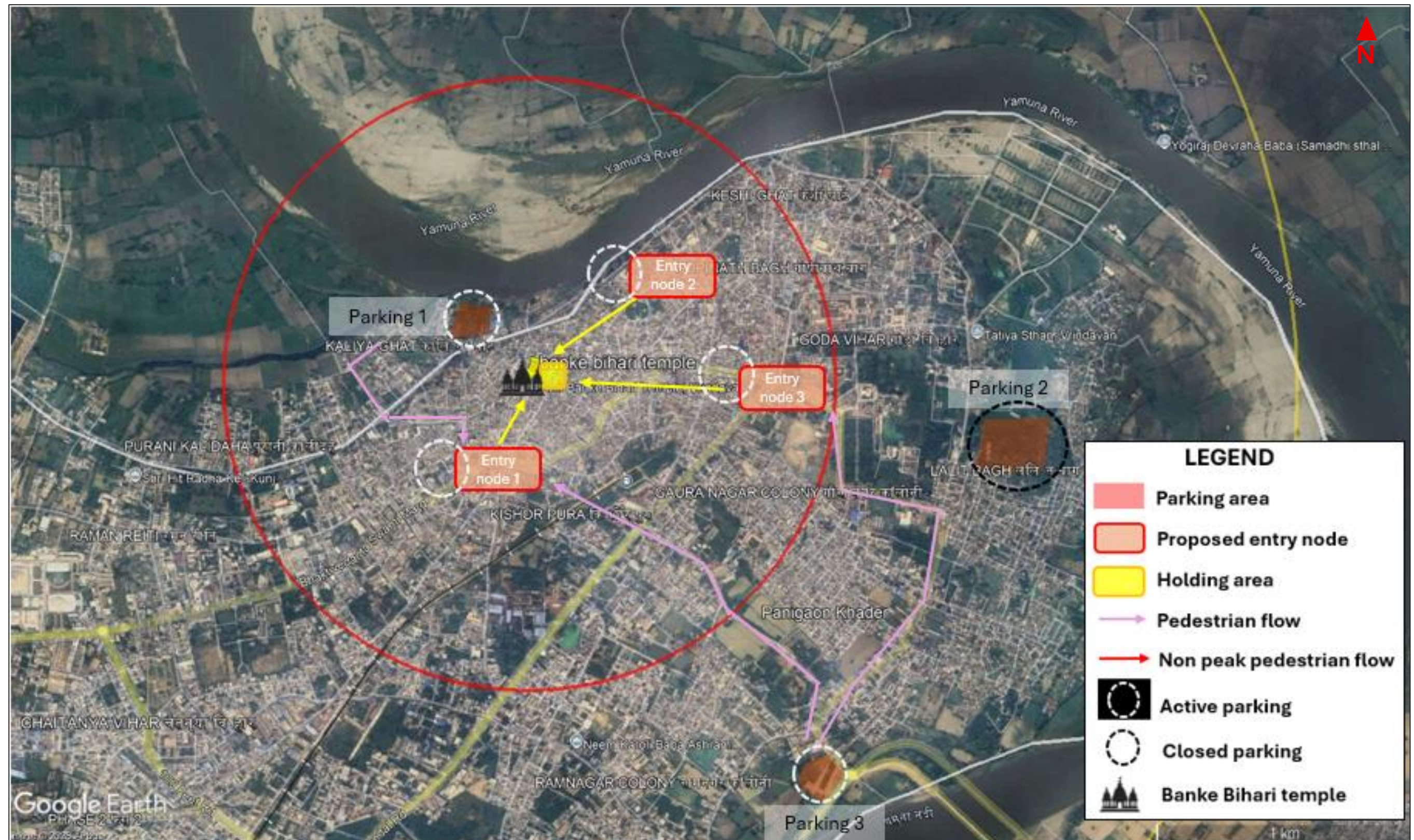


Figure 6.3: Pedestrian and Vehicular System – Normal Day Scenario

Source: Author

Under normal day conditions, the inflow of visitors remains within the carrying capacity of the precinct, allowing the system to function in a largely open and self-regulating manner. As illustrated in the normal day map, all three proposed entry nodes operate without strict control, enabling distributed access into the pedestrian priority zone. The absence of rigid entry regulation reduces delays and allows visitors to move through multiple routes based on convenience.

