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A CASE STUDY OF PUNE METRO TO EXAMINE THE FACTORS THAT LEAD TO DELAY AND ITS EFFECTS ON PROJECT

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ABSTRACT

The Pune Metro Rail Project, an ambitious urban mass transit initiative, aims to address Pune's growing traffic congestion and pollution. However, the project has faced significant delays due to prolonged governmental approvals, public opposition, and unforeseen disruptions like the COVID-19 pandemic. These delays have led to substantial cost overruns, increasing the estimated project cost from INR 10,183 crores to INR 11,522 crores. Additionally, construction activities have exacerbated traffic congestion and hindered urban development around metro corridors. This study examines the factors contributing to these delays and their broader impacts on urban planning and economic growth. Key findings suggest that streamlined approval processes, proactive stakeholder engagement, and advanced construction techniques could mitigate such setbacks in future metro projects. By implementing efficient project management strategies, the Pune Metro can serve as a model for improving transit infrastructure in other Indian cities, ensuring timely completion and enhanced urban mobility.

Keywords: Pune Metro, Project Delay, Cost Overrun, Urban Transport, Construction Challenges, Stakeholder Engagement

I. INTRODUCTION

The Pune Metro Rail Project is one of India's most ambitious urban mass rapid transit systems (MRTS), designed to alleviate traffic congestion, reduce pollution, and enhance the city's transportation efficiency[1]. As Pune experiences rapid urbanization, the need for a robust public transport system became crucial. The project, which spans over multiple phases, has faced numerous delays and challenges, impacting its cost, timeline, and overall effectiveness. Understanding the causes of these delays and their effects on the project is critical for future planning and implementation of similar projects in India[2].

1. Background and Purpose of the Pune Metro

Pune, a bustling metropolitan city in Maharashtra, has been grappling with increasing traffic congestion, pollution, and a lack of efficient public transport. As of 2025, Pune's urban population has grown significantly, leading to a surge in traffic demand that road-based systems can no longer efficiently handle[3]. The Pune Metro Project aims to provide an alternative by introducing a state-of-the-art metro rail system designed to reduce road congestion, enhance the city's air quality, and offer a reliable mode of transport for its citizens. The Pune Metro is planned to be built in multiple phases, with Phase 1 and Phase 2 covering different corridors and connecting key areas of the city[4]. This system will help alleviate traffic pressure, particularly along the most congested roads, and will provide a sustainable solution to the city's expanding population. Despite its promise, the project has faced significant delays, which have had profound effects on its budget, schedule, and the city's traffic issues [5].

2. Challenges Leading to Delays

A variety of factors have contributed to the delays in the Pune Metro project, ranging from political issues to logistical difficulties. One of the primary reasons has been the lengthy approval process, which started with initial feasibility reports that faced prolonged reviews. Although the project was first proposed in 2007, its Detailed Project Report (DPR) was not finalized until 2012, and approval from the Union Government came only in 2016. These delays in governmental decisions caused a significant postponement in the start of construction. Another major factor has been the opposition from local stakeholders, particularly in the form of public protests and the resistance of non-governmental organizations (NGOs) [6]. These groups raised concerns about the

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environmental impact, the loss of land for construction, and the aesthetic disruption caused by the elevated metro structures [7]. The city's narrow roads were another key challenge, with local residents arguing that the elevated routes would worsen traffic congestion. In response, changes in alignment and construction plans were made, further complicating the timeline. The COVID-19 pandemic further exacerbated these delays. During the lockdowns, construction work came to a standstill due to a shortage of labor, disruptions in the supply chain for essential materials like cement, steel, and aggregates, and travel restrictions that halted the transportation of construction workers and resources. The long-term effects of the pandemic on construction timelines are still being felt, with many contractors and stakeholders struggling to meet deadlines [7].

3. Effects of Delays on the Project

The delays in the Pune Metro project have had substantial effects on both the project itself and the broader urban development landscape. One of the most significant impacts has been the cost overrun. The initial estimate for the project was approximately INR 10,183 crores, but by 2015, this figure was revised upwards to INR 11,522 crores due to delays and inflation in material costs. These increases have caused financial strain on both the municipal corporations and the state and central governments, who are jointly funding the project [8]. Another critical effect has been the prolonged disruption in traffic management. Pune's roads, already struggling under the weight of growing traffic, have been further congested due to construction activities for the metro. The continuous construction of viaducts, stations, and underground tunnels has caused bottlenecks and delays in the flow of traffic, impacting commuters and local businesses. Despite the long-term benefits of the metro, these short-term inconveniences have led to frustration among the public [7].[8],[9].

