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Pedestrian Safety in Pilgrim City-
A Case of Ujjain

May 2024

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A Case of Ujjain

Master of Planning
(Transport Planning and Logistics Management)

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Thesis submitted in partial fulfillment of the requirements for
The award of the degree of

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Declaration

I **Ashutosh Kumar Tiwari**, Scholar No. **2022MTPLM003** hereby declare that the thesis titled **"Pedestrian Safety in Pilgrim City- a Case of Ujjain"** submitted by me in partial fulfilment for the award of **Master of Planning**, at School of Planning and Architecture, 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.

Signature of the Student

Date: _____

Certificate

This is to certify that the declaration of **Ashutosh Kumar Tiwari** is true to the best of my knowledge and that the student has worked under my guidance in preparing this thesis.

RECOMMENDED

_____
Signature of the Guide
Dr. Mohit Dev

ACCEPTED

_____
Prof. Saurabh Popli
Head, Department of Transport Planning

May 2024

Acknowledgements

I would like to extend my heartfelt thanks and profound appreciation to all those who have played a vital role in successful culmination of my thesis, titled “Pedestrian safety in Pilgrim City- A case of Ujjain”

I would like to start by thanking my guide Dr.Mohit Dev. Your guidance and constant support made this thesis possible. I thank him always having the patience to listen to me and always finding the time to discuss my work with me. I would also like to extend my heartfelt appreciation to Dr. Mayank Dubey. I appreciate him for always motivating me and believing in me.

I would also like to express my gratitude to my parents for being a pillar of strength during the tough times. Additionally, I would like to acknowledge friends Satya, Akash, Yogeshwari, & my classmates. I thank them for supporting me.

I would like to extend my heartfelt appreciation to everyone who has played a direct or indirect role in the advancement of this research their assistance encouragement and invaluable perspectives have been instrumental in molding this thesis. I am truly grateful for your Support

Abstract

Pedestrian management in mass religious gatherings in India, especially in towns like Ujjain, will always be challenging, especially when it comes to large crowds. This thesis explores the critical domain of pedestrian safety in such events and regular days. The will focus on the city of Ujjain, renowned for its religious importance. Depicting this city, this will examine the parameters of pedestrian parameters as presented in the city's dedicated pedestrian sections where physical distancing becomes very crucial when large public gatherings take place. The thesis will scrutinize pedestrian movement patterns, traffic dynamics, pedestrian density, speed, and point capacities of processions to draw conclusions regarding the best way to enhance pedestrian safety in the city and other such pilgrim cities in the country. Ujjain, due to its religious importance, receives heavy pilgrim traffic during festivals and other events. While pilgrims throng to towns and cities to take part in culturally and spiritually significant gatherings, pedestrian flow management and safety issues are immense challenges in this context. An analysis of the complex interaction of pedestrian behavior with infrastructure dynamics is key to risk reduction and improving the pedestrian experience overall. Therefore, this thesis embarks on a comprehensive analysis of pedestrian dynamics within the vicinity of the Ujjain city, specifically focusing on areas that experience heavy footfall during religious and non-religious gatherings. At its core, the study assesses pedestrian movement and Level of Service in these areas, which include pedestrian density, flow rate, and pedestrian speed, and the availability of separate pedestrian space. Estimation of these parameters shall pinpoint potential bottlenecks and congestion points and areas that may lack adequate infrastructure to serve pedestrian traffic to the best of its capacity. Besides, the study looks into the capacity of the procession point, an area that serves as the focal point where crowds gather during religious processions throughout the year and during special months to have an idea of its impact on the whole pedestrian flow and safety. Furthermore, a pedestrian network simulation model in PTV Vissim/Viswalk was established to focus on high footfall points and the Mahakaal corridor. It helps analyze the pedestrian movement patterns during both peak and off-peak periods. This will help in ascertaining the dynamics of the pedestrians and subsequently

plan the management concerning the same. Interventions proposed towards enhancing pedestrian safety and LOS include the improvement of the infrastructure, encompassing widening of pathways for pedestrians, better signage and wayfinding systems, and the implementation of the crowd management strategies. In this way, the study proposes that these public spaces need to be cultivated to provide sufficient resting spots and facilities for pilgrims. This way, the health and well-being of the pilgrims can be well taken care of during these religious gatherings.

Keywords: Mass Gathering, Pedestrian Management, Pedestrian Level of Service, Procession Point, Simulation, Safety

सारांश

भारत में सामूहिक धार्मिक समारोहों में पैदल यात्री प्रबंधन, विशेष रूप से उज्जैन जैसे शहरों में, हमेशा चुनौतीपूर्ण रहेगा, खासकर जब बड़ी भीड़ की बात आती है। यह थीसिस ऐसे आयोजनों और नियमित दिनों में पैदल यात्री सुरक्षा के महत्वपूर्ण क्षेत्र की पड़ताल करती है। थीसिस अपने धार्मिक महत्व के लिए प्रसिद्ध उज्जैन शहर पर केंद्रित होगी। इस शहर का चित्रण करते हुए, थीसिस शहर के समर्पित पैदल यात्री वर्गों में प्रस्तुत किए गए पैदल यात्री मापदंडों के मापदंडों की जांच करेगी, जहां बड़े सार्वजनिक समारोह होने पर शारीरिक दूरी बहुत महत्वपूर्ण हो जाती है। थीसिस शहर और देश के ऐसे अन्य तीर्थ शहरों में पैदल यात्री सुरक्षा बढ़ाने के सर्वोत्तम तरीके के बारे में निष्कर्ष निकालने के लिए पैदल यात्री आंदोलन पैटर्न, यातायात गतिशीलता, पैदल यात्री घनत्व, गति और जुलूसों की बिंदु क्षमताओं की जांच करेगी। अपने धार्मिक महत्व के कारण, उज्जैन में त्योहारों और अन्य आयोजनों के दौरान तीर्थयात्रियों की भारी आवाजाही होती है। जबकि तीर्थयात्री सांस्कृतिक और आध्यात्मिक रूप से महत्वपूर्ण समारोहों में भाग लेने के लिए कस्बों और शहरों में आते हैं, पैदल यात्री प्रवाह प्रबंधन और सुरक्षा मुद्दे इस संदर्भ में बड़ी चुनौतियां हैं। बुनियादी ढांचे की गतिशीलता के साथ पैदल यात्री व्यवहार की जटिल बातचीत का विश्लेषण जोखिम को कम करने और पैदल यात्री अनुभव को समग्र रूप से बेहतर बनाने की कुंजी है। इसलिए, यह थीसिस उज्जैन शहर के आसपास पैदल चलने वालों की गतिशीलता के व्यापक विश्लेषण पर आधारित है, विशेष रूप से उन क्षेत्रों पर ध्यान केंद्रित करती है जहां धार्मिक और गैर-धार्मिक समारोहों के दौरान भारी पैदल यात्रियों की आवाजाही होती है। इसके मूल में, अध्ययन इन क्षेत्रों में पैदल यात्री आंदोलन और सेवा के स्तर का आकलन करता है, जिसमें पैदल यात्री घनत्व, प्रवाह दर, और पैदल यात्री गति, और अलग पैदल यात्री स्थान की उपलब्धता शामिल है। इन मापदंडों का आकलन संभावित बाधाओं और भीड़भाड़ वाले बिंदुओं और उन क्षेत्रों को इंगित करेगा जहां पैदल यात्री यातायात को उसकी

सर्वोत्तम क्षमता तक सेवा प्रदान करने के लिए पर्याप्त बुनियादी ढांचे की कमी हो सकती है। इसके अलावा, अध्ययन जुलूस स्थल की क्षमता पर भी गौर करता है, एक ऐसा क्षेत्र जो केंद्र बिंदु के रूप में कार्य करता है जहां साल भर धार्मिक जुलूसों के दौरान और विशेष महीनों के दौरान भीड़ इकट्ठा होती है ताकि पूरे पैदल यात्री प्रवाह और सुरक्षा पर इसके प्रभाव का अंदाजा लगाया जा सके। इसके अलावा, पीटीवी विस्सिम/विसवॉक में एक पैदल यात्री नेटवर्क सिमुलेशन मॉडल उच्च पैदल यात्री बिंदुओं और महाकाल गलियारे पर ध्यान केंद्रित करने के लिए स्थापित किया गया था। यह पीक और ऑफ-पीक दोनों अवधियों के दौरान पैदल यात्रियों की आवाजाही के पैटर्न का विश्लेषण करने में मदद करता है। इससे पैदल यात्रियों की गतिशीलता का पता लगाने में मदद मिलेगी और बाद में उसी के संबंध में प्रबंधन की योजना बनाई जाएगी। पैदल यात्री सुरक्षा और एलओएस को बढ़ाने की दिशा में प्रस्तावित हस्तक्षेपों में बुनियादी ढांचे में सुधार, पैदल चलने वालों के लिए मार्गों का चौड़ीकरण, बेहतर साइनेज और वेफाइंडिंग सिस्टम और भीड़ प्रबंधन रणनीतियों का कार्यान्वयन शामिल है। इस प्रकार, अध्ययन का प्रस्ताव है कि तीर्थयात्रियों के लिए पर्याप्त विश्राम स्थल और सुविधाएं प्रदान करने के लिए इन सार्वजनिक स्थानों को विकसित करने की आवश्यकता है। इस तरह, इन धार्मिक समारोहों के दौरान तीर्थयात्रियों के स्वास्थ्य और भलाई का अच्छी तरह से ख्याल रखा जा सकता है।

कीवर्ड: सामूहिक सभा, पैदल यात्री प्रबंधन, पैदल यात्री सेवा का स्तर, जुलूस बिंदु, सिमुलेशन, सुरक्षा

Table of Contents

List of Tables

List of Figures

List of Annexure

Presentation Sheets

Abbreviations

LOS Level of Service

MMPS Mahakaal mandir prabhandak samiti

USCL Ujjain smart city Limited

CBD Central business Districts

HCM Highway Capacity Manual

SPV Special Purpose Vehicle

CHAPTER 1: INTRODUCTION

1.0 Background

Since few decades the first and most crucial mode of traversing to places has been by foot. The experience of a pedestrian is not bound to just travelling a point to another. With development, the population worldwide has gravitated towards a system dependent on automobile use which, in turn, creates a demand for wider roads to accommodate traffic while side tracking the public on foot as well as on non-motorized vehicles (like bicycles). Pedestrians are, in fact, considered to be the most susceptible to danger among all road users. To tackle such issues, places with higher footfall are mapped so that intervention in some form can ensure pedestrian safety and better pedestrian environment quality. To this extent, the scope for the study has been narrowed to places which experience high footfall due to locals as well as Tourist crowds are a hallmark of contemporary living. However, without adequate comprehension or control, whether at religious gatherings, entertainment venues, or transportation hubs, they can pose significant risks and consequences (Pembuain, Priyanto, and Suparma 2019). Sime (1993) has suggested that insufficient attention to the way that people behave in a crowd and the relationship between behaviour and systems design are major factors in crowd disasters. Without understanding crowds and crowd behaviour, Berlonghi (1995) argued that we are left with random attempts at crowd control and crowd management which may result in serious losses of life, health, property and money. This research outlines the emerging discipline of crowd science and the contribution this discipline could process of planning for safer outcomes at mass gathering events at pilgrimage sites commences with establishing a foundational understanding of crowd science, embedding it within a wider sociological context.

1.1 General

City where temples are/used to be the center & devotees have to come to gain grace and perform religious practices. India's rising population is an attraction that attracts thousands of people for various great pilgrimages such as the Kumbh Melas, Rath Yatras, and many other sacred places, including historical monuments. This flow, however, is a daunting challenge, especially in the case of

the huge number of attendees often results in extreme density, which is dangerously threatening the safety of the situation. The huge number of people surging forward to the limited space and facilities of these areas causes these crowd disasters, such as stampeding or trampling incidents. The crowding situation in these areas pushes facilities and resources to their very limits. The limited space and facilities available to host the huge number of people come to a boiling point, causing overwhelming situations. This makes the safety and well-being of individuals in these situations increasingly difficult. The rampant densities of crowds during these incidents intensify the disaster risk, especially in stampedes and trampling incidents that can result in devastating effects. The force created by masses in confined areas can quickly turn into chaos and panic, confusion, and ultimately, tragic outcomes. Adding to this is the inefficient measures of crowd management and lack of emergency preparedness, which increases the risk of overcrowding and makes attendees vulnerable to the consequences of it.

Moreover, addressing the issues of overcrowding requires proactive planning, well-developed infrastructure, and effective crowd management measures. This includes mechanisms of crowd control, such as entry and exit points, crowd flow management systems, and proper signage to guide attendees safely through the area. Another important aspect includes increasing infrastructure capacities and strength, like transport networks and accommodation facilities. Thirdly, information dissemination to attendees on safety procedures and practices could minimize disaster chances and the possibility of overshooting in holding the event. This includes communicating to pilgrims and tourists proper pathways, separation of private space, and calmness in crowded conditions. Another important factor to consider is event staff and volunteers' preparations with knowledge of crowd management procedures and first aid, thus expanding capacity and readiness to respond immediately in the event of an emergency. In summary, safety is a key area of priority. On top of that, comprehensive measures for crowd management will ensure that India can continue to welcome pilgrims and tourists to its sacred places with minimal risk and always a safer, more enriching experience for all attendees.

1.1.1 Indian Scenario

Several such studies have raised concerns over the incidences happening in India, with about 67% of the cases occurring during religious meetups. Based on these studies, the incidences reported here are basically analyzed and estimated to be occurring at religious functions. However, at the same time, it is worth noting that about 8% of the cases are reported to be entertainment-related incidents, including concerts, festivals, and cultural activities. Although not as high as religious gatherings, such entertainment-related incidents have made all the more risky because of the massive crowds and the dynamic nature of the event. Crowd management, lack of proper infrastructure, and poor safety measures can jointly result in such incidents. The remaining 15% can be categorized as miscellaneous, which covers a broad spectrum of public works, construction sites, and other communal places. Although such incidents do not have anything to do with crowd dynamics related to religious or entertainment activities, they still create a demand for safety and adherence to regulations in all such public places. Whether it is a construction accident, a transport mishap, or a public health crisis, the impact of such incidents can be, at times, hazardous, making it high time for an efficient risk management system and emergency response. Political gathering and events also account for about 10% according to the studies. Although such incidents do not always involve crowds in the usual sense, they still raise unique challenges related to crowd control, security, and potential unrest. For example, in political rallies, protests, or election campaigns, a large crowd may include individuals with various interests and affiliations. This becomes an excellent opportunity for any kind of confrontation, clash, or other disturbing incident. Proper crowd control, law enforcement, and communication strategies are important to prevent those risks for the safety and security of all involved.

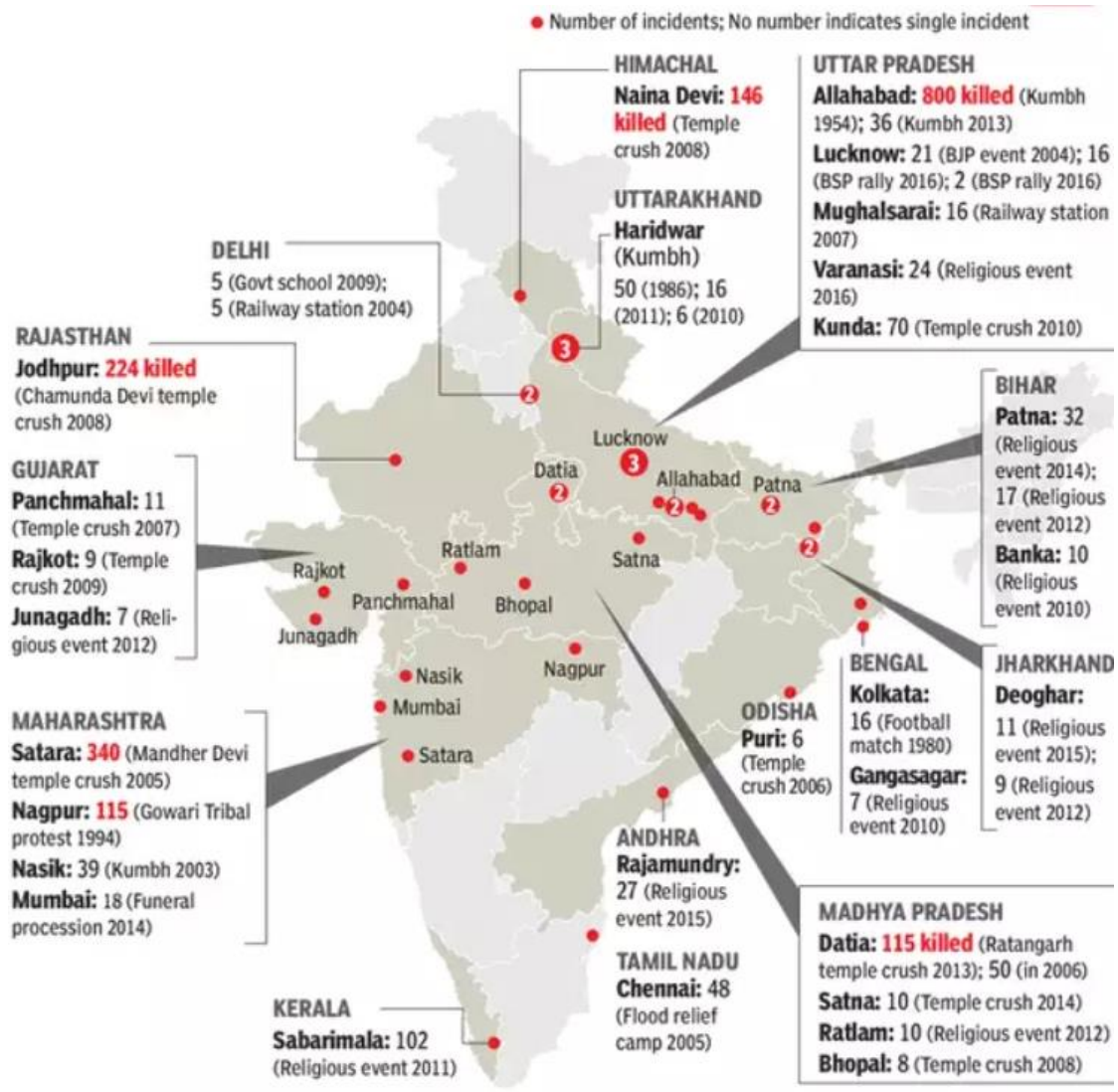


Fig 1 Stampede in India

Source: (TOI Newspaper)

1.1.2 Schemes

The Government of India, in collaboration with the Ministry of Tourism, initiated the National Mission on Pilgrimage Rejuvenation and Spiritual Augmentation Drive (PRASAD) in 2014-15. Subsequently, in 2017, they expanded the scheme to include heritage sites and renamed it PRASHAD. The objectives of this scheme were as follows:

- Revitalize and enhance the spiritual experience at significant national and global pilgrimage destinations.

- Improve the tourism appeal of identified pilgrimage destinations and heritage cities through integrated and sustainable tourism development projects.
- Utilize pilgrimage and heritage tourism as catalysts for economic growth and job creation.
- Embrace community-based development by adopting "Pro-Poor" tourism and promoting responsible tourism initiatives.
- Engage local communities in tourism activities by generating employment opportunities and raising awareness about the benefits of tourism, such as increased income and improved living standards.
- Encourage the promotion of local heritage, including heritage structures, arts, culture, handicrafts, and cuisine, to create livelihood opportunities in identified areas.
- Address infrastructural gaps at pilgrimage destinations and heritage cities through integrated tourism development plans.
- Establish a monitoring mechanism to ensure timely implementation of projects in collaboration with states/union territories and other stakeholders.
- Enhance safety and security measures for pilgrims and tourists and improve the quality of tourism services.
- Facilitate the convergence of state and central government schemes and private sector initiatives for integrated site and destination development

The PRASHAD scheme placed particular emphasis on the prior development of 12 cities, recognizing their significance as pilgrimage destinations and heritage hubs. These cities were identified as focal points for concentrated efforts aimed at enhancing their tourism infrastructure, promoting cultural heritage, and stimulating economic growth. Here's an expansion on this focus The 12 selected cities under the PRASHAD scheme were chosen based on their historical, cultural, and religious importance, as well as their potential to attract both domestic and international tourists. These cities represent a rich tapestry of India's diverse heritage and spiritual legacy, each offering unique experiences and attractions to visitors through targeted interventions and integrated tourism development initiatives, the government aimed to transform these cities into world-class tourism destinations. This involved upgrading their existing infrastructure, such as

transportation networks, accommodation facilities, and tourist amenities, to meet international standards and accommodate the growing influx of visitors. Moreover, the scheme sought to leverage the cultural and architectural heritage of these cities to create immersive and memorable experiences for tourists. This included restoration and conservation efforts aimed at preserving heritage structures, monuments, and sites of historical significance, ensuring their longevity for future generations to appreciate and enjoy.In addition to infrastructure and heritage conservation, the PRASHAD scheme focused on promoting sustainable tourism practices and community engagement. By embracing the principles of responsible tourism and pro-poor development, the government aimed to empower local communities and create economic opportunities that would benefit residents directly.

Furthermore, the development of these 12 cities was envisaged as a catalyst for broader regional development, with spin-off benefits expected to extend beyond tourism to areas such as job creation, small business growth, and improved quality of life for residents.

1.1.2 Cause of Stampede

The pedestrian is the most vulnerable road user mainly because of the intense impacts of populous, crowded centers of activity like pilgrim cities, where large groups of people walk alongside vehicular traffic in a religious atmosphere. In such a context, the pedestrian is undoubtedly the most vulnerable user of the road for various reasons.

- High Foot Traffic: Pilgrim cities often experience a significant influx of devotees and tourists, especially during religious festivals and auspicious occasions. This surge in foot traffic intensifies the competition for space on roads and sidewalks, increasing the likelihood of pedestrian accidents.
- Limited Infrastructure: Many pilgrimage sites and historic cities were developed centuries ago, with infrastructure designed to accommodate pedestrian traffic rather than modern vehicular flows. Consequently, sidewalks may be narrow, uneven, or poorly maintained, exposing pedestrians to tripping hazards and collisions with obstacles.

- Congested Roads: The narrow lanes and congested thoroughfares characteristic of pilgrim cities can make walking alongside vehicular traffic particularly perilous. Pedestrians may find themselves squeezed onto narrow sidewalks or forced to share the road with motorized vehicles, heightening the risk of accidents, especially at intersections and busy junctions.
- Lack of Awareness: In the hustle and bustle of pilgrimage sites, both pilgrims and local residents may be preoccupied with religious rituals or navigating through crowded spaces, leading to a lack of awareness regarding pedestrian safety practices. This can result in risky behaviours such as jaywalking, crossing roads without looking, or disregarding traffic signals.
- Inadequate Safety Measures: Despite their cultural and historical significance, many pilgrimage cities may lack adequate safety measures to protect pedestrians. Insufficient street lighting, poorly marked crosswalks, and inadequate signage can contribute to confusion and increase the likelihood of accidents, particularly at night or during inclement weather.
- Traffic Congestion: The influx of pilgrims and tourists often exacerbates traffic congestion in pilgrimage cities, leading to slower-moving vehicles and increased frustration among drivers. This congestion can create additional hazards for pedestrians, as impatient motorists may resort to risky manoeuvres or disregard pedestrian right-of-way in their efforts to navigate congested roads.

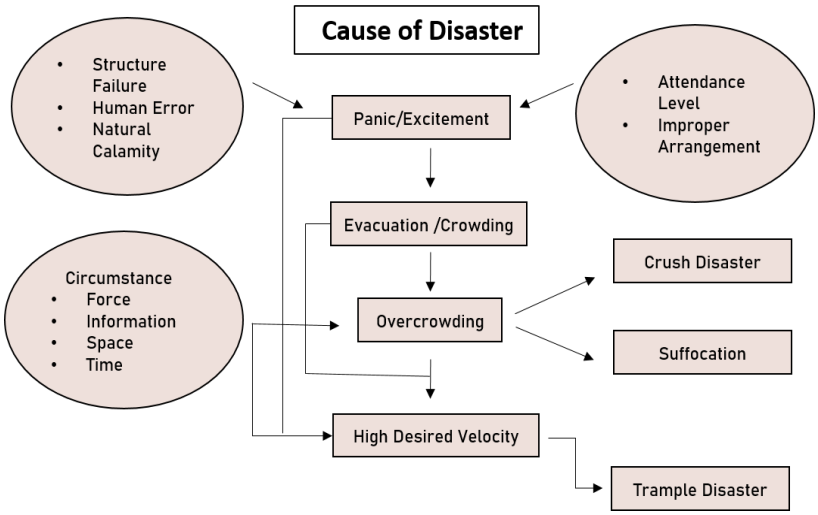


Fig 2 Stampede Reason

1.2 Aim & Objectives

1.2.1 Aim: - To Develop an efficient Circulation/Pedestrian Mobility Plan for the safe movement of attendees.

1.2.2 Objectives:

- To identify the existing condition of road & pedestrian facilities & area of improvement.
- To analyze the existing Level of Service (LOS) for pedestrians and to compare it with the standard to understand gaps.
- To devise a strategy that mitigate the risk of stampedes and ensure event safety.

1.3 Methodology

1.3.1 Methods and tools for crowd risk analysis

Routes-Areas-Movement-Profile (RAMP) analysis, the various components which has been explained as follows:

• Routes: Describes the pathways taken by crowds to enter, circulate within, and exit the site, utilizing flow path analysis.

• Areas: Identifies the capacity of different sections of the event, as well as the presence of crowd densities (low, medium, high) and associated site risks.

• Movement: Assesses the speed of movement through various parts of the system (e.g., ticket/search areas) and overall crowd flow across the site, employing flow rate analysis.

• Profile: Predicts the anticipated behaviour of the crowd as they transition between different areas of the site.

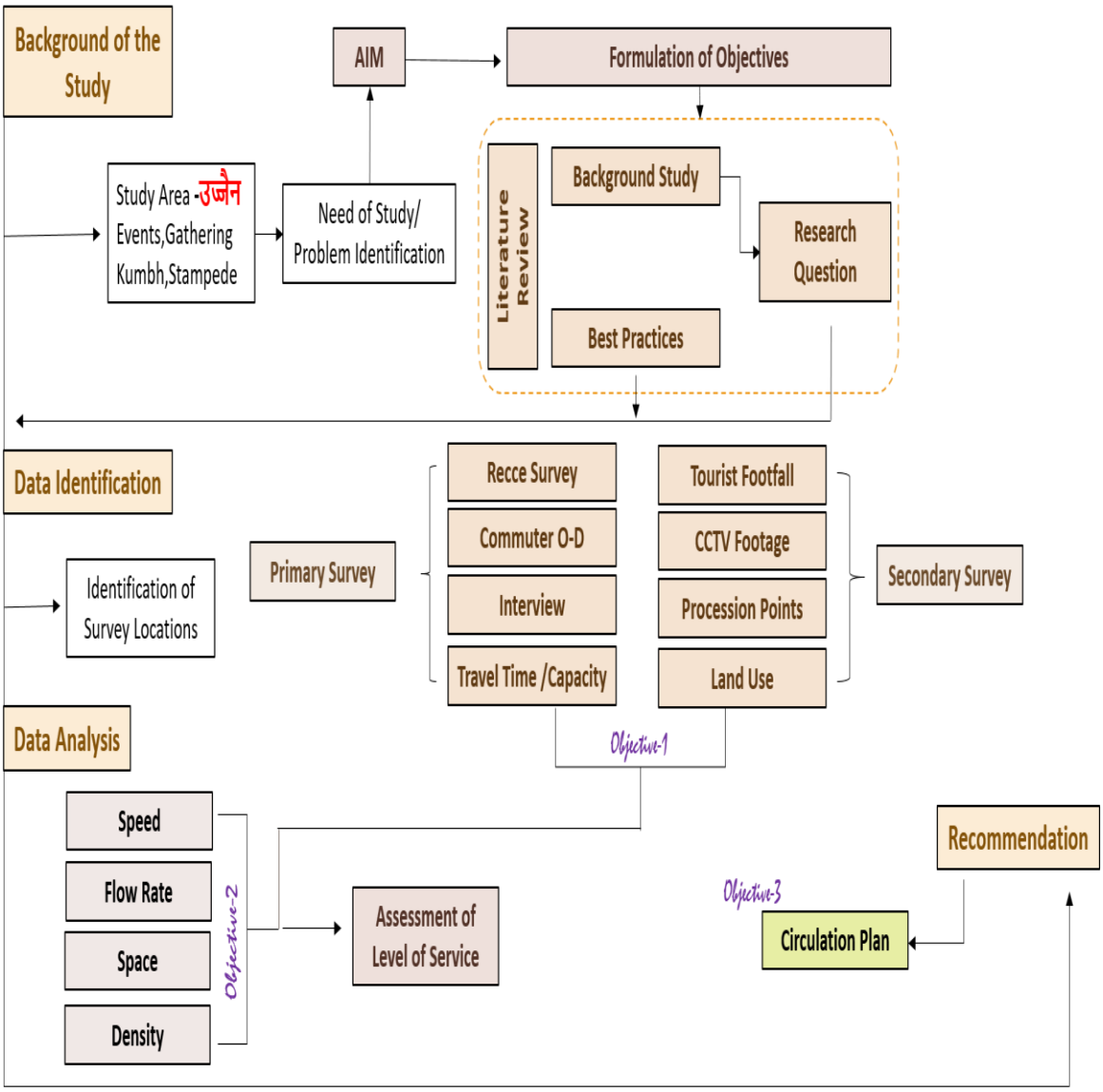


Fig 3 Methodology

The methodology chart depicts a comprehensive blueprint of the process involved step-by-step to achieve the desired outcome of Mahakaal corridor plan –Ujjain. The steps under this chart explain the most pivotal component of the whole process that defines specific tasks and actions needed to move progress toward the ultimate goal.