The pedestrian flow under this condition is characterized by a dispersed pattern, with movement distributed across primary and secondary corridors. The flow arrows shown in the map indicate a multi-directional but organized movement toward the temple, supported by adequate corridor widths ranging between 6 to 10 meters, *Figure 6.3*. Based on standard pedestrian flow capacity, these corridors are capable of accommodating approximately 6,000 to 8,000 persons per hour collectively without reaching critical density levels.

The holding area, located near the primary entry node, remains largely inactive under normal conditions. With a total area of 1,853 square meters, it functions in a standby mode, accommodating only minor fluctuations in inflow. At a moderate density of 0.75 square meters per person, the holding area can comfortably accommodate approximately 2,400 persons, though under normal conditions its occupancy is typically limited to less than 30–40% of this capacity.

Vehicular movement during this scenario is also relatively stable. Parking facilities operate at partial capacity, with Parking 1 and Parking 3 catering primarily to local and regional visitors, while Parking 2 remains underutilized. The estimated vehicular load during normal days, approximately 8,000 to 10,000 vehicles per day, is effectively distributed across these parking nodes, preventing congestion along access routes.

The overall system under normal conditions therefore operates with minimal intervention, relying on spatial organization and distributed movement patterns to maintain efficiency. The pedestrian density within the core remains within the comfortable range of 2 to 3 persons per square meter, ensuring a smooth and safe experience for visitors.



Figure 6.4: Pedestrian and Vehicular System – Peak Day / Festival Scenario

Source: Author

In contrast, the peak day scenario represents a high-stress condition where the system must operate under significantly increased demand. As illustrated in the peak day map, the mode of operation shifts from open access to controlled movement, with strict regulation of inflow and redistribution of crowd within the precinct, *Figure 6.4*.

The total footfall during peak periods may range between 1.5 to 2 lakh visitors per day, with peak hourly inflow reaching approximately 20,000 to 25,000 persons. Under such conditions, unrestricted entry would result in rapid overcrowding within the core. To prevent this, the proposed system activates controlled entry mechanisms at all designated entry nodes.

Each entry node functions as a regulated checkpoint where the rate of pedestrian inflow is adjusted based on real-time conditions within the precinct. The introduction of controlled entry reduces the effective inflow rate to manageable levels, typically between 8,000 to 10,000 persons per hour, ensuring that the internal density does not exceed safe limits.

The holding area plays a critical role in this scenario. Operating at full capacity, it accommodates approximately 2,500 to 3,500 persons at any given time, depending on crowd density. The use of a zig-zag queue system within the holding area allows for efficient utilization of space while maintaining order and reducing congestion. Visitors are released in batches of approximately 300 to 500 persons at intervals of 5 to 10 minutes, ensuring a steady and controlled flow into the temple.

Pedestrian movement within the core becomes more structured and directional under peak conditions. The map illustrates clearly defined one-way movement corridors, which eliminate cross-flow conflicts and improve overall efficiency. Entry and exit routes are strictly segregated, with exit routes aligned along peripheral corridors to facilitate rapid dispersal.

Vehicular management also becomes more stringent during peak periods. All three parking nodes operate at or near full capacity, accommodating an estimated 20,000 to 25,000 vehicles per day. Parking 2 functions as the primary hub, handling the majority of incoming traffic, while Parking 1 and Parking 3 serve as supplementary facilities. The activation of these parking nodes ensures that vehicular movement is contained within the outer area, preventing congestion within the core precinct.

The pedestrian-only zone is strictly enforced during peak conditions, eliminating all vehicular interference and allowing for maximum utilization of available space for movement. Despite the high density, which may reach up to 4 to 5 persons per square meter, the system remains stable due to controlled inflow and structured circulation.

6.11 System Efficiency and Capacity Justification

The effectiveness of the proposed system can be evaluated in terms of its ability to balance demand and capacity across different conditions. The introduction of multiple entry nodes distributes inflow, reducing pressure on individual access points. The combined capacity of primary pedestrian corridors ensures that the system can accommodate high volumes of movement without reaching critical thresholds.

