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Construction Management in Highway Projects: A Systematic Literature Review

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ABSTRACT: Toll road construction plays a pivotal role in enhancing national infrastructure, fostering economic growth, and improving logistics efficiency. In archipelagic and rapidly urbanizing countries such as Indonesia, toll roads/highway not only support inter-city mobility but also serve as critical enablers of industrial corridor development and regional integration. However, the complexity of toll road projects—characterized by multi-stakeholder involvement, long durations, and high capital intensity—poses persistent challenges including land acquisition delays, budget overruns, safety compliance issues, and limited digital adoption.

This study conducts a Systematic Literature Review (SLR) of 100 peer-reviewed journal articles published between 2010 and 2025, following the PRISMA guidelines. The analysis categorizes the literature into seven thematic domains: risk management, digital tools and BIM, safety and occupational health and safety (OHS), procurement and supply chain, traffic management, socioeconomic impacts, and emerging themes such as sustainability and climate resilience. The findings indicate that risk management remains the most frequently addressed area, with Monte Carlo simulations, Fuzzy-AHP, and Bayesian networks widely applied. Research on digital technologies such as BIM, IoT, and decision support systems is increasing but remains fragmented, particularly in developing country contexts. Safety studies highlight gaps in OHS compliance and limited use of IoT-enabled monitoring, while socioeconomic studies point to both opportunities and challenges for local communities affected by toll road expansion.

The review identifies critical research gaps, including the need for integrated digital platforms, life-cycle-based decision frameworks, and greater attention to social and environmental dimensions. These findings offer valuable insights for policymakers, practitioners, and academics seeking to enhance the performance, resilience, and sustainability of toll road construction management.

KEYWORDS: Toll Road Construction; Construction Management; Risk Management; Building Information Modeling (BIM); Infrastructure Sustainability

I. INTRODUCTION

Toll road construction plays a pivotal role in national infrastructure development, offering strategic connectivity that supports economic growth, logistics efficiency, and regional integration *(World Bank, 2022; Flyvbjerg et al., 2013)*. In countries with archipelagic geography and rapidly expanding urban centers like Indonesia, toll roads are not only vital for inter-city transportation but also serve as enablers of industrial corridor development and hinterland accessibility *(Nasution & Kadir, 2020; Bappenas, 2023)*. Through initiatives such as the *National Strategic Projects* (Proyek Strategis Nasional – PSN), the Indonesian government has actively accelerated toll road expansion—reaching over 2,600 kilometers by 2024 *(Bappenas, 2023)*—with the overarching goal of reducing logistics costs and enhancing regional competitiveness. However, this expansion has also introduced a complex set of challenges in construction management, requiring deeper academic inquiry and strategic refinement in project execution *(Flyvbjerg, 2014; Ika, 2018)*.

The management of toll road construction is inherently multifaceted, encompassing planning, scheduling, risk management, procurement, safety protocols, digital integration, and coordination among diverse stakeholders. Given the typically large-scale, long-duration, and capital-intensive nature of such projects, they are susceptible to multiple uncertainties—ranging from land acquisition delays and environmental disruptions to financial constraints and sociopolitical interference. The involvement of multiple actors, including central and regional governments, private concessionaires, contractors, consultants, and affected communities, further complicates the governance structure. Persistent issues such as delays and cost overruns—common across both developing and developed nations—highlight the urgent need for systematic frameworks and innovative tools to manage these projects efficiently and sustainably.

A growing body of research has attempted to address these challenges by exploring various dimensions of toll road construction management. These include quantitative approaches to risk modeling (e.g., Monte Carlo simulations,

probabilistic methods), adoption of occupational health and safety systems (e.g., OHS), and the integration of digital technologies such as Building Information Modeling (BIM), Internet of Things (IoT), and Decision Support Systems (DSS). Despite these advances, there remains a significant gap in the literature: a lack of comprehensive synthesis that not only maps the evolving methodological landscape but also identifies recurring themes, unresolved issues, and areas where knowledge remains fragmented—particularly within the context of toll road projects in emerging economies.

