Innovations

Transport Management with Intelligent Transportation Systems for Public Transportation in Bhopal Smart City

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Abstract:

Intelligent Transportation Systems (ITS) play a vital role in managing public transportation in Bhopal Smart City, aiming to enhance the efficiency and safety of the city's transportation network. This dissertation explores the implementation of ITS technologies to improve traffic management, reduce congestion, and enhance the overall transportation experience for users. Real-time traffic monitoring, advanced traffic management systems, and intelligent transportation management systems are among the key ITS technologies deployed. The application of ITS technologies in public transportation systems, specifically buses and trains, is a major focus in Bhopal Smart City. Real-time traffic monitoring systems provide transport operators with up-to-date information on traffic conditions, enabling them to modify routes and schedules to minimize delays. Sophisticated traffic management systems analyze traffic patterns and optimize traffic flow by adjusting traffic lights and control devices using data from various sources, including cameras and sensors. Moreover, intelligent transportation management technologies are implemented to enhance the overall transportation experience for

users. Passenger information systems provide real-time updates on bus and rail schedules, assisting travelers in better planning their journeys. Mobile ticketing and payment systems simplify and improve the convenience of using public transportation, allowing users to pay fares and purchase tickets using their mobile phones. By leveraging ITS technologies, Bhopal Smart City aims to optimize traffic management, enhance public transportation services, and offer a seamless and efficient transportation experience for its residents and visitors. The integration of real-time monitoring, advanced management systems, and intelligent transportation solutions contributes to the city's vision of a modern and sustainable transportation network. In conclusion, Bhopal Smart City's efforts to transform its public transportation system have come to rely heavily on Intelligent Transportation Systems (ITS). The city works to increase efficiency, reduce congestion, and improve user experiences through the use of real-time traffic monitoring, sophisticated traffic management, and intelligent transportation management technologies. In order for the city to realise its goal of a cutting-edge, environmentally friendly, and user-focused transportation network, ITS technologies are essential.

***Keywords**: 1. Intelligent Transportation System 2. Congestion Reduction 3. Real Time Traffic Monitring 4. Sustainable Transportation 5. Transportation Efficiency*

1. Introduction

Bhopal Smart City has adopted Intelligent Transportation Systems (ITS) as a game-changing option in the pursuit of effective and efficient traffic management. In line with the city's reputation for innovation and sustainability, this dissertation investigates the integration of ITS technology to improve the public transport system in the city.

The installation of ITS in Bhopal Smart City focuses primarily on overcoming traffic issues, congested areas, and overall transportation efficiency. Through sensors and surveillance systems, real-time traffic monitoring provides transport operators with data-driven insights that enable route changes and proactive traffic management to reduce delays.

By constantly adjusting signals, lanes, and signal timings based on real-time data from numerous sources, advanced traffic management systems further improve traffic flow. These technologies ease traffic congestion and provide customers with more seamless public transit services.

Real-time updates on schedules and mobile ticketing alternatives are features of intelligent transportation management technologies that improve user experiences. This makes it easier to pay for tickets and streamlines trip planning.

The use of ITS by Bhopal Smart City demonstrates its dedication to technologically driven sustainable urban development. This effort intends to develop an effective, congested-free transport network, enhancing both residents' and visitors' overall commuting experiences. This dissertation will explore further into the effects of particular ITS technologies on traffic management, providing insightful information for improving public transport in advanced cities like Bhopal.

2. Study Area

The city of Bhopal, which is situated in the Madhya Pradesh state of central India, is included in the research area for the application of intelligent transportation systems (ITS) in traffic management for public transportation in Bhopal Smart City. The capital of Madhya Pradesh, Bhopal, is renowned for its attempts to embrace technologically-driven urban development solutions