The chart of the methodology from the formulation of objectives/goals related to Ujjain moves forward towards the first phase of planning. A thorough approach is followed here to identify critical stakeholders/Offices, resource allocation, and setting clear timelines. This phase is crucial as it provides the backbone to

subsequent activities as all the preparation required is set in place before moving ahead.

Moving away from the planning phase of the methodology chart, one can see the implementation phase, in which the meticulously outlined plan is practically undertaken. The implementation phase involves the execution of various activities, focusing primarily on data collection, analysis, and decision-making. One aspect of data collection involved liaisoning with various offices, including the Mahakaal Mandir Prabandhak Samiti (MMPS), Ujjain Smart City limited (USCL), Simhastha Mela Office, and the Ujjain Municipality Office. These various entities offer different datasets, all relevant to the objectives of this study. For example, the Mahakaal Mandir Prabandhak Samiti reveal information on crowd management strategies and visitor demographics; the Ujjain Smart City office reveal information on urban infrastructure and technology utilization and route planning and parking space and better management of city area. Similarly, the Simhastha Mela Office revealed information on past event crowd dynamics.

After gathering all data the cruicial steps comes for the data scrunity and the process for analysis of data for the better outcomes result as the video graphic is collected for 2 days i.e Normal days and Events Days for better understanding of the increase of footfall.

CHAPTER 2: LITERATURE

2.1 What is crowd

Crowd science delves into the exploration of how density, dynamics, and both individual and collective behaviours shape a crowd. Its origins trace back to the foundational investigations conducted by Still (2000) on crowd dynamics, which he defines as the investigation of how and where crowds assemble and move when reaching a critical density of more than one person per square meter. Still, in 2013, on page 93, builds on this foundation by incorporating insights derived from social psychology and behavior to develop a more encompassing understanding of crowd phenomena. Thus, this interdisciplinary approach, as expounded by Still in 2013, broadens the scope of the topic of inquiry to light up the complex interplay of the various factors influencing crowd behavior and dynamics.

2.1.1 Key elements of crowd

The principal problems stem from density, dynamics, and behavior (Raineri, 2013a). Chief concerns are density, dynamics, and behavior (Raineri, 2015a). Density concerns itself with the number of people and/or objects in a given area and is an essential parameter in addressing crowding (Drintewater and Gudjonsson, 1989) and is an essential parameter in addressing crowding. Crowd dynamics are movement of crowds and the actions of people within those crowds. Crowd behaviour arises from different modes of individual and group motivation, such as flight/fight responses in emergencies and crowd frenzy in non-emergencies.

2.2 Crowd density

Density is a physical attribute of the environment and is normally considered an early indicator of crowding, while crowding is the individuals' subjective perception or response to their environment. Several researchers have used density as the explanation to crowding for instance, Eroglu and Machleit 1990 have used density as the measure of crowding, similarly, Stokols 1978, Sundstrom 1978 also used density to measure crowding. In most cases, crowding is associated with an abundance of people in a small space, and this is experienced as discomfort and anxiety.

As observed by Fruin, p.40, a density of 7 persons or more per square meter poses serious issues. This high density can cause two primary problems.

Breathlessness can occur under the huge crowd pressures combined with anxiety, and hot conditions and thermal insulation through contact with other bodies may weaken or even lead to fainting of some people. Increased risks of crush asphyxia due to the crushing of the crowd can occur. The difficulty in helping people who have been crushed is extremely high, which in turn increases the likelihood of them being trampled on. At last, shock waves can travel through the crowd with sufficient impact to lift a person from their feet and toss them over several meters.

There are two general types of fatalities from incidents of overcrowding. One is from being trampled to death. Although the density of the crowd is high, pedestrians will still move around. However, when a pedestrian falls, they are unable to regain their footing because of the bumping from the movement of other pedestrians. Thus fatalities can occur from being knocked down by other pedestrians who are unaware of the fallen person.

The second type of death involves crush when pedestrians are crushed. In such cases, the crowd density is high and movement is almost impossible. Crush forces developed inside the crowd when crushing happens are fatal. The crush forces are so heavy that they bend steel fencing or even push down brick walls, a clear indication that the push of the crowd is so enormous. The closer people get to any barrier that blocks the path of the crowd, the more pressures they will generally experience, the more likely they are to die.

2.3 Crowd risk analysis

Still (2014) highlights that the majority of crowd-related incidents stem from failures in design, particularly concerning entry systems. Examples such as the tragedies in Cincinnati, USA (1979 – 11 dead, 23 injured), Hillsborough, UK (1989, 96 dead, more than 700 injured), and Love Parade, Duisberg, Germany (2010, 21 dead, more than 500 injured) underscore instances where there was a fundamental failure to grasp the risks associated with crowds entering events. When crowds arrive at an event, careful consideration must be given to throughput—the rate of passage through the system—and the availability of holding (queuing) areas. These areas must accommodate the anticipated crowd numbers effectively. If the rate of arriving crowds surpasses the capacity to enter, queues will form. If queues

develop too rapidly, overcrowding can occur, posing potentially fatal consequences if left unaddressed. Egress, or the process of exiting the venue, also presents challenges (see, for example, Dickie 1993; Raineri 2015b, p. 126-129; Still 2000, 2013), with potential disruptions to movement flows and instances of competitive rushes to leave. Furthermore, a significant proportion of crowd-related risks are attributed to irrational and high-risk behavior exhibited by patrons, particularly in general admission or standing-room-only areas within venues (Milsten, Seaman, Liu, Bissell & Maguire 2003). The likelihood of issues arising in crowds is further heightened by reactions to perceived risks or competitive rushes.

“Carrying Capacity Assessment for Religious Crowd Management -An Application to Sabarimala Mass Gathering Pilgrimage, India” (Illiyas, Mani, and Babu 2021)-
In India, crowd management systems at religious sites are essential, often tailored to the unique characteristics of each location, event, and the constituency of followers. However, the concept of crowd carrying capacity is often overlooked in the context of religious observances, hindering the formulation of effective crowd management protocols and guidelines. To address this gap, a recent study focused on estimating the crowd carrying capacity of the Sabarimala pilgrimage site in Kerala, India. Drawing on methods used to assess the physical carrying capacity of tourist destinations, researchers adapted and contextualized these approaches for assessing crowd carrying capacity.
By analyzing the venue's characteristics, the pilgrimage itself, and the pilgrims, researchers identified active crowd areas and space utilization patterns. The assessment measured both comfortable crowd density and threshold crowd density. Two key factors influencing pilgrim movement within the venue were identified: the service level within the holy step and the capacity of the darshan facility. The service level within the holy step emerged as the primary regulator of pilgrim movement, including movement for deity darshan. Consequently, the comfortable capacity within the holy step was deemed the effective carrying capacity within the venue.
Maintaining a comfortable crowd density throughout the event is crucial to prevent crowd crushes. The method employed in this study for assessing crowd carrying capacity is relatively straightforward, providing a valuable tool for modelling crowd

management protocols at other religious pilgrimage sites in India. With its consideration of crowd density and regulatory factors, this assessment method holds potential for effective utilization in various religious pilgrimage settings in ensuring the comfort and safety of pilgrims throughout a religious gathering in the country.

In most cases, in non-conventional mass gathering venues such as cinemas, metro stations, and bus depots, the organizers usually embark on the assessment of operational capacities during the designing phase. However, in religious mass gathering destinations in India, the capacities have not been pre-defined for articulated planning. The space available to participants and the venue capacity are key factors for planning, preparedness, monitoring, and ensuring the safe conduct of mass gathering events (HSE, 2000; Fruin, 1993; NDMA, 2014).

In India, religious mass gathering venues are controlled for access by the spatial capacity. Visitors and pilgrims are administered with prior registration and entry passes for some religious mass gathering venues. However, most religious mass gathering venues do not have any pre-registration activity and do not have size restrictions. Therefore, there is a massive influx of visitors in numbers that exceed the venue holding capacity, and there are high crowd densities that act as some inherent reasons for crowd disasters in India (Gayathri et al., 2017; Holman & Balsari, 2017; Burkle & Hsu, 2011; Ankita & Prashansa, 2015).

Notably realized this past years are the recognition of density and crowd carrying capacity as being essential in maintaining mass gathering safety. In this light, this study focused on developing a simple method that would allow religious venues to systematically assess their crowd carrying capacity. From tourism carrying capacity assessment methods, the present study formulated religious crowd carrying capacity assessment methods, which would consider the Sabarimala pilgrimage venue, which is one of the most popular religious mass gathering venues in India.

“Crowd Management and Strategies for Security and Surveillance During the Large Mass Gathering Events: The Prayagraj Kumbh Mela 2019 Experience”(Kanaujiya and Tiwari 2022)-

The Kumbh Mela stands as the largest religious and spiritual mass gathering on Earth, captivating vast numbers of Hindus worldwide. With approximately 240

million pilgrims participating in the 2019 Kumbh Mela, effective crowd management and security and surveillance strategies pose significant challenges. This paper endeavors to identify various risk factors and their management strategies within this context. It examines the roles and responsibilities of different stakeholders in crowd management, aiming to address challenges such as the lack of knowledge regarding crowd size, crowd psychology, and behaviour patterns.

Despite encountering difficulties, such as those related to understanding crowd dynamics, this paper presents a comprehensive approach to risk analysis, preparedness, management, and mitigation. The overarching goal is to minimize incidents during spiritual mass gathering events and enhance the overall user experience by employing a design thinking approach. While this paper attempts to encompass various aspects of crowd management and security and surveillance strategies during mass gathering events, there remains ample opportunity for further exploration and investigation into additional approaches. The mega tent city that hosts millions of pilgrims on the riverbed holds significance not only for India but also for international mass gathering research, offering multifaceted issues for study. This presents an opportunity to gather field-level evidence and establish a knowledge base for disaster management policies and practices.

“Human stampedes during religious festivals: A comparative review of mass gathering emergencies in India”(Illiyas et al. 2013)-

The escalating population of India and the tendency for people to congregate for common reasons, mainly for religious reasons, have, therefore, led to ever increasing crowds. Crowds involve both viewers and performers. However, many religious activities attract more than just the performers. Events and mass gatherings, as defined by the United States Federal Emergency Management Agency (FEMA), are gatherings of a large number of individuals for non-regular affairs in a community. World Health Organization defines the mass gathering as: any contact between large numbers of people where the spread of infectious diseases can occur more easily. Crowds, often referred to from the perspective of emergency medicine, are a defined event in temporary buildings or open spaces where the responses to emergencies may be delayed due to loss of access or other reasons. Researchers estimate crowd estimates to classify an event as a

mass gathering, usually resulting in tens of thousands of people over a period. Large crowds create several problems, including traffic congestion, rise in crime, pollution, and changes in the terrain, which, in turn, create medical emergencies and disasters. Human stampedes are a common hazard in mass gatherings and occur when people rush in response to perceived danger or loss of space, usually causing injuries and deaths. Biomedical, environmental, and psychological factors determine the incidence of human stampedes. Though the disaster risk management perspective of mass gatherings has been researched extensively concerning mass casualty management and medical care aspects, the hazards at the mass gathering have not been studied sufficiently. Very little literature is available in this view, which underscores the requirement for successful planning, preparation, and responses. The social force model, introduced by Helbing and Molnar, simulates the movement of crowds and describes how panicked crowds move; it is acknowledged that crowd behavior is influenced by people and is a social and dynamic phenomenon independent of the situation.

‘‘Evaluation of Senior Pedestrian’s Travel Experience at Ekamara Kshetra Bhubaneswar ‘‘ (Narayan and Chani 2020)-

In October 2017, an evaluation of the travel experience for senior pedestrians at this religious site involved administering a structured questionnaire to a randomly selected sample of 120 senior respondents. Using a five-point Likert scale, participants rated various aspects of the built environment, ranging from very satisfied to very dissatisfied. Descriptive analysis was utilized to discern patterns in the respondents' experiences. Additionally, principal component analysis was employed to identify common factors or components. The findings revealed that the majority of senior pedestrians reported unfavorable walking experiences at the site, as indicated by the selected indicators.

“Pedestrian Characteristics and Behaviour on Surrounding Temple Area Madurai”(Bharthy g, 2013)-

A comprehensive understanding of pedestrian behaviour under mixed traffic conditions is crucial for developing necessary infrastructure and enhancing pedestrian safety in congested areas. While roads should ideally prioritize

pedestrian safety and security, this is not always the case. Despite pedestrians being vital to urban development, central business districts (CBDs) often attract more customers, including visitors drawn to iconic attractions located in these areas. Walking is a fundamental daily activity, with pedestrians constituting a portion of every trip. In Madurai, limited space for development and high population density pose significant constraints on growth.

“Determination of pedestrian’s personal space in mass religious gatherings - A case study of Kumbh Mela” (M, Sobhana, and Verma 2018)-

Personal space, the physical distance between individuals in a social setting, is known to vary depending on cultural norms, individual preferences, and situational factors. Understanding personal space involves recognizing different zones of interaction and the associated activities, relationships, and emotions. This paper aims to define and explore personal space within high-density crowd situations, specifically during the Kumbh Mela, one of the world's largest religious gatherings. Video data captured during the Panchkroshi Yatra, a religious walkathon within the Kumbh Mela, is analysed to investigate factors influencing personal space. Factors such as walking speed, gender, presence of luggage, and the number of individuals surrounding an individual are examined to identify thresholds of personal space. The analysis reveals that an individual's average walking speed, the size of the group they are in, and the gender ratio of group members significantly impact personal space. Furthermore, it is noted that personal space tends to follow an asymmetrical pattern rather than a symmetrical one.

“Understanding Crowd Dynamics in Processions during Mass Religious Gatherings A case study of Shahi Snan in Kumbh Mela” (A Verma, 2018)-

Large gatherings in public spaces often exhibit complex crowd dynamics, which can lead to serious consequences if not properly understood and managed. Mass religious processions, in particular, are characterized by emotional and impulsive participants, making them susceptible to crowd disasters. These events pose significant safety hazards to attendees. This paper aims to document the typical crowd dynamics observed during the 2016 Kumbh Mela procession and highlight characteristics of the crowd that have not been previously reported but have a significant impact. Factors such as extreme crowd pressures, individual loss of

control due to psychological and physiological factors, crowd heterogeneity, group behaviour, and induced competitiveness contribute to the complexity of crowd dynamics in such events. The motivations driving participation in these processions often lead to unexpected behaviours, further complicating crowd management. The interplay of physical and psychological forces on participant's results in serpentine behaviour, increasing the risk of crowd crushes or other hazardous situations. Understanding the unique characteristics of the crowd participating in Kumbh Mela processions is crucial for effective planning and the implementation of well-organized movement patterns to mitigate potential risks.

"Spatial Strategies for Crowd Management in Haridwar, India"(Kasthala, B.V., and Lakra 2019)-

This study delved into the spatial analysis of crowd management and emergency preparedness strategies devised by authorities during the Ardh Kumbh Mela in 2016, held in Haridwar, India. Leveraging tools and technologies such as Remote Sensing and Geographic Information System (GIS), research aimed to assess and propose recommendations for enhancing crowd management and emergency response protocols. Through extensive field visits during the event, we scrutinized the effectiveness of proposed strategies, including critical aspects like crowd flow routes, infrastructure provisions, and emergency access to healthcare facilities. Utilizing methodologies such as crowd capacity analysis, infrastructure evaluation, and crowd flow modeling, we derived actionable guidelines for Crowd Control Management. This endeavor underscores the potential of integrating technology-driven approaches to mitigate crowd-related hazards in densely populated settings, particularly during large-scale gatherings like religious festivals.

"Traffic Management of Pedestrian at Railway Stations using Vissim"(Parthiban et al. 2021)-

In conclusion, this thesis addresses the burgeoning challenges posed by the exponential increase in passenger traffic during pilgrim seasons at Indian railway stations, particularly in densely populated states like Kerala. Focusing on key stations such as Palakkad Junction, Thrissur, Kottayam, Chengannur, and Trivandrum Central, which witness substantial annual passenger footfall, the study

assesses passenger satisfaction and service levels concerning platform amenities. Emphasizing pedestrian attributes including age, gender, and luggage carriage, alongside flow dynamics such as density and speed, the research employed simulation models, notably PTV Vissim/Viswalk, to analyze station pedestrian networks, specifically stairways and entrance passageways. By comparing field observations with simulation results, the study provides insights into pedestrian level of services, offering valuable input for policymakers striving to enhance station infrastructure to global standards.

"Preparedness for Mass Gatherings: Factors to Consider According to the Rescue Authorities" (Koski, Kouvonen, and Sumanen n.d.)-

Ensuring the safety of participants and minimizing emergency response delays during mass gatherings necessitates comprehensive multi-authority preparedness. While rescue authorities play a pivotal role in pre-planning, their perspectives on various aspects of preparedness remain relatively unknown. Through semi-structured thematic interviews with 15 rescue authorities involved in mass gathering planning, this study sought to elucidate the factors deemed crucial by these authorities. Analysis revealed three main categories: cooperation in pre-planning, factors essential in emergency plans, and actions during the event, further delineated into 11 generic categories and 42 sub-categories. The findings underscore the complexity of mass gathering preparedness and highlight the need for further exploration, particularly in understanding and optimizing the distribution of operative workload during events to maximize resource efficiency.

"Impacts of Pedestrian Traffic on Urban Form: A Case of Historic Core of Kathmandu"(Limbu and Bahadur 2021)-

Pedestrian movement stands out as an environmentally sustainable mode of transportation, contributing to reduced air and noise pollution by minimizing reliance on automobiles. Moreover, it fosters economic vitality by increasing foot traffic and thus potential business opportunities. Beyond its economic benefits, pedestrian transportation enhances social interaction, equality, and fairness within communities. However, as urban landscapes evolve, so does the distribution of pedestrian activity. This research focused on investigating the impact of pedestrian traffic on the urban form within the historic core of Kathmandu, a municipality

experiencing rapid urbanization and a corresponding surge in pedestrian activity. Through a combination of qualitative and quantitative methods, including interviews, surveys, and pedestrian counts at various stations, the study comprehensively analysed elements of urban form in the study area. Based on these findings, the research provides valuable conclusions and recommendations for effective urban form and pedestrian traffic management, not only for Kathmandu but also for other urban areas undergoing rapid urbanization globally.

“Risk management strategies to avoid stampede at Mass gatherings”(Taneja and Bolia 2019)

In summation, the troubling trend of stampedes occurring at various sites of mass gatherings, be it religious congregations, railway stations, or social, political, and sports events, underscores the urgent need for comprehensive and effective risk management strategies. This challenge is particularly acute in regions like India, where infrastructural capacities often fall short of accommodating large crowds safely. To address this pressing issue, it is imperative to develop multifaceted risk aversion strategies that go beyond mere crowd control. These strategies should encompass a range of crucial elements, including but not limited to:

Enhanced Crowd Management: Implementing robust crowd management protocols that take into account factors such as crowd density, flow dynamics, and emergency response mechanisms.Venue Suitability Assessment: Conducting thorough assessments to determine the suitability of venues for hosting events based on factors such as capacity, accessibility, and emergency egress routes.

Optimal Route Guidance: Providing clear and effective route guidance to attendees to prevent congestion and facilitate smooth movement within the venue.

Identification of High-Risk Areas: Identifying and addressing potential pinch points or high-risk areas where crowd density is likely to escalate, leading to increased vulnerability to stampedes or other crowd-related disasters.

Pedestrian Simulation Integration: Leveraging advanced pedestrian simulation technologies to simulate crowd behaviour and dynamics, enabling the development of more informed and effective risk management strategies.By integrating these approaches into a comprehensive risk management framework, we can work towards mitigating the potential for tragedy and safeguarding the well-

being of all participants in mass gatherings. It is through proactive risk assessment, strategic planning, and the harnessing of innovative technologies that we can strive to create safer and more secure environments for all.

“Evaluation of human behaviour at pedestrian crossings”(Mako and Szakonyi 2016)-Road traffic crashes result from a multitude of factors, including road layout, vehicle characteristics, and the behavior of road users. In our study, we initially investigated the primary causes of pedestrian fatalities and assessed the safety impact of road measures such as traffic lights, roundabouts, and refuge islands at pedestrian crossings. The findings revealed compelling evidence for the positive effects of these measures, particularly in reducing pedestrian-related accidents.
Subsequently, we conducted a site survey to evaluate the frequency of irregular crossing manoeuvres by both car drivers and pedestrians at designated pedestrian crossings. Our analysis indicated that car drivers exhibited the highest degree of irregular behaviour at crossings lacking refuge islands. Conversely, crossings equipped with features such as flashing yellow lights, refuge islands, and traffic lights prompted more compliant behaviour from car drivers. Further into the research, we examined the waiting time for pedestrians and the delay experienced by vehicle drivers at pedestrian crossings. The results underscored the importance of efficient pedestrian crossing design in minimizing wait times for pedestrians and reducing delays for vehicle traffic. Overall, our study highlights the critical need for a collaborative effort between the human and engineering fields to achieve even greater improvements in the safety of vulnerable road users. By implementing effective road measures and promoting responsible behaviour among road users, we can strive towards creating safer road environments for everyone.

“Stampede Events and Strategies for Crowd Management”(Shao, Shao, and Kuo 2019)-
Public events, ranging from sports matches to concerts and firework displays, often draw large crowds, making evacuation procedures during emergencies particularly challenging. Ensuring evacuation safety is a crucial aspect of fire protection engineering design. Stampedes, commonly occurring at entrances, exits, corners, and staircases along evacuation routes, pose significant risks to crowd safety. This

study investigated past incidents and relevant documentation, utilizing Simulex software to manipulate various parameters such as crowd size, density, and exit conditions. By comparing simulation results with data from existing literature, the study aimed to identify key factors contributing to stampedes. Based on these findings, the study offers several recommendations to enhance risk management strategies and improve the likelihood of survival in emergency situations.

“Prediction and Diversion Mechanisms for Crowd Management Based on Risk Rating” (Zhang, Yao, and Xie 2017)-

In conclusion, an analysis of past accidents underscores the multifaceted factors influencing crowd evacuation, ranging from hazard identification failures to environmental constraints. While various elements contribute, the human factor remains paramount in safety and disaster management. This study delves into crowd behaviours impacting emergency situations and explores predictive techniques. It proposes risk-based plans to mitigate potential threats according to crowd density. Practical crowd management measures, demonstrated through a metro station case study in China, highlight the importance of tailored strategies at different risk levels. Ultimately, fostering risk consciousness among stakeholders and implementing scientifically sound safety procedures are advised for effective crowd security management.

“The Effect of Events on Pedestrian Behaviour and its Comparison with Normal Walking Behaviour in CBD Area in Indian Context”(Sukhadia et al. 2016)-

In conclusion, the prevalence of religious events in CBD areas significantly increases pedestrian traffic, often leading to overcrowded sidewalks due to uncontrolled vehicular growth and encroachments by hawkers and shopkeepers. This compromises pedestrian efficiency and safety, forcing pedestrians to share the main carriageway with vehicles, causing friction and endangering safety. Through a study conducted in Vadodara city, focusing on Durgashtami and Dushera events of the Navratri festival along with a normal working day, it was observed that pedestrian flow was bidirectional with a 20% reduction in walking speed during events compared to normal days. This reduction in speed can lead to congestion and discomfort, resulting in up to a 40% increase in pedestrian

overrun on event days and 20% on normal days. Empirical relationships between pedestrian flow, speed, density, and space were established. The study concludes that the level of service is higher on normal working days compared to event days. To enhance comfort, safety, and prevent the need for pedestrians to share the main carriageway, implementing event-based Traffic Management Solutions (TMS), such as prohibiting on-street parking, may prove effective.

"Level of Service Criteria of off-street Pedestrian Facilities in Indian Context using Affinity Propagation Clustering"(Sahani and Bhuyan 2013)-

In conclusion, while pedestrian level of service (PLOS) methodologies have evolved over time, there remains a lack of suitable approaches tailored to the diverse walking environments of India. Existing models often originate from contexts with homogeneous traffic flows, such as those in developed nations, and may not be universally applicable. However, the HCM (2010) methodology shows promise for adaptation to the Indian context with appropriate modifications. In this study, we adopted the PLOS methodology outlined in HCM (2010) and utilized AP clustering techniques to define six PLOS categories for off-street walking facilities in India. These categories differ significantly from those outlined in HCM (2010) due to factors such as heterogeneous traffic flows, lax enforcement of traffic laws, varied road geometries, and unauthorized activities along pedestrian pathways. While the AP clustering method shows potential for defining PLOS categories in other countries, it requires extensive datasets, which may pose a challenge. Further research, including qualitative studies and investigations in larger cities, is recommended to refine and expand upon the findings of this study, ultimately contributing to the development of comprehensive PLOS methodologies applicable to diverse urban settings.

"Factors influencing Pedestrian Speed in Level of Service (LOS) of pedestrian facilities"(Sangeeth and Lokre 2019)

In conclusion, understanding the requirements for pedestrian infrastructure necessitates evaluating existing facilities and their impact on pedestrian flow. Various methods for assessing Level of Service (LOS) for pedestrian facilities exist, outlined in sources like the Highway Capacity Manual (HCM) and Indian Roads

Congress (IRC). This study identified discrepancies in LOS based on different parameters, prompting a focused investigation into pedestrian speed. Factors such as age group, gender, group size, and trip purpose were identified as influencing pedestrian speed. Primary data collected through surveys confirmed that pedestrian speed varies significantly according to these factors. As a result of this study, a new chart for evaluating pedestrian LOS based on pedestrian speed was developed and validated. This chart provides a more nuanced understanding of pedestrian flow dynamics, contributing to the improvement of pedestrian infrastructure planning and design.

2.4 Scope & Limitation

2.4.1 Scope

The crowd control and circulation planning process for large scale events at Mahakaal Mandir and its surrounding centers on several special factors unique to the holy site. The process commences through a deep analysis of the temple site and the design and facility features. Special attention is paid to the features that impact on the crowd dynamics and flow in the holy area. A more detailed risk analysis is undertaken on the number of people at the crowd during religious functions, emergency exit locations, and adherence to public health protocols relevant to the temple environment. The plan will also include a robust communication plan for Mahakaal Mandir to ensure that both worshippers and guests get relevant information in an effective manner. Engaging with relevant stakeholders such as local police, security personnel, and temple administrators offers a coordinated

Sacred entry and exit processes are implemented to show respect to the sacred nature of the temple, yet prevent overcrowding, which reduces wait times and ensures the smooth passage of visitors. Personnel of temples have been trained in crowd control and emergency response protocols and effective communication strategies sensitive to the sacred atmosphere.

2.4.2 Limitations

There is no emphasis on the holistic development of all sacred sites of Ujjain city in terms of plan and condition for the footpaths and infrastructure.

Religious character is not emphasized on in detail even though that aspect plays a role in the selection of site because of high footfal

CHAPTER 3: STUDY AREA

3.1 Introduction to Site

Ujjain, a revered holy metropolis nestled within the heart of Madhya Pradesh, holds a sacred role at the banks of the sacred river Kshipra. Situated on the southern edge of the Malwa Plateau, Ujjain serves as the proud district headquarters, strategically positioned 190 kilometres away from the kingdom capital, Bhopal. Renowned for its cultural significance and historic historical past, Ujjain stands because the administrative epicentre of the Ujjain district. With a populace of approximately five.15 lakhs, as in step with the 2011 census, Ujjain ranks because the 5th largest metropolis in Madhya Pradesh. The metropolis's expansive municipal boundary area spans 92.68 rectangular kilometres, whilst its making plans boundary place extends to 152 rectangular kilometres. This delineation underscores the metropolis's spatial expanse and administrative jurisdiction.

Ujjain's illustrious records dates again to the Parmar length, reflecting a rich tapestry of cultural and architectural heritage. The town boasts a myriad of web sites steeped in religious importance, from ancient temples to respected pilgrimage locations, drawing devotees and religious seekers from far and extensive. Beyond its religious landmarks, Ujjain's organic town core exudes a unique allure, characterised by way of winding streets, bustling markets, and architectural marvels that narrate tales of bygone eras. Heritage hotspots dot the cityscape, keeping the legacy of its illustrious past and imparting glimpses into its storied history Moreover, Ujjain is replete with pockets of intangible historical past, wherein age-old traditions, rituals, and cultural practices thrive amidst the current-day hustle and bustle. These cultural enclaves function repositories of lifestyle and identification, embodying the essence of Ujjain's vibrant cultural tapestry.

