CHAPTER 51

Developing a Framework to Address Challenges in Urban Road Development: A Case Study of Pune City

Tejas Dilip Yelwande[1], Swarup Patil[2], Sujit Patil[2], Omkar Sawant[2] and Nilesh Agarchand Patil[2]

ABSTRACT

This paper identifies that urban road development faces various risks, including poor planning, high cost, bureaucracy, and environmental factors in fast-growing urban cities such as Pune in India. Such pertaining problems have resulted in poor perhaps standards of the roads hence leading to traffic jams, car tracks, encroachment, and insecurity throughout the lives of the people as well as the transport systems throughout the regions. The purpose of this research is to: outline these challenges and propose a framework capturing them so that, improvement strategies can be implemented effectively to improve efficiency and sustainability for urban road projects. In this research data collection encompassed both qualitative data collection tools. Secondary data were collected by conducting paper and electronic literature searches and analyzing published case studies of typical urban road projects in different countries. The primary data collection was through visual data of road concerns in Aundh, Pune. The study identified growth constraints such as Poor condition of roads; Drainage problems; Lack of provision for pedestrians; and Coordination not effective. Therefore, assigning the study a set of objectives will provide a framework comprising infrastructure development, policy and regulatory reforms, increased stakeholder cooperation, implementation of sustainable construction practices, and efficiency of community engagement. This framework is designed to rationalize and facilitate road developmental procedures, integrate environmental concerns, and meet community requirements. Pursuing this line, the study helps enhance the road infrastructure in urban cities, promote economic development, and provide better, secure transportation systems in Pune and other emerging cities.

Keywords: Urban road development; Infrastructure challenges; Sustainable practices; Stakeholder coordination; Pune city.

1.0 Introduction

In areas around Pune, India, where population, number of cars owned, and economic activities are on the rise, there is a greater need for speedy road construction.

[1]*Corresponding author; School of Construction, NICMAR University, Pune, Maharashtra, India (E-mail: P2370761@student.nicmar.ac.in)*
[2]*School of Construction, NICMAR University, Pune, Maharashtra, India*

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The contemporary strategies for urban road development in Pune are hampered by a combination of poorly conceived and executed plans, limited financial resources, bureaucratic impediments, and environmental concerns (Kale, 2023). With the persistence of alarming population increase in the cities, unrelieved population pressure over the already extended trunk and other services has caused traffic jams, accidents, and environmental threats. These challenges are critical to guarantee not only efficient mobility but improvement in the living conditions of inhabitants as well. The road network is the most critical asset of a nation, as it not only supports economic activities but also fortifies the financial stability of any nation. The road network of India is the foundation of its transportation system, facilitating domestic and international trade, connecting rural areas to urban centers, and enabling the mobility of its citizens. India has one of the world's greatest road networks, with a total of over 5.5 million kilometers of roadways, which include expressways, national highways, state highways, district roads, and rural roads (Khanani, 2021).

Road infrastructure is the most critical public resource, as it facilitates the exchange of goods and services between large cities, small communities, and rural areas. In India, economic activities are stimulated by the presence of well-maintained and efficient road infrastructure, which reduces transportation costs, improves access to markets, and enhances regional integration. It is also essential in agriculture, as it facilitates the expeditious and efficient conveyance of agricultural produce from rural areas to urban markets. Furthermore, it enhances the overall quality of life for citizens by providing essential connectivity for social services, including healthcare, education, and emergency services (Matu, 2020).

1.1 Purpose of the study

The purpose of this study is to identify and address the challenges encountered in urban road development, focusing on Pune City's infrastructure issues. Through the analysis of existing road conditions and developmental constraints, this research aims to propose a practical framework that incorporates infrastructure development, policy reforms, stakeholder cooperation, sustainable construction practices, and community engagement. This framework is intended to guide effective improvements in road infrastructure that align with urban sustainability goals, promoting safe, secure, and efficient transportation systems. The study ultimately seeks to contribute to enhanced urban mobility and economic development, offering a model that could be adapted for use in other rapidly growing urban areas facing similar challenges.

