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Application of Lean Construction to Improve Cost Efficiency Due to Delays in the Manggarai–Jatinegara Railway Facilities Development Project (Package A, Phase II, Mainline I)

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Abstract

The budget allocated for infrastructure development increased by 7.57%, reaching IDR 125.18 trillion in 2022. To support this growth, the integration of intermodal transportation systems is essential. The Manggarai–Jatinegara Railway Facilities Development Project (Package A, Phase II, Mainline I) represents a significant infrastructure initiative in this context. Preventing construction delays requires proactive measures to ensure project safety and quality, alongside efforts to enhance efficiency and value. Lean Construction is a methodology focused on increasing efficiency, minimizing waste, and maximizing value for all project stakeholders. This study aims to identify the factors causing delays and cost overruns in the Manggarai Station project and formulate appropriate strategies and steps to address these issues. The research employs the Analytic Hierarchy Process (AHP) to analyze data collected from selected respondents, enabling weighted prioritization of the identified factors according to their rank. The study demonstrates that Lean Construction strategies, particularly waste reduction through improved coordination and preventive measures, effectively mitigate these issues. The findings provide practical insights for project managers and policymakers to institutionalize Lean Construction in Indonesia's railway megaprojects.
Keywords: Project Delay, Cost Overruns, Lean Construction, Construction Project, Railway

Abstrak

Anggaran yang dialokasikan untuk pembangunan infrastruktur meningkat sebesar 7,57%, mencapai Rp125,18 triliun pada tahun 2022. Untuk mendukung pertumbuhan ini, integrasi sistem transportasi antarmoda menjadi sangat penting. Proyek Pembangunan Fasilitas Perkeretaapian Manggarai–Jatinegara (Paket A, Tahap II, Mainline I) merupakan salah satu inisiatif infrastruktur yang signifikan dalam konteks tersebut. Pencegahan keterlambatan konstruksi memerlukan langkah-langkah proaktif untuk menjamin keselamatan dan kualitas proyek, sekaligus upaya meningkatkan efisiensi dan nilai. *Lean Construction* adalah metodologi yang berfokus pada peningkatan efisiensi, meminimalkan pemborosan, dan memaksimalkan nilai bagi seluruh pemangku kepentingan proyek. Penelitian ini bertujuan untuk mengidentifikasi faktor-faktor penyebab keterlambatan dan pembengkakan biaya pada proyek Stasiun Manggarai serta merumuskan strategi dan langkah yang tepat untuk mengatasinya. Penelitian ini menggunakan metode *Analytic Hierarchy Process* (AHP) untuk menganalisis data yang dikumpulkan dari responden terpilih, sehingga memungkinkan prioritisasi berbobot terhadap faktor-faktor yang telah diidentifikasi sesuai tingkat kepentingannya. Hasil penelitian menunjukkan bahwa strategi *Lean Construction*, khususnya pengurangan pemborosan melalui koordinasi yang lebih baik dan langkah-langkah pencegahan, efektif dalam mengurangi permasalahan tersebut. Temuan ini memberikan wawasan praktis bagi manajer proyek dan pembuat kebijakan untuk menginstitusionalisasikan *Lean Construction* dalam megaproyek perkeretaapian di Indonesia.
Kata Kunci: Keterlambatan Proyek, Pembengkakan Biaya, *Lean Construction*, Proyek Konstruksi, Perkeretaapian

1. Introduction

Infrastructure development is fundamental in supporting economic growth, enhancing connectivity, and improving the overall quality of life, especially in developing nations such as Indonesia. Under President Joko Widodo's administration, infrastructure has been prioritized as a central pillar of the national development agenda. This is reflected in a substantial increase in government expenditure, amounting to IDR 125.18 trillion in 2023, a 7.57% rise from the previous year. Within this broader policy framework, the government has undertaken large-scale transportation projects to integrate urban mobility systems, particularly in Jakarta, where intermodal connectivity is needed.