Moreover, the delay in the metro's completion has stalled the planned development around metro stations. One of the key objectives of the metro project is to foster urban renewal by encouraging high-density development along the metro corridors. However, with the delayed timeline, real estate projects dependent on the metro's completion have been postponed, impacting economic growth in these areas.

4. Key Findings and Recommendations for Future Metro Projects

The case of Pune Metro provides several key lessons for future urban metro projects in India and other developing nations. First, it is essential to streamline the approval process and involve stakeholders early in the planning stage to avoid unnecessary delays. A well-planned and transparent procurement process can minimize political interference and facilitate smoother implementation.

Second, urban planners should consider the socio-political impact of the metro, especially in densely populated areas where land acquisition can be a sensitive issue [9]. Engaging with local communities and NGOs, and addressing their concerns proactively, could reduce resistance and help speed up project execution. Finally, the use of modern construction technologies and better risk management strategies, such as effective supply chain management and contingency planning for unforeseen events like pandemics, can help mitigate the effects of such disruptions. By investing in digital tools for project management and adopting innovative construction methods like modular construction, the timeline and budget of future metro projects can be better controlled [10].

The Pune Metro project, while an essential component of the city's long-term transportation infrastructure, has faced delays due to a combination of governmental, logistical, and external factors. These delays have not only escalated costs but have also caused significant disruptions in the city's development and daily life [11],[12]. However, with the right strategies, including improved planning, stakeholder engagement, and the adoption of

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advanced technologies, future metro projects can avoid similar setbacks and contribute effectively to urban mobility solutions.

II. RELATED WORK

The construction of metro rail systems, while critical for addressing urban mobility challenges, often faces substantial delays and cost overruns. Numerous studies have explored the factors contributing to these delays, the effects on project timelines, and the broader implications for urban development. In the context of metro rail projects in India, particularly the Pune Metro, various research papers have identified common themes in project delays, such as financial issues, land acquisition, inadequate planning, and unforeseen challenges like natural disasters and pandemics [13],[14].

According to Musarat et al. (2021), inflation in construction material costs is a major factor leading to budget overruns in metro rail projects. The study emphasizes how fluctuating prices of raw materials such as steel, cement, and machinery can lead to significant cost overruns if not properly accounted for in the initial budget. Similarly, Danish and Ahmad (2019) identify factors such as poor bidder selection, incorrect bid pricing, and insufficient cash flow as critical contributors to delays in construction projects, particularly in India. They argue that financial difficulties faced by contractors often lead to slow progress on the ground, affecting the overall project schedule.

Land acquisition issues have also been highlighted in several studies as a primary cause of delays. Mittal and Paul (2018) focus on the difficulties faced in securing land for metro rail projects in India, which often leads to delays in the initiation of construction. They argue that delayed land acquisition and shifting of utilities significantly extend project timelines. Similarly, Karthik (2018) addresses the complexity of land acquisition and the often-lengthy legal processes that exacerbate delays, particularly in urban areas with high land costs.

Design and planning issues are another common theme in the literature. For example, Medda (2019) discusses how delays in design approvals and changes in scope can disrupt the project flow. She explains that incomplete or inaccurate initial designs, as well as frequent revisions, often cause delays in the execution phase. Rastogi (2018) adds that geotechnical challenges, such as unexpected soil conditions and underground infrastructure, can further complicate the design and construction of metro systems, particularly when tunneling and underground stations are involved.

The impact of the COVID-19 pandemic on construction schedules has been another area of research. Wagh (2019) explores the specific risks associated with the underground construction of metro tunnels, noting that the pandemic disrupted the supply of construction materials and the workforce, leading to significant delays in several metro projects in India. Similarly, Sonar (2022) discusses how the pandemic exacerbated existing challenges in the construction sector, including labor shortages and project financing issues.

Further, studies by Bhutania et al. (2019) emphasize the effect of work zone disruptions on traffic flow during metro construction, which increases congestion and delays. They argue that careful scheduling and traffic management plans are necessary to mitigate the negative effects of construction on the surrounding urban environment.