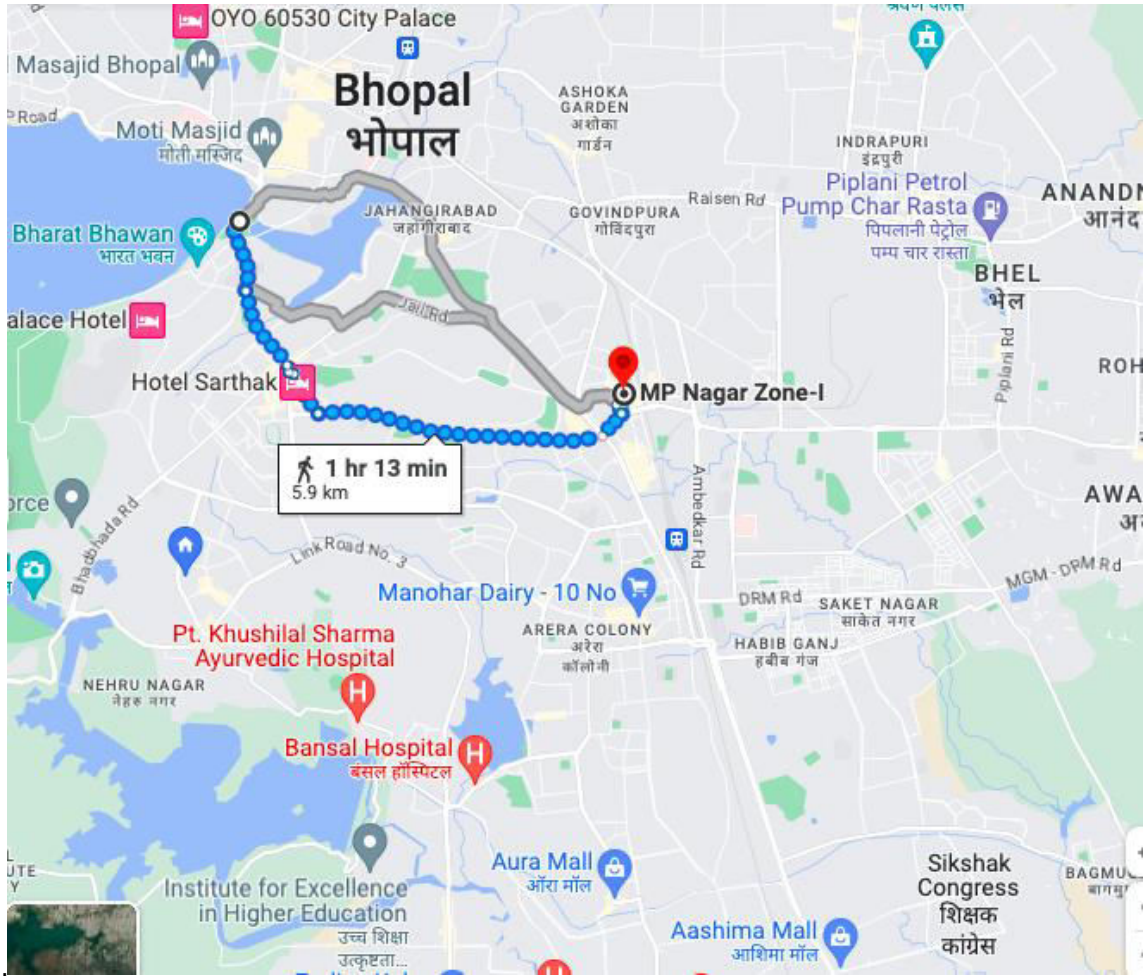

Figure 1: Study Area Location Bhopal Kamla Park Road to MP Nagar Zone-1 Bhopal

1. **City Road Network:** This term refers to all of Bhopal's paved surfaces, including main thoroughfares, arterial roads, and neighbourhood streets.
2. **Routes of public transportation:** The study would concentrate on the schedules and offerings of the buses that operate in Bhopal. Bus lines, and transit hubs are included in this.
3. **Traffic Congestion Points:** Identification of areas within the city where traffic congestion is a recurring issue, such as major intersections, bus terminals, and areas with high traffic volume.
4. **ITS Deployment Sites:** Locations where ITS technologies have been deployed, including real-time traffic monitoring systems, traffic management centers, surveillance camera installations, and passenger information systems.
5. **Passenger Amenities:** Facilities and locations where passenger-centric ITS solutions are implemented, such as mobile ticketing and payment systems, digital information displays at bus stops and train stations.
6. **Urban Developments:** Any ongoing or planned urban development projects that might impact traffic management and public transportation within the city.

The study area effectively covers the entirety of Bhopal Smart City's urban and transportation environment, with a focus on areas and components pertinent to the application and effects of ITS in traffic management

and public transit services. In order to evaluate the success and difficulties of ITS deployment in improving transportation effectiveness and user experience in Bhopal, It will analyse data and acquire insights from these areas.