Amidst its urban panorama, Ujjain is blessed with herbal vistas that add to its attraction, with scenic landscapes and verdant surroundings presenting respite and rejuvenation to citizens and visitors alike. From serene riverside Ghats to lush green parks, Ujjain's herbal splendour enhances its cultural richness, developing a harmonious combo of history and nature In essence, Ujjain stands as a testament to India's cultural heritage, embodying centuries of culture, spirituality, and

architectural splendour. With its sacred sites, historic landmarks, and colourful cultural scene, Ujjain beckons travelers to embark on a adventure of exploration and discovery, delving into the soul of this ancient city and experiencing its timeless attraction first-hand.

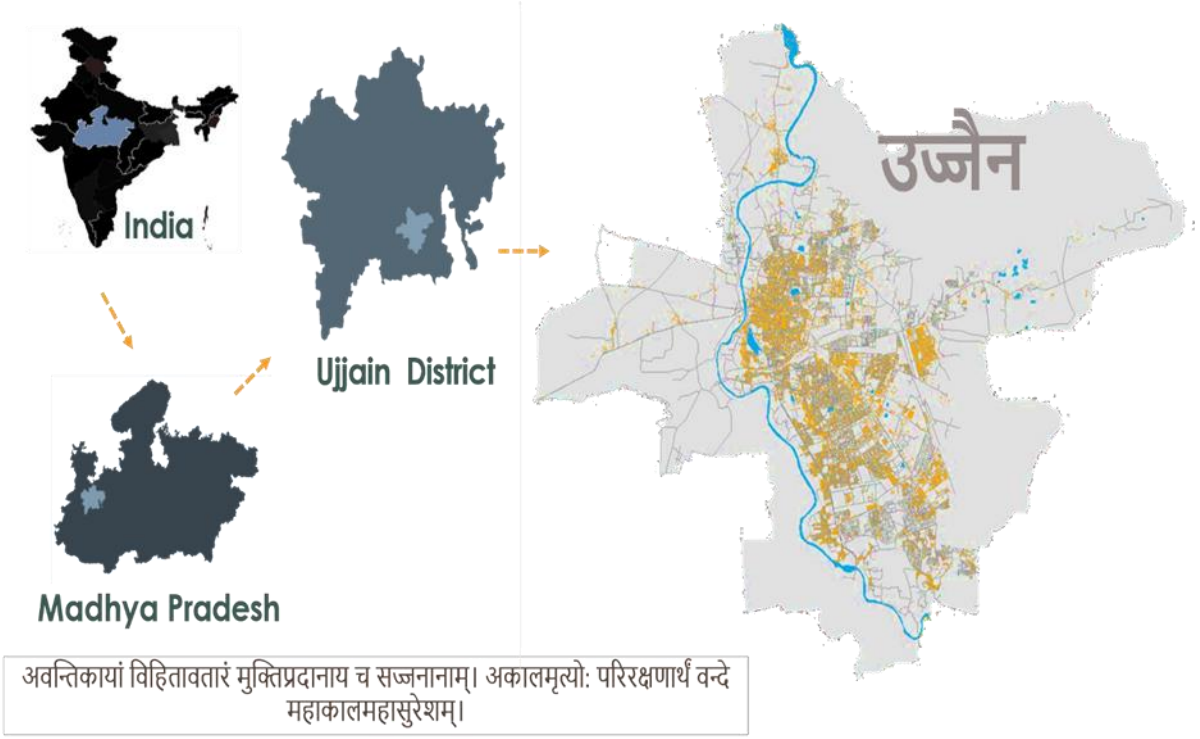


Fig 4 Key Map

3.2 Regional Settings

Ujjain, situated inside the heart of India, boasts incredible connectivity with different elements of the united states of america through a well-hooked up network of roads and railways. Travelers can easily get right of entry to the town via numerous transit centres located both within and in the place of Ujjain.

Railway connectivity is powerful, with two foremost rail terminals serving as important transportation hubs for the metropolis. Additionally, three bus terminals cater to the various needs of visitors, presenting handy get right of entry to to and from Ujjain. While the town itself does no longer have an airport, the nearby Devi Ahilyabai Holkar Airport in Indore, placed approximately ninety kilometres away, serves as the nearest air transit hub.

Ujjain falls in the administrative obstacles of the Ujjain district, which encompasses numerous other cities and cities, together with Nagda, Badnagar, Pradeep, Fatehabad Chandrawatiganj, Khachrod, Mahidpur, Tarana, and Unhel. This

broader district region contributes to the general connectivity and accessibility of Ujjain, facilitating motion and interplay among neighbouring groups. The town benefits from a complete avenue community, with key arterial routes consisting of Aagar Road, Indore Road, Badnagar Road, and Maksi Road linking Ujjain to principal urban centres and transportation hubs throughout the . While Ujjain itself does not have a national highway passing via its limits, the nearby National Highway NH-three, positioned simply 35 kilometres away, serves as a vital conduit for nearby and interstate travel. Furthermore, the Bhopal-Ratlam rail community traverses through Ujjain, bolstering its connectivity with neighbouring towns and regions. Additionally, State Highway 27 performs a pivotal role in linking Ujjain with the close by town of Indore, similarly improving accessibility and facilitating seamless travel among these two huge city centres.

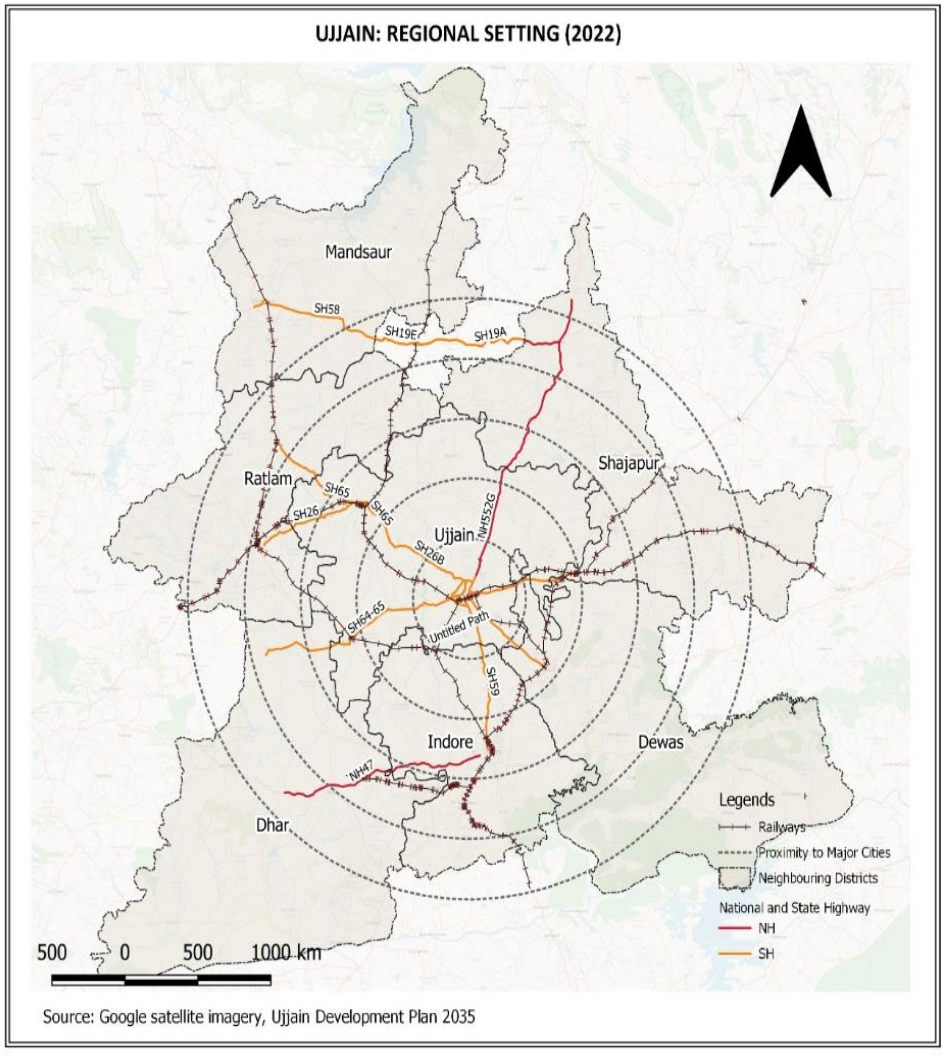


Fig 5 Regional Map *Source:Ujjain development plan*

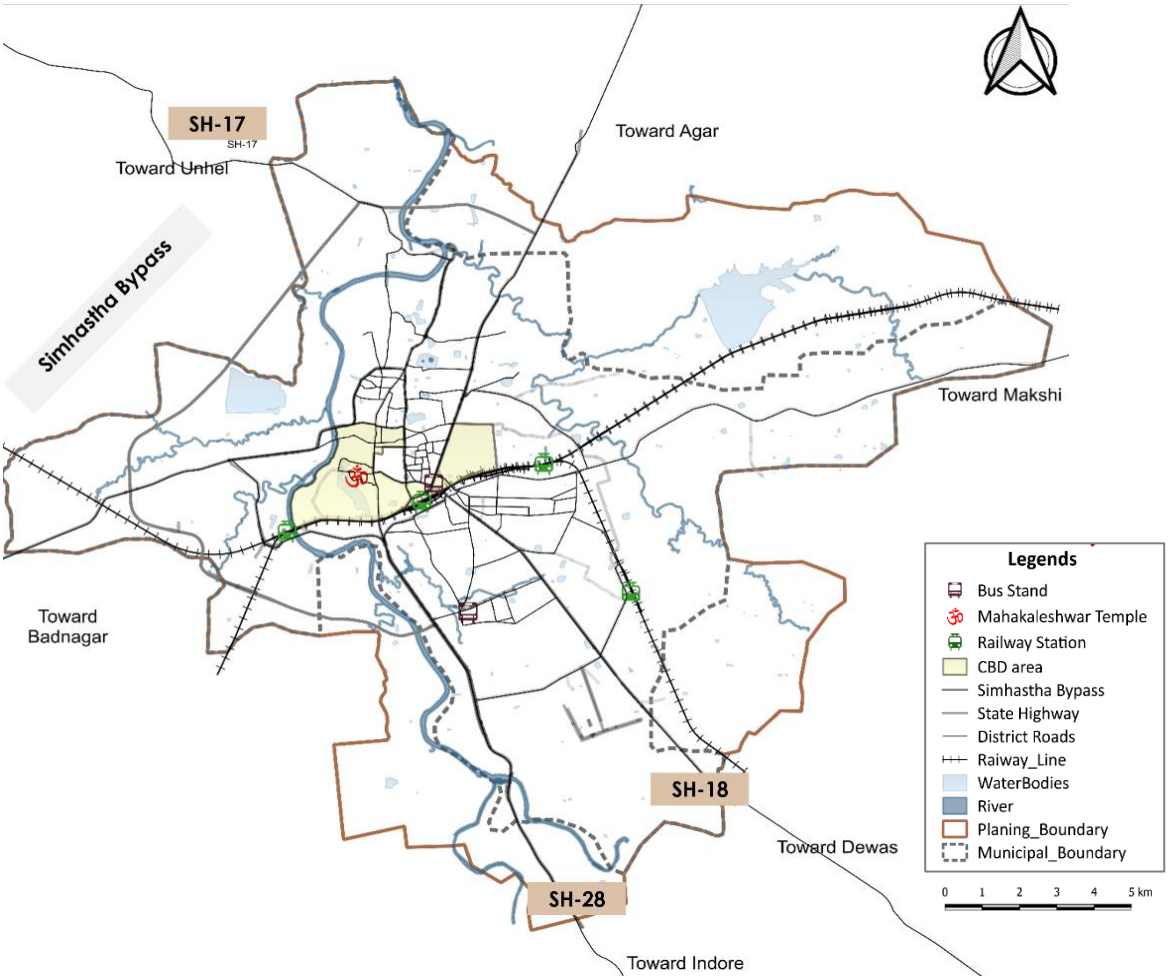


Fig 6 Ujjain map

Source:Ujjain development plan

3.3 Existing Land Use

The land-use map, as illustrated in Fig-6, offers treasured insights into the spatial distribution of built-up areas inside Ujjain. Among the numerous land-use classes, residential utilization could be the essential land-use kind, occupying a full-size portion of the city landscape at 19%. This suggests the town's primary characteristic as a residential hub, catering to the housing needs of its population. Following closely behind residential regions, transportation infrastructure claims a remarkable part of the built-up space, accounting for six.46% of the whole place. This consists of roads, highways, bridges, and other transportation-related centers, reflecting the metropolis's efforts to set up green connectivity and mobility networks to facilitate motion inside and past its borders. Another prominent land-use category is leisure space, encompassing parks, playgrounds, and amusement

facilities, which together occupy four% of the whole location. These recreational facilities play a essential role in enhancing the first-class of lifestyles for residents and presenting spaces for relaxation, socialization, and out of doors activities. In addition to these primary land-use classes, the urban fabric of Ujjain features numerous built-up areas dedicated to commercial, public semi-public, mixed-use, and industrial activities. Commercial zones, such as Freeganj and the cloth markets near the Mahakal Mandir, serve as bustling hubs of economic activity, characterized by vibrant markets, shops, and businesses. Furthermore, the city boasts a rich heritage of architectural marvels, with several ASI-marked heritage sites showcasing a blend of Maratha and Rajput architectural styles. These heritage sites not only serve as cultural landmarks but also attract tourists from far and wide, contributing to the city's historical significance and tourism potential.

Overall, the land-use map of Ujjain paints a comprehensive picture of its urban landscape, reflecting a harmonious balance between residential, commercial, recreational, and cultural activities. This dynamic mix of land uses underscores the city's vitality, diversity, and cultural heritage, making it a vibrant and liveable urban centre in the heart of India.

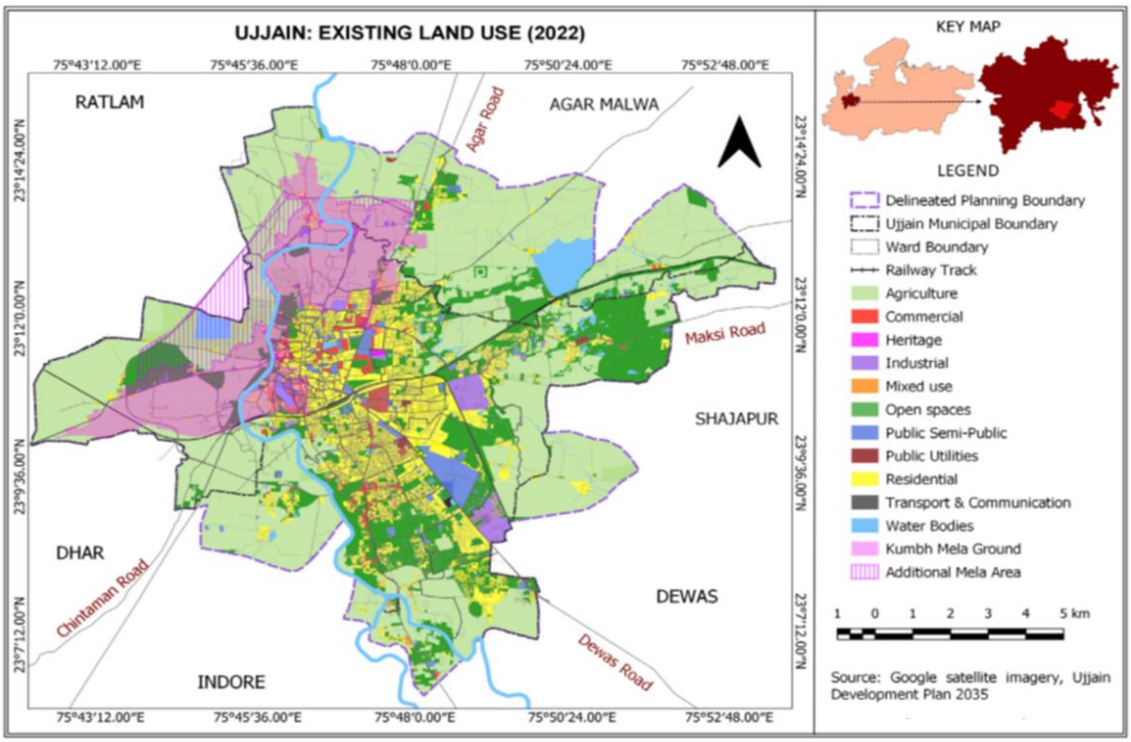


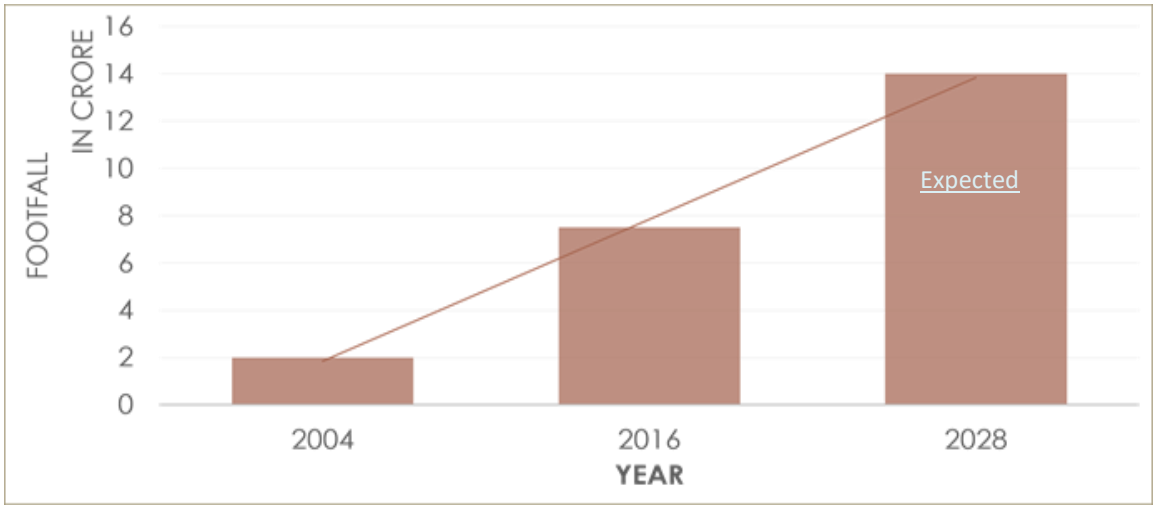
Fig 7 Land Use Map (2022)

Source:Ujjain development plan

3.4 Data Collected & Analysis

3.4.1 Events & Tourist Footfall

Ujjain, renowned for its cultural and religious significance, hosts a myriad of regular events that reflect the city's rich heritage. The most prominent among these is the Simhastha Kumbh Mela, a grand Hindu festival that occurs every 12 years, drawing millions of pilgrims to the banks of the Shipra River. This event witnesses elaborate rituals, spiritual discourses, and vibrant processions, making it a spectacle of faith and devotion.



Graph 1-Simhastha Footfall

Source:Ujjain simhastha karyalaya

The graph-1 depicts the anticipated rise in the number of devotees during the upcoming Simhastha festival from 2004 to 2016 and in 2016, this grand Hindu festival attracted an astounding 6.15 Crore devotees over a span of two months. And for 2028, reflecting the expected increase in tourist footfall is around +14 Crore. Apart from the Simhastha (Kumbh Mela), the city is host to the Mahakaleshwar Jyotirlinga Utsav, an annual celebration dedicated to Lord Shiva, the presiding deity of the revered Mahakaleshwar Temple. Devotees gather to participate in religious ceremonies, cultural performances, and processions during this event.

Ujjain is also known for the Kalidasa Festival, an annual cultural extravaganza that pays homage to the classical Sanskrit poet Kalidasa. This festival showcases various classical arts, including music, dance, and drama, attracting artists and enthusiasts from across the country. Furthermore, the city observes various religious and cultural events throughout the year, such as Naagpanchmi,

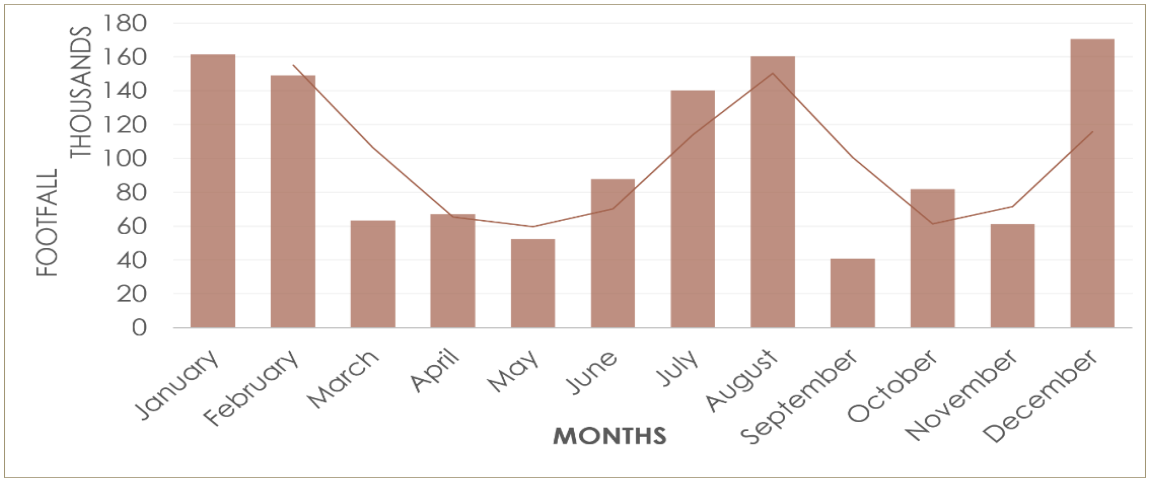
Panchkroshi yatra and Holi & etc. Where locals and visitors come together to celebrate with festivals. These events contribute to Ujjain's vibrant atmosphere, providing a unique blend of spirituality, tradition, and cultural vibrancy for residents and tourists alike. The table-1 provides an overview of annually celebrated festivals and events in Ujjain, each with its dedicated duration of days. These occasions serve as focal points for the city, drawing tourists in accordance with their significance to specific places and deities.

Table 1-Events details & Footfall

Festival/Mela	Period (month)	Duration (days)	Place	Estimated Visitors
Simhastha / Kumbh	After every 12 years	30	Kumbh Mela Ground	**5-6 Crore**
Vaishakah Snan	चैत्र-वैशाख (Mar-Apr)	30	Near Bada Pul, Ramghat to Triveni,Lal pul.	**25000-30000**
Panchkroshi Yatra	वैशाख (Apr-May)	5	Mangalnath,K.d palace, Pingleshwar,Triveni,Bilkeshwar (118km)	**25000-30000**
Ganga Dussera	वैशाख-ज्येठ (May-June)	9-10	Ram Ghat	**25000-30000**
Nag Panchmi	श्रावन (July-Aug)	30	Mahakaal mandir, Nagchandeshwar	**50000-60000**
Kartik Snan	कार्तिक (Oct-Nov)	30	Near Bada Pul-Ram Ghat	**30000-40000**
Makar Sankranti	पौष (Dec-Jan)	1-2	Mahakaal Temple	**20000-25000**
Magh Snan	माघ-फाल्गुन (Jan-Feb)	30	Bada Pul-Triveni Ghat	**20000-25000**
Maha Shivratri	माघ-फाल्गुन (Jan-Feb)	1-2	Mahakaal Temple	**1-2 lakh +**

Source:Ujjain smart city limited (USCL)

Ujjain, with its cultural and religious significance, experiences a substantial influx of visitors throughout the year. The floating population in the city is notable, ranging from an average of 30,000 to 50,000 individuals. This dynamic figure reflects the steady stream of tourists, pilgrims, and travellers who are drawn to the city for its historical charm and spiritual allure. Moreover, the annual tourist footfall as shown (Graph-2) arrival numbers for Ujjain provide a comprehensive perspective. In the fiscal year 2022-23, the city welcomed approximately 12, 35,944 tourists. This consistent flow of visitors attests to the city's enduring appeal as a tourism destination, offering a blend of historical landmarks, religious sites, and cultural events that captivate the interest of travellers throughout the year.

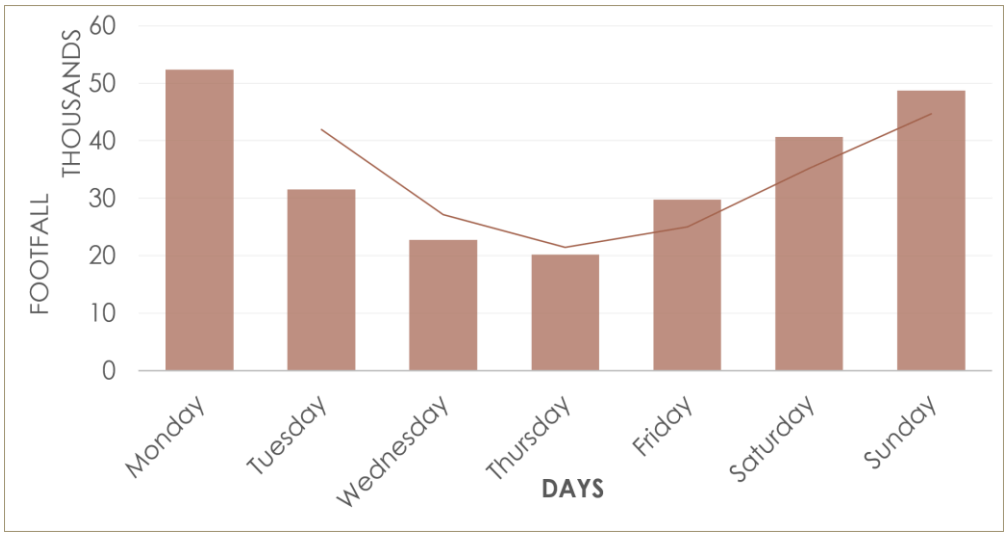


Graph -2 Monthly Footfall FY-2022-23

Source:Ujjain smart city limited (USCL)/MMPS

Ujjain's ability to host and accommodate such diverse and substantial crowds reflects its significance as a cultural and religious center, contributing to the city's vibrancy and economic activity. The continuous flow of visitors underscores Ujjain's position as a prominent destination for those seeking spiritual solace, cultural exploration, and a glimpse into India's rich heritage city from last few year which is increasing in footfall also because of its attractive site beautification i.e mahakaal corridor.

As the below shown graph-3 is the latest details of 26 January 2024 to 02 February 2024 month footfall of last weekend's days.