1.2 Scope

This study focuses on urban road development in Pune city, India, and aims to examine the challenges faced in the development and maintenance of urban road infrastructure. The scope covers issues related to poor road conditions, inadequate drainage systems, lack of pedestrian provisions, and ineffective coordination among various stakeholders involved in road

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development. By analyzing both primary and secondary data, the study emphasizes the need for a comprehensive framework to address these challenges, specifically targeting urban areas experiencing rapid population growth and increased demand for efficient transportation systems. The research will be limited to Pune city, with a case study on road conditions in the Aundh area, while also considering comparative insights from other global urban road projects.

1.3 limitations of the study

- *Time constraints:* The study's limited timeframe may have impacted the depth of data collection and analysis.
- *Geographical scope:* The findings from this study are primarily relevant to Pune and may not be directly applicable to other cities, though they offer insights that could be adapted.
- *Response bias:* While every effort was made to collect honest feedback, there may have been response bias in the surveys and interviews, as participants may have been influenced by social or political considerations when discussing urban road issues.

2.0 Literature Review

2.1 Introduction

This literature review examines existing research on urban road development, focusing on connectivity, safety, and effective planning. Urban road networks are essential for a city's functionality, impacting traffic flow, accessibility, and residents' quality of life. Rapid urbanization, especially in cities like Pune, poses significant challenges to road infrastructure. The review explores how factors such as network complexity, residential area size, and intersection density affect connectivity. It also highlights trends and strategies in road safety, emphasizing design and regulatory measures. These insights inform the development of a comprehensive approach to improving Pune's urban road systems.

2.2 Challenges in urban road development

The socio-economic effects of road infrastructure in peri-urban areas were studied by (Khanani, 2021), who focused on the cities of Kisumu (Kenya) and Accra (Ghana). Khanani's findings revealed that road development projects improved accessibility and employment but also resulted in gentrification, displacing low-income residents and altering the social fabric. This highlights the need for policies that address socioeconomic disparities in infrastructure development to balance benefits across communities. Khanani (2021) examined the potential and challenges of Automated Driving Systems (ADS) in urban transport. Shladover argued that while ADS has attracted significant attention, deployment remains slow due to technical, regulatory, and infrastructural challenges. His research suggested that ADS adoption will likely follow the advancement of electrification and connectivity, providing cities with time to prepare for this shift in urban mobility. Chen (2021) analyzed the impact of road network topology on public transportation in China, finding a significant correlation between road network

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centralization and public transportation utilization. The study argued that a centralized and axial-shaped road network enhances public transport frequency, suggesting that urban planners should consider network layout in developing efficient public transport systems to promote sustainable urban mobility.

2.3 Sustainable road infrastructure practices

The integration of strategic planning and transition management is essential for sustainable urban road infrastructure, as highlighted by (Chen, 2023) in their study on Ugandan town councils. They explored how transition management mediates the relationship between strategic planning systems and sustainable urban road infrastructure development. Using a descriptive cross-sectional survey design and path analysis, they found that transition management plays a partial mediating role (path coefficient = .435), suggesting that effective knowledge-sharing among stakeholders is crucial for collective problem-solving and achieving sustainable road outcomes. The significance of sustainable urban road development is further examined by (Wang, 2024), who applied the Triple Bottom Line theory—emphasizing economic, social, and environmental dimensions—to assess urban roads' sustainability. They developed a comprehensive evaluation system using an analytic hierarchy process to create sustainability indicators across these dimensions. This framework provides a sustainable development model for urban roads, confirming the theory's effectiveness in fostering balanced development in urban infrastructure planning (Matu, 2020).

2.4 Policy and governance in urban road projects

In the context of rural and urban settings, (Shamdasani, 2021) highlights the economic benefits of improved rural road infrastructure in India, where road connectivity influences agricultural production by enhancing labor mobility and crop diversification, ultimately supporting poverty reduction. (Kale, 2023) review sustainable project planning for road infrastructure in India, advocating for life cycle cost analysis and other tools to ensure the sustainability and resilience of infrastructure projects in line with Vision 2030 goals. (Shah, 2024) underscores the challenges facing urban transportation in India, such as increased motorization, congestion, and outdated regulations, which affect public health and the environment. Shah calls for integrated land-use planning, improved public transit, and non-motorized transport promotion to mitigate urban transportation inefficiencies and environmental impacts (Wanume, 2023).

2.5 Research gap

The research gap in urban road development, particularly in Pune city, lies in the lack of a comprehensive framework that integrates infrastructure development, policy reforms, and stakeholder cooperation. While existing studies address individual challenges, there is limited research on a holistic approach to improving road systems in rapidly urbanizing cities, with a focus on sustainability and community engagement.