The holding area acts as a buffer that absorbs excess demand, preventing sudden spikes in density within the core. Its capacity, derived from spatial calculations, aligns with the required holding volume for peak conditions, ensuring that the system remains within safe operational limits.

The integration of parking facilities at the outer level reduces vehicular congestion and supports the transition to a pedestrian-dominated environment. The combined parking capacity, exceeding 3,000 cars and several thousand two-wheelers, is sufficient to accommodate the majority of incoming vehicles, reducing the need for on-street parking and associated conflicts.

Overall, the system demonstrates a high level of efficiency, with each component contributing to the regulation and distribution of movement. The adaptability of the system across different scenarios ensures that it remains functional and safe under varying conditions.

6.12 Junction Improvement and Micro-Level Flow Optimization

The efficiency of the proposed circulation system is significantly dependent on the performance of critical junctions within the precinct. As identified in the analysis, these junctions currently function as points of conflict where multiple pedestrian streams intersect without any defined hierarchy or directional guidance. This results in localized congestion, reduced flow efficiency, and increased risk under high-density conditions.

The proposal addresses these issues through targeted micro-level interventions that reorganize movement at these nodes. Rather than large-scale physical reconstruction,

which is not feasible within the dense urban fabric, the approach focuses on functional widening and directional structuring of junction spaces.



Figure 6.5: Junction Improvement Plan and Critical Nodes

Source: Author

The identified junctions, as shown in the map, are located along primary approach corridors leading to the temple. These include intersections near the proposed entry nodes and points where multiple streets converge. At these locations, the effective width available for movement is often reduced due to encroachments, informal vending, and irregular built edges.

The first level of intervention involves the removal and regulation of edge obstructions, including temporary encroachments and informal extensions of commercial activities. This increases the effective movement width without requiring structural demolition. Even an increase of 1 to 1.5 meters in effective width at critical points can enhance pedestrian capacity by approximately 20–30%, significantly improving flow conditions, *Figure 6.5*.

The second level of intervention focuses on directional segregation within junctions. Using surface markings, signage, and temporary barriers, movement streams are guided along defined paths, reducing cross-flow conflicts. For instance, incoming and outgoing pedestrians are directed along separate sides of the junction, ensuring smoother transitions and reducing friction.

The third component involves visual clarity and wayfinding, where clear signage is introduced to indicate direction toward entry nodes, holding areas, and exit routes. In high-density environments, the absence of clear directional cues often leads to hesitation and erratic movement, which contributes to congestion. By improving legibility of space, the proposal enhances the predictability of movement patterns.

In peak conditions, these junctions may be further regulated through the deployment of personnel and temporary barricading to enforce directional flow. The combination of spatial reorganization and operational control ensures that these nodes do not become bottlenecks within the system.

6.13 Emergency Evacuation Strategy and Risk Mitigation

Given the high-density nature of the temple precinct, the incorporation of an effective evacuation strategy is essential to ensure safety under emergency conditions. The evacuation plan is designed as an extension of the circulation system, ensuring that movement during emergencies follows familiar routes and does not require abrupt changes in behaviour.



Figure 6.6: Emergency Evacuation and Assembly Plan

Source: Author

The evacuation system is structured around three key components: clear exit routes, distributed evacuation paths, and designated assembly areas. The primary exit routes are aligned with the main pedestrian corridors identified in the proposal, ensuring that they remain unobstructed and capable of handling high volumes of movement, *Figure 6.6*.

The total evacuation capacity of the system is derived from the width and number of available exit routes. Assuming an average corridor width of 6 meters and a pedestrian flow rate of approximately 82 persons per meter width per minute under emergency conditions, a single corridor can accommodate approximately 490 persons per minute. With at least three major exit corridors, the system is capable of evacuating approximately 1,400 to 1,500 persons per minute.

Under peak conditions, where the core precinct may accommodate approximately 15,000 to 20,000 persons at a given time, the total evacuation time can be estimated at approximately 15 to 20 minutes, which falls within acceptable safety thresholds for high-density environments.