Graph 3-Weekend footfall (26 Jan- 02Feb 2024)

Source:Ujjain smart city limited (USCL)/MMPS

3.4.2 Procession Location & Capacity

Ujjain, a city deeply entrenched in religious and cultural traditions, several significant procession points exist, with the most notable being around the Mahakaleshwar Temple during religious festivals like the Kumbh Mela. Ujjain has developed its infrastructure to accommodate large gatherings during major events. The Mahakaleshwar Temple premises and the areas around the Shipra River, where the Kumbh Mela takes place, are equipped to handle the immense crowds that gather during these festivals. The city's administration and local authorities take measures to ensure the safety and convenience of the visitors, implementing crowd control mechanisms and facilitating the smooth flow of processions. While specific capacity figures may vary based on the event and the venue, Ujjain's ability to host significant gatherings is a testament to its cultural importance and the preparedness of the city to manage the influx of devotees and tourists during various religious and cultural celebrations. The combination of historical significance, religious festival, and effective event management makes Ujjain a prominent destination for those seeking to participate in grand processions and ceremonies. The designated area marked on the map stands out as the focal point for both tourists and locals alike, serving as a hub for various attractions and religious processions. While the exact capacity of the procession point remains unspecified, the significance of the adjacent ghat cannot be overstated. This particular ghat, revered by visitors, offers a plethora of experiences, including the renowned evening aarti ceremony, a spectacle that draws crowds from far and wide. Additionally, it provides pilgrims and devotees with the opportunity to partake in the age-old tradition of cleansing their souls through a sacred dip in the holy waters. Thus, the combined allure of cultural festivities, spiritual rituals, and the serene ambiance makes this area a pivotal destination within the region, captivating the hearts and minds of all who visit. The capacity analysis provided focuses primarily on the major chunk of the ghat portion, shedding light on its significance within the broader context of the area. This segment of the ghat serves as a pivotal gathering point , accommodating a substantial number of pilgrims and tourists who converge here for various religious and cultural activities. With meticulous attention to detail, the capacity analysis delves into the infrastructure and spatial layout of this ghat section, aiming to optimize its functionality

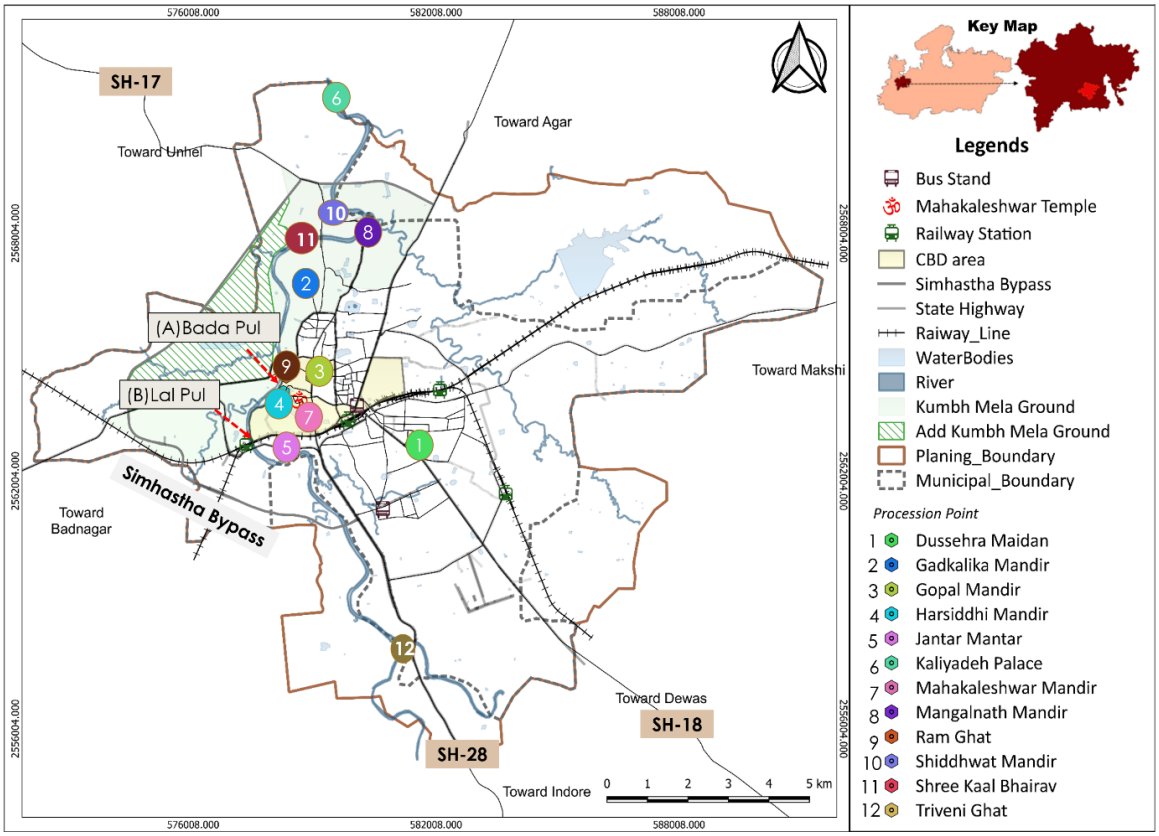


Fig 8 Procession Locations in Ujjain

Source:Ujjain smart city limited (USCL)/MMPS

राम घाट

नाग पंचमी

महाकाल सवारी

Image Source: USCI

Capacity of Ghats-

The comprehensive analysis extends to encompass the entirety of the Ghats lining the Kshipra coast, stretching from Triveni to Kaliadeh Palace. Through meticulous calculations, the analysis determines the maximum capacity of the entire platform, considering a conservative estimate of one person per square meter of available area. By accounting for the total surface area of the platform across all Ghats along the Kshipra coast, the analysis offers insights into the collective capacity to accommodate visitors during peak times of pilgrimage and cultural events. This calculation involves measuring the length and width of each Ghat, factoring in any variations in size and configuration, and aggregating these dimensions to derive the total usable area.on the basis of **one person per square meter area**.

Table 2- Capacity of Ghats

Location	Person attending one time
Eastern Ghats (A to B)	32943
Western Ghats (A to B)	27997
Other Ghats	14687
Total	75,627

Kumbh is the mega event in city which leads to various permanent and temporary changes. Permanent construction include road widening, ghat reconstruction, etc. which aims at overall beautification of city. A significant disparity is seen between the two visiting groups- Around 31 lakh tourists with short average stay visit Ujjain annually whereas over 7 crore pilgrims with longer average stay during the holy occurrence of Kumbh. The possible explanation for ephemerality could be attributed to the lack of conservation and promotion of heritage sites like Vedhshala, Bhartrihari caves, Kaliyadeh palace and Narsingh ghat that are experiencing steady decline in footfall. The total tourist inflow in Ujjain stands at 3% of the total tourist visiting Madhya Pradesh; which has slipped 2 percentage points from 2017 to 2018. The low tourist count could be associated with the skewed target group of tourists by the city - Majorly elderly population (especially males).Various other cultural activities take place at different time in the city that

have been marked highlighting Procession routes and spots where different communities celebrate. Paryushan - a Jain community festival – is celebrated on the occasiona of Lord Mahavira's birth date and this tradition has been preserved for past 42 years by this community. Similarly, a Christian community procession takes place on the occassion of Christmas which is celebrated in two main churches in the city - Masihi Church and Catholic Church, near Dewas Road.

The MP Tourism Department and Ujjain Smart City SPV (Special Purpose Vehicle) have undertaken active steps toward promoting tourism in the circuit. To cater to the needs of the target population, the state authorities have introduced projects like the preparation of Mahakaal Van and the conservation of facades of streets and galleries. Ujjain is also part of PRASHAD scheme. Lack of community participation and policy support to the indigenous artisans stand as the hindrance to the promotion of fading art and knowledge like Bherugarh hand printing,

Batik art and wooden comb making which was once popular across the world to grow as a viable economic source.

3.4.3 Traffic Inflow

Ujjain, an ancient city nestled in the heart of Madhya Pradesh, India, boasts strategic connectivity with its surrounding regions, fostering a dynamic flow of traffic through six primary directions. Each entry point serves as a gateway to Ujjain's rich cultural heritage and economic vitality, facilitating seamless access for travellers from neighbouring towns and cities. From the north, well-maintained roads provide a smooth passage for traffic entering Ujjain, linking the city to prominent urban centres such as Indore. This northern approach serves as a vital artery, channelling a steady stream of visitors and commuters into Ujjain's bustling streets. Similarly, the southern entry points offer convenient connectivity to cities like dewas and Dhar, drawing travellers from afar to explore Ujjain's myriad attractions. This

southern corridor serves as an essential conduit, enabling the smooth movement of traffic and enhancing the city's accessibility from the region to the east, roads extending from towns like Maksi and Shajapur provide easy access to Ujjain, further bolstering the city's connectivity and facilitating efficient travel for residents and visitors alike. This eastern ingress contributes to Ujjain's accessibility, serving as a vital link to neighboring communities. On the western front, entry points from locations such as Nagda and Ratlam establish crucial connections with Ujjain, ensuring continuous vehicular movement and enhancing the city's economic ties with the western region. This western corridor serves as a gateway to Ujjain's cultural heritage and economic opportunities. Moreover, travelers arriving from the northwest are greeted by scenic landscapes as they journey from towns like Barnagar and Mahidpur to Ujjain. This northwest approach adds to the city's charm, offering visitors a picturesque route to explore Ujjain's cultural treasures.Finally, the southwest direction provides access to Ujjain from towns like Badnagar and Khachrod, further expanding the city's reach and reinforcing its status as a pivotal hub in the region.Collectively, this well-connected network of roads and highways positions Ujjain as a strategic nexus, facilitating the efficient and diverse movement of traffic from all directions. This seamless connectivity not only enhances Ujjain's cultural and economic vibrancy but also reinforces its status as a prominent destination for travelers seeking to experience the essence of ancient India. The fig-10 depicts the traffic volume data captured during the Mahashivratri special event in Ujjain in 2022, revealing a significant influx of vehicles into the city. The total number of vehicles recorded highlights the considerable demand for parking facilities, particularly during this auspicious occasion. However, the existing parking capacity in the city, which amounts to 2150 ECS (Equivalent Car Spaces), falls short of adequately accommodating this surge in vehicle numbers. The challenge of insufficient parking space exacerbates congestion issues, particularly around the city's core areas, junctions, and other key locations. This influx of vehicles not only strains the existing infrastructure but also disrupts the smooth flow of traffic, impacting the overall mobility within the city. Furthermore, the situation is compounded by the presence of vehicles from outside the city, adding to the congestion and exacerbating traffic-related issues

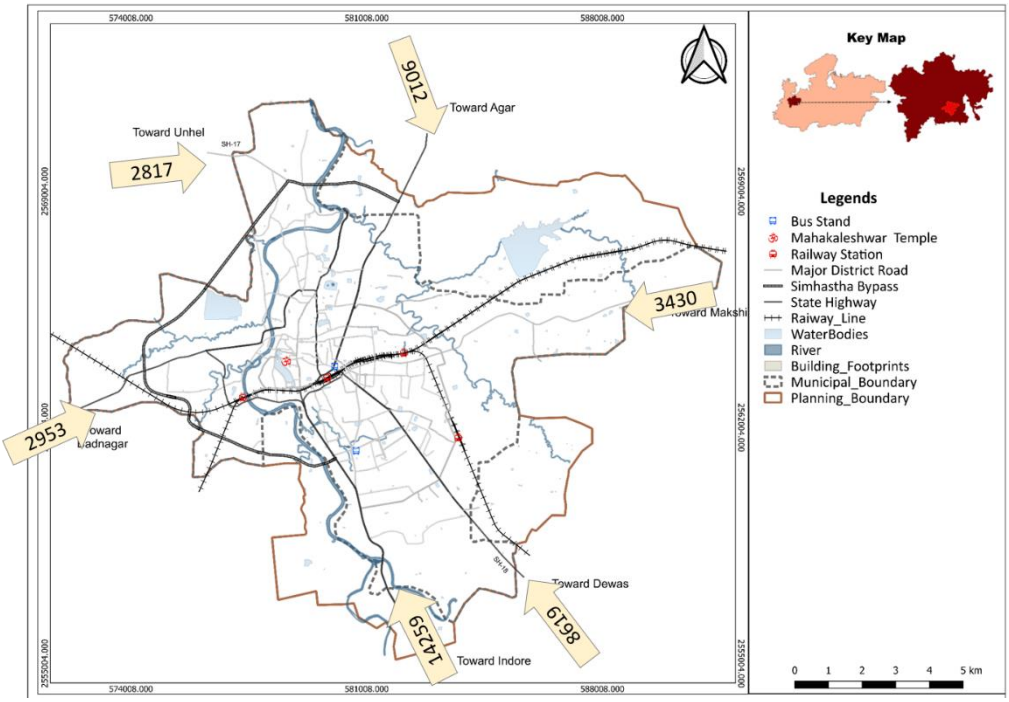


Fig 10 Traffic Inflow

Source:Ujjain smart city limited (USCL)/MMPS

This influx, combined with the normal city traffic, creates significant challenges for commuters, residents, and businesses alike. Efforts to address this issue include leveraging the Smart City initiatives, which encompass eight designated parking zones, as well as collaborating with private players to optimize parking spaces. However, despite these measures, the demand for parking still outweighs the available capacity, underscoring the need for further strategic planning and infrastructure development to alleviate congestion and enhance the overall urban mobility experience during events like Mahashivratri.

3.4.4 Corridor Profile

Following the completion of the initial phase of MRIDA-1 (Mahakaal Rudrasagar Integrated Development Approach), the corridor profile of the Mahakaal Mandir has undergone a transformative evolution. This revered site, known for attracting throngs of devotees and tourists alike, now boasts increased physical capacity, capable of accommodating a staggering 1,04,597 individuals. This expansion not only reflects the growing popularity of the site but also underscores the importance of catering to the needs of the ever-increasing number of visitors.Moreover, alongside the augmentation of physical capacity, there has been a concerted effort

to enhance the effective capacity of the site, ensuring that visitors can experience the spiritual sanctity and cultural richness of the Mahakaal Mandir in a comfortable and conducive environment. With an effective capacity of 65,989, the site can now better manage the flow of visitors, mitigating overcrowding and enhancing the overall visitor experience.

The transformation extends beyond mere capacity enhancements, as the plaza area has also been revitalized to accommodate up to 20,000 individuals. This expansive plaza serves as a vibrant hub of activity, providing ample space for congregations, gatherings, and cultural events. Moreover, it offers visitors a tranquil oasis amidst the bustling energy of the pilgrimage site, allowing them to pause, reflect, and immerse themselves in the spiritual ambiance of the surroundings. Central to the allure of the Mahakaal Mandir are the 108 monuments and other scenic attractions that dot the landscape, captivating visitors with their awe-inspiring architecture and evocative sound and light displays. These attractions not only serve as points of interest but also play a pivotal role in enriching the visitor experience, offering glimpses into the rich cultural heritage and spiritual significance of the site.

Despite these remarkable advancements, concerns linger regarding the lack of effective crowd control measures implemented by security personnel. The absence of robust crowd management strategies poses a potential risk of disaster, as unchecked movement and congestion within the site could lead to chaotic situations and compromise the safety of visitors. Thus, it becomes imperative for authorities to prioritize the implementation of stringent security protocols to ensure the well-being and security of all those who visit this sacred pilgrimage site.

The Ujjain city core area, encompassing the Mahakaal Corridor and its surroundings, spans approximately 310 acres or 125 hectares. Within this vibrant district, the Central Business District (CBD) covers an extensive area of 1023 acres, bustling with commercial, cultural, and administrative activities. With a population of 87,776 residents, the CBD serves as a vital hub for the city's economic and social life. At the heart of this urban landscape lies the Mahakaal Corridor, stretching over 2.5 kilometres, offering a scenic pedestrian route that showcases the rich heritage and spiritual essence of the region. Complementing this corridor are additional pedestrian routes totalling 8.94 kilometres, facilitating

seamless mobility and fostering a pedestrian-friendly environment within the core area. Despite its pedestrian-friendly focus, the city maintains a robust road network spanning 54 kilometres, catering to both vehicular and pedestrian traffic. This extensive network connects various key points within the CBD, ensuring accessibility and facilitating the flow of commuters and visitors alike. Navigating this urban expanse are a total of 74 junctions, comprising both three- and four-arm intersections. These junctions serve as critical nodes within the city's transportation network, regulating traffic flow and ensuring efficient movement throughout the core area.

In essence, the Ujjain city core area, anchored by the Mahakaal Corridor, epitomizes a harmonious blend of historical grandeur, commercial vitality, and urban functionality. As a Vibrant center of activity and cultural significance, it continues to evolve, catering to the needs of its residents and visitors while preserving its rich heritage for generations to come.

Near the corridor, there are several parking locations available with limited capacity and restricted access roads. These parking facilities cater to different destinations along the route, accommodating both two-wheelers and four-wheelers.

- Chaardham offers parking space for four-wheelers, with a capacity of 300 units, ensuring ample room for vehicles in proximity to the corridor.
- Hatkeshwar provides parking options for both two-wheelers and four-wheelers, with space for 200 units of two-wheelers and 100 units of four-wheelers.
- Madhav Sewa accommodates parking for two-wheelers and four-wheelers, with a capacity of 120 units and 60 units, respectively.
- Neelkanth offers parking facilities for both two-wheelers and four-wheelers, with space for 300 units of each type.
- Triveni provides parking space for two-wheelers and four-wheelers, with a capacity of 200 units and 400 units, respectively.Hari Phatak offers parking

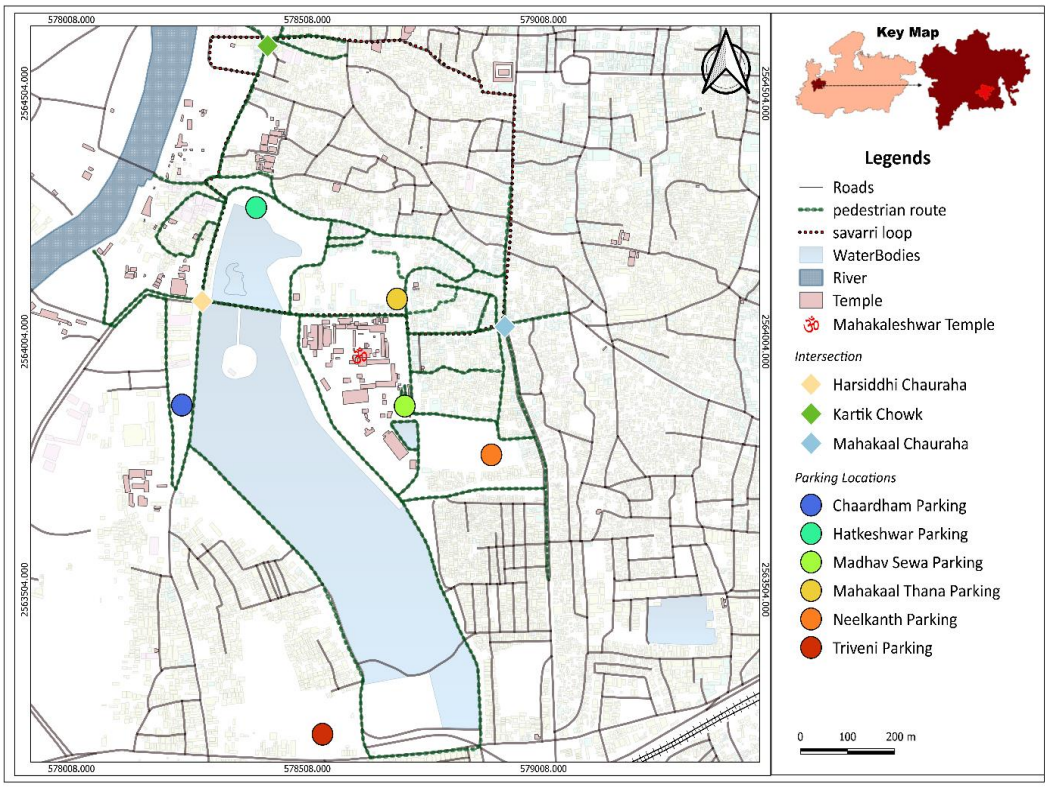


Fig 11 Parking Locations & Intersections

Source:Author Generated

In total, these parking locations provide a combined capacity equivalent to 2150 car spaces, ensuring that pilgrims and visitors have convenient access to parking facilities near the corridor. Despite limited capacity and restricted access roads, these parking areas serve as essential amenities for those embarking on the sacred journey through the corridor, facilitating smoother travel experiences and ensuring efficient management of vehicular traffic.

3.4.5 Activity Zone

The fig 12-13 represents the origin and destination points derived from a sample of 133 individuals, showcasing the diverse reasons for their travels. Among the sampled population, a significant majority, comprising 89%, are devotees undertaking the journey primarily for darshan (religious worship or pilgrimage). These individuals embark on their travels with the sole purpose of seeking spiritual fulfilment and engaging in sacred rituals at their chosen destination. Conversely, the remaining 11% of the sampled population are travelers whose motivations for the journey are primarily work-related. These individuals have specific professional

or business obligations that necessitate their travel to particular destinations, distinct from the spiritual pursuits of the devotees.

From the data gathered on the origin and destination map, it becomes evident that following their visit to the Mahakaal Temple, pilgrims prioritize their next destinations. The second most sought-after site is the Kaal Bhairav Temple, situated approximately 6 kilometres away. While various modes of transportation are available, it is observed that e-rickshaws are prominently utilized for this leg of the journey. Following Kaal Bhairav Temple in priority is the Mangal Nath Mandir, located approximately 5 kilometres from the Mahakaal Temple. Similarly, pilgrims have several transportation options at their disposal for this journey, yet e-rickshaws remain a prevalent choice among travelers.Additionally, the nearby Harsiddhi Mandir, merely 900 meters away from Mahakaal Mandir, holds significant importance for pilgrims. The short walking distance makes it easily accessible for devotees who prefer a more leisurely approach to their pilgrimage experience. Lastly, one of the most noteworthy attractions is the Ram Ghat, particularly renowned for its evening Aarti ceremony. Pilgrims are drawn to this sacred site to witness the divine rituals and partake in the spiritual ambiance that permeates the atmosphere during this revered ceremony.

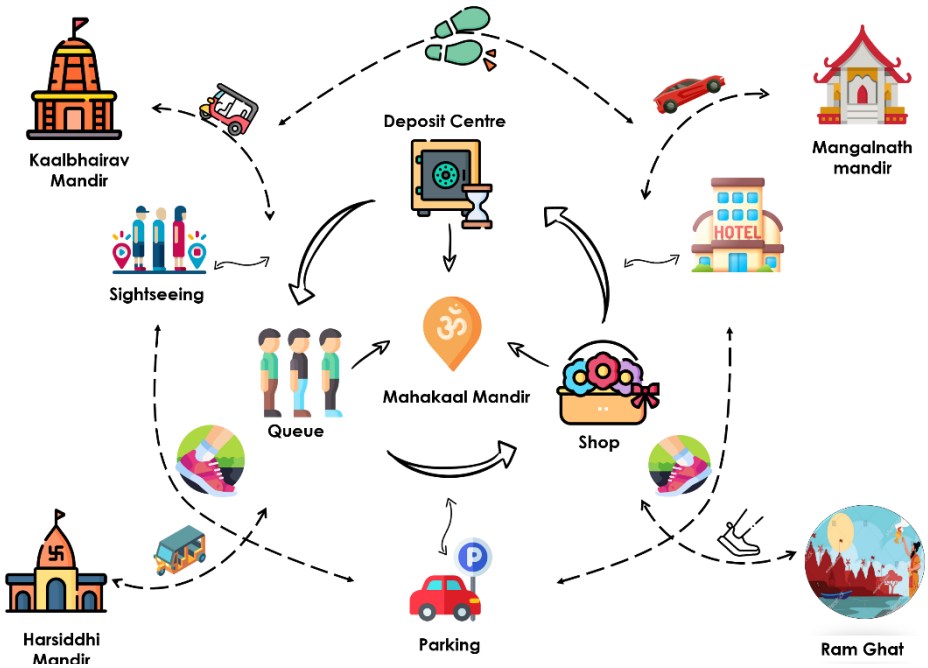


Fig 12 Activity Map

Source:Author Generated

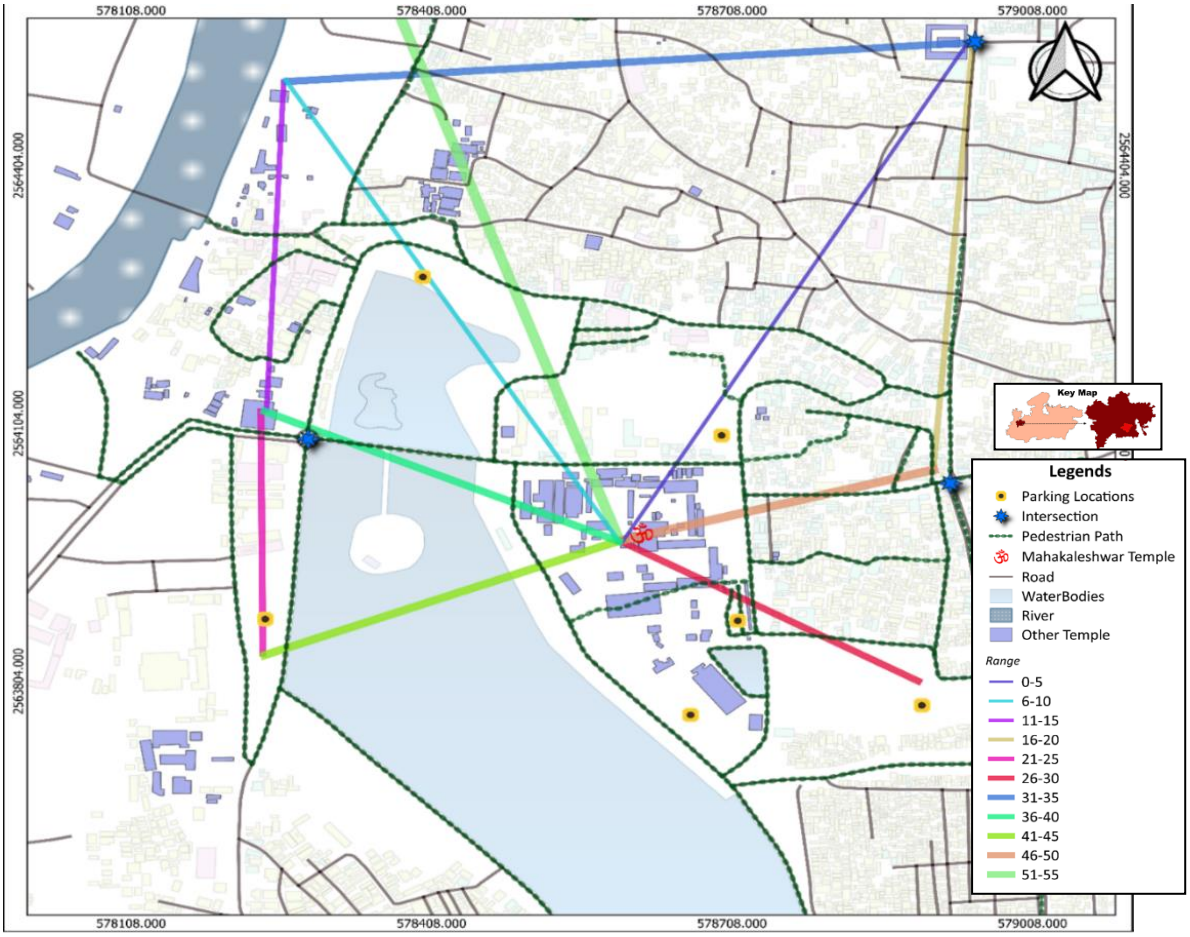


Fig 13 Origin-destination survey

Source:Author Generated

Through the analysis of travel patterns and destination preferences, it is apparent that pilgrims exhibit a diverse range of priorities and preferences as they navigate their spiritual journey through these sacred sites. This understanding enables stakeholders to tailor transportation services and infrastructure development to better serve the needs of pilgrims and enhance their overall pilgrimage experience. Observations reveal a distinct pattern of activities among devotees as they embark on their pilgrimage journey to the sacred sites. Typically, pilgrims commence their journey from their accommodations or designated parking areas, following a primary axis path that guides them towards their chosen destination. Along this path, they engage in sightseeing, exploring various interconnected landmarks and attractions that enrich their spiritual experience. Upon reaching their destination, pilgrims often participate in rituals and offerings, seeking blessings from the divine. A common activity observed at these sites is the submission of offerings and donations at designated collection centres, symbolizing devotees' reverence and

devotion. Following the spiritual rituals, pilgrims often visit nearby shops to procure gifts and offerings for Lord Shiva, further demonstrating their commitment to their faith and devotion. This act of gifting reflects a tradition deeply ingrained in Hindu culture, where devotees express their gratitude and reverence through offerings and donations. One of the most significant aspects of the pilgrimage experience is the anticipation and preparation for darshan, the sacred act of witnessing the deity. Devotees patiently wait in queues, enduring the hustle and bustle of the entry and exit points, with an average waiting time of approximately 45 minutes. This period of anticipation is filled with a sense of excitement and reverence as devotees eagerly await their turn to offer their prayers and seek blessings from the divine presence.

Through keen observation of these activities, we gain insights into the rituals, traditions, and expressions of faith that characterize the pilgrimage experience for devotees. By understanding these dynamics, stakeholders can tailor their services and facilities to enhance the overall pilgrimage journey, ensuring a seamless and spiritually enriching experience for all pilgrims

CHAPTER 4: DATA ANALYSIS

4.1 Relative Importance Index

The Relative Importance Index (RII) is a statistical measure used to assess the relative importance or priority of different items or factors within a given set. It is commonly employed in market research, social sciences, and various other fields to understand the perceived significance of various attributes or variables.

The RII is calculated using survey data, where respondents are asked to rate the importance of each item or factor on a numerical scale. The formula for calculating RII involves the following steps:

- Assign each item or factor a numerical rating based on the responses received from survey participants. Typically, the ratings range from 1 to 5, with 1 indicating low importance and 5 indicating high importance.
- Calculate the mean (average) rating for each item or factor across all survey respondents.
- For each item, calculate the proportion of respondents who rated it as "high importance" (i.e., those who assigned a rating of 4 or 5).
- Compute the RII for each item using the formula: RII = (Mean Rating of "High Importance" / Maximum Possible Rating)The maximum possible rating is the highest rating on the scale, which in this case would be 5.
- The resulting RII values represent the relative importance or priority of each item or factor within the set, with higher values indicating greater perceived importance.

By analysing the RII values, researchers can identify the key drivers or factors that influence respondents' perceptions and preferences within the surveyed population. This information is valuable for making informed decisions, prioritizing resources, and designing strategies that align with the priorities and preferences of the target audience.

An extensive interview survey was undertaken within the vicinity of the Mahakaal corridor, involving a diverse group of respondents. A total of 133 individuals participated in the survey, reflecting a broad spectrum of perspectives and backgrounds. Among the participants, there was a notable representation of locals, comprising 17% of the total, while 43% hailed from the same state, Madhya

Pradesh. The remaining respondents originated from various other regions, contributing to the diversity of the sample.