3. Objective of the study

In order to improve traffic control and the convenience of route users, the goal of this research is to examine the traffic situation along the chosen route in Bhopal Smart City. The following are the project's objectives that help it achieve its goal:

- Analyze the current traffic management systems for public transportation in Bhopal Smart City.
- Identify the challenges and bottlenecks in the current systems.
- Propose and evaluate solutions using Intelligent Transportation Systems (ITS) technologies and techniques, such as Real-time traffic monitoring systems, Advanced Traffic Management Systems (ATMS), Intelligent Transportation Management Systems (ITMs), Public Transit Priority Systems (PTPS), and Mobile Ticketing and Payment Systems (MTPS).
- Develop a comprehensive plan for the implementation of ITS technologies and techniques in Bhopal Smart City to improve traffic management for public transportation.
- Provide recommendations for the continuous monitoring and evaluation of the proposed solutions to ensure their effectiveness and sustainability over time.

4. Methods of the Study

Stage 1: Choosing a Study Area For the project.
Stage 2: Zoning of Study Area into various sections for data collection
Stage 3: Data collection involved manually counting the number of vehicles operating during peak hours.

Stage 4: A significant limitation is that it is frequently impossible to draw generalizable conclusions from individual research or to apply the findings from individual studies to evaluate TSP in other places. Various simulation studies have revealed that the outcomes differ greatly from one study to the next.

Stage 5: BRT and feeder routes are still being built and tested, therefore it's impossible to assess the impact of BRT construction in terms of exact number of passengers who will use the routes.

Stage 6: The passenger demand and size of the study area are constrained by BCLL (Bhopal Smart City) transit data from 2021

5. 1 Traffic Management

Traffic management refers to the strategies, techniques, and systems implemented to effectively control and regulate the flow of traffic on roads, highways, and other transportation networks. The primary goal of traffic management is to ensure the safe and efficient movement of vehicles, pedestrians, and other road users while minimizing congestion, delays, accidents, and environmental impacts.
Traffic management involves various components and measures, including:
Traffic Monitoring: The collection and analysis of traffic data using technologies such as sensors, cameras, and vehicle detection systems. This data helps in understanding traffic patterns, volume, and flow characteristics.

Traffic Control: The use of traffic control devices such as traffic lights, signals, signs, and road markings to guide and regulate the movement of vehicles at intersections, junctions, and other critical points. Intelligent Transportation Systems (ITS) are often used for adaptive and dynamic control based on real-time traffic conditions.

Traffic Signal Timing: Optimizing the timing of traffic signals to ensure smooth traffic flow, minimize congestion, and reduce waiting times for vehicles at intersections. This involves considering factors such as traffic volume, peak hours, pedestrian movement, and traffic patterns.

Traffic Incident Management: Responding to and managing traffic incidents, accidents, and emergencies to ensure the safety of road users and minimize disruptions to traffic flow. This includes rapid incident detection, timely response, and effective coordination with emergency services.

Traffic Planning and Engineering: Designing and planning transportation infrastructure, including roads, highways, and intersections, to accommodate current and future traffic needs. This includes considerations for capacity, safety, pedestrian facilities, and sustainable transportation options.

