An Assessment of Traffic Congestion and Parking Problems in Kolhapur City Using Network Analysis

Sunita Kadam[1], Dr. P. T. Patil[2], Bhagyashri Kalbhor[3]

Abstract

Due to the nation's fast urbanisation and increasing reliance on private vehicles, parking problems and traffic congestion have gotten worse in Indian cities. Mobility problems are becoming more common in medium-sized cities like Kolhapur, just like in urban areas. Mixed traffic, restricted road capacity, and unlawful on-street parking have all significantly reduced travel efficiency. This study assesses the parking issues and traffic congestion in Kolhapur City using network analysis and the Passenger Car Unit (PCU) technique. Primary traffic volume data were obtained from field surveys conducted during peak hours in key functional zones, including commercial, industrial, educational, religious, and tourist sectors. Secondary data came from publications, city reports, and census data. The data reveals that business and tourism routes have the highest levels of congestion because of roadside parking, two-wheeler dominance, and junction bottlenecks. PCU-based evaluation is used to identify critical routes that are prone to congestion, such as Javlacha Ganpati to D-Mart and Janata Bazar to Ganesh Mandir. To improve urban mobility, the paper highlights how urgently Kolhapur City requires integrated parking and traffic management strategies.

Keywords: *PCU, urban transportation, traffic congestion, parking issues, network analysis, Kolhapur City*

Introduction

Rising population, motorisation, and unplanned urban expansion put increasing strain on urban transportation networks in quickly expanding cities. Inadequate parking spaces and traffic congestion have become major issues that impact economic productivity, environmental sustainability, and mobility. In developing countries like India, the number of private cars has grown much faster than the number of roads. This has led to frequent traffic jams and poor use of city road networks (Pucher et al., 2005; World Bank, 2017).

Similar transportation issues are plaguing Kolhapur, a well-known tier-II city in Maharashtra. Over the past ten years, the city—which is well-known for its commercial significance and cultural legacy—has seen a consistent rise in the number of cars on the road. However, the road network, comprising high-density commercial zones, mixed land use, and narrow streets, has failed to keep pace with this expansion. Because of this, major thoroughfares like Mahadwar Road, Rajarampuri, and Shahupuri often have extremely heavy traffic, particularly during rush hours (Government of Maharashtra, 2020).

Network efficiency and structure, along with traffic volume, influence urban traffic congestion. Conventional methods of traffic analysis frequently overlook the intricacy of metropolitan road systems. In this regard, network analysis, which is based on graph theory, offers a strong framework for assessing connectivity, locating crucial nodes, and comprehending traffic flow patterns. Using tools like ArcGIS and QGIS (Porta et al., 2006), researchers can model road networks and evaluate congestion hotspots using measures like centrality and accessibility.

In cities like Kolhapur, where on-street parking predominates due to a lack of regulated parking infrastructure, parking issues exacerbate traffic congestion. Improper parking practices increase travel delays, disrupt traffic flow, and decrease effective road width. According to studies, cars looking for parking spots contribute significantly to urban traffic congestion (Shoup, 2006). The mismatch between parking supply and demand in commercial locations results in inefficient land use and unlawful parking, which exacerbates traffic.

Given these difficulties, an integrated evaluation of parking problems and traffic congestion utilising cutting-edge analytical methods is required. Through network analysis, this study seeks to assess Kolhapur city's parking and traffic conditions, finding high-demand areas and crucial bottlenecks. To improve overall urban mobility and sustainability, the results are anticipated to assist policymakers and urban planners in creating efficient parking and traffic management plans.

In an attempt to bridge this gap, this study investigates parking problems and traffic congestion in Kolhapur City using PCU-based network analysis. The study's objectives are to identify congestion hotspots and provide planning-based solutions suitable for medium-sized Indian cities.

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Review of Literature

To ensure accessibility and promote economic growth, urban transportation is essential. However, metropolitan road networks are under tremendous strain due to rising motorisation and fast urbanisation. The main reasons for congestion, according to earlier research, are vehicle increase, insufficient road capacity, and ineffective traffic management.

Roadside parking, mixed traffic situations, and a lack of lane discipline all contribute to congestion, according to research done in emerging nations. By combining several vehicle types into a single unit, the Passenger Car Unit (PCU) technique has been widely utilised to analyse heterogeneous traffic. Research has shown that PCU-based analysis is useful for determining the degree of traffic on urban highways.