In sum, the literature reveals a complex array of factors contributing to delays in metro rail projects, with issues ranging from financial challenges, land acquisition, and design flaws, to external factors like pandemics and political resistance. Addressing these factors requires a multi-faceted approach that involves proper planning, timely execution, and proactive stakeholder engagement to minimize delays and ensure the successful completion of metro rail projects. Understanding these delays and their consequences is essential for improving the management and delivery of future metro projects in India and other developing nations [15], [16].

III. PROBLEM STATEMENT

“Metro is one of the finest choices when transportation infrastructure grows fast in metro centers. However, construction progress often does not match real planning, causing time and expense loss. It is important to identify the root causes so that similar projects can be avoided”.

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IV. RESEARCH METHODOLOGY

To understand the factors causing delays in the Pune Metro Project and their subsequent effects, a comprehensive research methodology is required. This methodology is designed to identify the root causes of the delays, evaluate their impact on the project timeline and budget, and suggest strategies to mitigate these challenges in future metro rail projects. The following methodology outlines the stages of the research process, from literature review to data collection, analysis, and the implementation of solutions.

1. Literature Review and Problem Identification

The first step in this methodology involves an extensive literature review to explore the various factors contributing to delays in metro rail projects, particularly in India. The purpose of this phase is to gather insights from previous studies on delays in metro rail construction worldwide, with a focus on India, where many metro projects face similar challenges.

The literature review helps to identify common causes of delays such as financial issues, land acquisition delays, inadequate planning, unforeseen natural conditions, and regulatory and political obstacles. Several studies, including those by Musarat et al. (2021), Danish and Ahmad (2019), and Mittal and Paul (2018), have identified these factors as being crucial in explaining the delays in metro projects. Moreover, literature from experts like Karthik (2018) and Wagh (2019) provides detailed insights into the specific challenges faced by metro projects in urban India, including issues of land acquisition, design changes, and delays due to geotechnical factors.

Based on this literature review, the problem is identified: delays in the Pune Metro Project have stemmed from multiple factors, including delays in land acquisition, political challenges, design approvals, and the impact of the COVID-19 pandemic. The literature review also highlights that most studies focus on identifying these delays but lack a comprehensive approach to understanding their interconnectedness and cumulative effects on the project's timeline and budget. This gap is addressed in the methodology by using a mixed-methods approach, combining both qualitative and quantitative data collection techniques.

2. Data Collection: Primary Data Through Surveys and Questionnaires

Once the key issues have been identified through literature review, the next step involves the collection of primary data from key stakeholders involved in the Pune Metro Project. The primary data is essential to understanding the specific challenges faced during the construction phase, the causes of delays, and their impacts on the project's performance.

The primary data collection is carried out using structured questionnaires and surveys distributed to various stakeholders. These include project managers, engineers, architects, contractors, local government officials, consultants, and other professionals with direct involvement in the Pune Metro Project. The purpose of these surveys is to gain insights into the real-world experiences and perceptions of these stakeholders regarding the delays and challenges they faced throughout the project.

The questionnaire is designed to address specific delay factors, such as:

- **Land Acquisition Issues:** Delays in acquiring land and the challenges in negotiating with private property owners.
- **Regulatory Delays:** Issues related to obtaining necessary permits and clearances from local bodies.
- **Design and Planning Issues:** Delays in design approvals, scope changes, and difficulties in adhering to initial plans.
- **Supply Chain and Labor Issues:** Delays in the supply of materials, equipment shortages, labor shortages, and the impact of the COVID-19 pandemic.
- **Political and Social Resistance:** Opposition from local communities, environmental groups, and political entities that affect project timelines.
- **Financial Issues:** Delays caused by funding shortages, changes in financial backing, or the economic impact of unforeseen events such as the pandemic.

The survey also uses Likert scales to measure the severity of each factor and its frequency of occurrence during the project. Respondents rate the factors based on their perceived impact on project delays, providing valuable

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data on the relative importance of each factor. The collected data helps identify the most critical delay factors, which can then be analyzed further in the subsequent steps.

3. Delphi Technique for Expert Opinion Gathering

To refine the understanding of the delay factors identified through the survey, the Delphi technique is employed. The Delphi method is a systematic, interactive forecasting method that relies on a panel of experts to reach a consensus. The Delphi technique involves iterative rounds of questionnaires sent to a panel of experts in the field of metro rail construction, project management, and urban infrastructure.