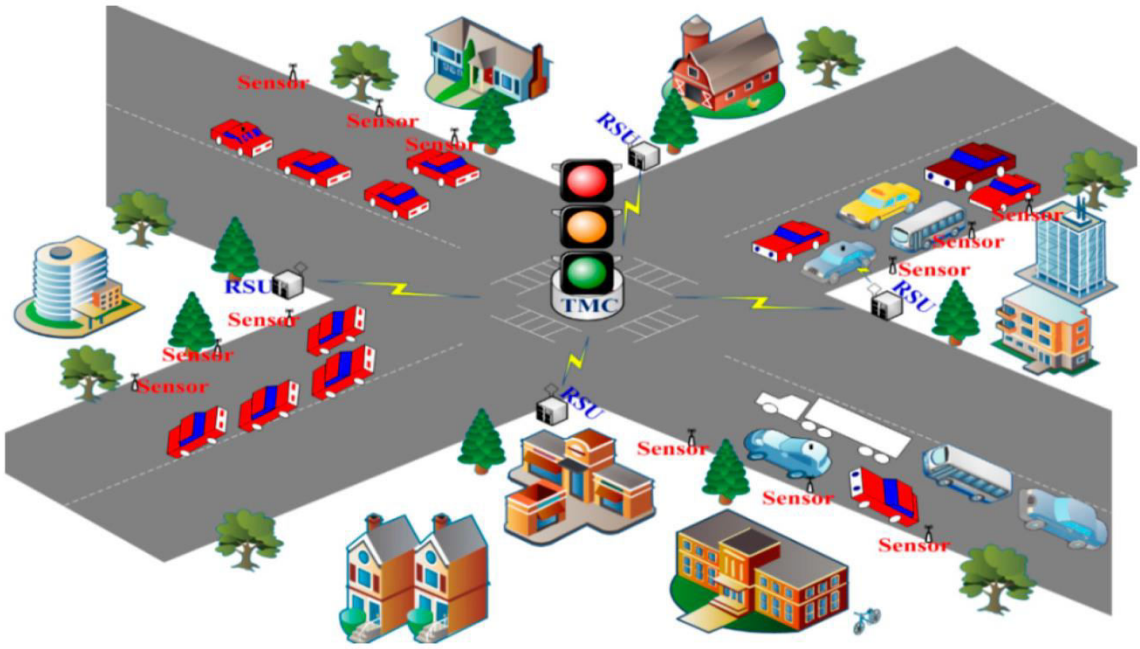

Figure 5: 1 Traffic arrangement and sensor

Public Transportation Management: Coordinating and optimizing public transportation systems, such as buses, trains, and metros, to improve efficiency, reliability, and accessibility. This involves route planning, scheduling, fare collection, and integration with other modes of transport.

Intelligent Transportation Systems (ITS): Utilizing advanced technologies, such as real-time traffic information, GPS navigation, smart parking systems, and traveler information services, to enhance traffic management, provide real-time updates to users, and optimize transportation networks.

Effective traffic management plays a crucial role in reducing congestion, improving road safety, enhancing transportation efficiency, and promoting sustainable mobility. It requires a combination of infrastructure planning, technological advancements, policy frameworks, and public awareness to create a safe and efficient transportation system for both urban and rural areas.

5. 2 Public Transportation

Public transport, usually referred to as mass transit, includes any forms of shared travel that are open to the general public. Buses, trains, trams, and ferries are examples of modes that connect different locations within cities or regions along fixed routes and schedules. It has numerous benefits:

1. it improves accessibility by providing access to employment, school, shopping, healthcare, and leisure activities for persons without private vehicles.
2. it is economical. The cost of a fare is often less than the cost of owning a car, which includes gas, parking, insurance, and maintenance.
3. Through promoting the use of shared mobility, public transit benefits the environment by easing traffic congestion and lowering greenhouse gas emissions.
4. It's provides effectiveness and time savings, frequently with designated lanes and dependable schedules, enabling travellers to make the most of journey time.
5. It promotes social fairness by giving low-income people, the elderly, and people with disabilities mobility choices, assuring equal access to crucial services. Thus, public transit continues to be a viable, reasonably priced, and inclusive option for urban mobility.