Integrating TransJakarta, MRT Jakarta, LRT Jakarta, and the KRL Commuter Line is central to improving public transport efficiency and accessibility. One of the flagship projects supporting this integration effort is the Manggarai–Jatinegara Railway Facilities Development Project (Package A, Phase II, Mainline I). The project, implemented by the Directorate General of Railways (DJKA), aims to upgrade Manggarai Station into a central railway hub, replacing Gambir Station as the main departure point for long-distance trains. With a projected capacity of 1.2 million passengers per day, Manggarai Station is envisioned as a multimodal node integrated with various public transport systems. In addition to meeting technical and operational standards, the project aims to fulfill the Minimum Service Standards (SPM) for railway infrastructure as stipulated in Ministerial Regulation No. 63 of 2019, including safety, reliability, comfort, accessibility, and equality.

Despite its strategic significance, the project has encountered several obstacles during implementation, most notably, schedule delays and cost overruns. Such challenges are common in large infrastructure projects, often caused by ineffective planning, resource mismanagement, poor coordination, and unforeseen technical complexities. These issues undermine the project's economic viability, disrupt public trust, and delay the benefits intended for the community. Therefore, an urgent need is to adopt more efficient project management approaches that address both timeliness and cost performance.

One promising method increasingly adopted in the global construction industry is Lean Construction. Derived from lean manufacturing principles, Lean Construction Management (LCM) seeks to minimize waste across processes, whether in materials, time, labor, or equipment, and maximize value for all stakeholders. The approach emphasizes streamlined workflows, continuous improvement, proactive planning, and efficient communication among project participants. While its application has shown positive results in various countries, empirical studies on Lean Construction implementation in Indonesia's railway sector remain limited, particularly in state-led megaprojects.

Delays in construction projects are a ubiquitous challenge worldwide, with numerous studies identifying recurring factors across different countries and project types. Systematic reviews have catalogued over a hundred individual delay causes, but consistently the most cited ones include: design changes or rework, poor planning and scheduling, inadequate communication and coordination among stakeholders, material shortages or late delivery, financial constraints or delayed payments, labor shortages or low workforce productivity, and weak project management practices (Durdyev, Ismail, & Bakar, 2019; Mohammed & Bello 2022). Further, a cross-study synthesis by Ibrahim (2025) classified the top categories of delay factors in both developed and developing countries as *orders and requirements*, *experience and productivity*, *financial problems*, *planning*, and *external/management* (Ibrahim, 2025). These findings suggest that although local contexts differ, many core delay drivers are shared internationally, especially in infrastructure and large-scale projects where complexity and stakeholder multiplicity exacerbate coordination, financial, and design risks.

While the existing literature robustly outlines global delay factors and provides general mitigation strategies, several critical gaps remain, particularly in the domain of railway infrastructure and Lean Construction integration. First, *context specificity* is limited: most studies focus on buildings, roads, or bridges, and relatively few examine rail projects where factors like track interface, signaling, operational constraints, and regulatory safety requirements can dominate delay dynamics. Second, *integration of Lean Construction methods in transport infrastructure* is underexplored: although lean concepts are increasingly studied in general construction, there is a paucity of rigorous empirical studies applying lean systematically in railway mega-projects, especially in developing countries (Moradi, 2023). Third, *lack of methodological consistency and prioritization frameworks* remains problematic: many studies use descriptive lists or Relative Importance Index (RII), but fewer adopt multi-criteria decision methods like AHP to derive hierarchies of factor importance across stakeholder perspectives. Finally, *limited case breadth and generalizability* is common—many works are based on a single project or region, reducing transferability of findings to other contexts. Addressing these gaps in your research not only strengthens its novelty but contributes to filling an underdeveloped intersection of lean, decision analysis, and railway infrastructure delay control.

This research addresses this gap by examining how Lean Construction principles can mitigate delays and reduce unnecessary costs in complex railway infrastructure projects. Specifically, the study focuses on the Manggarai–Jatinegara Railway Facilities Development

Project (Package A, Phase II, Mainline I). This study aims to identify the key factors contributing to project delays and cost overruns in the Manggarai Station development, and to formulate effective strategies and practical steps to overcome these challenges through implementing Lean Construction principles.