Throughout the survey, participants were engaged with 11 carefully crafted questions, each designed to explore different facets of the thesis topic. Specifically, 5-6 inquiries delved into the factors influencing pedestrian experiences within the corridor, addressing concerns related to safety, accessibility, infrastructure, and overall pedestrian comfort. Subsequently, another set of 5-6 questions focused on identifying the most critical areas requiring improvement within the corridor, aiming to uncover actionable insights for enhancing the overall pedestrian experience.

Following the survey, a Relative Importance Index (RII) analysis was conducted to discern the relative significance of the factors identified through the survey responses. This analysis provided valuable insights into the ranking of these factors, enabling researchers to prioritize interventions and allocate resources effectively to address the most pressing concerns. Furthermore, the demographic composition of the survey participants revealed an interesting gender distribution, with 62 respondents identifying as male and the remaining respondents as female. This gender diversity enriched the dataset, offering a well-rounded perspective on the pedestrian experience within the Mahakaal corridor. Notably, the survey findings underscored the overwhelming priority placed on the temple among respondents, with a striking 89% expressing a preference for visiting the temple over engaging in other essential tasks or activities. This emphasis on spiritual devotion highlights the profound significance of the Mahakaal temple within the cultural and religious landscape of the region, shaping the behaviours and priorities of visitors and locals alike.

The Formula which is used:- $RII = \Sigma W / (A*N)$

W - Scale for rating a factor

(Ranges from 1-Very Unsatisfied, 2-Unsatify 3 Neutral 4-Satisfy 5- Very Satisfy)

A – The highest weight in the scale;

N - Total number of respondents.

The factors were presented to the users and masses for their responses, with each factor rated on a Likert scale ranging from 1 to 5, indicating the level of agreement or importance. After gathering responses, each rating was multiplied by its corresponding Likert scale number to calculate the total score for each factor.

To determine the overall mean score, the sum of all the calculated scores for each factor was divided by the total number of responses. This process involved multiplying the Likert scale responses (1-5) by the number of respondents who selected each rating. For example, if the Likert response "5" had a value of 21, it was multiplied by 5, while responses of "4," "3," "2," and "1" were multiplied by their respective values. These individual scores were then summed across all respondents for each factor. Once the total scores for each factor were calculated, they were summed together and divided by the total number of responses to obtain the mean score. This mean score provided an overall indication of the perceived importance or agreement level for each factor among the respondents. This method allowed for a comprehensive analysis of the collective opinions and preferences regarding the factors presented, enabling researchers to gain insights into the relative significance of each factor as perceived by the users and masses.

Table 3-Factor Affecting Pedestrians

Indicators/Factors	5	4	3	2	1	Total(N)	∑W	MEAN (∑W/N)	A*N	RII	RANK
Side walk Quality	21	42	47	16	7	133	453	3.406015	665	0.681203	1
Traffic management	16	38	42	32	5	133	427	3.210526	665	0.642105	2
Connectivity of this site	15	36	42	31	9	133	416	3.12782	665	0.625564	4
Parking	12	35	43	35	8	133	407	3.06015	665	0.61203	5
Amenities	9	34	46	29	15	133	392	2.947368	665	0.589474	6
Density /Space	21	30	42	31	9	133	422	3.172932	665	0.634586	3

Once the mean values for each factor were calculated, the next step involved determining their relative importance by multiplying the total number of responses (n) by the highest value on the Likert scale, which is 5. This multiplication was performed to scale the total responses to a common maximum value, enabling a fair comparison of the factors' importance levels. By multiplying the total number of responses for each factor by 5, we obtained a standardized measure that reflected the maximum potential importance rating for that factor. This standardized value allowed us to compare the relative importance of different factors on a consistent

scale. After scaling the total values, the factors were ranked based on their relative importance, with higher scaled values indicating greater perceived importance among the respondents. This ranking provided valuable insights into which factors were considered the most significant or impactful by the users and masses. This approach enabled researchers and stakeholders to prioritize actions and decision-making based on the factors that were deemed most important by the respondents. By identifying the factors with the highest relative importance, organizations could focus their efforts and resources on addressing the most critical aspects of the problem or situation at hand, thereby maximizing the effectiveness of their initiatives and interventions.

In summary, scaling the total values by multiplying them by 5 and ranking the factors based on their relative importance allowed for a clear understanding of the key drivers or priorities identified by the respondents. This information served as a valuable guide for strategic planning and decision-making processes, ensuring that resources were allocated efficiently to address the most pressing needs or concerns identified by the user community.

Table 4-Improvement Required

Improvement factor	5	4	3	2	1	Total(N)	∑W	MEAN (∑W/N)	A*N	RII	RANK
Amenities	34	49	25	16	9	133	482	3.62406	665	0.724812	**2**
Seating space facility	23	25	42	39	4	133	423	3.180451	665	0.63609	**3**
Accessible Sidewalk Space	43	36	38	10	6	133	499	3.75188	665	0.750376	**1**
More Seperation from City Traffic	19	30	42	23	19	133	406	3.052632	665	0.610526	**4**
Would like to Walk More for Darshan	15	19	42	31	26	133	365	2.744361	665	0.548872	**5**

Following the assessment of factors affecting users, a similar methodology was employed to gauge their preferences for improvement areas. Respondents were asked specific questions regarding areas where they believed enhancements were necessary, with each response rated on a Likert scale ranging from 1 to 5. Once responses were collected, the Relative Importance Index (RII) was calculated for each improvement area. This involved multiplying the total number of responses by 5, the highest value on the Likert scale, to standardize the total values. By scaling the total responses, a fair comparison of the relative importance of different

improvement areas was facilitated. Subsequently, improvement areas were ranked based on their RII values, with higher scaled values indicating greater perceived importance among respondents. This ranking process allowed for a clear identification of the most critical improvement areas according to user preferences. By prioritizing improvement areas based on their RII values, organizations could focus their efforts and resources on addressing the most pressing concerns identified by users. This strategic approach ensured that initiatives and interventions were aligned with user needs and preferences, thereby maximizing their effectiveness and impact.

4.2 Pedestrian Level of service

For a given road or facility, capacity could be constant. But actual flow will be different for different days and different times in a day itself. The intention of LOS is to relate the traffic service quality to a given flow rate of traffic (*Tom V. Mathew and K V Krishna Rao, NPTEL May 3, 2007*)[1]. The Highway Capacity Manual (HCM) is used as the standard for analyzing traffic of different transportation modes and uses the concept of level of service (LOS) as a qualitative measure to describe operational conditions of vehicular and pedestrian traffic, “based on service measures such as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience” *(NYC DCP, Transportation Division, April 2006)*[2].

Pedestrian characteristics have been mentioned in Fruin. Traditional characteristics in HCM terms are:

- Observed volumes and flow rates for different facilities *(Colin Henson, Levels of Service for Pedestrians)*[5]
- Transport variation (seasonal, daily, hourly, sub-hourly); *(Colin Henson, Levels of Service for Pedestrians)*[5]
- Spatial distribution (directional split, composition, e.g., percentage disabled or mobility impaired); *(Colin Henson, Levels of Service for Pedestrians)*[5]
- Speed (trends, variation by time and trip purpose, which might include “just walking about”); *(Colin Henson, Levels of Service for Pedestrians)*[5]

- Density (relationships with speed, flow or both); and (*Colin Henson, Levels of Service for Pedestrians)*[5]
- Spacing and headway characteristics. *(Colin Henson, Levels of Service for Pedestrians)*[5]

The analysis of pedestrian flow varies subtly from that of vehicular flow. The fundamental relationships among speed, volume and density are similar. With the increase in volume and density of pedestrians, congestion increases which, as a result hampers speed and ease of conveyance. Once pedestrian density reaches its upper limit/saturation point and is on the edge of excess, volume and speed form a negative, declining curve. “The qualitative measures of pedestrian flow similar to those used for vehicular flow are the freedom to choose desired speeds and to bypass others. Other measures more specially related to pedestrian flow include the ability to cross a pedestrian traffic stream, to walk in the reverse direction of a major pedestrian flow and to generally maneuver without conflicts and changes in walking speed or gait” *(Colin Henson, Levels of Service for Pedestrians)*[5]*.* Apart from those mentioned above, additional environmental factors that play a role in the walking experience and, therefore, help in the calculation of LOS are as follows:

- Comfort factors – climate control and weather protection, arcades, shelters for transit and other pedestrian facilities; *(Colin Henson, Levels of Service for Pedestrians)*
- Convenience factors – walkable distances, directness of pathway, sidewalk ramps, directional signage, directory maps and other features that promote pedestrian travel; *(Colin Henson, Levels of Service for Pedestrians)*
- Safety - provided by separation of pedestrians from vehicular traffic, in a horizontal fashion in malls and other vehicle-free areas, and in a vertical fashion using overpasses and underpasses. Traffic control devices can also help provide separation of pedestrian and vehicular traffic with respect to the times of the day; Security features are inclusive of lighting, open lines of sight, and the degree and type of street activity; (*Colin Henson, Levels of Service for Pedestrians)*

- Economy parameters which are related to the costs associated with delay in travel and inconvenience, and to the rental value and retail development which are influenced by pedestrian environment. *(Colin Henson, Levels of Service for Pedestrians)*

Pedestrian LOS is categorized as follows:-

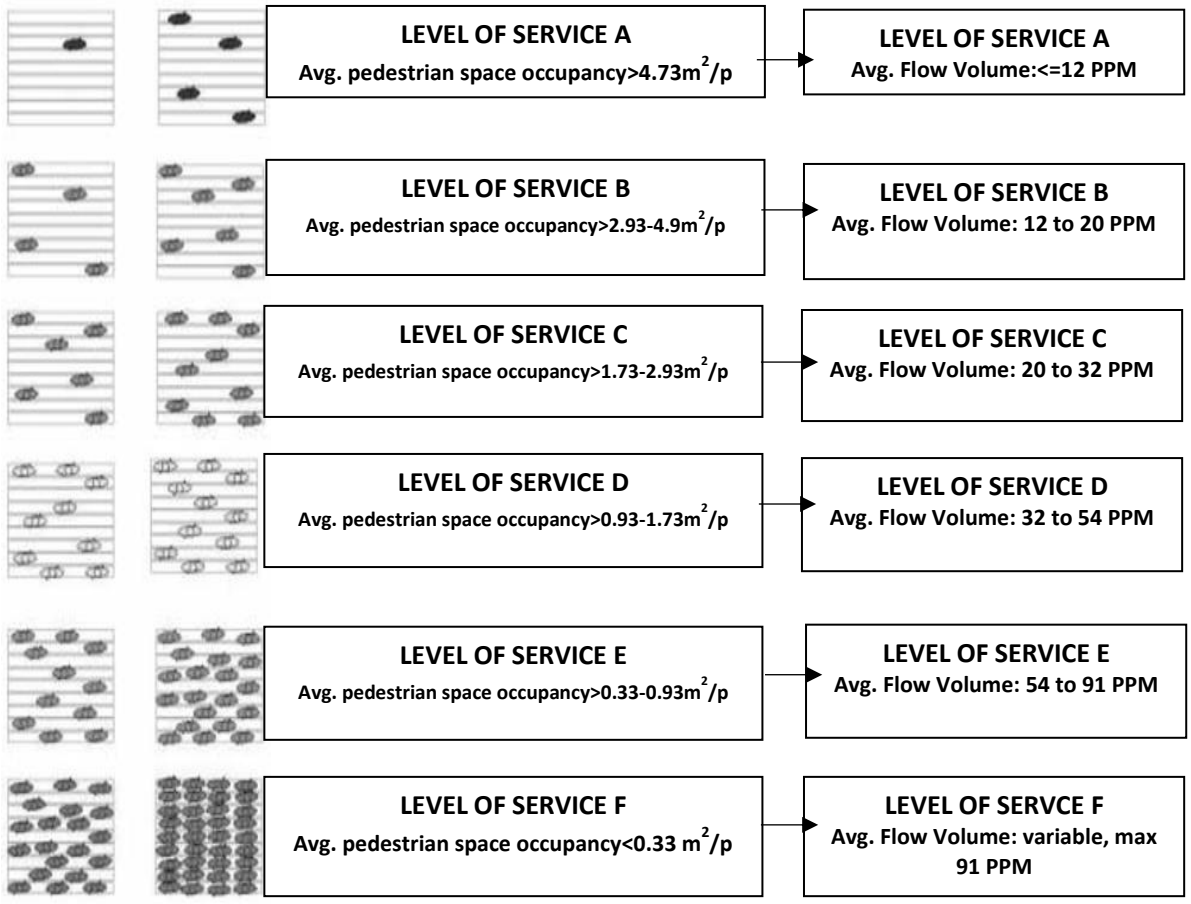


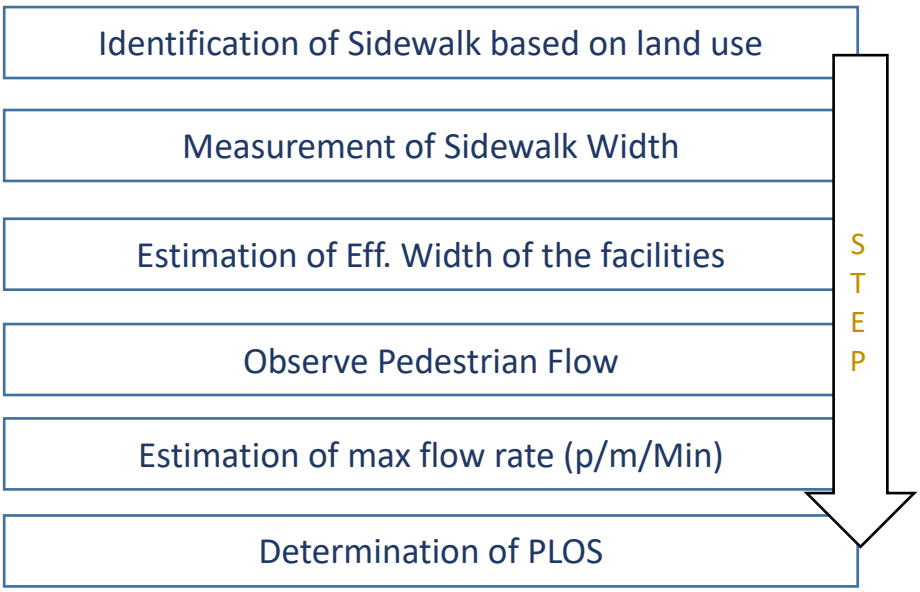
Fig 14 Pedestrian LOS
Source -IndoHCM

Calculating the Pedestrian Level of Service (LOS) involves several steps to assess the quality of pedestrian facilities and the overall walking experience. Here's a basic outline of the steps typically involved in this process:

Define LOS Parameters: Determine the factors that contribute to the pedestrian LOS, such as sidewalk width, surface conditions, traffic volume, pedestrian flow, and intersection design.

Data Collection: Gather data on relevant parameters, which include sidewalk width measurements, pedestrian counts, traffic volume, and intersection geometry. This data collected through field surveys, traffic counts, pedestrian observations, and existing records

4.2.1 Steps to calculate Pedestrian LOS



Survey Area-

The survey was conducted over the course of an hour at four major intersections, with a specific focus on tracking pedestrian movement. While the study encompassed three intersections due to the predominance of vehicular traffic at the fourth, each selected intersection offers unique insights into pedestrian dynamics within the core city area of Ujjain.

One of the key intersections under scrutiny is Mahakaal Chauraha, strategically located in the heart of the city. This intersection serves as a crucial nexus for both vehicular and pedestrian traffic. The eastward direction leads to the railway station and city traffic, while the northbound path witnesses a significant influx of pedestrians. Notably, the west side of Mahakaal Chauraha serves as the main entrance to the revered Mahakaal Mandir, a mere 200 meters away, attracting a substantial volume of pedestrian traffic. Meanwhile, the southern route leads to the Indore road and serves as a gateway to the city, with traffic emanating from the

Hari Fhatak intersection. The primary observation gleaned from the survey underscores the prominent flow of pedestrians directed towards the Mahakaal Mandir from this intersection, highlighting its pivotal role as a religious and cultural landmark. Another significant intersection under scrutiny is Harsiddhi Chauraha, which serves as a central hub for various temples and sacred sites. Positioned to the east of this intersection is the renowned Mahakaal Mandir, while the northbound direction leads to the esteemed Harsiddhi Temple. To the west lie pathways leading to Kaal Bhairav, further enriching the area's spiritual significance. The stretch between Harsiddhi Chauraha and Mahakaal Mandir emerges as a focal point for pedestrian activity, characterized by dense foot traffic and limited space. Numerous factors, including the presence of street vendors and encroachments, contribute to the complexities of pedestrian movement in this area. Given its paramount importance in facilitating religious and cultural activities, a comprehensive examination of this region is imperative to gain insights into the dynamics and challenges associated with pedestrian flow.

By focusing on these key intersections, the survey endeavors to shed light on the intricacies of pedestrian movement within Ujjain's core city area, offering valuable insights for urban planning and infrastructure development initiatives aimed at enhancing the pedestrian experience and ensuring the seamless integration of religious and cultural landmarks within the urban fabric.

The third intersection, known as Kartik Chowk, holds significant importance due to its proximity to Ram Ghat, a renowned destination for pilgrims. Situated near the historic Gangaur Gate, this intersection serves as a vital access point for those seeking to reach the ghats along the Kshipra River. Additionally, Kartik Chowk is a crucial transit hub for the Mahakaal Sawari, a ceremonial procession that culminates at Ram Ghat, passing through densely populated residential areas and congested zones.The strategic location of Kartik Chowk facilitates access from various directions. To the east lies the route from Gopal Mandir, while the westward path leads to Gangaur Gate. The southern direction connects to the road leading towards Harsiddhi Mandir and the bustling Chauraha area.The bustling activity and historical significance of Kartik Chowk make it a focal point for both residents and pilgrims alike. Its role as a gateway to religious sites and cultural landmarks,

coupled with the passage of significant processions like the Mahakaal Sawari, underscore its importance as a central node in the city's urban fabric.

However, the dense settlements and congested tracks surrounding Kartik Chowk also present challenges, particularly in terms of traffic management and pedestrian safety. Efforts to address these issues while preserving the area's historical and cultural heritage are essential for ensuring the continued accessibility and vibrancy of Kartik Chowk as a vital intersection in Ujjain.

The Hari Fhatak Bridge stands as the pivotal artery of transportation, serving as the primary gateway to and from the city of Ujjain, while also connecting it to a myriad of destinations beyond its borders. Positioned strategically along the Ujjain city railway track, this intersection holds immense significance in facilitating the movement of both vehicular and pedestrian traffic. To the east, the arms of the Hari Fhatak Bridge lead towards the bustling railway station, serving as a vital conduit for commuters arriving and departing from the city by train. This eastern route serves as a lifeline for transportation, ensuring seamless connectivity between Ujjain and other parts of the region. Conversely, the western route extending from the Hari Fhatak Bridge directs traffic towards notable landmarks such as the Triveni Museum and Jantar Mantar, enriching the cultural landscape of Ujjain. This western passage serves as a gateway to exploration, inviting travellers to delve into the historical and architectural treasures that adorn the city. Heading north from the Hari Fhatak Bridge provides access to the old city, offering a glimpse into Ujjain's rich heritage and storied past. This direction also leads to the previous entrance to the revered Mahakaal Mandir, a sacred destination steeped in religious significance and cultural tradition.

On the southern end, the Hari Fhatak Bridge connects to the road leading to the Nana Kheda bus stand and Indore traffic, facilitating the seamless movement of commuters and travellers to and from these bustling hubs of activity. This southern artery serves as a vital link in the transportation network, ensuring efficient connectivity between Ujjain and neighboring towns and cities.In essence, the Hari Fhatak Bridge epitomizes the essence of connectivity, serving as a pivotal intersection that knits together the fabric of Ujjain's urban landscape. Its strategic location and comprehensive network of routes make it an indispensable

component of the city's transportation infrastructure, playing a crucial role in facilitating mobility, commerce, and cultural exchange.

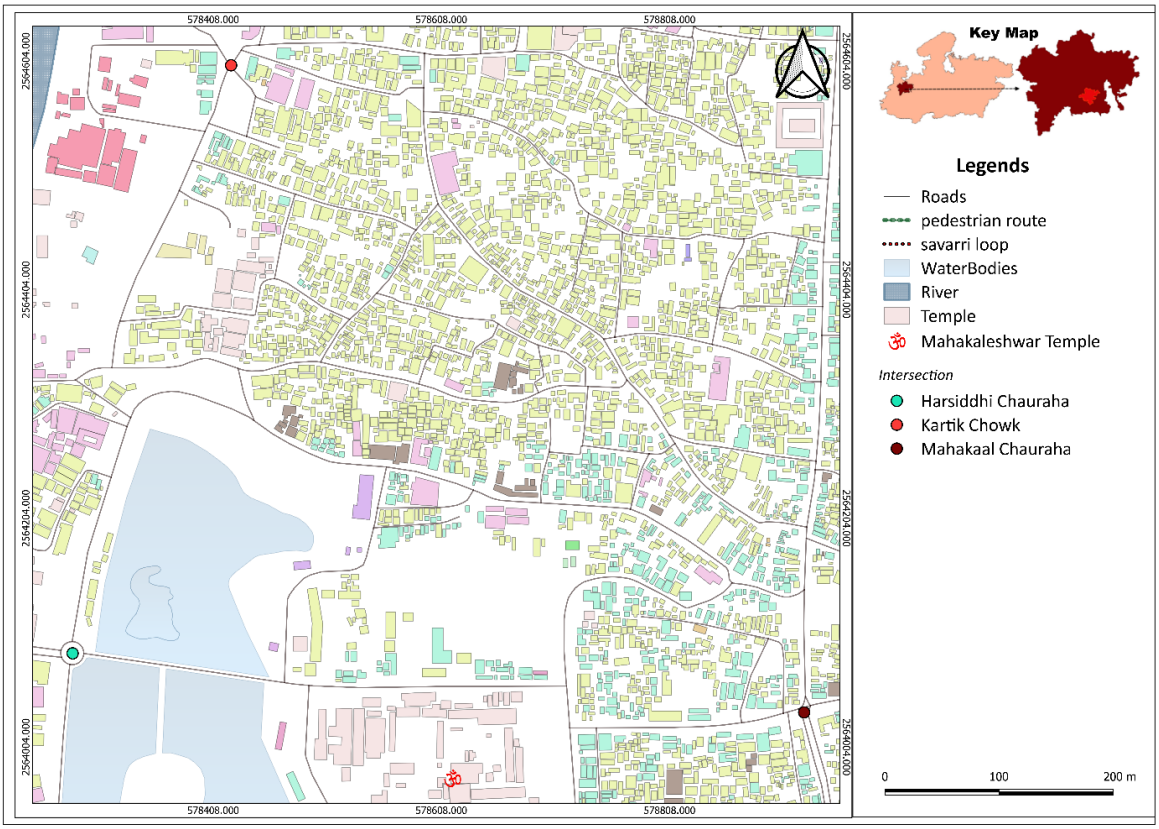


Fig 15 Intersection
Source:Author Generated

Intersection-Mahakaal Chauraha

The temple finds itself situated amidst a web of urban challenges, each direction presenting its own set of obstacles for the devout pilgrims who journey there seeking solace and spiritual fulfilment To the east, where the sun rises and brings with it the promise of a new day, lies a bustling thoroughfare teeming with the ceaseless flow of city traffic. Here, pilgrims must navigate through the cacophony of honking horns and hurried commuters, their journey to the temple hindered by the relentless march of vehicles. Adding to the chaos, an adjacent auto stand stands as both a convenience and a hindrance, offering transportation options while also contributing to the congestion that plagues this side of the temple.

Turning to the north, pilgrims encounter a similar challenge as they are confronted once again with the relentless buzz of urban life. Here, the temple's northern facade

stands vulnerable to the relentless onslaught of city traffic, creating a barrier that must be overcome in the pursuit of spiritual fulfillment. The presence of the adjacent auto stand only serves to exacerbate the issue, further complicating the pilgrims' journey as they seek refuge within the temple's sacred walls. Meanwhile, to the west, the temple finds itself hemmed in by the unforgiving constraints of narrow roads and encroachments. Here, pilgrims must navigate through a labyrinth of obstacles, their path to the temple obstructed by the encroaching tendrils of urban development. With each step, they are reminded of the relentless march of progress, which threatens to engulf the temple in its ever-expanding embrace.

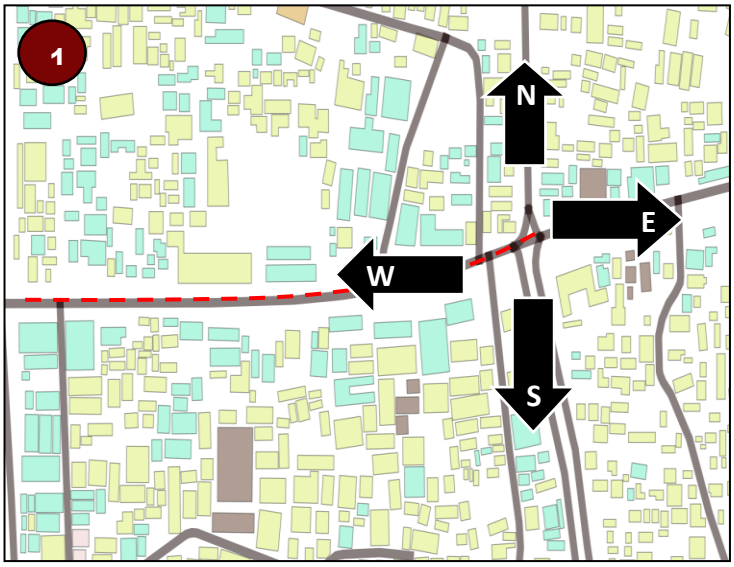


Fig 16 Mahakaal Intersection Details

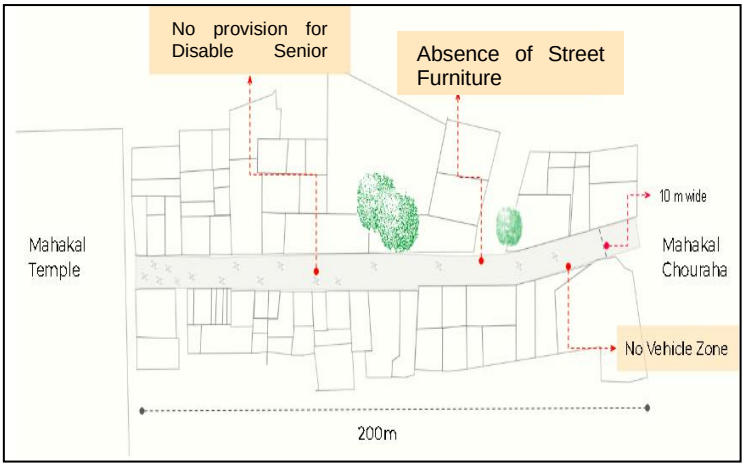


Fig 18 Cross Section

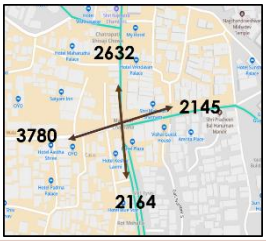


Table 5 Normal Days Footfall Mahakaal chauraha

Direction	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	536	17.8	B	1.40	C
W	995	33.1	D	0.92	E
N	658	22	C	1.58	E
S	601	20.1	C	1.69	D

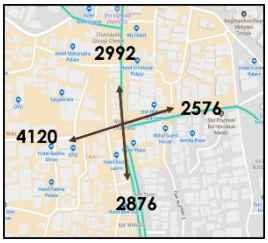


Table 6-Events Days Footfall Mahakaal chauraha

Direction	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	650	21.6	C	1.0	D
W	1030	34.3	D	0.9	E
N	748	24.9	C	1.1	D
S	729	12.02	B	1.2	D

Analysis process for the normal day movement-

The pedestrian level of service analysis for the Mahakaal intersection draws from the principles outlined in the Indo Highway Capacity Manual. This comprehensive study divides the intersection into four distinct zones: East, West, North, and South, each representing a different direction of pedestrian movement. To conduct the analysis, research conducted a thorough survey over the course of one hour, utilizing video graphics to capture and segment the data into four 15-minute intervals. Within each interval, the peak 15-minute period was identified, pinpointing the timeframe during which the highest volume of pedestrians traversed each pathway. With the peak periods identified, calculations were performed to determine the maximum flow of pedestrians per minute per meter width of the road for each pathway. This involved dividing the peak pedestrian count by the width of the pathway, yielding a measure of pedestrian flow efficiency. Simultaneously, the analysis extended to the spatial aspect of pedestrian movement, assessing density

by quantifying the number of pedestrians per square meter over the 15-minute peak period. By breaking down this 15-minute period into one-minute increments, researchers identified the minute with the highest pedestrian density, providing insight into spatial utilization. Further examination involved comparing these calculated values against established standards to ascertain the level of service (LOS) for each pathway. LOS provides a metric for assessing the quality of pedestrian experience, considering factors such as flow efficiency and spatial comfort. Additionally, the study incorporated a grid-based approach to evaluate pedestrian movement across a 10x10 grid. By tallying the number of pedestrians crossing each grid cell, gained a comprehensive understanding of pedestrian distribution and movement patterns within the intersection.