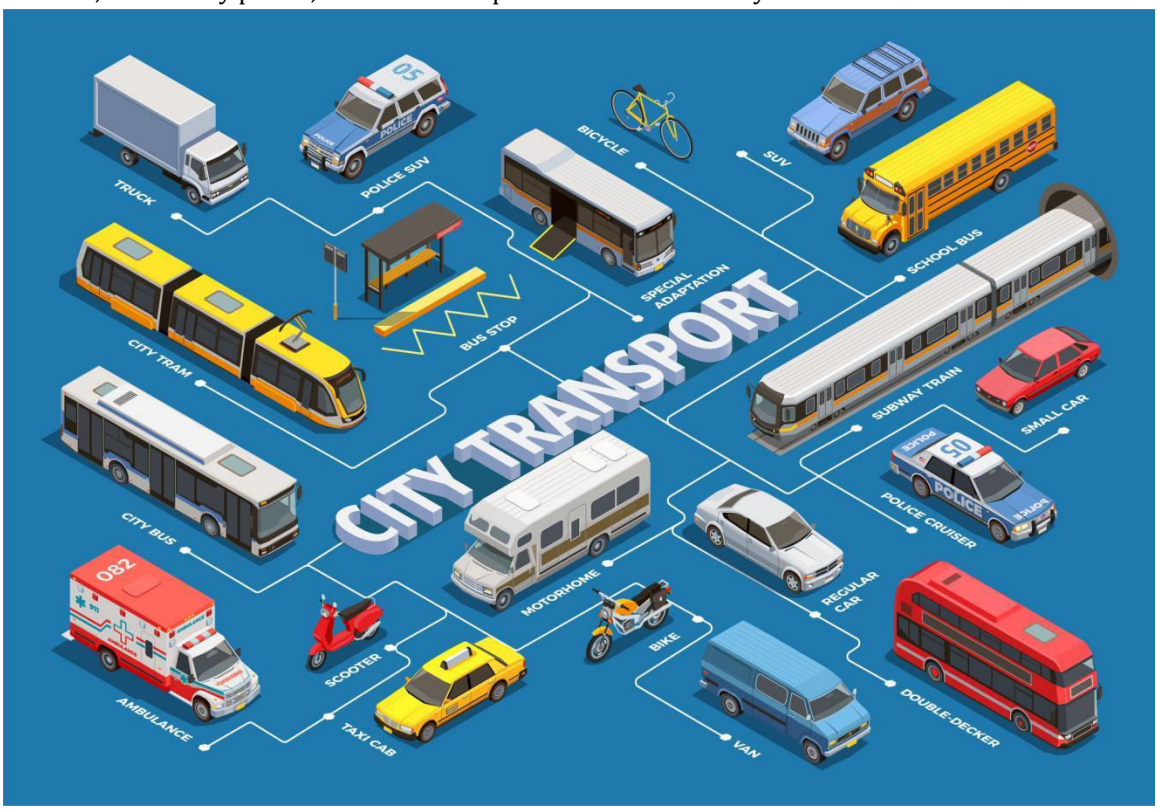

Figure 5: 2 Public transport option in urban

Public transportation networks are typically managed and operated by government authorities or transportation agencies, which oversee route planning, scheduling, fare collection, maintenance, and overall management of the system. They play a critical role in ensuring the efficiency, safety, and quality of public transportation services.

5. 3 Intelligent Transportation System

Intelligent Transportation Systems (ITS) improve transportation networks by utilising cutting-edge technologies and data systems. ITS strives to enhance safety, decrease congestion, better manage traffic, and provide better traveller information. It includes elements like real-time traffic control systems, allowing for dynamic changes in traffic flow. Cooperative driving is improved through vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication. Intelligent travel decisions can be made with the help of advanced traveller information systems. With intelligent ticketing, real-time passenger data, and incident management systems that quickly identify and address traffic incidents, ITS also enhances public transportation. ITS integrates technology, data, and communication across many modes of transportation to optimise mobility overall.

Figure 5: 3 Intelligent Transportation System

Environmental Monitoring and Sustainability: ITS supports environmental monitoring and sustainability efforts by collecting data on air quality, noise levels, and other environmental parameters. This data can be used to implement measures for reducing emissions, optimizing traffic flow to minimize fuel consumption, and promoting sustainable transportation options.

The Bhopal City bus traffic volume from the collected data is selected and presented in the following tables.

Table 1. Detail of Route wise City Buses of Ridership of 12 days.

Route No.	01-Apr-23	02-Apr-23	03-Apr-23	04-Apr-23	05-Apr-23	06-Apr-23	07-Apr-23	08-Apr-23	09-Apr-23	10-Apr-23	11-Apr-23	12-Apr-23	Total Ridership
303	6853	6629	7156	7343	6870	4188	7532	3539	7659	7178	7656	6177	**78780**
304	5446	5769	6122	6003	5958	5063	6317	4180	5553	6665	6121	5236	**68433**
306	7418	8195	8284	7744	8147	6174	8573	5600	8314	8975	9071	8910	**95405**
307	5948	6865	7294	6981	6887	5390	7467	2354	7468	7690	7425	7287	**79056**
309	6866	7507	7091	6874	6575	4854	6480	884	6796	6427	7226	7218	**74798**
311	4584	5504	5673	5453	5294	3522	5162	3136	5661	5850	5990	5277	**61106**
SR2	9582	11009	12012	12153	11434	7692	12640	7201	12304	12806	12713	11342	**132888**
SR4	13785	14301	14893	14394	13713	12938	15519	6975	16484	16278	16294	14504	**170078**
SR5	14870	15335	14679	14762	15864	11947	15739	11199	16113	16636	16381	14155	**177680**
SR8	14492	16524	16970	16335	16708	11891	18478	10093	17180	18415	18527	16157	**191770**
TR1	14603	15917	15600	15166	14983	11299	15661	9521	15585	14581	13990	13128	**170034**
TR4A	1631	1579	1764	1811	1782	1152	1869	1510	1932	2106	2195	1617	**20948**
TR4AC	5894	6309	6881	6587	6608	4432	6679	4848	6845	7465	7269	5825	**75642**
TR4B	17603	18971	19802	18879	19980	16134	19982	12048	19982	19576	18354	19297	**220608**
RIDERSHIP	**129575**	**140414**	**144221**	**140485**	**140803**	**106676**	**148098**	**83088**	**147876**	**150648**	**149212**	**136130**	**1617226**