Geographic Information Systems (GIS)-based network analysis has also become more popular recently. It assists in determining routes that are prone to traffic, evaluating connectivity, and recommending detours. Nonetheless, the majority of current research concentrates on large cities, with comparatively few studies examining medium-sized cities, especially those with religious and touristic significance. By using PCU (Passenger Car Unit) and network analysis approaches in Kolhapur City, this study adds to the body of literature.

Study Area

Kolhapur City is situated in southwest Maharashtra between latitudes 16°42′ N and longitudes 74°14′ N. Situated on the banks of the Panchganga River, the city spans around 66.82 square kilometres. As of the 2011 Census, Kolhapur had 549,236 residents.

The city functions as a regional hub for commerce, tourism, education, business, and religious activities. Important locations including the Mahalaxmi Temple, Rankala Lake, industrial districts, and educational institutions generate a lot of daily traffic. The inner-city road network is especially susceptible to traffic bottlenecks because of its small streets, diverse land use, and lack of parking spots.

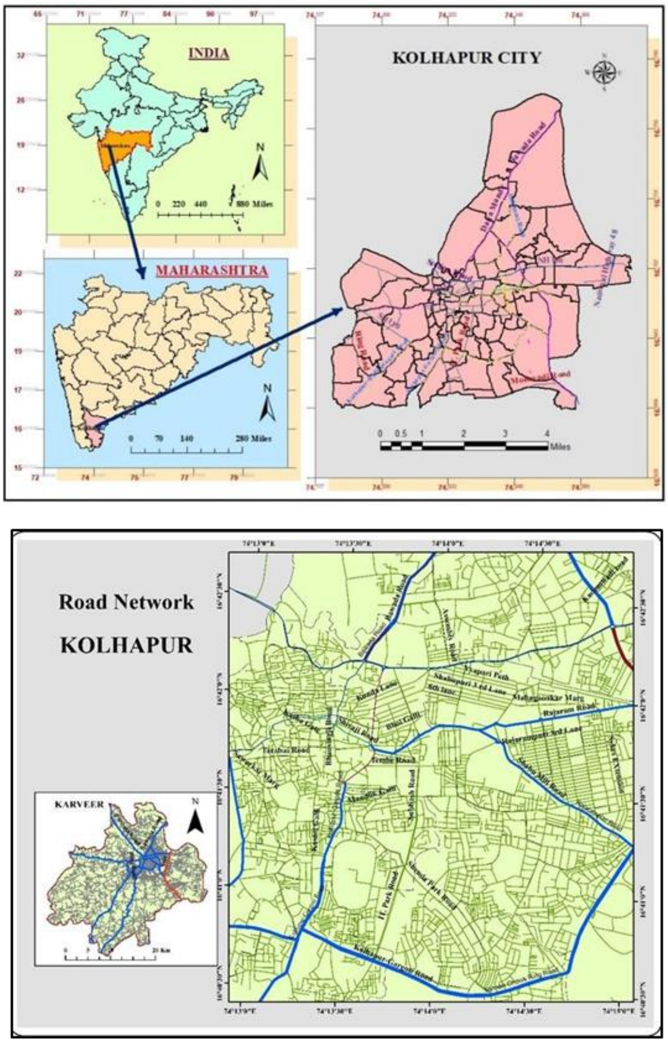

Fig.1 Location Map

Objectives

1. To examine Kolhapur City's traffic congestion levels and their spatial distribution.
2. To pinpoint areas with parking issues and routes that are prone to congestion.
3. To use Passenger Car Unit (PCU) analysis to evaluate traffic flow.