Analysis for the Event day pedestrian movement-

The analysis of pedestrian movement at the Mahakaal intersection delves into the dynamics of events days, where the influx of visitors and participants significantly alters the pedestrian flow within the vicinity. Drawing upon methodologies outlined in the Indo Highway Capacity Manual, this study divides the intersection into four distinct zones: East, West, North, and South, mirroring the diverse directions of pedestrian movement during events. To conduct the analysis, research undertook a meticulous survey spanning one event day, leveraging video graphics to segment the data into four 15-minute intervals. Within each interval, the peak 15-minute period was identified, shedding light on when the highest volume of pedestrians traversed each pathway, driven by the ebb and flow of event activities.

With the peak periods pinpointed, calculations were performed to determine the maximum flow of pedestrians per minute per meter width of the road for each pathway. This involved dividing the peak pedestrian count by the width of the pathway, providing insights into the efficiency of pedestrian flow amidst the event hustle and bustle. Simultaneously, the study delved into spatial considerations, assessing density by quantifying the number of pedestrians per square meter over the 15-minute peak period. By breaking down this period into one-minute increments, researchers identified the minute with the highest pedestrian density, offering valuable insights into spatial utilization amidst the event fervor.Further analysis involved comparing these calculated values against established standards to ascertain the level of service (LOS) for each pathway during events.

LOS serves as a metric for evaluating the quality of pedestrian experience, considering factors such as flow efficiency and spatial comfort amidst the unique dynamics of event days. Additionally, the study employed a grid-based approach to evaluate pedestrian movement across a 10x10 grid during events. By tallying the number of pedestrians crossing each grid cell, gained a comprehensive understanding of pedestrian distribution and movement patterns amidst the bustling atmosphere of event days.

Intersection-Harsiddhi Chauraha

The eastern and northern sides of the revered Harsiddhi temple, along with the bustling chauraha that surrounds it, grapple with persistent obstacles arising from the ceaseless flow of city traffic. This traffic predominantly comprises two-wheelers and E-rickshaws, which weave through the streets with a frenetic energy, creating a constant stream of movement that can impede the peaceful ambiance sought by temple-goers.The cacophony of engines revving and horns blaring adds to the chaos, making it challenging for pilgrims and visitors to navigate the streets with ease. The narrow pathways that lead to the temple entrance become crowded and congested, as both devotees and casual passers-by jostle for space amidst the sea of vehicles. Adding to the complexity of the situation are the encroachments by street vendors, who set up shop along the sidewalks, vying for the attention of those who pass by. Their stalls spill out onto the already limited pedestrian walkways, further narrowing the paths and creating bottlenecks that hinder the flow of foot traffic. For pilgrims and worshippers, this urban hustle and bustle can detract from the spiritual experience they seek at the temple. Instead of a tranquil journey of reflection and devotion, they find themselves navigating a maze of distractions and impediments, their progress slowed by the chaotic energy of the city streets. Despite these challenges, the Harsiddhi temple remains a beacon of faith and devotion for those who seek solace within its hallowed walls. Pilgrims persevere, undeterred by the obstacles that surround them, their determination to connect with the divine guiding them through the bustling thoroughfares and crowded sidewalks to find sanctuary within the temple's sacred precincts

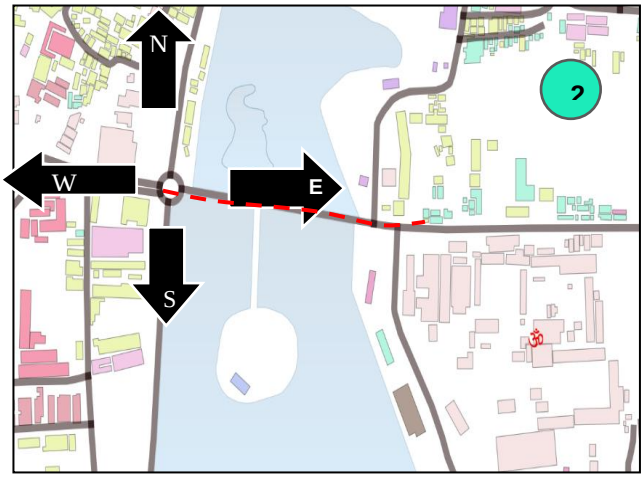


Fig 19 Harsiddhi Chauraha Detail

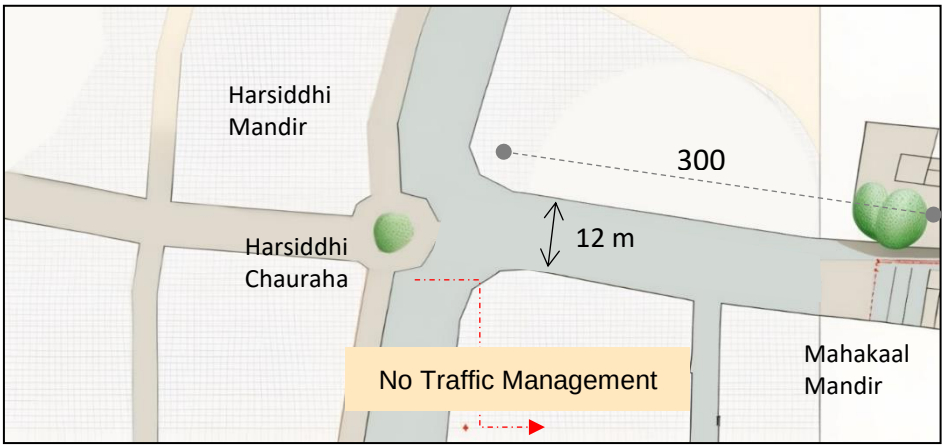


Fig 20 Cross section details

Table 7-Normal Days Footfall Harsiddhi chauraha

Direction	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	830	27.6	C	1.26	D
W	518	17.2	B	2	C
N	635	14.1	C	1.9	C
S	581	20.1	C	1.6	D

Table 8-Events Day Footfall Harsiddhi chauraha

Direction(S)	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	1010	33.6	D	0.86	E
W	522	17.4	B	1.42	D
N	726	24.2	C	1.08	D
S	741	24.7	C	1.0	D

Analysis process for the Event day movement-

The analysis of pedestrian movement at the Harsiddhi Chauraha delves into the dynamics of event days, where the influx of visitors and participants significantly alters the pedestrian flow within the vicinity. Drawing upon methodologies outlined in the Indo Highway Capacity Manual, this study divides the intersection into four distinct zones: East, West, North, and South, mirroring the diverse directions of pedestrian movement during events. To conduct the analysis, research undertook a meticulous survey spanning one event day, leveraging video graphics to segment the data into four 15-minute intervals. Within each interval, the peak 15-minute period was identified, shedding light on when the highest volume of pedestrians traversed each pathway, driven by the ebb and flow of event activities. With the peak periods pinpointed, calculations were performed to determine the maximum flow of pedestrians per minute per meter width of the road for each pathway. This involved dividing the peak pedestrian count by the width of the pathway, providing insights into the efficiency of pedestrian flow amidst the event hustle and bustle. Simultaneously, the study delved into spatial considerations, assessing density by quantifying the number of pedestrians per square meter over the 15-minute peak period. By breaking down this period into one-minute increments, researchers identified the minute with the highest pedestrian density, offering valuable insights into spatial utilization amidst the event fervour.

Further analysis involved comparing these calculated values against established standards to ascertain the level of service (LOS) for each pathway during events. LOS serves as a metric for evaluating the quality of pedestrian experience, considering factors such as flow efficiency and spatial comfort amidst the unique

dynamics of event days. Additionally, the study employed a grid-based approach to evaluate pedestrian movement across a 10x10 grid during events. By tallying the number of pedestrians crossing each grid cell, research gained a comprehensive understanding of pedestrian distribution and movement patterns amidst the bustling atmosphere of event days.

Analysis process for the Normal day movement-

The analysis of pedestrian movement at the Harsiddhi Chauraha extends to regular days, where the flow of foot traffic is a consistent aspect of urban life. Following the methodologies outlined in the Indo Highway Capacity Manual, the intersection is divided into four distinct zones: East, West, North, and South, reflecting the typical directions of pedestrian movement. To conduct the analysis, research conducted a comprehensive survey over the course of a normal day, segmenting the data into four 15-minute intervals using video graphics. Within each interval, patterns of pedestrian movement were observed, providing insights into the ebb and flow of foot traffic throughout the day. Peak periods of pedestrian activity were identified within each interval, shedding light on when the highest volume of pedestrians traversed each pathway. These peak periods offer valuable information regarding the busiest times of day and the pathways most heavily utilized by pedestrians. Calculations were then performed to determine the maximum flow of pedestrians per minute per meter width of the road for each pathway. This analysis helps gauge the efficiency of pedestrian flow under typical conditions, providing a basis for understanding pedestrian mobility within the intersection. Simultaneously, spatial considerations were taken into account, with density assessments conducted to quantify the number of pedestrians per square meter over the 15-minute intervals. By examining pedestrian density, researchers gained insights into spatial utilization and congestion levels within the intersection throughout the day.

Intersection-Kartik Chowk

The western side of the chowk, serving as the pathway to Ram Ghat, holds significant importance for pilgrims making their way to this sacred destination. However, the presence of on-street parking along this route presents a significant obstacle to the smooth movement of pilgrims. On-street parking occupies valuable space along the roadside, narrowing the available pathway for pedestrians. This obstruction not only limits the width of the road but also creates a visual barrier that

can impede the flow of foot traffic. Pilgrims, seeking to traverse this route with ease and reverence, find themselves contending with the added challenge of navigating around parked vehicles, disrupting the fluidity of their journey. Compounding this issue is the already narrow nature of the road itself. The limited space available for pedestrian movement is further constrained by the presence of on-street parking, exacerbating congestion and making it difficult for pilgrims to move freely towards their destination. Additionally, the congested infrastructure surrounding the chowk exacerbates the challenges faced by pilgrims on the western side. The convergence of various modes of transportation, including pedestrians, vehicles, and possibly even vendors, creates a chaotic environment that can be overwhelming for those seeking a peaceful pilgrimage experience

Overall, the combination of on-street parking, narrow roads, and congested infrastructure on the western side of the chowk presents a significant obstacle to the movement of pilgrims towards Ram Ghat. Addressing these challenges requires careful urban planning and infrastructure improvements aimed at enhancing pedestrian accessibility and ensuring a smoother pilgrimage experience for all.

Fig 21 Kartik Chowk Details

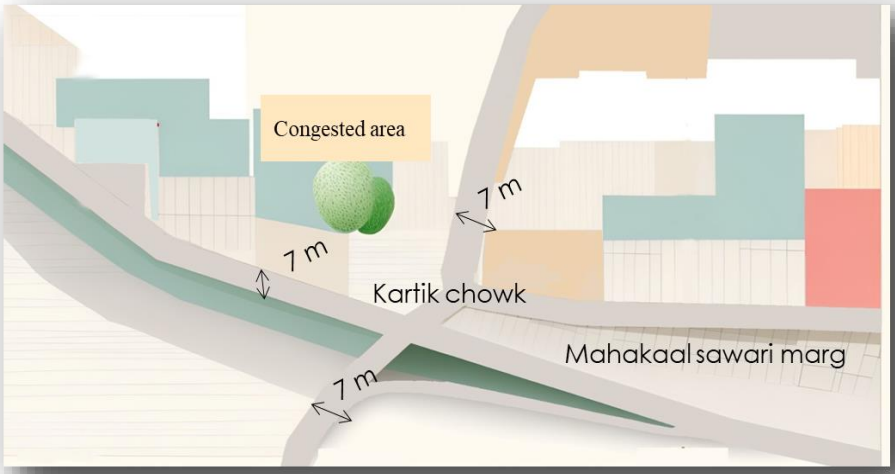


Fig 22 Cross Section

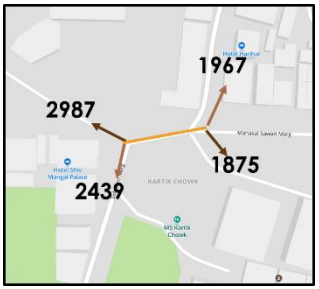


Table 9-Normal Day Footfall kartik chowk

Direction	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	490	16.3	B	2.5	C
W	610	20.3	C	2.0	C
N	739	24.6	C	1.4	D
S	462	15.4	B	2.7	C

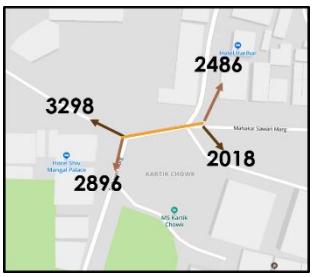


Table 10- Events Day Footfall kartik chowk

Direction	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	625	20.8	C	1.8	C
W	739	24.6	C	1.0	D
N	835	27.8	C	0.9	E
S	515	17.1	B	2	C

Analysis process for the Normal day movement-

The analysis of pedestrian movement at the Kartik Chowk extends to regular days, where foot traffic is a consistent aspect of urban life. Following the methodologies outlined in the Indo Highway Capacity Manual, the intersection is divided into four distinct zones: East, West, North, and South, reflecting the typical directions of pedestrian movement. To conduct the analysis, researchers undertook a comprehensive survey over the course of a normal day, segmenting the data into four 15-minute intervals using video graphics. Within each interval, patterns of pedestrian movement were observed, providing insights into the ebb and flow of foot traffic throughout the day.

Peak periods of pedestrian activity were identified within each interval, shedding light on when the highest volume of pedestrians traversed each pathway. These peak periods offer valuable information regarding the busiest times of day and the pathways most heavily utilized by pedestrians. Calculations were then performed to determine the maximum flow of pedestrians per minute per meter width of the road for each pathway. This analysis helps gauge the efficiency of pedestrian flow under typical conditions, providing a basis for understanding pedestrian mobility within the intersection. Simultaneously, spatial considerations were taken into account, with density assessments conducted to quantify the number of pedestrians per square meter over the 15-minute intervals. By examining pedestrian density, researchers gained insights into spatial utilization and congestion levels within the intersection throughout the day. Furthermore, these calculated values were compared against established standards to determine the level of service (LOS) for each pathway on normal days. LOS serves as a metric for evaluating the quality of pedestrian experience, considering factors such as flow efficiency and spatial comfort in the absence of event-driven fluctuations.

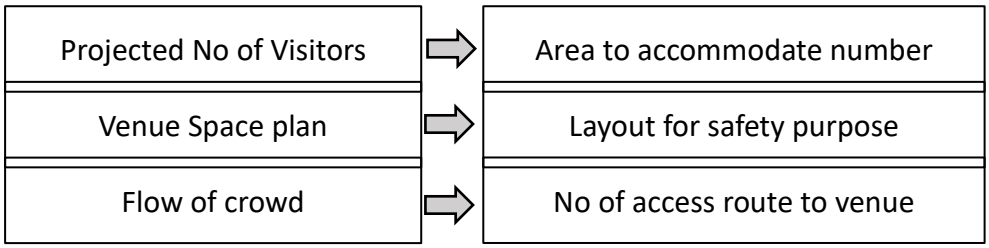
Analysis process for the Event day movement-

On event days, the scrutiny of pedestrian movement at Kartik Chowk takes on added significance, as the influx of visitors and participants dramatically alters the flow of foot traffic within the vicinity. Utilizing methodologies delineated in the Indo Highway Capacity Manual, the intersection is meticulously divided into four zones: East, West, North, and South, aligning with the diverse directions of pedestrian

movement during events. To undertake this analysis, researchers embarked on an extensive survey spanning the duration of a single event day, employing video graphics to segment the data into four 15-minute intervals. Within each interval, the dynamics of pedestrian movement were closely observed, unveiling the fluctuations in foot traffic driven by the unfolding events. Identifying peak periods within each interval shed light on when pedestrian traffic reached its zenith along each pathway, providing valuable insights into the busiest times of the day and the routes most heavily frequented by pedestrians. Subsequent calculations aimed to ascertain the maximum flow of pedestrians per minute per meter width of the road for each pathway. This analytical approach served to gauge the efficiency of pedestrian flow amidst the bustling activity of event days, offering crucial information for understanding pedestrian mobility within the intersection under such dynamic circumstances. Concurrently, spatial assessments were conducted to evaluate pedestrian density by quantifying the number of individuals per square meter over the 15-minute intervals. This examination provided a deeper understanding of spatial utilization and congestion levels within the intersection amid the fervour of event proceedings.

Furthermore, these derived values were juxtaposed against established benchmarks to determine the level of service (LOS) for each pathway during events. LOS serves as a pivotal metric for evaluating the pedestrian experience, encompassing factors such as flow efficiency and spatial comfort amid the heightened energy of event-driven pedestrian movement.

4.3 Circulation Plan



Preparing a circulation plan for Mahakaal Mandir involves a meticulous process aimed at ensuring the safe and efficient movement of the projected number of visitors. With the temple's significance drawing pilgrims from far and wide, careful

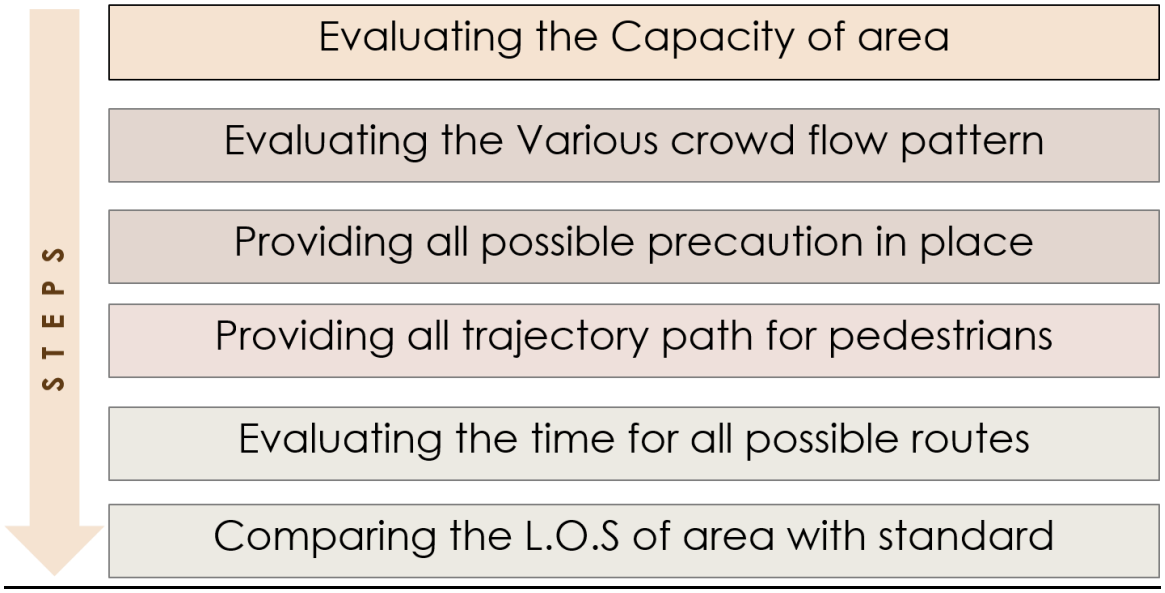
planning is essential to accommodate the influx of individuals while maintaining order and safety within the premises. The first step in crafting such a plan is to project the anticipated number of visitors. This involves analysing historical data, considering seasonal trends, and accounting for any upcoming events or festivals that may impact attendance. By conducting a thorough projection, planners can gain valuable insights into the scale of the expected crowd and tailor their planning efforts accordingly. Once the projected number of visitors is determined, the next crucial step is to identify and delineate the appropriate venue space to accommodate this influx of individuals. This includes assessing the capacity of the temple premises itself, as well as any surrounding areas or additional facilities that may be utilized to accommodate visitors, such as parking lots, waiting areas, or overflow spaces. With the venue space identified, the layout plan must be carefully devised to ensure the safety and ease of flow for the crowd. This entails considering factors such as the placement of entry and exit points, the arrangement of queuing areas, and the allocation of space for essential facilities such as restrooms, first aid stations, and security checkpoints. Special attention must also be paid to accessibility for individuals with disabilities, ensuring that all visitors can navigate the space comfortably and safely.

In addition to the layout of the venue space, the circulation plan must address the flow of the crowd throughout the premises. This involves strategically directing the movement of visitors to minimize congestion, reduce bottlenecks, and maintain a steady flow of foot traffic. Strategies such as implementing one-way pathways, designated pedestrian lanes, or directional signage can help guide visitors along their intended routes and prevent overcrowding in key areas. Furthermore, the circulation plan should account for the number of access routes available to visitors, both within the temple premises and in the surrounding area. This may involve coordinating with local authorities to manage traffic flow and pedestrian access, as well as identifying alternative routes or transportation options for visitors arriving from different directions. Throughout the planning process, safety considerations should remain paramount. This includes assessing potential hazards and risks, implementing crowd control measures, and ensuring that emergency response procedures are in place. Regular monitoring and

communication among staff and volunteers are also essential to address any unforeseen challenges or changes in circumstances.

In conclusion, preparing a circulation plan for Mahakaal Mandir requires a comprehensive and systematic approach, encompassing projections of visitor numbers, venue space planning, crowd flow management, and access route coordination.

Steps Taken by PTV Viswalk software for making of circulation plan:-



The comprehensive plan for Mahakaal Mandir extends beyond the confines of its sacred precincts, encompassing the entirety of its surrounding area. While the inner plan of the temple itself may be restricted by logistical limitations, the external environment plays a crucial role in facilitating the smooth flow of visitors to and from the revered site. This holistic approach to planning takes into account the original length and width of roads and pathways, ensuring an accurate representation of the external landscape. Central to this comprehensive plan is the simulation of pedestrian movement. Drawing upon data reflecting the typical tourist footfall, an approximate capacity of 35,000 pedestrians is inputted into the model. This figure mirrors the levels of activity experienced on normal days, providing a realistic basis for understanding crowd dynamics within the vicinity of the temple.With the input of pedestrian capacity established, the next step involves providing a static route to guide the simulated pedestrians along designated

pathways. This route is informed by observed movement patterns gleaned from previous studies and real-world observations. It takes into account factors such as bidirectional movement, allowing pedestrians to traverse the area efficiently while adhering to predetermined pathways. Throughout the simulation, pedestrians are directed to follow the prescribed route. This route is strategically designed to align with observed pedestrian flow and exit points, ensuring that movement remains smooth and organized. By adhering to the designated pathways, congestion is minimized, and pedestrian circulation is optimized within the surrounding area. The comprehensive plan for Mahakaal Mandir aims to create a safe and efficient environment for visitors, facilitating seamless movement and enhancing the overall experience for pilgrims and tourists alike. By incorporating observed data and simulating pedestrian behaviour under realistic conditions, planners can gain valuable insights into crowd dynamics and distribution patterns, allowing for informed decision-making and the implementation of effective crowd management strategies. Beyond pedestrian movement, the comprehensive plan also considers factors such as infrastructure, amenities, and safety measures. Infrastructure improvements may include widening pathways, adding signage, or enhancing lighting to improve visibility and navigation for pedestrians. Amenities such as rest areas, water stations, and restroom facilities are strategically located to meet the needs of visitors and enhance their overall experience. Safety measures are paramount in ensuring the well-being of visitors. This may involve implementing crowd control measures, establishing emergency response procedures, and coordinating with local authorities to manage traffic flow and pedestrian access. Regular monitoring and communication among staff and volunteers are essential to address any unforeseen challenges or changes in circumstances. By taking a holistic approach to planning, the comprehensive plan for Mahakaal Mandir aims to create an environment that fosters reverence, tranquillity, and accessibility for all visitors. Through careful consideration of pedestrian movement, infrastructure, amenities, and safety measures are taken

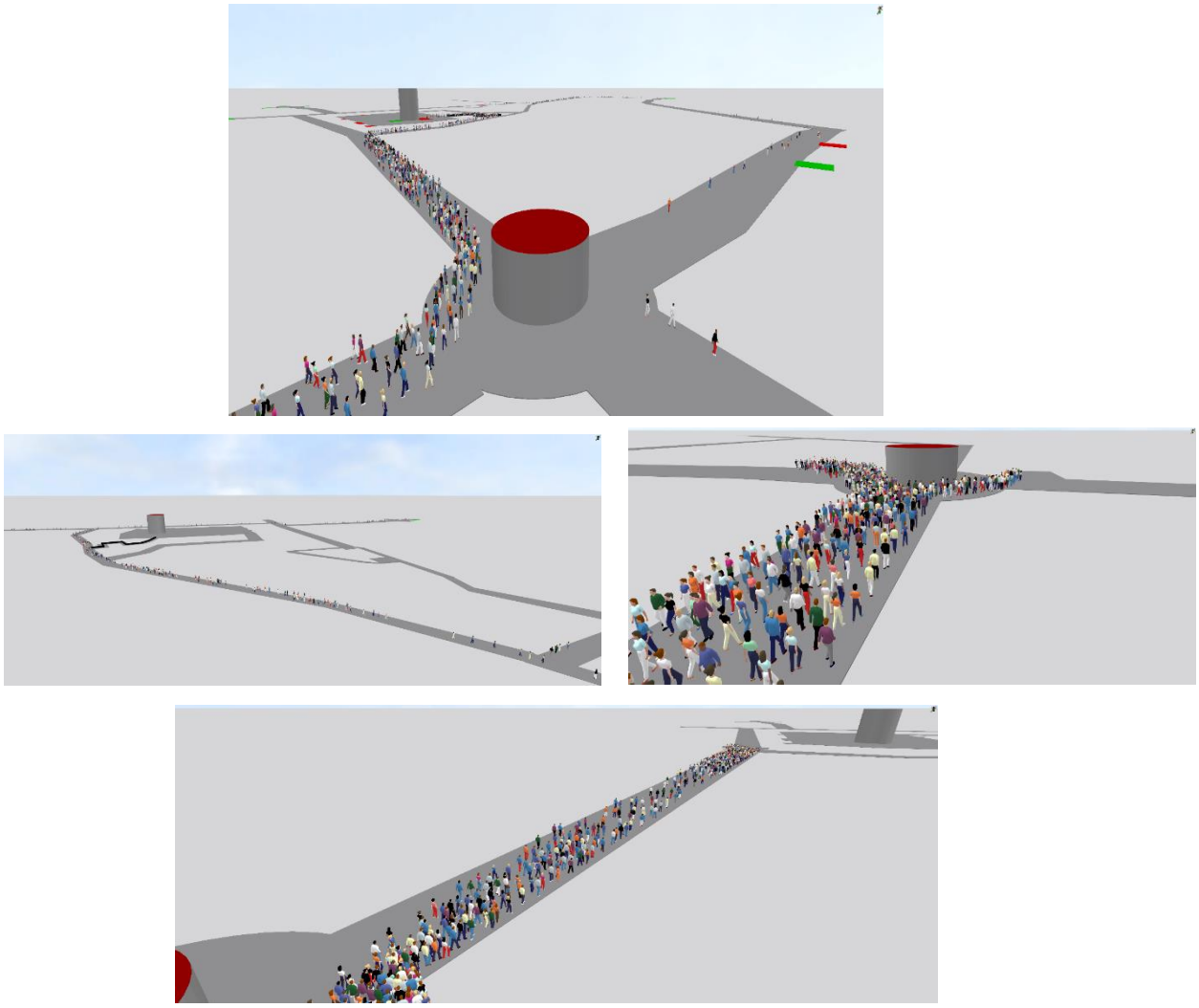


Fig 23 PTV Viswalk (Simulations)

The planning and analysis of pedestrian movement at Mahakaal Mandir entail the development of various route plans tailored for both normal day and event day scenarios. Due to limitations imposed by pedestrian capacity within the licensed software, the analysis is conducted based on approximations, yielding data that provides an indicative understanding of pedestrian flow dynamics. For both normal day and event day movements, multiple route plans are devised to accommodate the expected foot traffic. These plans consider factors such as historical data, seasonal trends, and anticipated events that may influence visitor numbers. Routes are strategically designed to optimize pedestrian flow, minimize congestion, and ensure efficient access to and from the temple premises. Following the implementation of route plans, analysis is conducted to assess pedestrian

movement patterns and distribution. Despite the inherent limitations of the software, the data obtained provides valuable insights into pedestrian behaviour under different conditions. These insights are crucial for understanding crowd dynamics and informing decision-making in urban planning and infrastructure development the approximate data obtained from the analysis is compared with predetermined range values to evaluate the effectiveness of the route plans. Discrepancies between observed and expected values are carefully examined to identify areas for improvement and optimization. This iterative process allows to refine route plans and enhance their efficacy in managing pedestrian movement. Additionally, the analysis considers the unique challenges posed by event days, where the influx of visitors significantly impacts pedestrian flow. Specialized route plans are developed to accommodate the increased foot traffic, with a focus on maintaining safety, order, and accessibility for all visitors. Despite the limitations imposed by pedestrian capacity within the software, the analysis provides valuable insights into pedestrian movement dynamics at Mahakaal Mandir. By leveraging approximate data and comparing it with predetermined benchmarks and make informed decisions to optimize route plans and enhance the overall visitor experience, ensuring that the sacred site remains accessible and welcoming to all. The circulation plan is made after going through the land use safety measure perspective at all respect so that no interaction between the tourist will be there and a discussion with stakeholders.