Table 2. Detail of Passenger type wise Ridership

Date	Day	CARD	CASH	SUBSIDY PASS	PREPAID	TOTAL PASSENGER
1-Apr	Sat	33088	92129	2777	1581	129575
2-Apr	Sun	18198	118876	2167	1173	140414
3-Apr	Mon	38998	100030	3340	1853	144221
4-Apr	Tue	41646	93547	3397	1895	140485
5-Apr	Wed	42228	93307	3334	1934	140803
6-Apr	Thu	40822	60701	3394	1759	106676
7-Apr	Fri	39949	103284	3169	1696	148098

8-Apr	Sat	36825	41532	3151	1580	83088
9-Apr	Sun	18825	123788	2282	1025	153920
10-Apr	Sat	36615	108589	3721	1723	150648
11-Apr	Sun	17117	128467	2562	1066	149212
12-Apr	Mon	36071	94689	3682	1688	136130
Total		**400382**	**1146939**	**36976**	**18973**	**16172266**

Table 3. Detail of Major Stop Wise Ridership

Stop Name	01-Apr-23	02-Apr-23	03-Apr-23	04-Apr-23	05-Apr-23	06-Apr-23	07-Apr-23	08-Apr-23	09-Apr-23	10-Apr-23	11-Apr-23	12-Apr-23	Total
Kamla Park	78	102	105	99	93	111	73	102	98	108	113	98	**1180**
Polytechnic Square	201	208	232	178	290	166	189	188	153	170	197	247	**2419**
Rangmahal	5390	5577	5683	5416	4382	5468	5811	4709	5361	5433	5599	4285	**63114**
New market	2250	2348	2263	2209	2103	2204	2511	2128	2280	2260	2240	1962	**26758**
Congress bhawan	261	145	128	130	164	233	153	181	208	109	144	175	**2031**
1250 hospital	742	828	806	816	753	659	472	788	778	736	660	763	**8801**
Chinar Park	266	184	243	239	246	197	146	201	225	169	205	240	**2561**
Vyapam	39	46	31	32	89	31	60	38	50	45	40	40	**541**
Board office	12595	13053	12763	12324	8127	13102	12981	12075	13026	12669	12924	8279	**143918**
MP Nagar Zone1	1618	1514	1859	1529	1366	1647	1445	1591	1184	1619	1768	1303	**18443**
Total Ridership	23440	**24005**	**24113**	**22972**	**17613**	**23818**	**23841**	**22001**	**23363**	**23318**	**23890**	**17392**	**269766**

6. Traffic Data Analysis

The traffic count was done for three major routes which are connected and form a circular network which is interconnected by various local streets at multiple locations. The three routes for which the data was collected are as follows:

i. TR1 (Chirayu Hospital to AakritiEcoCity)
ii. SR5 (Chirayu Hospital to Awadhpuri)
iii. TR4A (Chirayu to CRPF Bagh-Sewaniya)

Data Analysis for TR1 (Chirayu Hospital to Aakriti Eco City)

The TR1 route, spanning from Chirayu Hospital to AakritiEcoCity, experiences substantial traffic congestion

due to numerous shops lining both sides of the road and the presence of a BRT Corridor. Notably, the busiest sections are between Bairagarh and Kohefiza, as well as Kamla Park to Polytechnique Square.

Traffic data was meticulously analyzed, converted into traffic volume using standard passenger metrics. Findings reveal that the highest traffic volume reaches 2886 during 8 AM to 11 PM, encompassing both traffic directions from Bairagarh to MP Nagar. Conversely, from 12 PM to 8 PM, the traffic direction from MP Nagar to Chirayu Hospital sees the peak volume, reaching 3904.5. These insights are crucial for traffic management and infrastructure planning in this corridor.