Data and Methodology

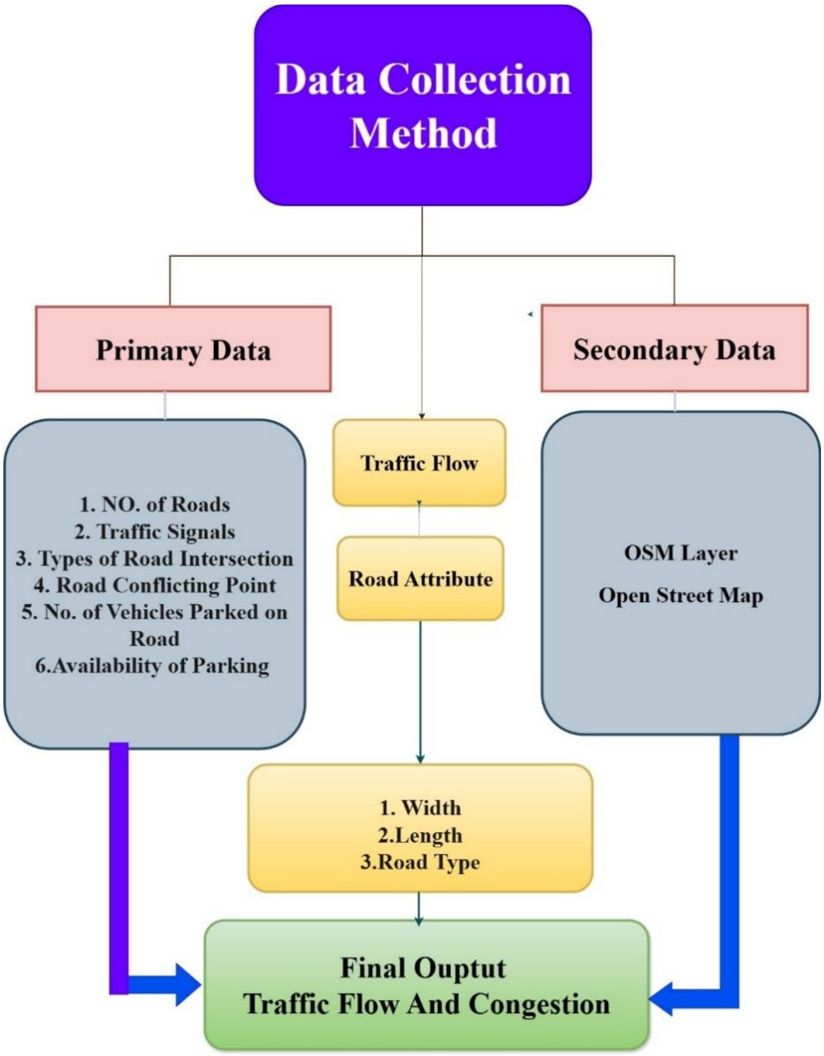

Fig.2 Methodology Chart

The study is based on both primary and secondary data.

1. **Primary Data**

On specific road segments that represent commercial, industrial, educational, religious, and tourist zones, traffic volume surveys were carried out. During morning and evening peak hours, manual vehicle counts were conducted using time intervals of 10 a.m. to 11 a.m. and 5 p.m. to 6 p.m. Two-wheelers, three-wheelers, cars, and heavy trucks were the different categories of vehicles. Parked cars by the side of the road were also noted.

2. **Secondary Information**

Secondary data was gathered from published research articles, Kolhapur Municipal Corporation reports, traffic department records, and Census of India publications.

Table 1. PCU values for different conditions

Sr. No.	Category of Vehicle	Equivalent PCU Factors Percentage Composition of Different Vehicles	
		5%	10% and above
1	Two-wheeler, Motorcycle or Scooter	0.5	0.75
2	Passenger car, Pick up van	1	1
3	Auto Rickshaws	1.2	2
4	Light commercial vehicle	1.4	2
5	Truck or bus	2.2	3.7
6	Agricultural tractor trailer	4	5
7	Cycle	0.4	0.5
8	Cycle Rickshaw	1.5	2
9	Horse drawn Vehicle	1.5	2
10	Hand Cart	2	3

(Source: IRC Guidelines.)

3. Analytical Methods

Using IRC standards, traffic volume is converted into PCU values.

Identifying regions of congestion through network analysis.

Routes are ranked according to traffic volume, PCU values, road width, parking intensity, and junction circumstances.