The proposal also introduces distributed evacuation paths, ensuring that crowd is not directed toward a single exit point. This reduces pressure on individual routes and prevents the formation of bottlenecks during evacuation.

Assembly areas are identified outside the high-density core, in locations that are accessible yet sufficiently removed from congestion zones. These areas are designed to accommodate evacuated crowd safely and are connected to the primary road network for further dispersal. Based on standard space requirements of approximately 1 square meter per person for temporary assembly, an area of 5,000 to 10,000 square meters is sufficient to accommodate the expected evacuation load.

The integration of evacuation routes within the regular circulation network ensures familiarity, reducing panic and confusion during emergency situations. In addition, the proposal recommends the use of public announcement systems and real-time monitoring to guide evacuation and provide instructions to crowd.

6.14 Phased Implementation Strategy

The implementation of the proposed system is structured in a phased manner to ensure feasibility, adaptability, and minimal disruption to existing activities. Given the

complexity of the precinct and the involvement of multiple stakeholders, a gradual approach is necessary to achieve effective transformation.

The short-term phase (0–1 year) focuses on immediate and low-cost interventions that can establish basic control over movement. This includes the demarcation of pedestrian routes, installation of signage, identification and marking of entry nodes, and initial regulation of encroachments. Temporary barricades and deployment of personnel are used to guide movement and test the effectiveness of proposed circulation patterns. This phase requires minimal investment and can be implemented using existing administrative resources.

The medium-term phase (1–3 years) involves the development of key infrastructure components, including the formalization of holding areas, improvement of junctions, and strengthening of parking facilities. This phase also includes the introduction of basic monitoring systems, such as CCTV cameras and communication networks, to support real-time management. Coordination between municipal authorities, traffic police, and temple management is formalized during this phase, ensuring a structured approach to operation.

The long-term phase (3–5 years) focuses on the consolidation and enhancement of the system through permanent infrastructure improvements and integration with broader urban planning initiatives. This may include the development of dedicated pedestrian corridors, advanced crowd monitoring systems, and improved connectivity between parking nodes and the core precinct. The objective of this phase is to ensure long-term sustainability and resilience of the system

6.15 Institutional Framework and Operational Management

The successful functioning of the proposed system depends on effective coordination between multiple stakeholders. The institutional framework is therefore designed to clearly define roles and responsibilities, ensuring that each component of the system is managed efficiently.

The municipal authority is responsible for infrastructure development, maintenance of public spaces, and regulation of land use activities, including control of encroachments. The traffic police are responsible for managing vehicular movement within the influence area, enforcing parking regulations, and controlling entry points during peak periods.

The temple management plays a central role in regulating internal operations, including the functioning of holding areas, queue systems, and entry control mechanisms. Their coordination with local authorities is critical for ensuring smooth operation during high-demand periods.

In addition, the proposal recommends the establishment of a centralized control unit that operates during peak periods. This unit is responsible for monitoring crowd conditions, coordinating between different agencies, and implementing real-time control measures. The use of CCTV systems and communication networks enables this unit to respond quickly to changing conditions and prevent the escalation of congestion.

The operational framework also includes the deployment of trained personnel at key locations, including entry nodes, junctions, and holding areas. These personnel play a crucial role in guiding movement, providing information, and ensuring compliance with regulations.

6.16 Implementing Agencies and Operational Framework

The implementation of the proposed integrated crowd and mobility management system for the Banke Bihari Temple precinct requires a coordinated and multi-institutional approach. Given the complexity of the precinct and the involvement of multiple functional domains such as traffic management, infrastructure provision, crowd regulation, and emergency response, it is essential to clearly define the roles and responsibilities of different agencies. The Municipal Corporation of Vrindavan–Mathura plays a primary role in the development and maintenance of physical infrastructure, including streets, holding areas, public amenities, and regulation of vending activities. The Traffic Police Department is responsible for managing vehicular circulation within the 3 km influence area, enforcing parking regulations, and implementing diversion strategies during peak periods.