Circulation Plan - **Special Days Plan- (A) 1-2-3-4-5-6-7-8-9**

Week Days Plan- (B-1) 10-11-7-6-5-12 & (B-2) 2-8-7-6-5-4-3

After simulation the Result which comes for the unidirectional movement with the time

Table 11-PTV Simulation Result

Route Plan	Max Time	Min Time	Average Time	Distance
A	35 Min	27Min	30 Min	3.7 km
B-1	17 Min	12 Min	15 Min	1.3 Km
B-2	28 Min	22 Min	26 Min	2.6 Km

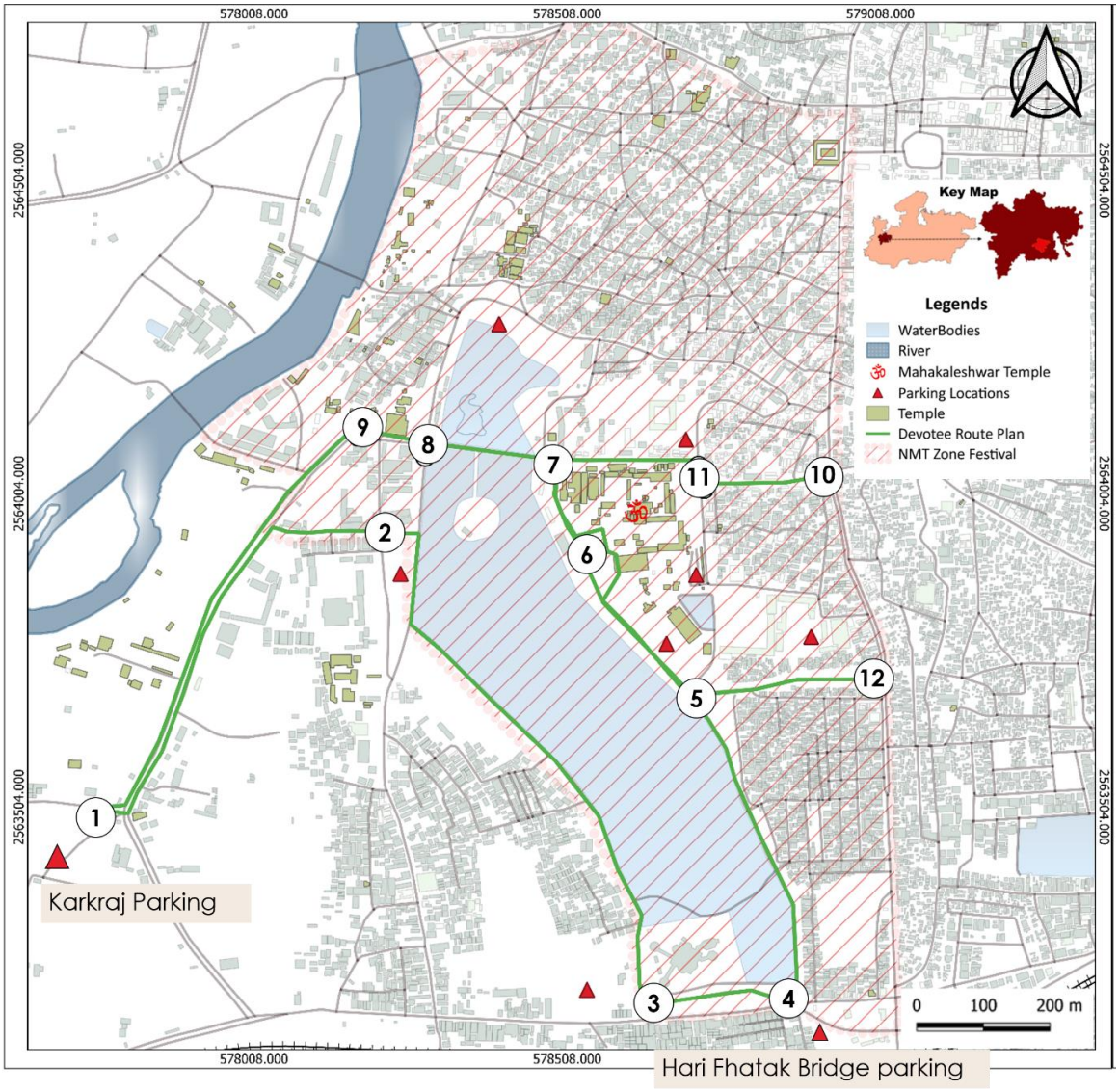


Fig 24 Circulation Plan

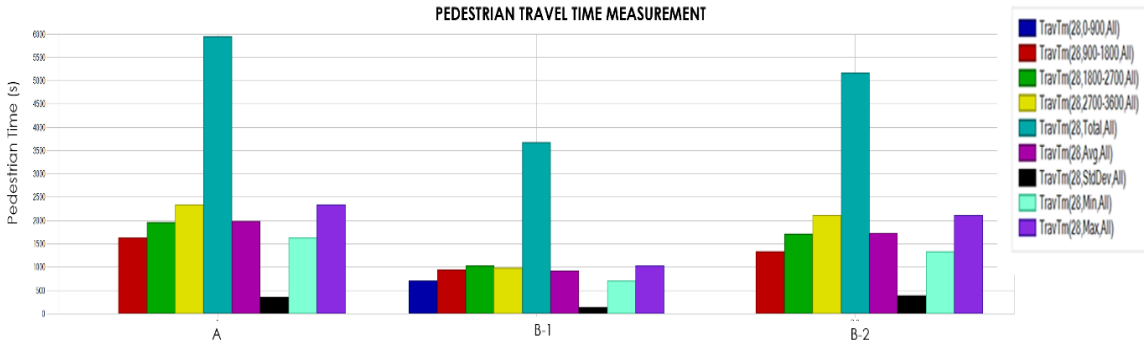


Fig 25 Travel Time Result

Source: Result Generated by the PTV-Viswalk software-

Heat map/Density map for the mahakaal Mandir-

This heat map is used to measure evacuation times, including individual and overall, and delay times & also density point. Due to limitations in the software's pedestrian capacity, a focused approach was adopted for the analysis, utilizing a smaller stretch to determine the level of service (LOS). Previous LOS assessments for the movement from Harsiddhi Chauraha to the Mandir indicated a classification of "C" for bi-directional flow, both in the initial findings and the subsequent study. However, upon implementing unidirectional movement, a notable improvement was observed. The LOS shifted to a more favourable classification of "B," suggesting enhanced efficiency and reduced congestion. This shift in LOS not only indicates an improvement in pedestrian flow but also signifies potential time savings for visitors. By prioritizing unidirectional movement, planners can streamline the flow of pedestrians, reducing bottlenecks and optimizing the overall visitor experience. This strategic approach not only aligns with observed data but also offers practical benefits in managing pedestrian movement effectively. Moreover, this finding underscores the importance of adapting route plans and circulation strategies to suit specific conditions and constraints. By identifying and implementing strategies that yield optimal LOS, planners can ensure smoother pedestrian movement, enhancing accessibility and convenience for visitors to Mahakaal Mandir. In summary, the focused analysis on a smaller stretch revealed significant insights regarding pedestrian movement dynamics. The shift from bi-directional to unidirectional flow resulted in a notable improvement in LOS, highlighting the efficacy of tailored circulation strategies. By leveraging such findings, planners can refine route plans and optimize pedestrian flow, ultimately enhancing the overall visitor experience at Mahakaal Mandir.

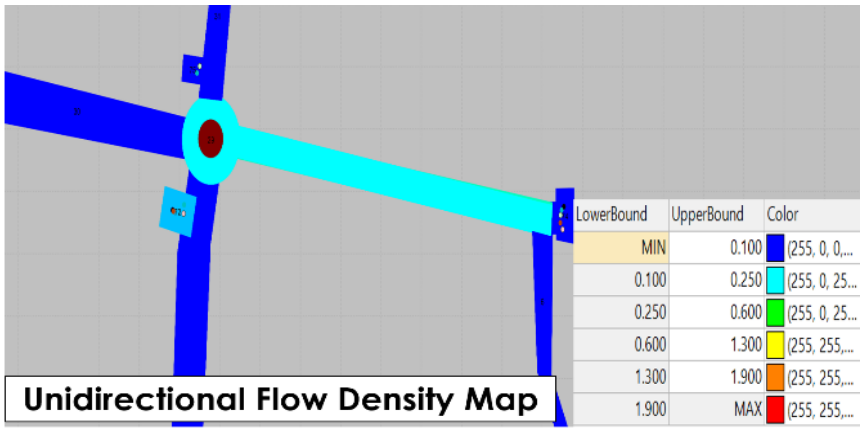


Fig 26 Result Analysis of Unidirectional flow plan

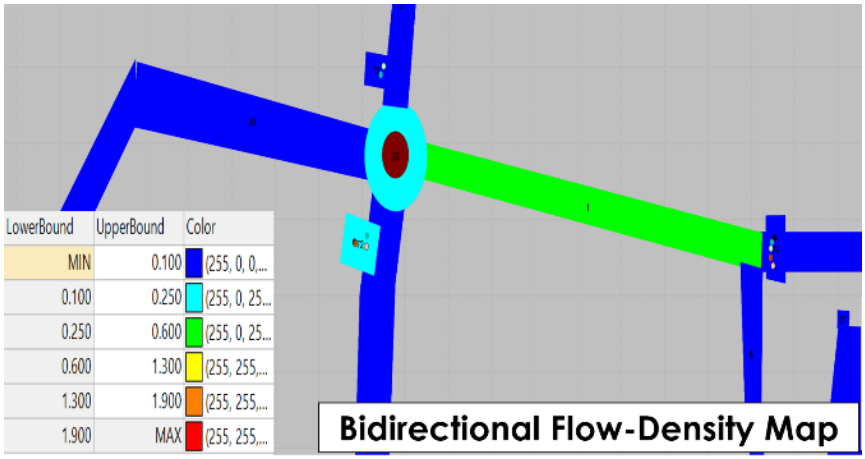


Fig 27 Result Analysis of Bidirectional flow plan

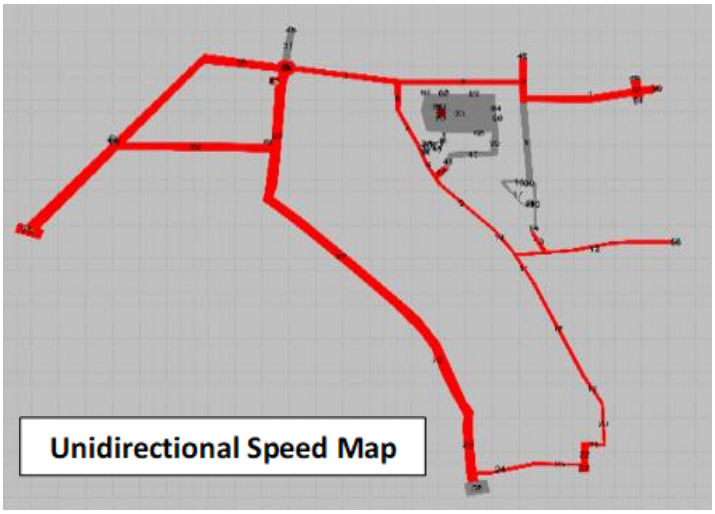


Fig 28 Result Analysis of Speed achieve by unidirectional plan

CHAPTER-5 CONCLUSION

After conducting intensive data collection and analysis using the PTV Viswalk software, several recommendations emerge to enhance pedestrian safety in Ujjain, a city known for its pilgrimage sites.

Implement Unidirectional Movement: It is recommended to establish designated pathways for devotees to follow unidirectional movement. This plan should be based on three major scenarios identified through the analysis, accommodating varying levels of tourist footfall. By directing pedestrian flow in a single direction, congestion and confusion can be minimized, enhancing overall safety and efficiency.

Expand Pathway from Mahakaal Chauraha to the Temple: Due to congestion along the pathway leading from Mahakaal Chauraha to the temple, expansion is necessary to accommodate the increasing number of pilgrims. Widening the pathway will improve pedestrian flow and alleviate crowding, reducing the risk of accidents and ensuring a smoother pilgrimage experience.

Allocate Footpath Businesses to Suitable Locations: To prevent obstruction and ensure adequate space for pedestrians to walk, footpath businesses should be allocated to suitable locations. By regulating the placement of stalls and vendors, tourists will have ample space to navigate without needing to change lanes, minimizing the risk of collisions and congestion.

Install Variable Sign Boards: Lack of signboards can lead to confusion among tourists. Installing variable signboards at strategic locations will provide clear directions and guidance, reducing the likelihood of pedestrians getting lost or encountering hazards.

Implement Traffic Diversion during High Footfall: During periods of high footfall, such as peak pilgrimage seasons, it is advisable to divert vehicular traffic away from the main city centre. Options include redirecting traffic from the Hair Fhatak Bridge or implementing temporary traffic stops on routes leading from Indore or Bhopal roads. This will create a safer environment for pedestrians by reducing the risk of accidents and congestion.

Publicize Contingency Plans: A contingency plan should be developed and widely publicized to tourists through banners, audio announcements, and video graphics. This plan should outline emergency procedures and alternative routes in case of unforeseen events, empowering tourists to make informed decisions and reducing dependence on external assistance.

Establish Resting Zones: Provide designated resting zones separate from entry and exit pathways of the temple. These zones should offer seating and facilities for pilgrims to rest and rejuvenate after darshan without disrupting the flow of tourists. Creating safe and comfortable resting areas will enhance the overall pilgrimage experience and promote pedestrian safety.

Enhancing pedestrian safety during festival: During times or periods of high footfall is to designate a non-motorized zone stretching from Harifhatk to Kartik Chowk. Moreover, vehicular entrance along the sides of this zone should be restricted. This initiative aims to prioritize pedestrian movement, ensuring safer and more efficient travel for pilgrims and visitors during peak periods.

Fig 29 Route plan for corridor
Source: Author Generated

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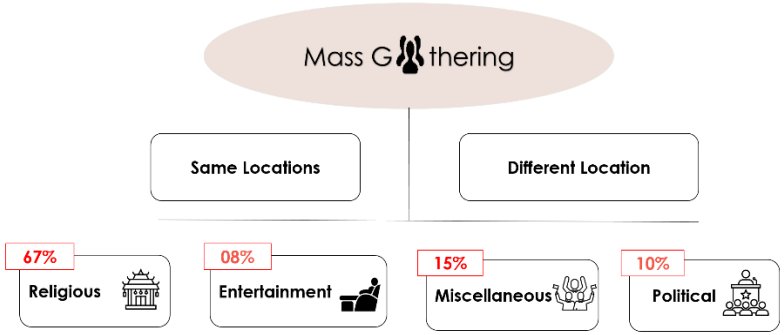
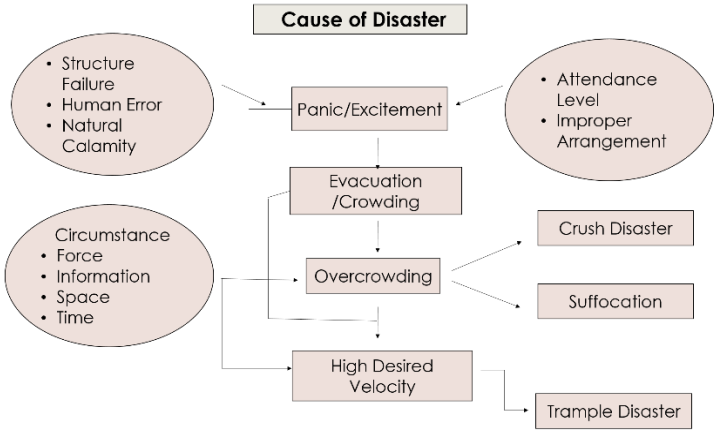
India's rising population attracts many people to important pilgrimages sites like *kumbh melas, rath yatra*, and other sacred sites, including historical monuments, which poses a great challenge on capacity of area & safety this extreme high density results in crowd disaster-stampede ,trampling.



- In most of Non Conventional Place (Stadium , Cinema Hall & etc.) - Operational area is designed on basis of Carrying Capacity of zone/Area.

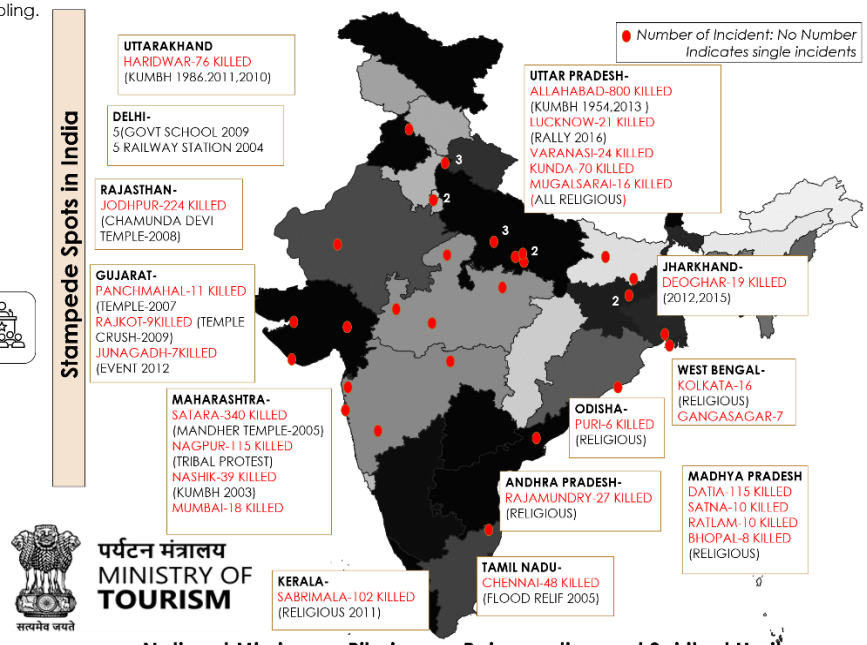
- Issue at Religious Place-
  1-No Pre-Defined Capacity.
  2-No proper Planning & Regulation for crowd control at entry/exit.
  3-No proper Monitoring



Pedestrians are considered to be the most susceptible to danger among all road users, & majorly at Pilgrim city.

Source- The Prayagraj Kumbh Mela , Carrying Capacity for Religious Crowd Management

Stampede Spots in India



पर्यटन मंत्रालय
MINISTRY OF TOURISM
सत्यमेव जयते

Scheme - Govt. of India

National Mission on Pilgrimage Rejuvenation and Spiritual Heritage Augmentation Drive
(PRASHAD-2017)

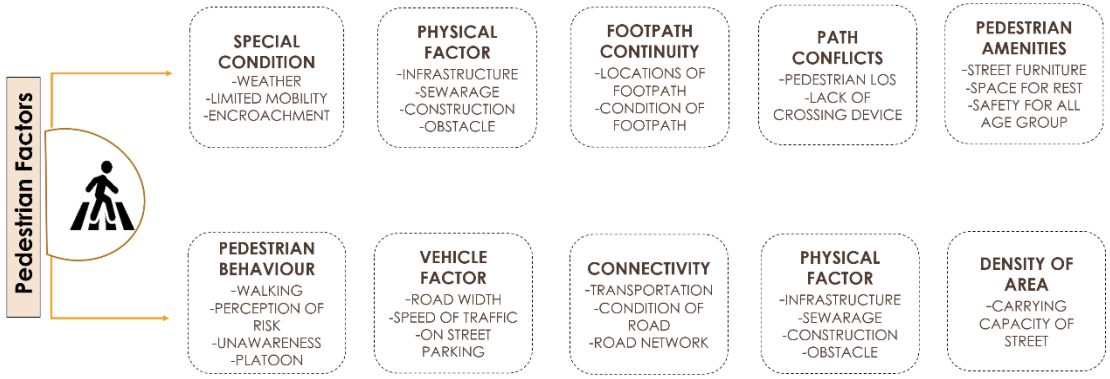
- It strives to create a comprehensive religious tourist experience by integrating the development of pilgrimage places in a planned, prioritized, and sustainable manner.
- The focus of the previously launched PRASAD Scheme was on the development and beautification of the identified pilgrimage destinations under the HRIDAY (Heritage City Development & Augmentation Yojana) Scheme.

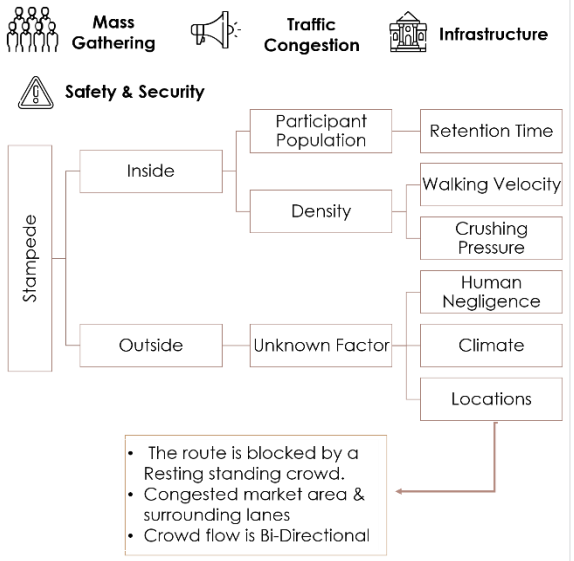
Project Elements:-

12 cities identified under the scheme

Source-tourism.gov.in/prashad-scheme

Name of Document	Author	Year	Outcomes
Crowd Management and Strategies for Security and Surveillance During the Large Mass Gathering Events: The Prayagraj Kumbh Mela 2019 Experience	Ashok Kumar Kanaujiya, Vineet Tiwari	2022	Pedestrian Prioritized
Pedestrian Charateristics and Behaviour on Surrounding Temple Area Madurai	Bharathy G, Ms.Karthigaipriya T	2017	Pedestrian Management
Study of Pedestrian stream Behaviour at Mass Gathering	Angshuman Pandit, Soumya Prasad Dey,Anuj Kishor Budhkar	2021	Los & Safety
Integration of Image Processing & Crowd Simulation for Crowd Dynamics in Kumbh Mela	P S Karthika , Ashish Verma S pal	2019	Simulation & Heat Map
Spatial Strategy for Crowd management at haridwar	Sindhuja Kasthala, Binoy B.V., Harshit S. Lakra	2019	Infrastructure & Capacity
Human stampedes during religious festivals: A comparative review of mass gathering emergencies in India	Faisel T. Illiyas, Shibu K. Mani, A.P. Pradeepkumar	2013	Physical Carrying Capacity
A review of pedestrian flow characteristics and level of service over different pedestrian facilities	Arunabha Banerjee, Akhilesh Kumar Maurya, Gregor Lämmel	2018	Purpose & Place
Evaluation of Senior Pedestrian's Travel Experience at Ekamara Kshetra Bhubaneswar	Rabi Narayan Mohanty , P.S. Chani	2019	Safety at Pilgrimage Site & Landuse
Understanding Crowd Dynamics in Processions during Mass Religious Gatherings-A case study of Shahi Snan in Kumbh Mela	H Gayathri, Siddhartha Gulhare, Ashish Verma	2018	Unstable Flow Pattern





AIM

To Develop an efficient Circulation/Pedestrian Mobility Plan for the safe movement of attendees.

OBJECTIVES

- To identify the existing condition of road & pedestrian facilities & area of improvement.
- To analyze the existing Level of Service (LOS) for pedestrians and to compare it with the standard to understand gaps.
- To devise a strategy that mitigate the risk of stampedes and ensure safety.

LIMITATION

There is no emphasis on the holistic development of Ujjain's other sacred site locations & large scale event-Kumbh

SCOPE

Identifying the elements relevant to pedestrian movement in the vicinity of the Mahakaal corridor

03 METHODOLOGY

Background of the Study

AIM → Formulation of Objectives

Study Area -उज्जैन
Events,Gathering
Kumbh,Locations

Need of Study/ Problem Identification

Literature Review
- Background Study
- Best Practices

Research Question

Data Identification

Identification of Survey Locations

Primary Survey
- Recce Survey
- Commuter O-D
- Interview
- Travel Time /Capacity

Secondary Survey
- Tourist Footfall
- CCTV Footage
- Procession Points
- Land Use

Objective-1

Data Analysis

Objective-2
- Speed
- Flow Rate
- Space
- Density

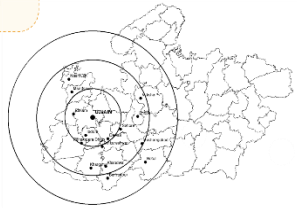
Assessment of Level of Service

Objective-3
Circulation Plan

Recommendation

REGIONAL CONTEXT

It is the 28th largest district of the state in respect of the area, which is 1.98% of the total area of 308245 sq. km. of Madhya Pradesh.
The city lies in the unique geographical location from where the Tropic of Cancer passes.



To reach Ujjain city:

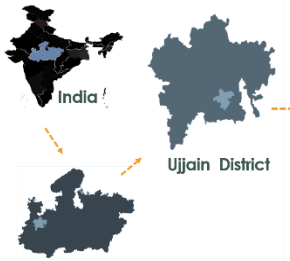
Through Airlines: The nearest airport to Ujjain is Indore

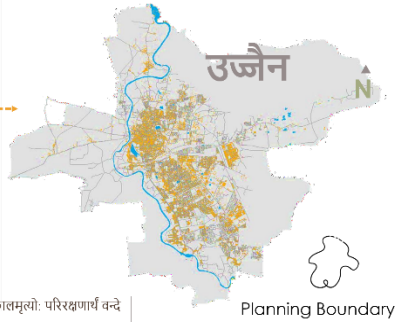
Through Rail: Ujjain is well linked with several cities through railways.

Through Road: One can reach the city by bus. After reaching the bus stand(***1****-Malipura,****2****-Nanakheda*), can hire taxis. It has good connectivity with cities like Indore (55 km), Bhopal (192 km), Dewas(47 km), Nagpur (543 km), and Unhel (37 km).

ABOUT-STUDY AREA

Ujjain is an ancient city of central India, in **Malwa. The region** is a plateau in the Vindhyachal ranges of **Madhya Pradesh**. Situated on the eastern bank of the holy **Kshipra River**, Ujjain radiates a distinct character of socio-religious cultural ethos, the city was called **Ujjayianni** old ancient times.
It is one of the seven sacred and pois cities of the Hindu mythology, and the **Kumbh Mela** religious festival is held here every twelve years. It is also abode to one of the twelve **Jyotirlinga shrines** dedicated to **lord Shiva**.