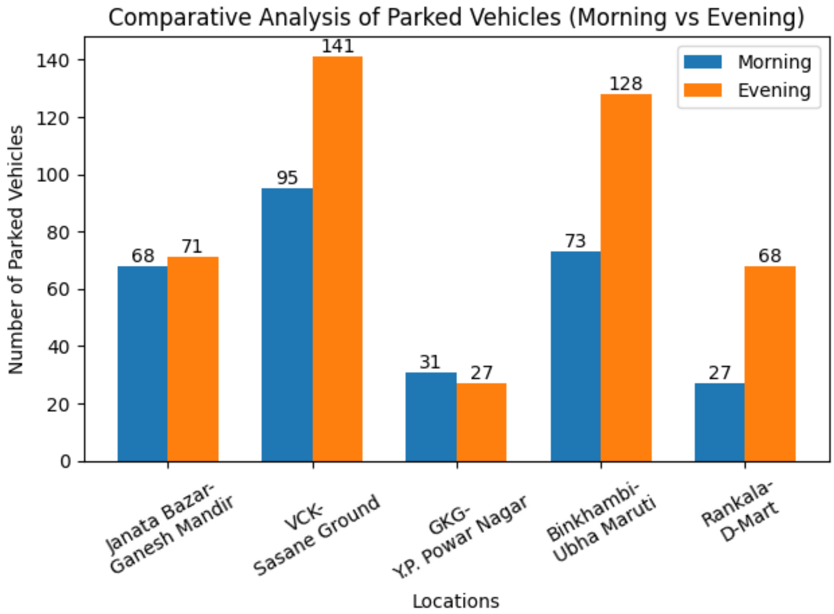

Fig. 3. Shiftwise Comaparatative Analysis of Parked Vehicals of Kolhapur City.

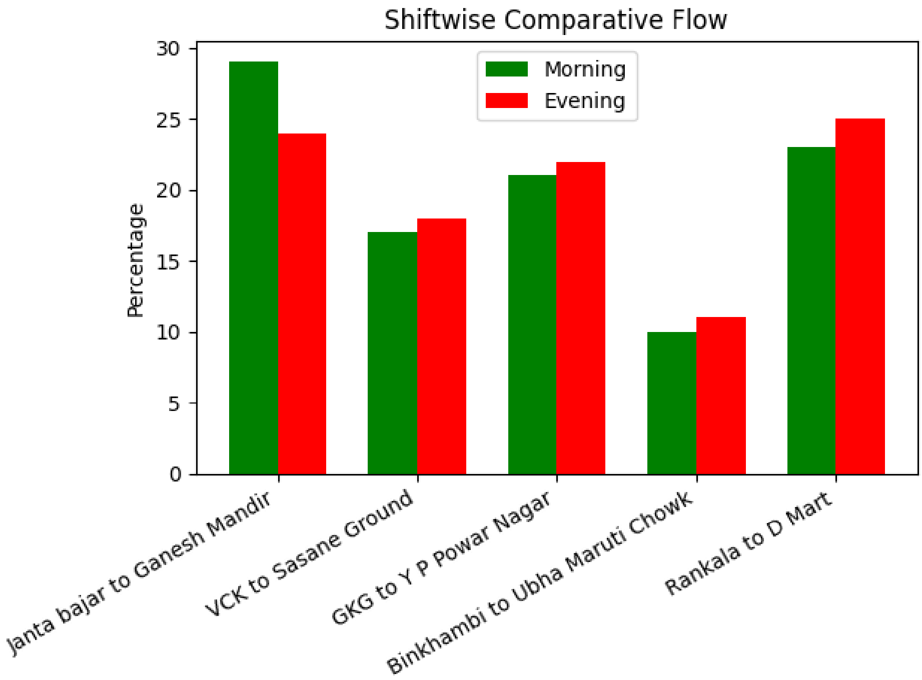

Fig. 4. Shift wise Comparative PCU Flow of Kolhapur City.

In Kolhapur, there is a notable rise in parking intensity in the evening at the majority of locations, according to a comparison of parked cars between morning and evening shifts. There is a noticeable increase in parked cars on routes like VCK to Sasane Ground and Binkhambi to Ubha Maruti Chowk, which suggests that there are more business and leisure activities in the evening. The effective road width is directly decreased by this increase in on-street parking, which also increases traffic during nighttime peak hours. The results emphasise the necessity of efficient parking management techniques to enhance overall traffic flow, especially in high-demand areas.

Table.2. Zonwise Ranking of All Parameters

Road Locations	Total Vehicle Flow	Rank	Parked Vehicles	Rank	PUC	Rank	Road Width (Average in mt.)	Rank	Divider	Rank	Rank Total
Janta Bazar to Ganesh Mandir	5283	5	68	3	5412	5	8.54	5	0	5	23
VCK to Sasane Ground	3403	3	95	5	3231	2	8.24	4	0	5	19
GKG to Y P Powar Nagar	3229	2	31	2	3953	3	11.2	3	0	5	15
Binkha mbi to Ubha Maruti Chowk	2219	1	73	4	1900	1	11.41	2	1	2	11
J. Ganpati to D-Mart	4777	4	27	1	4239	4	12.34	1	1	1	12

Source: Based on field survey

Analysis and Discussion

The current study integrates network-based spatial evaluation with Passenger Car Unit (PCU) analysis to provide a thorough assessment of parking conditions and traffic congestion in Kolhapur. The findings demonstrate how a variety of factors, including traffic volume, heterogeneous vehicle composition, land use features, road infrastructure, and parking behaviour, influence the city's congestion patterns. The results show that rather than being evenly spread throughout the metropolitan landscape, congestion is extremely localised and concentrated in particular corridors and nodes.