The temple management authority functions as a central stakeholder within the core precinct, overseeing internal crowd regulation, queue management systems, and darshan scheduling mechanisms. In addition, the district administration plays a crucial coordinating role, particularly during festivals and peak events, ensuring inter-agency collaboration and overseeing disaster management protocols. Supporting agencies such as the urban development authority, health department, and IT or smart city units contribute to planning approvals, medical preparedness, and technological integration

respectively. To ensure effective coordination among all stakeholders, the proposal recommends the establishment of a centralized command and control unit, which monitors real-time conditions and facilitates communication between agencies. This integrated operational structure ensures that crowd management is proactive, coordinated, and responsive to changing conditions.

6.17 Design of Holding Areas and Support Spaces

The provision of holding areas forms a critical component of the proposed crowd management system, functioning as controlled buffer spaces that regulate pedestrian inflow into the temple precinct. These spaces are strategically located near major entry nodes, particularly in proximity to Gate 2, where crowd pressure is highest. The holding area is designed to accommodate a large number of visitors in an organized and structured manner before they are allowed to proceed toward the temple. The spatial configuration follows a zig-zag queue system, which optimizes space utilization while maintaining order and flow continuity. Based on standard density norms, the holding area is capable of accommodating approximately 2,500 to 3,500 persons at a time, *Table 6.2*, depending on the level of crowd intensity, *Figure 6.7*.

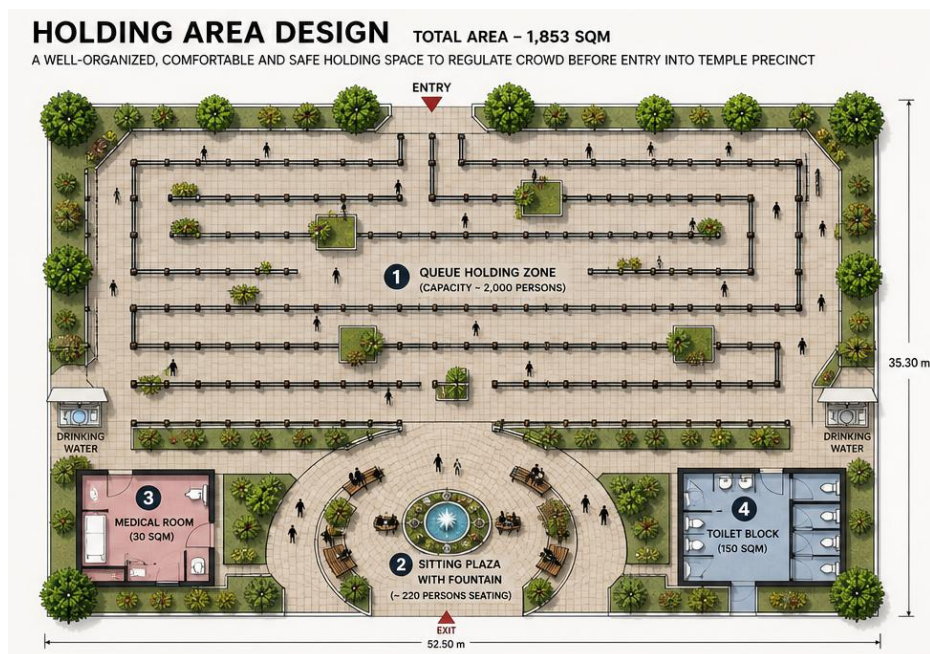


Figure 6.7: Holding Area
Source: Author

Table 6.1: Area Distribution Table

S. No.	Zone	Area (sqm)	% of Total Area
1	Queue Holding Zone	1,103	59.5%
2	Sitting Plaza with Fountain	407	22.0%
3	Medical Room (First Aid)	30	1.6%
4	Toilet Block (Male/Female)	150	8.1%
5	Drinking Water / Support Space	163	8.8%
	Total	1,853	100%

Source: Author

Table 6.2: Capacity Calculation Table

Parameter	Details
Queue Holding Zone Area	1,103 sqm
Assumed Density	0.5 – 0.6 sqm/person
Queue Holding Capacity	1,800 – 2,200 persons
Additional Capacity (Plaza + Circulation)	700 – 1,300 persons
Total Holding Capacity	2,500 – 3,500 persons

Source: Author

In addition to its functional role in regulating movement, the holding area incorporates a fountain-based waiting plaza that enhances user comfort and reduces psychological stress. The inclusion of a central fountain or mist feature creates a cooling microclimate, which is particularly beneficial in high-density conditions and during warm weather. Surrounding this feature, seating edges and shaded areas are provided, allowing visitors

to rest while waiting. This design intervention helps in reducing crowd agitation and discourages aggressive movement behavior, thereby contributing to overall safety and comfort.