2. Method

This study adopts a qualitative case study approach complemented by quantitative data analysis to explore factors contributing to project delays and cost inefficiencies, and to evaluate the potential of Lean Construction practices in mitigating these issues. The case study methodology is appropriate for an in-depth examination of complex, context-dependent phenomena within the real-life setting of a large infrastructure project.

The research was conducted at the Jl at the Manggarai–Jatinegara Railway Facilities Development Project (Package A, Phase II, Mainline I). Manggarai Utara, RW.1, Manggarai, Tebet Subdistrict, South Jakarta City, Special Capital Region of Jakarta 12850, Indonesia. This project represents a critical component of Indonesia's efforts to modernize its railway infrastructure and enhance multimodal connectivity within the Jakarta metropolitan area. The site was selected due to its strategic significance and documented challenges with project delays.

Figure 1. Research Location

3. Result

The identification process of delays in the Manggarai–Jatinegara Railway Facilities Development Project (Package A, Phase II, Mainline I) is outlined as follows:

1. Progress advancement not aligned with the project schedule
2. Delays in Specific Work Items
3. Contract Modifications and Work Addendums

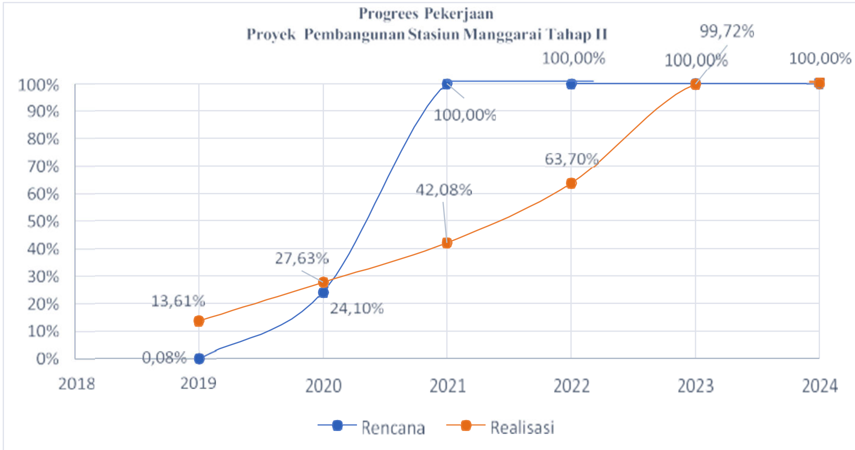

Figure 2. Construction Work Progress

Tabel 1. Chronology of Contract and Work Addenda

No.	Contract/ Addendum	Contract/Addendum Number	Date	Description
1	Contract	001/P1/BTPWJB/X/2019	11 October 2019	Original contract agreement
2	Addendum 1	Addendum 1	03 January 2020	Balance budget adjustment
3	Addendum 2	Addendum 2	30 July 2020	Change of Commitment Officer
4	Addendum 3	Addendum 3	23 July 2021	Contract value increased by 109.5%. Extension of project duration
5	Addendum 4	Addendum 4	19 November 2021	Balance budget
6	Addendum 5	Addendum 5	15 July 2022	Change in VAT from 10% to 11%
7	Addendum 6	Addendum 6	14 November 2022	Extension of project duration
8	Addendum 7	Addendum 7	27 April 2023	Change of Commitment Officer
9	Addendum 8	Addendum 8	11 August 2023	Change of KSO (Joint Operation) power of attorney
10	Addendum 9	Addendum 9	18 September 2023	Balance budget adjustment
11	Addendum 10	Addendum 10	13 December 2023	Final CCO (Construction Change Order) and extension of project implementation
12	Addendum 11	Addendum 11	29 December 2023	Extension of project duration
13	Addendum 12	Addendum 12	26 January 2024	Change of KSO power of attorney