अवन्तिकायां विहितावतारं मुक्तिप्रदानाय च सज्जनानाम्। अकालमृत्योः परिरक्षणार्थं वन्दे महाकालमहासुरेशम्।

Planning Boundary - 152 sq.Km

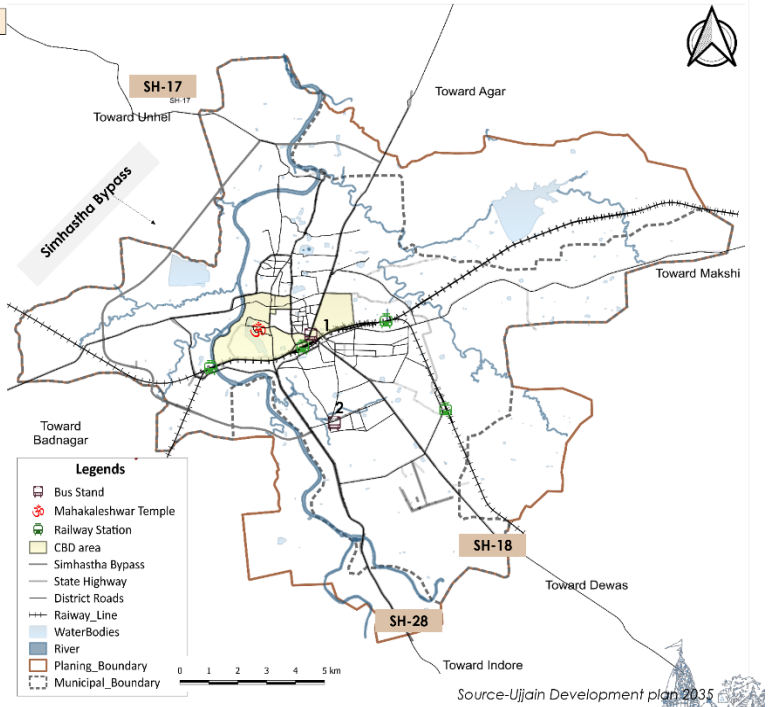
Population of City (2011)-5,15,215

Area Under CBD -1023 Acres

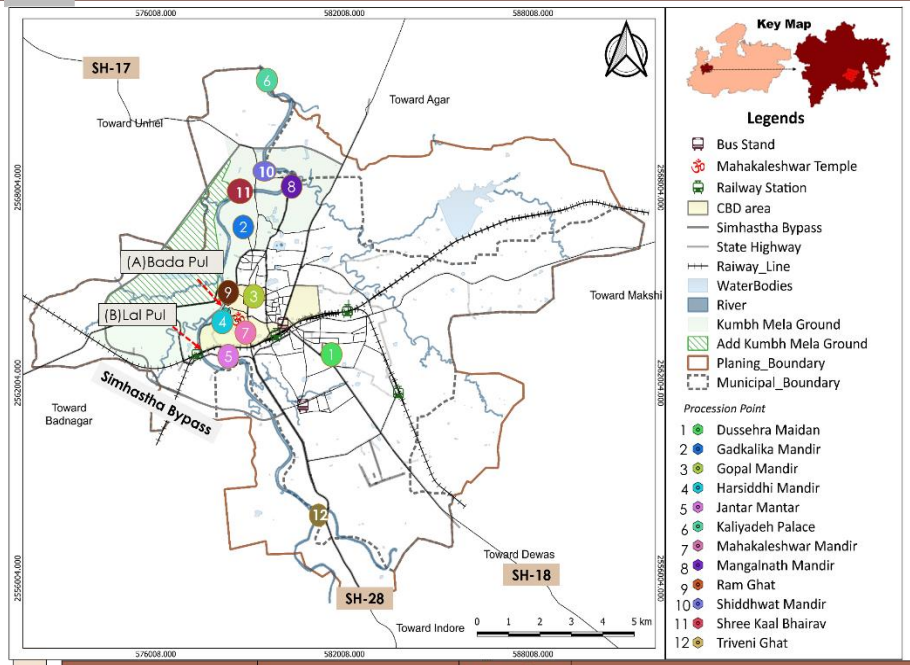
Population of CBD-87,776

Area under Mahakaal lok – 310 Acres

Municipal Boundary -92 sq.Km



Source-Ujjain Development plan 2035



राम घाट

नाग पंचमी

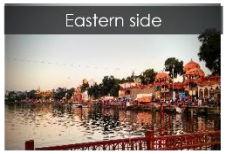
महाकाल सवारी

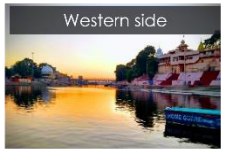
Capacity of Different Locations-

Calculated based on **one person per square meter area.**

There are numerous Ghats along the Kshipra coast, spanning from Triveni Ghat (12) to Kaliadeh Palace (6). However, the focal point for tourists lies between (A) Bada Pul and (B)Lal Pul. Consequently, the capacity of the area has been assessed for both the Eastern and Western Ghats sides.

Location	Person attending one time
Eastern Ghats (A to B)	32943
Western Ghats (A to B)	27997
Other Ghats	14687
Total	75,627





Corridor Capacity

Physical Capacity - **1,04,597**

Effective Capacity - **65,989**

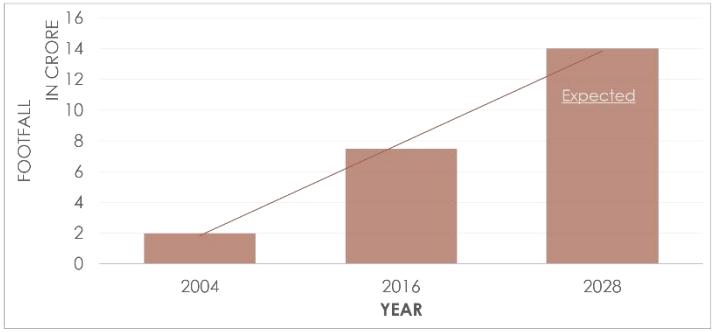
Plaza Capacity **20,000**

Source-Uscl / MMPS

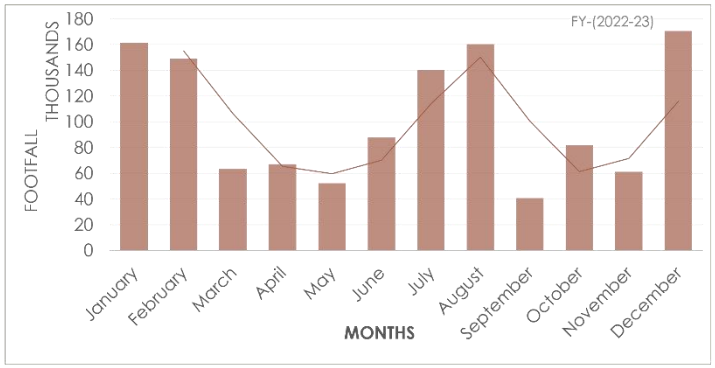
EVENTS DETAILS

Festival/Mela	Period (month)	Duration (days)	Place	Estimated Visitors
Simhastha / Kumbh	After every 12 years	30	Kumbh Mela Ground	**5-6 Crore**
Vaishakah Snan	चैत्र-वैशाख (Mar-Apr)	30	Near Bada Pul, Ramghat to Triveni,Lal pul.	**25000-30000**
Panchkroshi Yatra	वैशाख (Apr-May)	5	Mangalnath,K.d palace, Pingleshwar,Triveni,Bilkeshwar (118km)	**25000-30000**
Ganga Dussera	वैशाख-ज्येठ (May-June)	9-10	Ram Ghat	**25000-30000**
Nag Panchmi	श्रावन (July-Aug)	30	Mahakaal mandir, Nagchandeshwar	**50000-60000**
Kartik Snan	कार्तिक (Oct-Nov)	30	Near Bada Pul-Ram Ghat	**30000-40000**
Makar Sankranti	पौष (Dec-Jan)	1-2	Mahakaal Temple	**20000-25000**
Magh Snan	माघ-फाल्गुन (Jan-Feb)	30	Bada Pul-Triveni Ghat	**20000-25000**
Maha Shivratri	माघ-फाल्गुन (Jan-Feb)	1-2	Mahakaal Temple	**1-2 lakh +**

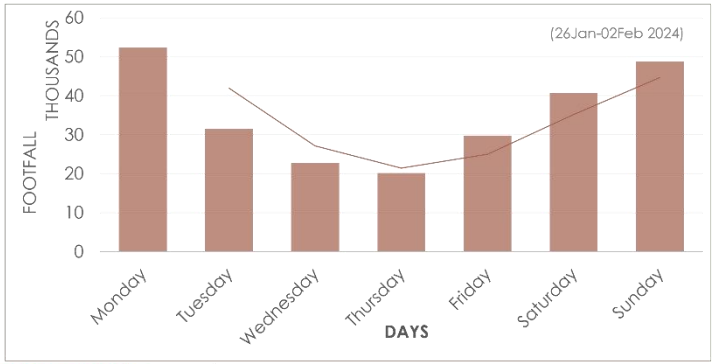
Simhastha Footfall



Monthly Footfall



Weekly Footfall



- Ujjain receives a *large influx of floating footfall* which ranges from an average of **30,000-50,000**, while the number of devotees for the Kumbh Mela in 2016 was around **6.15 Crore**. in 2 months & the expected footfall for the upcoming Simhastha 2028 is around 14 Cr.
- The Annual Number of Tourist arriving in Ujjain is approximately **12,35,944** (FY-2022-23)
- Considering that darshan is permitted for 17-18 hours daily, including the Basma Arti, we observe from the weekly footfall data that the greatest influx of visitors occurs on weekends and Mondays, the latter being particularly significant as it marks a special day dedicated to Lord Shiva.

Total Pedestrian Route Length-
8.94 Km.

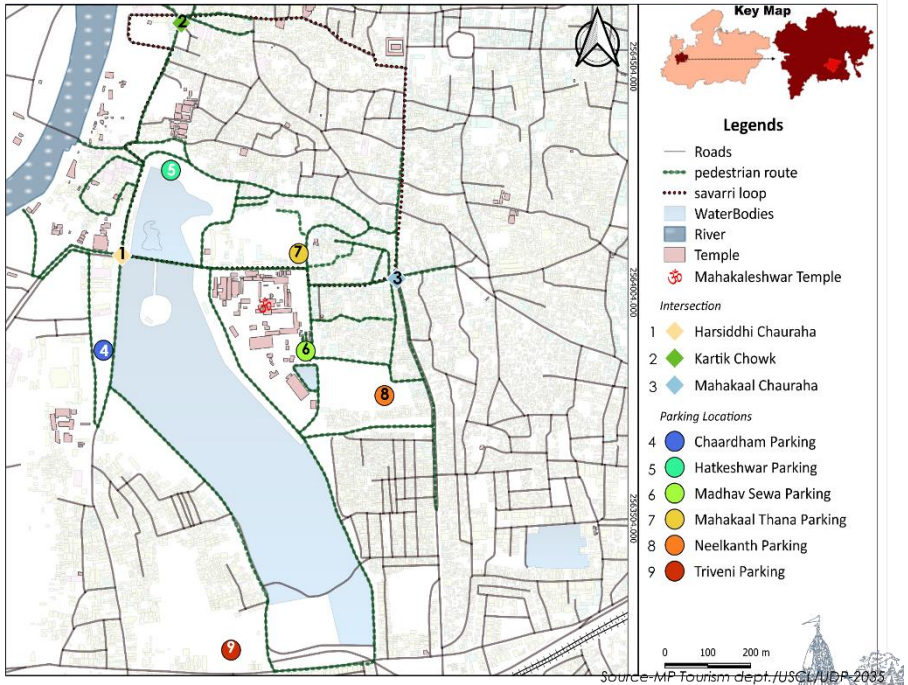
Mahakaal Corridor Pedestrian Route-
2.2 Km.

Parking Capacity of 6-zone
2120 ECS

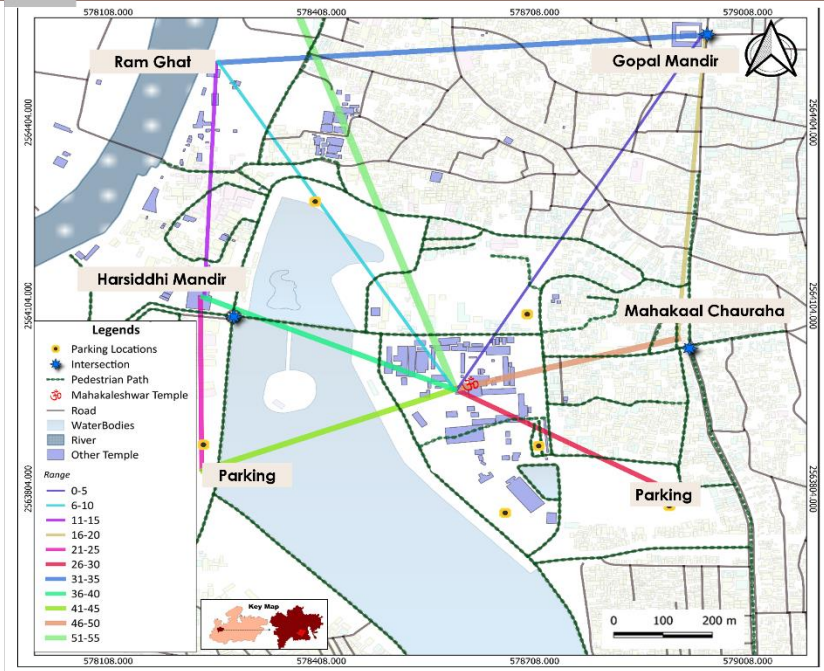
- *Chaardham- 4W-300*
- *Hatkeshwar-2W-200,4W-100*
- *Madhav Sewa-2W-120,4W-60*
- *Neelkanth-2W-300,4W-300*
- *Triveni-2W-200,4W-400*
- *Hari Phatak-2W-200,4W-450*

Total Hotel-**950+** Capacity-
5,70,000 approx.

Mahakaal Sawarri Route-
2.5 Km.



Source-MP Tourism dept./USCL/UDP-2035



Analysis – Relative Importance Index

Purpose of Visit:-

Pilgrimage **89%** Other **11%**

62% 38% = 133 Sample

Distance Travelled for Temple:-

Less than 1km - **22%**
1-2 KM- **25%**
3-5 KM- **25%**
5+ KM- **28%**

Origin

Local **17%**
Same State **43%**
Other State **40%**

The Relative Importance Index (RII) is a non-parametric technique used to analyzes questionnaire responses for data involving ordinal measurement of attitudes & quality performance

$$RII = \Sigma W/(A*N)$$

W - scale for rating a factor (ranges from 1-Very Unsatisfy, 2-Unsatify 3 Neutral 4-Satisfy 5- Very Satisfy)
A – the highest weight in the scale;
N - total number of respondents.

Factors

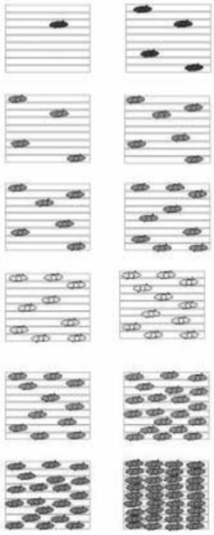
Indicators/Factors	5	4	3	2	1	Total(N)	∑W	MEAN (∑W/N)	A*N	RII	RANK
Side walk Quality	21	42	47	16	7	133	453	3.406015	665	0.681203	1
Traffic management	16	38	42	32	5	133	427	3.210526	665	0.642105	2
Connectivity of this site	15	36	42	31	9	133	416	3.12782	665	0.625564	4
Parking	12	35	43	35	8	133	407	3.06015	665	0.61203	5
Amenities	9	34	46	29	15	133	392	2.947368	665	0.589474	6
Density /Space	21	30	42	31	9	133	422	3.172932	665	0.634586	3

Improvement

Indicators/Factors	5	4	3	2	1	Total(N)	∑W	MEAN (∑W/N)	A*N	RII	RANK
Amenities	34	49	25	16	9	133	482	3.62406	665	0.724812	2
Seating space facility	23	25	42	39	4	133	423	3.180451	665	0.63609	3
Accessible Sidewalk Space	43	36	38	10	6	133	499	3.75188	665	0.750376	1
More Seperation from City Traffic	19	30	42	23	19	133	406	3.052632	665	0.610526	4
Would like to Walk More for Darshan	15	19	42	31	26	133	365	2.744361	665	0.548872	5

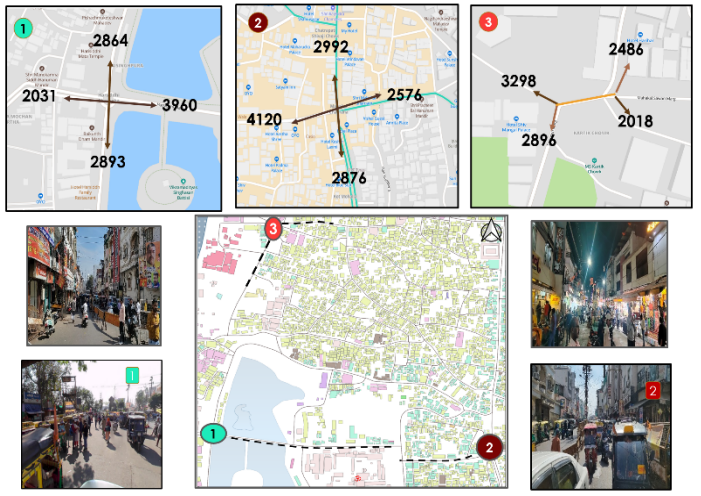
Analysis – Pedestrian Level of service

Pedestrian Capacity is defined as the space that corresponds to each pedestrian for free movement, expressed in m² & also "J.J Fruin stated that if the density approaches seven persons in 1 m2, the area becomes crowded."

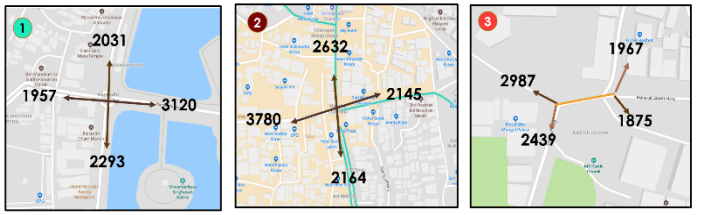


LEVEL OF SERVICE A Avg. pedestrian space occupancy>4.73m²/p	LEVEL OF SERVICE A Avg. Flow Volume:<=12 PPM
LEVEL OF SERVICE B Avg. pedestrian space occupancy>2.93-4.9m²/p	LEVEL OF SERVICE B Avg. Flow Volume: 12 to 20 PPM
LEVEL OF SERVICE C Avg. pedestrian space occupancy>1.73-2.93m²/p	LEVEL OF SERVICE C Avg. Flow Volume: 20 to 32 PPM
LEVEL OF SERVICE D Avg. pedestrian space occupancy>0.93-1.73m²/p	LEVEL OF SERVICE D Avg. Flow Volume: 32 to 54 P/P/M
LEVEL OF SERVICE E Avg. pedestrian space occupancy>0.33-0.93m²/p	LEVEL OF SERVICE E Avg. Flow Volume: 54 to 91 PPM
LEVEL OF SERVICE F Avg. pedestrian space occupancy<0.33 m²/p	LEVEL OF SERVICE F Avg. Flow Volume: variable, max 91 PPM

Event days



Normal days



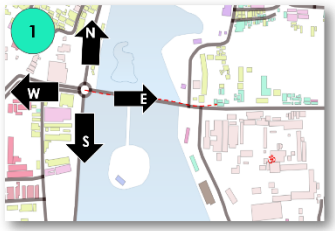
STEPS

- Identification of Sidewalk based on land use
- Measurement of Sidewalk Width
- Estimation of Eff. Width of the facilities
- Observe Pedestrian Flow
- Estimation of max flow rate (p/m/Min)

→ Determination of PLOS

Source-Indo HCM 2017

Harsiddhi Chauraha



Normal Days

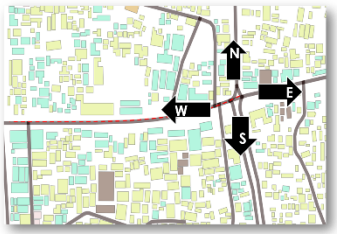
Direction	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	830	27.6	C	1.26	D
W	518	17.2	B	2	C
N	635	14.1	C	1.9	C
S	581	20.1	C	1.6	D

Events Days

Direction(S)	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	1010	33.6	D	0.86	E
W	522	17.4	B	1.42	D
N	726	24.2	C	1.08	D
S	741	24.7	C	1.0	D

The eastern and northern sides of the Harsiddhi temple and the surrounding chauraha experience hindrances due to city traffic, primarily consisting of two-wheelers & E-rickshaw, and encroachment by street vendors on the sidewalks, affecting pedestrian movement.

Mahakaal Chauraha



Normal Days

Direction	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	536	17.8	B	1.40	C
W	995	33.1	D	0.92	E
N	658	22	C	1.58	E
S	601	20.1	C	1.69	D

Events Days

Direction	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	650	21.6	C	1.0	D
W	1030	34.3	D	0.9	E
N	748	24.9	C	1.1	D
S	729	12.02	B	1.2	D

The temple's eastern and northern sides face city traffic hindrances for pilgrims, with an adjacent auto stand. Meanwhile, the western side is constrained by narrow roads and encroachments.

Kartik Chowk

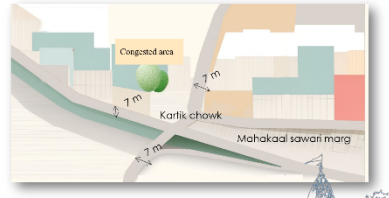
Normal Days

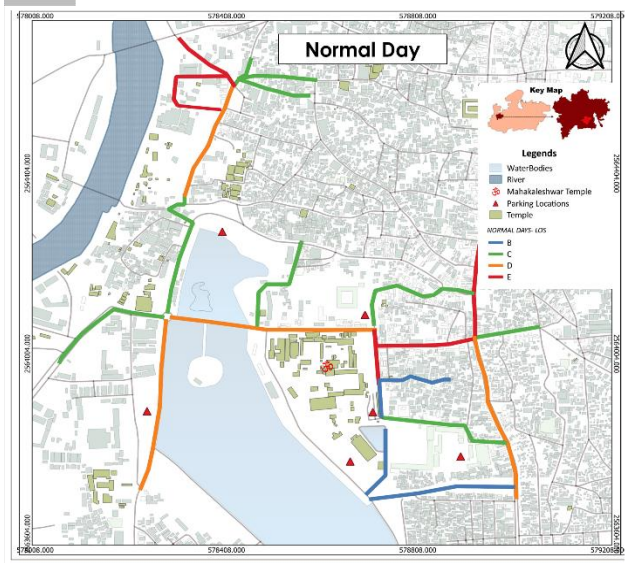
Direction	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	490	16.3	B	2.5	C
W	610	20.3	C	2.0	C
N	739	24.6	C	1.4	D
S	462	15.4	B	2.7	C

Events Days

Direction	Pedestrian (Peak 15 min)	Max Flow (P/min/m)	LOS by Flow	Pedestrian Space (M^2/P)	LOS by Space
E	625	20.8	C	1.8	C
W	739	24.6	C	1.0	D
N	835	27.8	C	0.9	E
S	515	17.1	B	2	C

The western side of the chowk serves as the route to Ram Ghat, yet the on-street parking poses an obstacle to pilgrims movement. The narrow road and congested infrastructure further compound the issue.





Challenges

Lack of basic facilities for pedestrian.

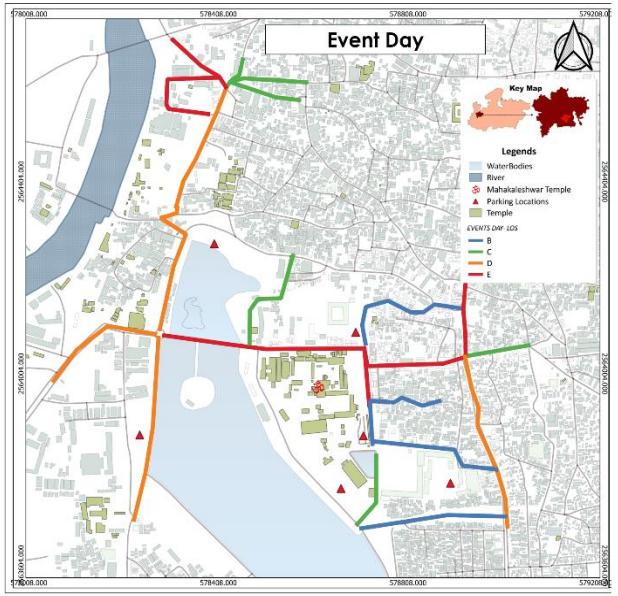
Unauthorized Pick up/ Drop point.

Encroachment by Street Vendor

On Street Parking & No Traffic Management

No Controlling at Entry /Exit & Lack of Signage Boards

Lack of segregation & not well maintained pathway



Analysis – Circulation Plan through PTV Viswalk

Projected No of Visitors	Area to accommodate number
Venue Space plan	Layout for safety purpose
Flow of crowd	No of access route to venue

STEPS

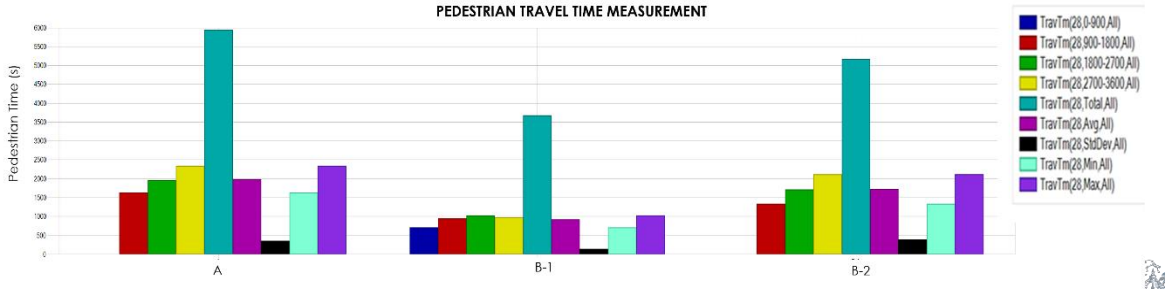
- Evaluating the Capacity of area
- Evaluating the Various crowd flow pattern
- Providing all possible precaution in place
- Providing all trajectory path for pedestrians
- Evaluating the time for all possible routes
- Comparing the L.O.S of area with standard

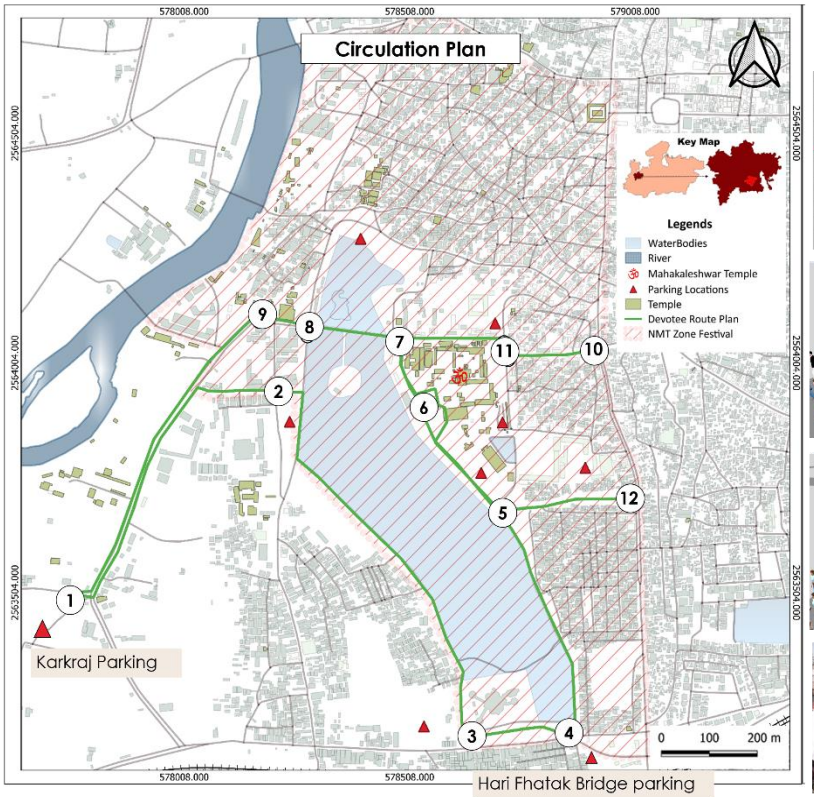
Estimated Time Calculated Through Viswalk Software Except Darshan Time by Devotees

Special Days Plan- (A) 1-2-3-4-5-6-7-8-9

Week Days Plan- (B-1) 10-11-7-6-5-12 & (B-2) 2-8-7-6-5-4-3

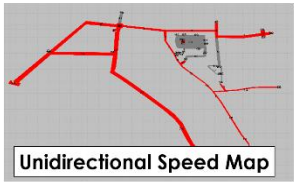
Route Plan	Max Time	Min Time	Average Time	Distance
A	35 Min	27Min	30 Min	3.7 km
B-1	17 Min	12 Min	15 Min	1.3 Km
B-2	28 Min	22 Min	26 Min	2.6 Km

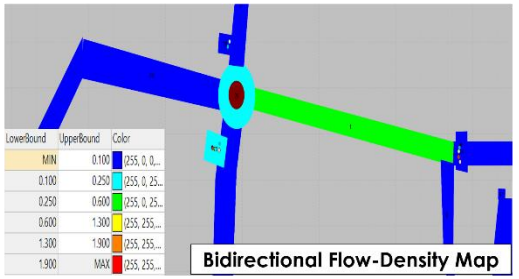


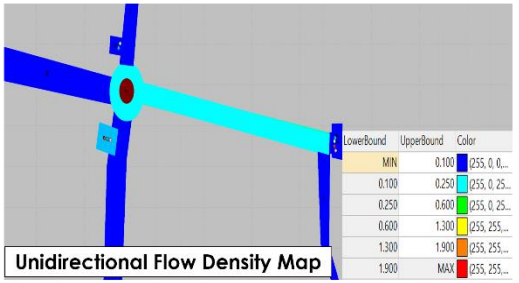


Heat/Density Map-

This heat map is used to measure evacuation times, including individual and overall, and delay times & also density point.







Signage and announcement system (variable message display boards)

Emphasize contingency planning, including alternative routes that all tourists should be aware of for self-reliance and reduced dependence.

Implementing unidirectional pedestrian flow to minimize intersecting movements and enhance safety.

Designated pedestrian-centric zone, particularly during events days.

Pedestrian zone with amenities along the path, especially designed for post-darshan activities.

Footpath business management involves allocating space for shops to prevent encroachment on pedestrian paths.

In the event of heavy traffic or significant pedestrian activity, implement restrictions from the Hari Fhatak Bridge and establish traffic diversion

Expanding the road from Mahakaal Chauraha to the temple pathway.

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by Ashutosh Kumar Tiwari

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