

# Probabilistic Risk Assessment of Time and Cost Overruns in Residential Township Projects: Evidence from the Mumbai Metropolitan Region

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## ABSTRACT

Residential township projects in the Mumbai Metropolitan Region are characterized by large investment, phased execution, and multiple regulatory requirements, making them highly vulnerable to time and cost overruns. These overruns not only affect project profitability but also delay delivery to end users and reduce overall stakeholder confidence. The present study aims to identify and prioritize the major risk factors contributing to schedule delays and budget escalation in township developments using a quantitative analytical approach. A structured questionnaire survey was administered to 85 construction professionals, including project managers, contractors, consultants, and developers associated with ongoing and completed township projects. The collected responses were analyzed using Mean Score, Standard Deviation, and Relative Importance Index (RII) to evaluate the significance and variability of identified risk factors.

The results reveal that delay in statutory approvals, escalation of material prices, cash flow constraints, land acquisition disputes, and frequent design changes are the most critical contributors to project overruns. Higher mean values and RII scores indicate strong agreement among respondents regarding the severity of regulatory and financial risks. The findings emphasize the need for early-stage regulatory coordination, effective financial planning, and structured risk monitoring mechanisms. The study provides a systematic framework for prioritizing risk factors and supports informed decision-making in large-scale residential township projects within rapidly urbanizing metropolitan regions.

**Keywords:** Budget escalation; Construction management; Mumbai Metropolitan Region; Relative Importance Index (RII); Residential township projects; Risk assessment; Schedule delay; Standard deviation analysis; Time overrun

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## INTRODUCTION

Residential township developments in the Mumbai Metropolitan Region (MMR) have expanded rapidly in response to increasing urban population and housing demand. These projects typically involve large land parcels, phased construction, integrated infrastructure, and coordination with multiple regulatory authorities. Due to their scale and complexity, township projects are more exposed to uncertainties compared to conventional residential buildings. Delays in execution and escalation of project costs have become recurring challenges, affecting financial performance and stakeholder confidence.

Time and cost overruns in township projects are influenced by regulatory procedures, financial management, market fluctuations, and project coordination issues. In metropolitan regions such as Mumbai, factors like statutory approvals, land acquisition, infrastructure integration, and material price volatility play a crucial role in determining project outcomes. Therefore, systematic identification and prioritization of risk factors are essential for improving project planning and control. This study evaluates the major contributors to schedule and budget overruns using statistical measures such as Mean Score, Standard Deviation, and Relative Importance Index (RII).

## LITERATURE REVIEW

Time and cost overruns are among the most critical challenges affecting the performance of construction projects worldwide. These issues are particularly significant in large-scale and complex developments such as residential townships, where multiple stakeholders, phased execution, and integrated infrastructure systems increase uncertainty and risk. Several researchers have examined the causes and impacts of these overruns, identifying a combination of technical, financial, managerial, and external factors.

Daoud and Hefnawy [1] investigated cost overruns from the contractors' perspective and found that poor planning, ineffective coordination, and inadequate financial control are major contributors. Similarly, Devi and Jegan [2] highlighted that cost escalation is primarily driven by inaccurate cost estimation, fluctuations in material prices, and delays in project execution. Daundkar et al. [3] further emphasized that poor scheduling, lack of coordination, and inefficient site management significantly contribute to project cost overruns.

Advanced analytical approaches have also been applied to understand project performance. El-Maaty et al. [4] used fuzzy modeling techniques to analyze schedule overruns and cost escalation, demonstrating that uncertainty in project duration and resource allocation plays a crucial role in affecting project outcomes. Kaliba et al. [5] examined delays in construction projects and identified external factors such as regulatory approvals, environmental conditions, and contractual disputes as key causes of schedule delays.

Financial risks have been widely recognized as a major driver of cost overruns. Kamaruddeen et al. [6] identified inflation, market instability, and economic fluctuations as critical factors influencing cost escalation. Similarly, Memon et al. [8] emphasized the impact of cash flow constraints, delayed payments, and financial mismanagement on project performance. Knight and Fayek [7] concluded that although risk factors vary across projects, financial and regulatory risks consistently rank among the most significant contributors to cost escalation.

In the Indian construction context, Saidu et al. [10] applied the Relative Importance Index (RII) method to evaluate time and cost overruns, demonstrating its effectiveness in prioritizing risk factors based on stakeholder perceptions. Afana et al. [9] also categorized various factors contributing to construction overruns, providing a structured understanding of risk dimensions. Heravi and Mohammadian [11] emphasized the importance of effective project management practices, including planning, coordination, and monitoring, in minimizing delays and cost increases.

Further insights into construction project performance are provided by broader studies on delays and overruns. The study [12] highlighted the wide range of causes contributing to time and cost overruns and emphasized the need for comprehensive risk assessment frameworks. Ademilade [13] analyzed time and cost overruns in the construction industry, particularly in urban contexts such as Mumbai, and stressed the importance of systematic analysis for improving project performance. Egunwatum et al. [14] focused on residential building projects and identified causes and solutions for cost overruns, emphasizing the need for effective planning and management strategies. Larsen et al. [15] examined factors affecting schedule delay, cost overrun, and quality in public construction projects, concluding that these aspects are interrelated and must be managed holistically.