4. Discussion

The identification of delays aims to determine the factors that most significantly impact the project timeline. In this study, data collection was conducted through interviews with key project stakeholders. The results of these interviews are summarized in the following table:

Table 2. Top Factors Contributing to Project Delays Based on Respondent Feedback

No.	Scope	Code	Delay data identification	Frequency
1	Late transfer of the construction site	A1	Uncertainty in the Finalization of Building Location	83
2		A2	Land Ownership Disputes Impeding Construction Activities	84

No.	Scope	Code	Delay data identification	Frequency
3		A3	Site Unavailability Due to Third-Party Occupation	89
4	Design review	B1	Lack of Detailed Engineering Design (DED) Documentation	85
5		B5	Design Drawings Misaligned with Operational Train Patterns	84

Table 3. Top Respondent-Reported Factors Contributing to Construction Cost Overruns

No.	Scope	Code	Delay data identification	Frequency
1	Changes in Project Scope	A1	Contract Amendments and Work Addenda	81
2		A3	Complex and Lengthy Bureaucratic Procedures	81
3	Materials, Labor, and Equipment Availability	B3	Equipment and Workforce Damage or Deficiencies	82
4		B5	Mismanagement of Materials, Labor, and Equipment	87
5	Interference from External Parties	D10	Theft of Materials and Equipment	80

The interview data were analyzed using the Analytic Hierarchy Process (AHP) to determine the weighting of work items, as shown below:

Table 4. Weighting of Delay Factors

	A1	A2	A3	B1	B5	Weight	Priority Vector	Matrix × Priority Vector	Consistency
A1	0.06	0.13	0.24	0.05	0.30	0.782	0.156	3.849	4.923
A2	0.10	0.08	0.08	0.20	0.20	0.662	0.132	3.849	5.814
A3	0.34	0.14	0.04	0.47	0.32	1.318	0.264	3.849	2.920
B1	0.04	0.26	0.31	0.07	0.14	0.818	0.164	3.849	4.707
B5	0.45	0.39	0.33	0.22	0.04	1.420	0.284	3.849	2.711

Table 5. Weighting of Factors Contributing to Construction Cost Overruns

	A1	A3	B3	B5	D10	Weight	Priority Vector	Matrix × Priority Vector	Consistency
A1	0.04	0.37	0.22	0.26	0.13	1.025	0.205	5.160	5.034
A3	0.38	0.04	0.08	0.31	0.27	1.083	0.217	5.160	4.766
B3	0.17	0.06	0.05	0.26	0.27	0.823	0.165	5.160	6.272
B5	0.32	0.36	0.41	0.03	0.26	1.380	0.276	5.160	3.739
D10	0.09	0.17	0.23	0.14	0.07	0.689	0.138	5.160	7.485