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3.0 Research Methodology

3.1 Introduction

The research methodology outlines the process of collecting, analysing, and interpreting data to develop a comprehensive framework to address the problems in urban road development, focusing on Pune City. The methodology for this study includes a mix of qualitative and quantitative approaches to gather detailed insights from both primary and secondary sources. This Figure 1 illustrates the research methodology workflow, outlining the sequential steps from identifying the problem, reviewing literature, collecting and analysing data, to developing a framework, validating findings, and providing recommendations, culminating in the conclusion.

3.2 Research methods used

A mixed-method approach was adopted, incorporating both qualitative and quantitative techniques to ensure a comprehensive analysis. The study commenced with an extensive literature review to identify prevalent challenges in urban road development. This was followed by field surveys where primary data was collected using geotagged photos, enabling an objective validation of the issues identified in prior research. Observations during site visits helped in capturing real-time conditions, while systematic documentation ensured data authenticity. The combination of these methods provided a holistic understanding of urban road infrastructure problems, aiding in the formulation of effective recommendations.

3.3 Research procedure

The research procedure followed a structured framework as illustrated (Figure 1) in the flowchart below:

- *Problem identification:* Key challenges in urban road development were identified through literature review.
- *Literature review:* Secondary data was gathered from previous studies to establish a theoretical foundation.
- *Data collection:* Geotagged photographs of urban roads in Pune city were taken to capture real-time conditions.
- *Observations:* Site visits and visual inspections were conducted to document and analyze road-related issues.
- *Framework development:* A structured approach was formulated to assess and categorize road infrastructure problems.
- *Validation and recommendations:* Findings were validated through comparative analysis, and recommendations were proposed based on research insights.
- *Conclusion:* The study's key findings were summarized, providing valuable input for future urban road development planning.

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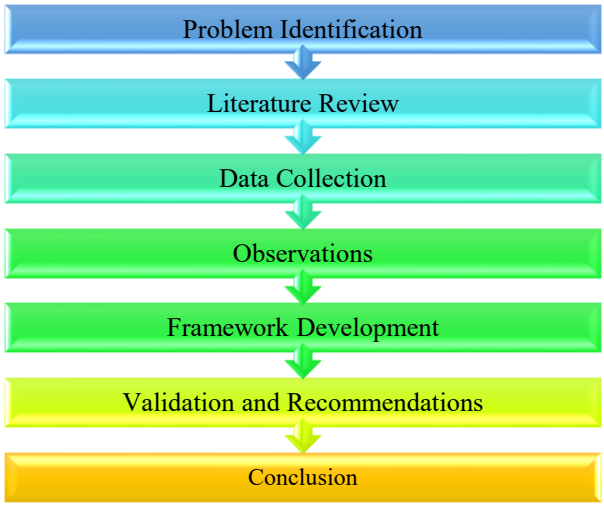
Figure 1: Flow Chart of Methodology



4.0 Data Collection and Analysis

This section describes the data collecting and analysis procedure used to detect and assess concerns with urban road development in Pune. The study used both secondary and primary data to get a thorough grasp of the challenges. Secondary data served as a theoretical underpinning, while primary data corroborated the conclusions via actual observations. The examination of this data led to the construction of a strong framework to handle the difficulties.

4.1 Secondary data collection

The secondary data collection process involved an extensive review of literature, including:

- Academic journals focusing on urban road development frameworks.
- Government policy documents and reports related to Pune's infrastructure development.
- Case studies and research papers highlight challenges in urban planning and road infrastructure.

The focus was on identifying recurring themes such as traffic congestion, inadequate road maintenance, lack of integration between road development and urban planning, and the absence of sustainable practices. Relevant statistical data on Pune's population growth, vehicle density, and road capacity were also gathered to provide contextual insights. The analysis of various studies highlights a wide range of road infrastructure challenges that impact urban and rural transportation systems. Several researchers have identified recurring issues that contribute to inefficient road networks, safety concerns, and urban mobility constraints. Bele (2012) identified multiple problems affecting road conditions, such as potholes, which lead to frequent

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surface damage and increased maintenance costs. Other significant concerns include open manholes, which pose safety hazards, and poor street lighting, which increases accident risks.