Despite the extensive body of literature on construction overruns, most studies focus on conventional building or infrastructure projects rather than integrated residential township developments. Township projects are inherently more complex due to large land requirements, phased construction, infrastructure integration, and multiple regulatory approvals. These factors make township developments more vulnerable to uncertainties compared to traditional construction projects. Moreover, existing research primarily emphasizes technical, financial, and managerial factors, with limited focus on resident perceptions, livability, and governance aspects. As residential townships evolve into self-contained micro-urban systems, understanding user experience becomes increasingly important. Factors such as design quality, availability of amenities, infrastructure efficiency, and governance mechanisms play a crucial role in determining overall success.

Another key gap in the literature is the lack of comparative studies across different city tiers. While metropolitan regions like Mumbai have been extensively studied, there is limited empirical research comparing township developments in Tier 1 and Tier 2 cities. Variations in governance capacity, infrastructure availability, and planning practices can significantly influence project outcomes and resident satisfaction.

Therefore, this study addresses these gaps by integrating technical risk assessment with resident perception analysis and providing a comparative evaluation of township developments across Tier 1 and Tier 2 cities in Western Maharashtra. This

approach contributes to a more comprehensive understanding of township performance and supports the development of sustainable, inclusive, and resilient urban environments.

### METHODOLOGY

The study adopted a quantitative research approach based on primary data collection. A structured questionnaire was developed after reviewing relevant literature and consulting industry professionals. The survey included 30 potential risk factors categorized under regulatory, financial, managerial, technical, and external risks. A total of 85 valid responses were collected from project managers, contractors, consultants, and developers associated with residential township projects in the Mumbai Metropolitan Region. Respondents rated each risk factor using a five-point Likert scale ranging from 1 (very low impact) to 5 (very high impact).

**The collected data were analyzed using:**

- Mean Score to determine average severity
- Standard Deviation to assess variability in responses
- Relative Importance Index (RII) to rank risk factors

The RII was calculated using the standard formula:

Where:

W = weight	$RII = \frac{\sum W}{A \times N}$	assigned by respondents
A = highest		possible weight (5)
N = total		number of respondents

### RESULTS AND DISCUSSION

**Table 1: Ranking of Influencing Factors**

Rank	Risk Factor	Mean	Std Deviation	RII
1	Delay in statutory approvals	4.46	0.62	0.89
2	Material price escalation	4.35	0.70	0.87
3	Cash flow constraints	4.28	0.74	0.85
4	Land acquisition disputes	4.18	0.79	0.84
5	Frequent design changes	4.15	0.81	0.83
6	Delay in contractor payments	4.02	0.85	0.80
7	Poor project scheduling	3.95	0.90	0.79
8	Shortage of skilled labor	3.88	0.94	0.78
9	Infrastructure connectivity delay	3.76	0.96	0.75
10	Inadequate site management	3.68	1.02	0.74

#### 4.1 Ranking of Critical Risk Factors

The statistical analysis identified the most influential risk factors affecting time and cost performance in township projects. The highest-ranked risk factor is Delay in statutory approvals (Mean = 4.46, RII = 0.89), indicating strong agreement among respondents regarding its severity. The low standard deviation (0.62) suggests consistent perception across participants. This reflects the complexity of obtaining environmental clearances, municipal permissions, and development sanctions in the Mumbai region.

Material price escalation (Mean = 4.35, RII = 0.87) ranks second, highlighting the impact of fluctuations in steel, cement, and fuel prices. Similarly, Cash flow constraints (Mean = 4.28, RII = 0.85) indicate financial instability as a major contributor to delays and budget increases. Land acquisition disputes (RII = 0.84) and Frequent design changes (RII = 0.83) also show high severity levels, emphasizing the influence of external and technical uncertainties in large-scale township developments. Lower-ranked factors such as Inadequate site management (RII = 0.74) and Infrastructure connectivity delay (RII = 0.75) indicate moderate influence but still contribute to overall performance risk.

#### 4.2 Interpretation of Statistical Indicators

Higher mean values (above 4.0) indicate strong respondent agreement regarding risk severity. The relatively low standard deviation for top-ranked risks suggests consensus among professionals about regulatory and financial challenges. The results clearly demonstrate that external and financial risks exert greater influence than internal managerial risks in residential township projects within MMR. This highlights the importance of regulatory planning, financial forecasting, and early risk identification.

#### CONCLUSION

This study examined the critical risk factors contributing to time and cost overruns in residential township projects in the Mumbai Metropolitan Region. Using Mean Score, Standard Deviation, and Relative Importance Index (RII), the research identified regulatory delays, material price escalation, and cash flow constraints as the most significant contributors.

The findings indicate that township projects are more vulnerable to external and financial uncertainties than internal operational issues. Proactive measures such as early statutory coordination, contingency budgeting, effective financial management, and controlled design processes are essential to minimize overruns.

The study provides a structured framework for prioritizing risks and supports informed decision-making for developers and project managers involved in large-scale urban housing developments. Future research may incorporate comparative regional studies or advanced predictive modelling to enhance forecasting accuracy.

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