1. **PCU-Based Traffic Flow Features**

The true load applied to the road network is shown by converting traffic volume into PCU values. The findings show that although two-wheelers make up the majority of all vehicles on all assessed routes, their combined effect greatly increases traffic. Particularly in mixed traffic situations, their agile movement, frequent passing, and lax lane compliance cause traffic flow turbulence.

The Janata Bazar to Ganesh Mandir route has the highest PCU values of any corridor evaluated, indicating severe traffic demand. With constant retail activity, pedestrian traffic, and frequent roadside encroachments, this route serves as a significant commercial spine. Low travel speeds and lengthy waits are caused by the effective roadway width being further reduced by the existence of unofficial vendors and loading and unloading operations.

In a similar vein, despite having comparatively higher road width and partial lane dividers, the Javlacha Ganpati to D-Mart corridor shows high levels of congestion. The concentration of businesses and shopping malls near D-Mart leads to strong traffic demand and parking strain. Intermittent traffic flow results from several conflict spots created by frequent vehicle entry and exit as well as pedestrian crossings.

Due to both the lack of median separation and parked cars, the VCK to Sasane Ground route exhibits moderate to severe congestion. The excessive number of parked cars drastically restricts effective road space, even if traffic volume is lower than on main commercial corridors. The Binkhambi to Ubha Maruti Chowk route, on the other hand, shows comparatively smoother traffic flow because of better road width and the existence of dividers, underscoring the significance of infrastructure design in controlling congestion.

2. **Traffic Congestion Analysis by Zone**

➢ Business **Zones (Janata Bazar, Ganesh Mandir, Shahupuri):**

Because of their high pedestrian volume, uncontrolled parking, and extensive business activity, these areas have the worst traffic. Widespread on-street parking results from the lack of defined parking places, which decreases the effective carriageway width. These intersections have lengthy wait times and lower average speeds, making them crucial bottlenecks. Tourist and Religious Zones (Mahalaxmi Temple Area): Traffic congestion around major religious sites varies but is particularly severe on weekends, during festivals, and during the busiest times of day. These areas are identified as high centrality nodes by the network analysis, highlighting their significance and susceptibility in the urban transportation system.

➢ Peripheral **and Industrial Zones (VCK to Sasane Ground, Y. P. Powar Nagar): There is a moderate amount of traffic in these areas: even** though there is less traffic than in commercial zones, the presence of heavy vehicles impacts traffic flow and raises PCU values. Poor lane discipline and roads without dividers exacerbate the problem.

➢ Residential **and Educational Zones:** Except during busy times like school and business hours, these zones show comparatively less traffic. Due to pick-up and drop-off operations, which result in localised bottlenecks, temporary congestion is seen close to educational institutions.

3. **Parking's Effect On-Street**

One of the study's most important conclusions is that on-street parking significantly contributes to traffic congestion. Field observations indicate that parked vehicles, especially cars and two-wheelers, take up a significant amount of road space in commercial districts. In some areas, such behaviour results in a 20–40% reduction in the effective width of roadways, which has an immediate effect on traffic capacity.

There are a lot of parked cars on routes like Janata Bazar to Ganesh Mandir and VCK to Sasane Ground, which is closely correlated with higher levels of traffic. Drivers are forced to park along roadsides due to the absence of defined parking zones, which causes friction and disrupts traffic flow. This result is consistent with other research showing how parking search behaviour contributes to urban congestion (Shoup, 2006)

4. **The Function of Network Features and Road Infrastructure**

According to the network analysis, traffic flow efficiency is significantly influenced by road infrastructure. Despite heavy traffic, roads with dividers and improved geometric design, such as Javlacha Ganpati to D-Mart, show comparatively smoother traffic flow. On the other hand, routes with low widths and no dividers, like the corridors in Janata Bazar, are more likely to get congested.

Congestion levels are also greatly influenced by junction density and intersection design. Inadequate signal timing, a lack of channelisation, and competing traffic movements all contribute to the high levels of congestion seen at key crossings. The network's overall performance is impacted by delays that spread across connected lines at these junctions, which serve as crucial nodes.