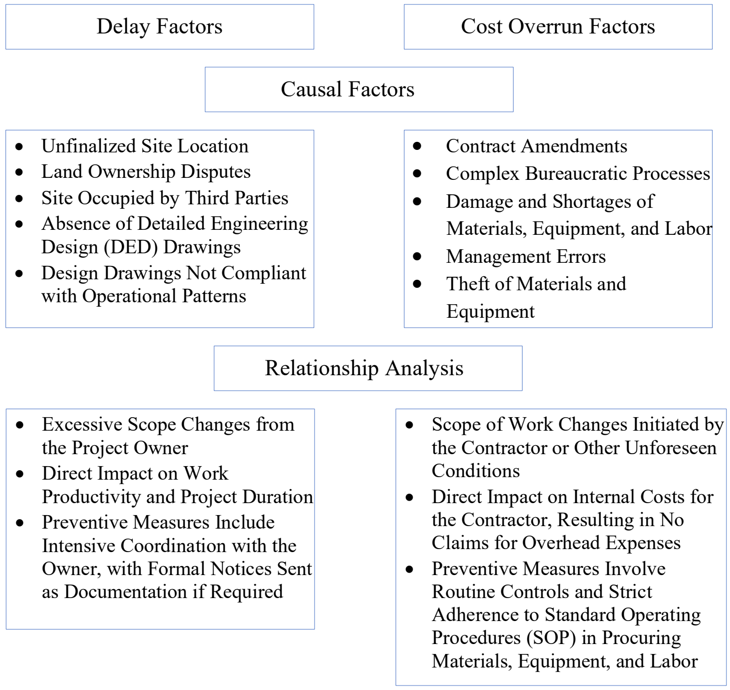

Figure 4. Relationship Between Project Delays and Construction Cost Overruns

Based on the data, a detailed discussion of the relationship between cost overruns and implementing Lean Construction or project management approaches to reduce resource waste, time delays, material wastage, and labor inefficiencies is necessary. In this context, the Lean Construction approach is linked to specific conditions such as waiting, unnecessary inventory, unnecessary motion, overproduction, and inappropriate processing. This assessment aims to identify appropriate actions or targets to address the issues encountered during the construction project execution. Each respondent evaluated the criteria based on perceived conditions, and the assessment results are presented as follows:

Table 6. Assessment of Lean Construction Approach

No.	Scope of Cost Overruns	Identification of Cost Overruns																								
		Waiting (e.g., waiting for work orders, drawings, materials, or site readiness)					Unnecessary Inventory					Unnecessary Motion					Over Production					Inappropriate Processing				
		R1	R2	R3	R4	R5	R1	R2	R3	R4	R5	R1	R2	R3	R4	R5	R1	R2	R3	R4	R5	R1	R2	R3	R4	R5
1	Contract Modifications and Work Addenda	5	5	4	4	4	1	2	1	4	2	2	5	2	5	1	3	2	3	1	4	1	4	5	2	2
2	Complex Bureaucratic Procedures	5	5	5	5	5	4	3	5	4	2	5	5	4	4	5	3	5	2	5	1	5	2	5	2	5
3	Damage and Shortage of Equipment and Labor	3	4	3	3	2	5	5	4	3	5	4	4	3	5	2	4	2	1	5	1	5	4	5	3	3
4	Mismanagement of Materials, Labor, and Equipment	5	4	5	4	4	5	4	5	5	5	4	1	4	5	5	5	4	5	5	3	3	5	5	2	3
5	Theft of Materials and Equipment	4	3	5	3	4	5	3	3	4	4	4	5	2	5	2	5	3	3	2	5	5	2	2	3	4
		22	21	22	19	19	20	17	18	20	18	19	20	15	24	15	20	16	14	18	14	19	17	22	12	17
		20.6					18.6					18.6					16.4					17.4				

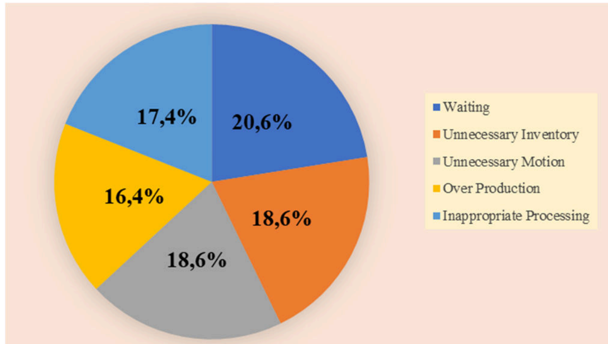

Figure 5. Graph of Lean Construction Approach to Reduce Construction Cost Overruns

Several strategies aligned with Lean Construction principles can be implemented to mitigate cost overruns during construction.

1. In the event of contract modifications or work addenda arising from unforeseen conditions, the following actions are recommended:
a. Communicate clearly and promptly with the project owner to provide information and clarify the resolution of emerging issues.
b. Inform the project owner of the potential impacts resulting from the changes, particularly in terms of time, cost, and resource allocation.
c. Ensure all modifications are formalized through legal documentation to maintain contractual transparency and accountability.
d. Provide protection measures if construction work cannot be completed due to scope changes.