In the context of the Pune Metro Project, the Delphi panel consists of experts with significant experience in metro construction, such as senior engineers, project managers, urban planners, and academic researchers. These experts are asked to rate and rank the factors contributing to delays based on their professional experiences. The process is iterative, with controlled feedback provided after each round of responses, allowing the experts to reconsider their opinions based on the group's collective input.

The Delphi technique serves several purposes in this methodology. First, it helps validate the findings from the survey and ensures that the factors identified are accurate and reflective of real-world experiences. Second, the method encourages experts to highlight any emerging issues or unrecognized factors that may contribute to delays. Finally, the Delphi method helps prioritize the delay factors by assessing the level of agreement among experts. The outcomes from the Delphi technique are used to refine the research and propose more focused solutions for mitigating delays in metro projects.

4. Data Analysis: Identifying Root Causes and Their Impacts

Once the primary data and expert opinions are collected, the next step is to analyze the data to identify the root causes of delays and their cumulative impact on the Pune Metro Project. The analysis is conducted using a combination of qualitative and quantitative methods.

The qualitative analysis involves coding the responses from surveys and interviews to identify recurring themes and patterns related to delays. This includes analyzing open-ended questions where stakeholders describe specific challenges they faced during the project. Thematic analysis is used to categorize these challenges into broad themes, such as financial difficulties, land acquisition problems, or labor shortages. This approach allows for a comprehensive understanding of the various factors at play and their interconnections.

For the quantitative analysis, statistical methods such as the Relative Importance Index (RII) are used to measure the severity and frequency of each delay factor. The RII is calculated for each factor based on the responses from the stakeholders. This allows the researcher to rank the factors in terms of their impact on the project's schedule and budget. Factors with the highest RII values are identified as the most critical, and the research provides recommendations for addressing these issues.

The analysis also involves calculating the financial impact of delays, particularly in terms of cost overruns. By comparing the original budget and timeline to the actual costs and completion dates, the researcher can estimate the extent to which delays have increased the overall cost of the project. This cost analysis helps in understanding the economic consequences of delays and serves as a basis for suggesting better project management practices in the future.

5. Recommendations and Solutions

The final stage of the methodology involves formulating recommendations based on the findings from the data analysis. The research provides practical solutions to address the root causes of delays and improve the efficiency of metro rail projects in India.

The recommendations focus on several key areas, including:

- Improved Planning and Design: Ensuring that the initial designs are thorough, realistic, and adaptable to unforeseen changes.
- Enhanced Stakeholder Engagement: Engaging local communities, environmental groups, and political bodies early in the planning process to minimize resistance and delays.
- Efficient Land Acquisition Processes: Streamlining land acquisition procedures and addressing any legal or bureaucratic obstacles that may cause delays.

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- Use of Advanced Construction Technologies: Leveraging technologies such as Building Information Modeling (BIM) and automation to speed up the construction process and reduce errors.
- Risk Management and Contingency Planning: Implementing robust risk management frameworks that account for external factors like pandemics, economic downturns, and natural disasters.

The research concludes by emphasizing the importance of incorporating these strategies into future metro projects to mitigate delays and cost overruns, ensuring timely and efficient completion of urban transportation infrastructure.

Elevated viaduct consisting pre-stressed concrete "Box" shaped Girders on Single pier with pile / Open foundations, and underground section with Tunnel Boring and station in underground station cut and cover.

Table 1. Construction Methodology

Estimated Cost (At August 2014 Prices, Without Taxes)	
Corridor I	5320
Corridor II	2532
Total	**7852**
Total Estimated Completion Cost (With Central Taxes)	
Corridor I	7422
Corridor II	3447
Total	**10869**

V. CASE STUDY

The Pune Metropolitan Region Development Authority (PMRDA) proposed taking over the Metro project, but the Pune Municipal Corporation (PMC) and Pimpri Chinchwad Municipal Corporation (PCMC) declined, stating that the project would be executed by a Special Purpose Vehicle (SPV). Instead, they suggested including PMRDA in the SPV to expand the Metro's reach. The Maharashtra Metro Rail Corporation, an SPV formed by the Government of India and the Government of Maharashtra, is responsible for implementing the Pune Metro project. It aims to develop world-class metro stations, preserve cultural heritage, and provide a modern, safe, and integrated public transport system for Pune and Pimpri Chinchwad.