The study also noted issues such as frequent digging for utility works, causing prolonged disruptions, and speed breakers without warning signs, leading to abrupt braking and accidents. Additionally, delayed response to road repairs, lack of parking facilities, misaligned drain covers, and overall inefficiencies in road maintenance were highlighted. Wang (2024) focused on waterlogging and poor drainage, which result from inadequate drainage systems, disrupting traffic and damaging infrastructure. The study also mentioned unpaved roads or temporary closures due to a lack of resources, which affect accessibility. Traffic congestion was noted as a persistent issue, along with the lack of bicycle lanes, discouraging sustainable transport. Moreover, concerns such as the absence of disabled-friendly infrastructure and obstructions caused by public transport vehicles were identified as barriers to efficient urban mobility. Matu *et al.* (2020) discussed issues related to traffic management, including malfunctioning traffic signals, which contribute to accidents and congestion. The study highlighted the lack of pedestrian crossings, increasing risks for pedestrians, and poorly managed traffic diversions during construction, leading to avoidable delays and inefficiencies.

Zhao *et al.* (2017) examined narrow or inadequate roads that fail to accommodate growing traffic volumes. The research also pointed to road width management issues, which disrupt traffic flow efficiency. Zhao (2019) identified poor road surface quality, which leads to vehicle damage and higher maintenance costs. Additionally, frequent traffic diversions without notice were reported as a significant inconvenience. Other concerns included noise pollution from traffic, affecting urban residents' quality of life, and road space encroachment by unauthorized vendors and other entities, reducing available space for movement. Wanume *et al.* (2023) also addressed the encroachment of road space, emphasizing its impact on pedestrian and vehicular mobility. Furthermore, the study pointed out poor road planning, which results in inefficient infrastructure development and resource misallocation.

Shi *et al.* (2019) focused on broader urbanization challenges, particularly urban sprawl, where rapid expansion occurs without adequate road planning, leading to inefficiencies. Additionally, traffic-generated pollution was identified as an issue resulting from increased vehicle usage on poorly designed roads. Fekadu Zeliku (2022) emphasized governance and community involvement, highlighting the lack of community participation in road development decisions, which often leads to poor infrastructure outcomes. The study also noted weak institutional structures, where disorganized local governance results in ineffective road projects.

Shamdasani (2021) addressed issues specific to rural areas, including rural connectivity gaps, which hinder economic development and market access. Additionally, the study discussed the lack of maintenance strategies, which leads to deteriorating road conditions over time, and inadequate last-mile connectivity, limiting access to essential services and economic opportunities. Zhang *et al.* (2023) explored challenges within gated communities, identifying restricted road networks that contribute to external congestion. The study also highlighted low

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road network density, reducing travel efficiency, and poor pedestrian access, which discourages walking and increases dependency on private vehicles. Overall, the collective findings from these authors reveal that road infrastructure issues are diverse and interconnected, impacting mobility, safety, and urban sustainability. Addressing these challenges requires a strategic approach, including improved planning, governance, maintenance, and community engagement.

Table 1 Summary of issues identified by different authors points out the issues founded by each author which are very relevant to the study and which is mentioned in the table below with the description of the issues.

Table 1: Summary of Issues Identified by Different Authors

Author	Issues	Description
Khumbelo Bele (2012)	Potholes	Frequent road surface damage causing unsafe conditions and additional maintenance costs.
	Open Manholes	Unsecured manhole covers leading to accidents and financial liabilities.
	Poor Street Lighting	Insufficient illumination increasing accident risks and reducing security.
	Frequent Digging for Utility Works	Continuous digging without proper coordination, causing prolonged road closures and damage to infrastructure.
	Speed Breakers Without Warning Signs	Improperly marked speed bumps causing abrupt braking and potential accidents.
	Delayed Response to Road Repairs	Inefficient handling of road issues leading to prolonged unsafe conditions.
	Lack of Parking Facilities	Insufficient designated parking areas leading to illegal parking and traffic obstruction.
	Misaligned Drain Covers	Improperly installed or damaged drain covers posing hazards to pedestrians and vehicles.
Yilin Wang (2024)	Waterlogging and Poor Drainage	Inadequate drainage systems causing frequent waterlogging, disrupting traffic and damaging infrastructure.
	Unpaved Roads or Temporary Closures	Roads left unpaved or temporarily closed due to lack of resources, leading to poor accessibility and inefficiencies.
	Traffic Congestion	Overburdened road networks unable to handle increasing vehicular loads, leading to delays and economic losses.
	Lack of Bicycle Lanes	Absence of dedicated cycling paths discouraging sustainable and safe commuting options.
	Lack of Disabled-Friendly Infrastructure	Insufficient accommodations for disabled individuals, such as ramps or tactile surfaces.
	Obstruction by Public Transport Vehicles	Unregulated stops by buses and other public transport vehicles obstructing traffic flow.
Johnson Matu et.al	Malfunction of Traffic Signals	Poor maintenance and delayed repair of traffic lights, leading to increased accidents and traffic congestion.