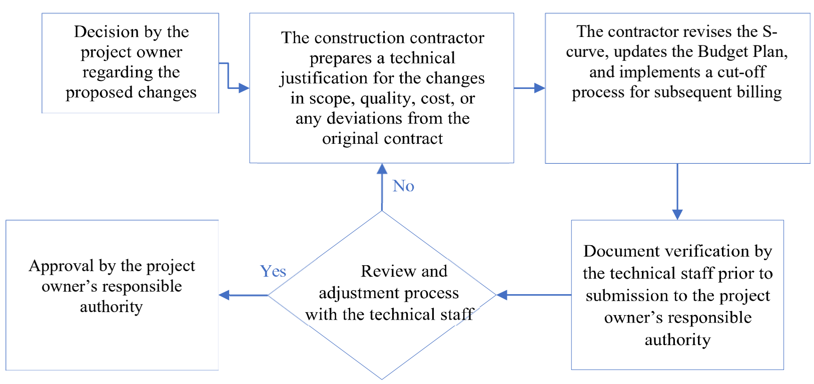

Figure 6. Stages or Steps for Legalizing Work Change Requests

For example, protecting railway utilities prevents issues in train operations. This action avoids damage in subsequent work stages.

2. Damage to equipment can be anticipated by:
   a. Reorganizing equipment after use and conducting handover of the used equipment

b. Conducting equipment inspection before use
c. Performing maintenance on the equipment used

3. Errors in managing materials, equipment, and labor will affect daily work productivity. The following efforts can be made to address this:
   a. Material and equipment procurement cycle
   b. Inspection of Incoming Materials
   c. Request form for material release from the warehouse
   d. Implementing security measures at the construction site, supported by deploying security personnel
   e. Installing perimeter fencing around the construction site
   f. Collaborating with local authorities in the event of civil disturbances to prevent worker injuries and the loss of materials or equipment.

Based on the empirical analysis, suppose that *waiting (time delays due to approvals, dependencies, information lag)* emerges as the highest weighted factor of delay, followed by *design rework / misalignment*. This finding resonates strongly with Lean Construction theory, which emphasizes that Waiting and Defects / Rework are two principal forms of *waste* (muda) that must be eliminated to maintain continuous flow (Womack & Jones, 1996). In the lean framework, waiting occurs when a process cannot proceed because of missing inputs or delayed decisions, and defects require rework that consumes time and resources without adding value (Womack & Jones, 1996). Thus, if waiting carries a higher weight in your results, it underscores that interventions aimed at reducing decision lag, streamlining approvals, and improving coordination may yield greater delay reduction than focusing solely on design correctness.

Furthermore, when the organizational or managerial factor (e.g. coordination, planning) is among the top-rated causes in your results, that aligns with broader findings in infrastructure and transport studies, which often highlight that poor project management is a root cause of delays (e.g. planning failures, poor supervision). In complex railway infrastructure contexts, project management weaknesses are magnified because of interdependencies across technical systems, multiple stakeholders, and regulatory requirements.