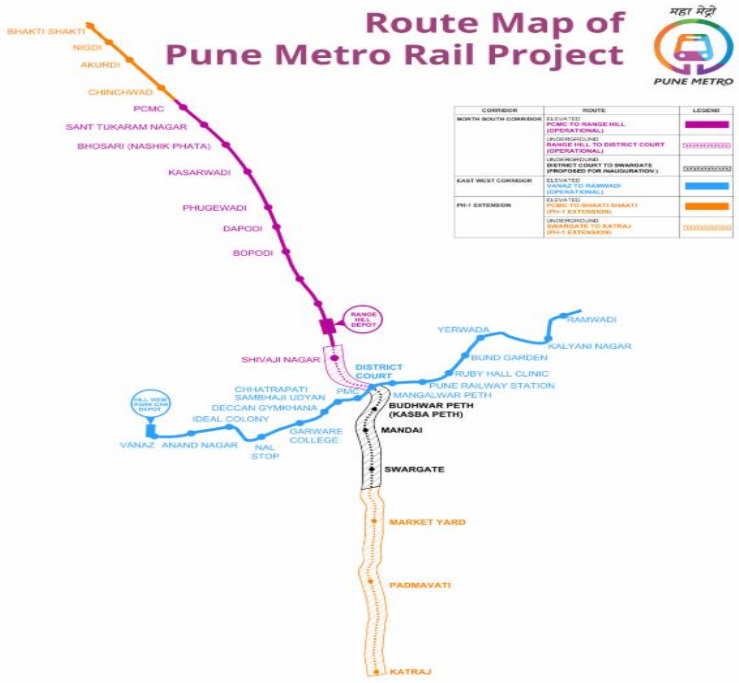

Figure 1. Route Map Pune Metro Rail Project

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Table 2. Shows Length of Viaduct

Description	Underground (km)	Elevated (km)	Total (km)
Corridor-1: PCMC - SWARGATE	5.019	11.57	16.589
Corridor-2: VANAZ - RAMVADI	NIL	14.925	14.925
		Total	31.515

5.1 Land requirement

Since land is a scarce commodity especially in metropolitan areas, every effort has been made to keep land requirement to the barest minimum and acquisition of private property is minimal. Land is mainly required for Depots and route alignment on sharp bends, station buildings, platforms, entry/exit structures, traffic integration, power sub-stations, ventilation shafts, administrative buildings and temporary construction depots / work sites etc.

Table 3. Summary of Permanent Land Requirement (Ha)

Description	Corridor I			Corridor II		
	Govt.	Private.		Govt.	Private.	
		Comm.	Res.		Comm.	Res.
Stations	4.2	--	0.80	0.30	0.60	1.53
Running Section	0.50	6.80	0.80	0.55	0.980	1.17
RSS/TSS	1.20	--	--	1.20	--	--
Depots	11.51	--	--	12.11	--	--
Total	17.41	6.80	1.60	14.16	1.58	2.70

Total Land required for both corridors: 31.57Ha (Govt.) + 12.68Ha (Private.) = 44.25 Ha

Table 4. Alignment Details of Pune Metro

Alignment	Corridor	Rail Length	No. Of Stations	
			Underground	Elevated
Line 1 (14 Stations)	PCMC - Swargate	17.4 KM	5	9
Line 2 (16 Stations)	Vanaz - Ramwadi	15.7 KM	-	16

Table 5. Station Details of Pune Metro

LINE 1 (PCMC - SWARGATE)	LINE 2 (VANAZ - RAMWADI)
PCMC	Vanaz
Sant Tukaram Nagar	Anand Nagar
Bhosari (N.P.)	Ideal Colony
Kasarwadi	Nal Stop
Phugewadi	Garware College
LINE 1 (PCMC - SWARGATE)	LINE 2 (VANAZ - RAMWADI)
Dapodi	Deccan Gymkhana
Bopodi	Chhatrapati Sambhaji Udyan
Khadki	PMC

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Range Hill	Civil Court
Shivaji Nagar	Mangalwar Peth
Civil Court	Pune Railway Station
Budhwar Peth	Ruby Hall Clinic
Mandai	Bund Garden
Swargate	Yerawada
	Kalyani Nagar
	Ramwadi