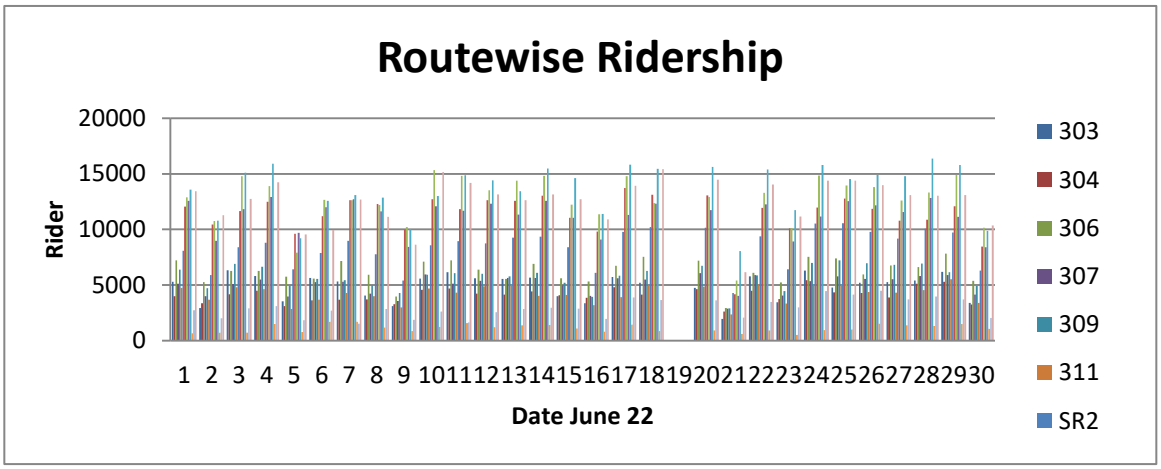

Figure 3: Traffic Volume of Chirayu to MP Nagar

The data analysis also reveals notable variations in traffic flow between the routes of Tilak MP Nagar to BairagarhChauraha and MP Nagar to BairagarhChauraha. A comparatively lesser volume is indicated by the average flow from BairagarhChauraha to Tilak MP Nagar, which is 2445.9. The average volume of the flow from MP Nagar to BairagarhChauraha, in comparison, is higher at 1736.7. This striking contrast implies that there is in fact a higher volume of traffic travelling from MP Nagar to BairagarhChauraha, emphasising the necessity for targeted traffic management strategies to address this directional mismatch.

Data Analysis for Ticket Category

The analysis of ticket category data shows distinct patterns in passenger payment methods. On average, 85,719 passengers opt for cash payments daily, indicating a prevalent use of traditional payment methods. Meanwhile, 3,245 passengers utilize digital passes, suggesting a growing trend in adopting cashless transactions. Additionally, 36,546 passengers benefit from subsidy passes, reflecting an important segment of the commuting population with financial assistance. A smaller group of 1,357 passengers relies on cash cards for their daily journeys. This data underscores the diverse preferences of passengers and highlights the need for flexible payment options and targeted strategies to cater to various passenger categorieeffectively.