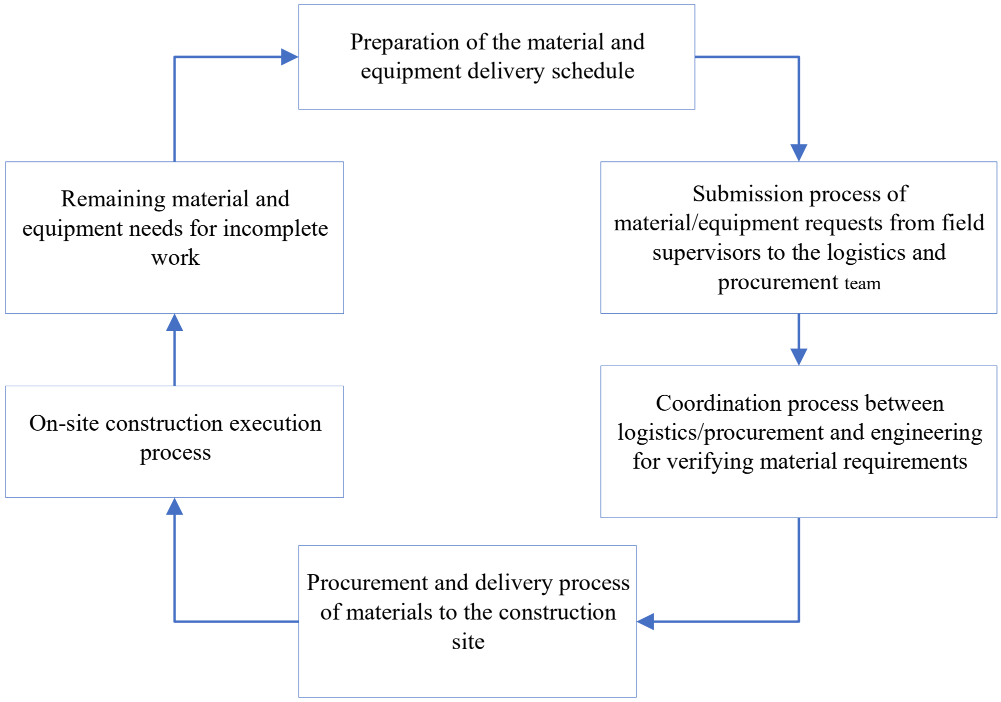

Figure 10. Material and Equipment Procurement Cycle

Importantly, in railway systems delays do not isolate locally but propagate across the network. Dekker et al. (2021) introduced a model of railway delay propagation using a diffusion-like process, showing that disruptions spread through adjacent nodes and links, amplifying the effects of initial delays (Dekker, Medvedev, Rombouts, Siudem, & Tupikina, 2021). This theory of delay propagation implies that even small internal delays (e.g. from waiting or rework) may cascade into broader disruptions across the railway network. Moreover, research into cascading mechanisms in transport networks indicates that interdependent operational elements (resources, schedules, train services) can trigger cascade amplification: local delays become systemic due to reuse of delayed resources for subsequent operations (Dekker & Panja, 2021). That means the factors your study identifies—if not mitigated—can lead to cascading effects far beyond their point of origin.

Given this theoretical backdrop, your empirical findings suggest that the prioritized mitigation strategies should focus first on reducing waiting time and decision latency, alongside improving early design coordination to minimize defects. However, because railway systems are susceptible to delay propagation, mitigation must also incorporate buffer strategies, modular scheduling, and risk containment to prevent cascade effects. In short, Lean interventions must be complemented by network-aware strategies to manage systemic delay spread in the railway domain.

5. Conclusion

This study concludes that delays and cost overruns in the Manggarai–Jatinegara Railway Facilities Development Project (Package A, Phase II, Mainline I) are primarily driven by unresolved site issues, land disputes, occupation by third parties, lack of Detailed Engineering Design (DED), and design drawings misaligned with operational requirements. In terms of cost overruns, the dominant factors identified include frequent contract modifications, lengthy bureaucratic procedures, equipment shortages or breakdowns, mismanagement of resources, and theft of construction materials. The Analytic Hierarchy Process (AHP) results indicate that "waiting"—defined as delays caused by pending instructions, approvals, or information—was the most critical form of waste, followed closely by design-related inefficiencies. These findings validate the study's initial hypothesis that Lean Construction can serve as an effective framework for mitigating delay and cost overrun in complex railway megaprojects.

From a theoretical perspective, this research contributes to the body of knowledge by integrating AHP with Lean Construction principles to systematically prioritize delay and cost factors in a developing-country context. Practically, it offers project managers and policymakers actionable strategies, such as improving approval workflows, strengthening early design coordination, and implementing preventive measures in procurement and site security, all of which directly address the identified waste categories. However, this study is limited by the relatively small number of respondents and the focus on a single case, which restricts the generalizability of the findings. Future research should therefore explore comparative studies across multiple railway or infrastructure projects, expand respondent diversity, and develop a more comprehensive Lean-based model tailored to the challenges of state-led megaprojects in emerging economies.

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