Pune Metro, an urban Mass Rapid Transit System (MRTS), is under construction with three lines led by Maharashtra Metro Rail Corporation Limited (Maha-Metro) and Pune Metropolitan Region Development Authority (PMRDA). The 31.254 km Phase 1 project, with two metro lines and 29 stations, had its Detailed Project Report (DPR) prepared by Delhi Metro Rail Corporation in 2009 and revised multiple times until November 2015. Despite state approval in 2012, the project faced delays due to red tape, political hurdles, and opposition from NGOs. Final approval came from the Union Government on December 7, 2016. Additionally, PMRDA is developing a third, mostly elevated, Hinjewadi–Civil Court line through a public-private partnership (PPP). In September 2019, PMRDA signed a 35-year concession agreement with a consortium of TRIL Urban Transport (Tata Group) and Siemens Project Ventures GmbH.

5.2System Specifications

- Top Speed: 80 kmph
- Average Speed: 34 kmph
- Track Gauge: Standard Gauge – 1435 mm
- Electrification: 25 kV, 50 Hz AC OHE
- Signalling: Communications-based Train Control (CBTC)

5.3 Key Figures

Operational: 0 km | Under Construction: 54.584 km | Approved: 4.41 km | Proposed: 26.464 km

- **Estimated Daily Ridership**: 6 lakh (Phase 1) & 2.6 lakh (Line-3) in 2027
- **Rolling Stock**: 104 coaches (26 train-sets x 4) to be supplied by Titagarh- Firema for Phase 1

5.4 Pune Metro under Construction Lines (Phase 1 + Line-3)

Line-1 (Purple Line): Pimpri Chinchwad Municipal Corporation (PCMC) – Swargate

- Length: 16.589 km
- Type: Elevated & Underground
- Elevated: PCMC – Range Hills Ramp: 11.570 km, 9 stations
- Underground: Range Hills Ramp – Swargate: 5.019 km, 6 stations
- Depot: Range Hills (13.27 hectares)
- Number of Stations: 14
- Station Names: PCMC, Tukaram Nagar, Bhosari, Kasarwadi, Fugewadi, dapodi, Bopodi, Khadki, Range Hill, Shivaji Nagar, Civil Court, Budhwar Peth, Mandai, Swargate

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Line-2 (**Aqua Line**): Vanaz – Ramwadi

- Length: 14.665 km
- Type: Elevated
- Depot: Hill View Depot at Kothrud (12 hectares)
- Number of Stations: 16
- Station Names: Vanaz, Anand Nagar, Ideal Colony, Nal Stop, Garware College, Deccan Gymkhana, Sambhaji Park, PMC, Civil Court, Mangalwar Peth, Pune Railway Station, Ruby Clinic, Bund Garden, Yerawada, Kalyani Nagar, Ramwadi

Line-3: Hinjewadi – Civil Court

- **Length**: 23.33 km
- **Type**: Elevated
- **Depot**: Maan Village (20 hectares)
- **Number of Stations:** 23

❖ **Station Names**: Megapolis Circle, Embassy Quadron Business Park, Dohler, Infosys Phase II, Wipro Phase II, Pall India, Shivaji Chowk, Hinjewadi, Wakad Chowk, Balewadi Stadium, NICMAR, Ram Nagar, Laxmi Nagar, Balewadi Phata, Baner Gaon, Baner, Krushi Anusadhan, Sakal Nagar, University, R.B.I., Agriculture College, Shivaji Nagar and Civil Court.

VI. CONCLUSION

Metro projects in India often face significant challenges due to analytical and methodological errors in project planning, leading to delays and cost overruns. The Pune Metro project exemplifies these issues, highlighting the need for rigorous evaluation of Detailed Project Reports (DPRs) by an impartial expert committee. Delays in metro projects stem from multiple factors, including the COVID-19 pandemic, labor shortages, land acquisition issues, material shortages, and changes in project scope. A study analyzing 27 delay factors using RII and SPS methods identified key contributors, with owners, materials, and external factors playing a crucial role. To mitigate delays, effective project management practices such as realistic goal-setting, proper scheduling, efficient resource allocation, and technological adoption are essential. India's rapid urbanization often results in large-scale projects that fail to meet expected benefits, overlooking smaller, more efficient solutions. By improving planning and execution strategies, metro projects can be completed on time while ensuring sustainable urban transport development.

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