The holding area is further supported by essential facilities such as a medical room, drinking water points, and sanitation infrastructure. The medical room, located adjacent to the main holding zone, is designed as a compact but fully functional first-aid facility capable of handling minor injuries, fatigue-related issues, and emergency situations. With an approximate area of 20 to 30 square meters *Table 6.1*, it is equipped with basic medical supplies and can accommodate a small number of patients at a time. The integration of these support facilities ensures that the holding area functions not only as a crowd control mechanism but also as a humane and user-oriented space within the precinct.

6.18 Use of Technology in Crowd Management

Technology plays a supportive yet significant role in enhancing the efficiency and responsiveness of the proposed crowd management system. The integration of surveillance, communication, and information systems enables real-time monitoring and proactive decision-making, which is essential in high-density environments such as the temple precinct. A network of CCTV cameras is proposed at strategic locations, including entry nodes, holding areas, major junctions, and the temple entrance. These cameras provide continuous visual data on crowd density and movement patterns, allowing authorities to identify congestion hotspots and take timely action.

All surveillance data is integrated into a centralized control room, which functions as the operational hub of the system. This control unit monitors live feeds, analyzes crowd conditions, and coordinates responses across different agencies. In addition to surveillance, a public announcement system is installed throughout the precinct to guide visitors, provide instructions, and manage crowd behavior during both normal and emergency conditions. These announcements play a crucial role in reducing confusion and improving compliance with movement regulations.

The proposal also incorporates digital and smart solutions such as dynamic signage and optional time-slot-based entry systems. Digital display boards placed at key locations provide information on waiting times, crowd conditions, and alternate routes, enabling visitors to make informed decisions. In peak scenarios, a controlled entry system based

on tokens or digital passes can be implemented to regulate inflow and prevent overcrowding. Furthermore, emergency communication systems, including alarm points and direct links to the control room, enhance the system's ability to respond quickly to critical situations. The integration of these technological measures ensures that the overall system is not only efficient but also adaptive and resilient under varying crowd conditions.

6.19 Overall System Feasibility and Planning Justification

The proposed system is grounded in realistic and implementable strategies that respond directly to the challenges identified in the analysis. By focusing on the reorganization of existing space rather than large-scale physical restructuring, the proposal ensures that interventions are feasible within the constraints of the precinct.

The integration of vehicular management, pedestrian circulation, holding areas, and evacuation planning creates a comprehensive system that addresses both functional and safety requirements. The use of quantifiable measures, including capacity calculations and flow estimates, provides a strong basis for evaluating the effectiveness of the proposal.

The phased implementation strategy ensures that the system can be developed gradually, allowing for adaptation and refinement over time. The clear definition of institutional roles further strengthens the feasibility of the proposal, ensuring that it can be effectively managed and sustained.

Overall, the proposal represents a balanced and integrated approach to crowd and mobility management, combining spatial planning, operational control, and behavioural guidance to create a system that is efficient, safe, and adaptable.

CHAPTER 7

CONCLUSION

7.1 Summary of the Study

This study was undertaken to address the complex challenges of crowd and mobility management within the Banke Bihari Temple precinct in Vrindavan, a high-density religious environment characterized by intense and fluctuating pedestrian activity. The analysis revealed that the existing conditions within the precinct are marked by unstructured movement patterns, overlapping activities, limited effective street width, and inadequate management systems, all of which contribute to recurring congestion and compromised safety, particularly during peak periods.

The study approached these challenges from a planning perspective, recognizing that crowd management in such contexts cannot be addressed solely through operational measures but requires a structured spatial and systemic response. The research was therefore conducted across multiple scales, encompassing a 3 km influence area to understand inflow dynamics and a 1.2 km core precinct to analyze detailed movement patterns and spatial constraints.