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(2020)	Lack of Pedestrian Crossings	Insufficient or unsafe pedestrian crossings contributing to accidents involving walkers.
	Poorly Managed Traffic Diversions During Construction	Inefficient handling of traffic during construction leading to unnecessary congestion and delays.
Guoliang Zhao *et al.* (2017)	Narrow or Inadequate Roads	Insufficiently wide or improperly designed roads that fail to accommodate growing traffic volumes.
	Road Width Management	Mismanagement of road width allocation affecting traffic flow efficiency.
Pengjun Zhao (2019)	Poor Road Surface Quality	Deterioration of road surfaces due to inadequate maintenance, increasing vehicle wear and tear.
	Frequent Traffic Diversions Without Notice	Unplanned diversions causing confusion and delays.
	Noise Pollution from Traffic	Excessive noise from vehicles impacting the quality of life in urban areas.
	Encroachment of Road Space	Unauthorized use of roadways and sidewalks by vendors and other entities, reducing available space for vehicles and pedestrians.
Paul Wanume *et al.* (2023)	Encroachment of Road Space	Unauthorized use of roadways and sidewalks by vendors and other entities, reducing available space for vehicles and pedestrians.
	Poor Road Planning	Ineffective planning leading to inefficient road usage and resource wastage.
Ge Shi *et al.* (2019)	Urban Sprawl	Rapid urban expansion without proper road infrastructure planning causing inefficiencies.
	Traffic-Generated Pollution	Increased vehicle usage on poorly designed roads leading to higher emissions.
Fekadu Zeliku (2022)	Lack of Community Participation	Low engagement of residents in road development decisions resulting in poor outcomes.
	Weak Institutional Structures	Disorganized local government institutions leading to ineffective road development.
Yogita Shamdasani (2021)	Rural Connectivity Gaps	Poor road links in rural areas limiting economic growth and market access.
	Lack of Maintenance Strategies	Poor planning for road upkeep, causing higher costs and reduced usability over time.
	Inadequate Last-Mile Connectivity	Poor infrastructure in rural areas reducing access to economic opportunities and services.
Yu Zhang et.al (2023)	Gated Community Road Issues	Restricted road networks within gated communities causing external congestion.
	Lack of Road Network Density	Low road connectivity leading to inefficiencies in travel and accessibility.
	Poor Pedestrian Access	Lack of pedestrian-friendly routes within residential areas, discouraging walking and increasing dependency on vehicles.

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4.2 Secondary data analysis

The secondary data was systematically analysed to extract key challenges and trends:

1. *Identification of core issues:* The analysis highlighted significant challenges such as poor traffic management, inadequate road width, lack of proper maintenance, and limited use of modern urban planning tools.
2. *Assessment of existing frameworks:* A review of current frameworks revealed their limitations in addressing Pune's evolving urban demands. Issues like insufficient stakeholder involvement and outdated planning methodologies were identified as critical weaknesses.
3. *Benchmarking best practices:* Successful urban road development models from other cities were examined, providing insights into best practices that could be adapted for Pune's context.

5.0 Conclusion

This research paper aimed to identify and analyze key challenges in urban road infrastructure by utilizing secondary data from past studies. Through an extensive literature review, common road-related problems such as potholes, poor drainage, traffic congestion, encroachments, inadequate pedestrian infrastructure, and lack of proper road maintenance were identified. These issues have significant implications on urban mobility, road safety, and economic efficiency. Additionally, various research studies provided insights into potential solutions, emphasizing the need for improved drainage systems, better traffic management, sustainable urban planning, and enhanced regulatory measures.

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