5. **Temporal Changes in Traffic Movement**

The study finds distinct temporal differences in patterns of traffic congestion. While evening peak hours (5:00 PM–6:00 PM) are more congested because of shopping, leisure, and return travels, morning peak hours (10:00 AM–11:00 AM) are mostly impacted by institutional and work-related travel. Due to increasing roadside activity and parking demand, the evening peak is typically more severe, especially in commercial and tourist zones.

Finding Critical Routes

- The study determines the following crucial routes based on the combined ranking of traffic volume, PCU (Passenger Car Unit) values, parking intensity, and road characteristics:
- Routes that are extremely congested: Janata Bazar to Ganesh Mandir and Javlacha Ganpati to D-Mart
- Routes from VCK to Sasane Ground and GKG to Y. P. Powar Nagar are moderately congested; routes from Binkhambi to Ubha Maruti Chowk are comparatively less congested. Priority locations for intervention are represented by these pathways. They are extremely susceptible to traffic breakdown because of high PCU values, poor parking management, and inadequate infrastructure.
- The last option route is determined to be GKG to Y. P. Powar Nagar. For the passage of two-wheeler traffic, this route is more practical. The alternate route is 677 meters long overall. This route is appropriate for minor traffic diversion due to its 5.8-metre road width.

Conclusion

According to the study's findings, parking issues and traffic congestion have grown to be significant obstacles to Kolhapur's effective urban mobility. A strong framework for comprehending the functional and spatial aspects of congestion in a medium-sized Indian metropolis is provided by the combined application of PCU analysis and network analysis. The findings show that traffic is mostly concentrated in business and religious areas, where heavy traffic, busy roadside activities, and insufficient parking spaces combine to produce serious bottlenecks.

The most crowded passageways, such as Janata Bazar to Ganesh Mandir and Javlacha Ganpati to D-Mart, need urgent planning attention. The study also shows that on-street parking contributes significantly to traffic jams and drastically lowers road capacity. Traffic flow dynamics are further complicated by the predominance of two-wheelers and the existence of mixed traffic situations, underscoring the shortcomings of traditional traffic management techniques. Network study shows that the structural features of the road network, especially at intersections and high-activity nodes, are directly related to congestion.

Kolhapur's traffic situation is expected to worsen due to growing urbanisation and motorisation if present trends continue. As a result, coordinated and sustainable transport planning methods are desperately needed. The creation of off-street parking spaces, stringent on-street parking regulations, better junction design, and encouragement of public and non-motorised transportation are important initiatives.

This study concludes by highlighting the need for a comprehensive strategy that incorporates advanced analytical tools like network analysis, regulatory interventions, and infrastructure development in order to effectively control traffic congestion in medium-sized cities like Kolhapur. For urban planners and legislators looking to increase mobility, lessen traffic, and improve the general quality of urban life, the research's conclusions offer insightful information.

Recommendations

- To control automobile demand, specific parking spaces should be built close to businesses along the Javlacha Ganpati D-Mart corridor. Heavy trucks should be prohibited during peak hours, and entry and departure routes should be controlled.
- Time-based parking and other regulated on-street parking systems should be implemented for the VCK to Sasane Ground route. To enhance traffic discipline, appropriate lane markings and traffic signage are necessary.
- This corridor should be constructed as an alternate route for the GKG to Y. P. Powar Nagar route in order to redirect traffic from crowded neighbourhoods. It is necessary to install directional signage and improve the road surface.
- For efficient traffic flow, the current road infrastructure and divider systems at Binkhambi-Ubha Maruti Chowk should be preserved. To prevent congestion in the future, traffic enforcement and monitoring should be improved.
- Peripheral parking facilities should be built in the Mahalaxmi Temple area to ease traffic close to the temple. During busy times and during festivals, only pedestrians should be allowed to move.
- Organised parking spots should be built away from the main road in the Rankala Lake region. On weekends and during evening peak hours, traffic regulations should be implemented.
- The architecture of Kolhapur's important intersections should be enhanced by appropriate channelisation and signal timing. To lessen bottlenecks, encroachments close to crossings should be removed.

- The route via Shahaji Law College and B. T. College is advised for traffic diversion in the Janata Bazar–Ganapati Mandir corridor. This road, which is 530 metres long and 8.9 metres wide, can successfully ease traffic on the main commercial stretch.
- An alternate route measuring 988 metres in length and 6.23 metres in width is recommended for the VCK to Sasane Ground corridor in order to spread the traffic load. This approach can assist in reducing traffic on the current road and is appropriate for regulated traffic flow.

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The authors declare that there are no conflicts of interest regarding the publication of this paper.

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