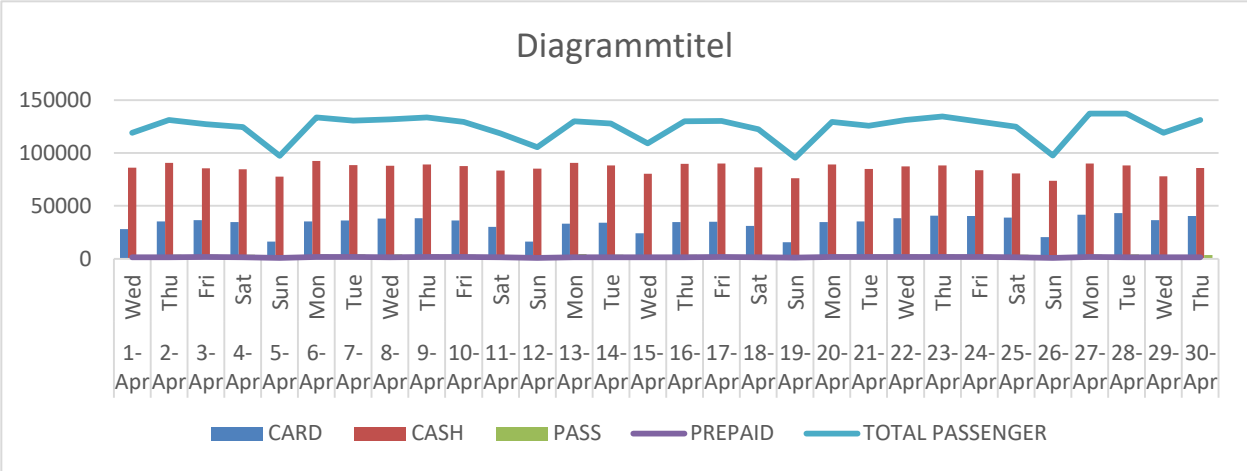

Figure 5: Ticket Category Vice Versa

The analysis suggests that transitioning from cash to digital ticketing can potentially lead to increased traffic volume and ridership. On average, there are 85,719 passengers using cash for ticketing, indicating a significant reliance on traditional payment methods. In contrast, only 3,245 passengers utilize digital passes.

To increase ridership and traffic volume, promoting digital ticketing options and encouraging passengers to shift away from cash payments should be a priority. Digital ticketing can offer convenience, efficiency, and often cost savings, making it an attractive choice for commuters. Implementing strategies to incentivize and educate passengers about digital ticketing could contribute to higher ridership and a smoother ticketing process.

6. Conclusions

In summary, the data analysis provides helpful information for enhancing the transportation system:

Traffic Direction: The necessity for focused traffic management solutions is highlighted by the fact that traffic flow from MP Nagar to BairagarhChauraha is substantially higher than in the opposite direction.

Ticketing Techniques: Given the predominance of cash payments, encouraging the implementation of digital ticketing is essential. This change may improve convenience and maybe boost ridership.

These findings imply that targeted changes to traffic control and ticketing procedures can boost productivity and improve commuters' experiences on the TR1 route between Chirayu Hospital and AakritiEcoCity.

Following are the Recommendations:

Here are some suggestions for controlling traffic in Bhopal Smart City and the surrounding area, broken down into points: As Bhopal city is a rapidly growing city so is its traffic. The high traffic creates heavy traffic congestion and massive traffic conflict.

1. **Traffic Flow Control:**
   I. To locate bottlenecks and hotspots of traffic congestion throughout Bhopal and its surrounding metropolitan areas, conduct a thorough investigation of traffic flow.
   II. To improve traffic flow, use intelligent traffic management technologies, such as adaptive traffic lights and real-time traffic monitoring.
   III. To shorten commute times and encourage more people to take buses, think about implementing dedicated bus lanes or priority lanes for public transportation.The conversion to One Way will lead to not only increasing traffic capacity but also various benefits like following,

2. **Promotion for digital tickets:**
   I. In order to decrease cash transactions and improve passenger convenience, promote digital ticketing choices for public transport services, including buses and metro.
   II. Create easy-to-use web and mobile interfaces for booking tickets and getting travel information.
   III. Encourage the move away from paper tickets or cash payments by introducing loyalty programmes or discounts for travellers who frequently use digital ticketing.formation with a mash like interconnecting road system.

3. **Data Monitoring and Analysis:**
   I. Create a centralised data monitoring system to gather and analyse real-time traffic, traveller, and ticketing data.
   II. Make informed decisions about route optimisation, traffic control tactics, and service enhancements using data analytics.
   III. To ensure efficiency and responsiveness, evaluate the effects of adopted measures frequently and alter methods as necessary.

4. **Expanding Bus Service:**
   I. Expand the bus service network to cover underserved or densely populated areas within Bhopal and its metropolitan region.
   II. Introduce more frequent and reliable bus services during peak hours to attract more passengers and reduce car usage.
   III. Consider eco-friendly and electric buses to align with sustainability goals.
   IV. In Bhopal and the surrounding metropolitan area, extend the bus service network to include underserved or highly populated areas.

5. **Integrated Transportation Planning:**
   I. Collaborate with urban planners and stakeholders to integrate transportation systems, such as buses and the metro, seamlessly into the city's overall infrastructure.
   II. Ensure convenient intermodal connectivity between different modes of transportation, allowing passengers to switch easily between buses and metro services.
   III. Prioritize pedestrian-friendly infrastructure and last-mile connectivity options to enhance the overall transit experience.

By putting these suggestions into practise, Bhopal may strengthen public transport offerings, better manage traffic, and encourage a move towards more practical and sustainable commuting options within the city and its surrounding area.

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