Through a combination of spatial analysis, behavioural observation, and system-level assessment, the study identified key issues related to mobility inefficiency, congestion concentration, land use conflicts, and lack of coordinated management. These findings formed the basis for the development of an integrated planning framework, which guided the formulation of the final proposal.

7.2 Key Contributions of the Proposal

The proposal developed in this study presents a comprehensive and multi-scalar approach to crowd and mobility management, integrating spatial planning, functional organization, and operational control. A key contribution of the proposal lies in its ability to reorganize the existing system without requiring large-scale physical transformation, making it both practical and context-sensitive.

At the city level, the introduction of a structured vehicular circulation system and peripheral parking strategy effectively reduces traffic pressure within the core precinct. By intercepting vehicles at strategic locations and facilitating a transition to pedestrian movement, the proposal addresses one of the primary causes of congestion.

Within the core precinct, the establishment of a pedestrian priority zone and a hierarchical circulation network significantly improves movement efficiency. The segregation of entry and exit routes, combined with the organization of activities and removal of obstructions, ensures a more predictable and stable flow of pedestrians.

The incorporation of a holding area and controlled entry system represents a critical intervention for managing peak conditions. By regulating inflow and distributing crowd over time, the proposal prevents excessive accumulation within the temple core and enhances overall safety. The quantification of capacities and flow rates further strengthens the proposal by providing a measurable basis for evaluating system performance.

Another significant contribution is the differentiation between normal and peak operational scenarios. By demonstrating how the same spatial system adapts to varying levels of demand, the proposal highlights its flexibility and resilience, ensuring that it remains effective under both everyday and extreme conditions.

7.3 Planning Significance and Applicability

The significance of this study extends beyond the immediate context of the Banke Bihari Temple precinct, offering insights into the planning of high-density religious and cultural environments. Such spaces are characterized by unique behavioural patterns, temporal variations in demand, and constraints imposed by historic urban fabric, making conventional planning approaches insufficient.

The study demonstrates that effective crowd management in such contexts requires an integrated approach that combines spatial organization, behavioural understanding, and management mechanisms. The emphasis on system-based planning, rather than isolated interventions, provides a framework that can be adapted to similar environments across different locations.

The use of quantifiable parameters, including pedestrian density, flow capacity, and spatial requirements, adds a level of rigor that enhances the applicability of the approach. By grounding design decisions in measurable criteria, the study ensures that the proposed interventions are not only conceptually sound but also practically viable.

7.4 Implementation Potential and Limitations

The proposal has been developed with a strong focus on feasibility and implementability, taking into account the physical, social, and administrative constraints of the precinct. The phased implementation strategy allows for gradual transformation, beginning with low-cost interventions and progressing toward more structured improvements. This approach ensures that the proposal can be adapted and refined over time based on observed performance.

However, the successful implementation of the proposal is contingent upon effective coordination between multiple stakeholders, including municipal authorities, traffic police, and temple management. Institutional capacity and governance play a critical role in ensuring that the system functions as intended, particularly during peak periods when the demand on the system is highest.

Another limitation lies in the dependence on behavioural compliance. While the design aims to guide movement and reduce conflicts, the effectiveness of the system ultimately depends on how users respond to these interventions. Continuous monitoring, awareness, and management are therefore essential to maintain system performance.

7.5 Final Reflection

The study underscores the importance of approaching crowd management as a planning challenge rather than a purely operational one. By reorganizing space, structuring movement, and integrating management mechanisms, it is possible to transform a highly congested and unstructured environment into a system that is efficient, safe, and adaptable.

The proposed plan for the Banke Bihari Temple precinct demonstrates that even within the constraints of a dense and historic urban fabric, meaningful improvements can be achieved through strategic and well-coordinated interventions. The emphasis on minimal yet effective change ensures that the character and functioning of the precinct are preserved while enhancing its capacity to accommodate large volumes of visitors.

In conclusion, the study provides a comprehensive and implementable framework for managing crowd and mobility in high-density religious precincts, contributing to both planning practice and academic discourse. It highlights the role of urban planning in

addressing complex, real-world challenges and reinforces the need for integrated and context-sensitive solutions.

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