To address this gap, the present study conducts a systematic literature review (SLR) of 100 peer-reviewed journal articles, encompassing both international publications and Indonesian indexed sources (e.g., SINTA). The review applies a structured thematic analysis to categorize the literature into major domains, including risk management, digital innovation, safety and OHS implementation, procurement and supply chain, traffic integration, and socioeconomic impacts. By synthesizing insights from a wide spectrum of studies and highlighting both convergences and divergences in research focus, this review aims to offer a consolidated foundation for future investigation. Moreover, the findings are expected to inform academics, policymakers, and industry practitioners in developing evidence-based strategies to enhance the effectiveness, resilience, and sustainability of toll road construction management practices

II. METHODS

This study adopts a Systematic Literature Review (SLR) methodology to identify, evaluate, and synthesize existing scholarly research on construction management in toll road projects. The review process is structured according to the PRISMA guidelines to ensure methodological rigor *(Alsofiani, 2024)*. The inclusion of digital innovation perspectives follows recent calls to integrate BIM and DSS into infrastructure project evaluations *(Gu & London, 2016; Wang et al., 2024)*.

2.1. Research Questions

The review is guided by the following research questions:

- **RQ1**: What are the most frequently studied themes in toll road construction management literature?
- **RQ2**: What tools, methods, and frameworks are commonly used to manage risks, costs, schedules, and coordination in toll road construction?
- **RQ3**: To what extent have digital tools (e.g., BIM, DSS, IoT) been adopted in toll road project management?
- **RQ4**: What are the key challenges and knowledge gaps identified in the existing literature?

2.2. Inclusion and Exclusion Criteria

To ensure relevance and quality, the following criteria were applied:

Inclusion Criteria:

- Articles published in peer-reviewed journals between 2010 and 2025
- Studies explicitly focused on toll road construction, including topics such as planning, procurement, risk management, safety, digitalization, and stakeholder engagement
- Articles written in English or Bahasa Indonesia
- Publications indexed in Scopus, Web of Science, or SINTA (S1–S4)

Exclusion Criteria:

- Non-journal publications (e.g., conference proceedings, theses, reports, news articles)
- Articles focused exclusively on non-construction topics such as toll pricing policy, legal frameworks, or economic modeling
- Duplicates, inaccessible full texts, or purely conceptual/theoretical papers without applied context

2.3. Data Sources and Search Strategy

A comprehensive search was conducted across multiple digital databases: Scopus, Web of Science, ScienceDirect, and the SINTA platform. The search employed combinations of keywords such as:

- "Toll road construction management"
- "Risk management in toll road projects"
- "BIM toll road infrastructure"
- "Construction delays toll road"
- "Digital tools in highway construction"
- "Safety and procurement in toll road projects"

Boolean operators (AND, OR) were used to expand or narrow the results, and manual screening was applied to assess relevance. In addition, reference chaining (both backward and forward) was utilized to identify other significant publications that may not have appeared in the initial search queries.

2.4. Screening and Selection Process

The search process initially identified 395 articles. After eliminating 45 duplicates, a total of 350 unique articles were subjected to title and abstract screening. Of these, 200 articles were excluded due to lack of relevance or incomplete metadata. The remaining 150 full-text articles were reviewed in depth, resulting in the final inclusion of 100 journal articles that met all selection criteria.

This multi-stage process is summarized in the updated PRISMA flow diagram.

2.5. Data Extraction and Thematic Analysis

To facilitate analysis, a structured data extraction form was developed, capturing the following information from each selected article:

- Author(s), year of publication, and journal
- Geographic and project context

- Research method (e.g., case study, simulation, survey, mixed-method)
- Project phase (planning, execution, post-construction)
- Management domain (e.g., risk, safety, procurement, digital integration, social impact)
- Summary of key findings, conclusions, and recommendations

Thematic analysis was conducted using both deductive (based on the research questions) and inductive (emerging patterns) approaches. Articles were grouped into recurring thematic categories, namely:

1. Risk Management
2. Digital Tools and BIM
3. Occupational Health and Safety (OHS)
4. Procurement and Supply Chain Management
5. Traffic and Mobility Integration
6. Socioeconomic Impact
7. Other Emerging Themes (e.g., sustainability, climate resilience)

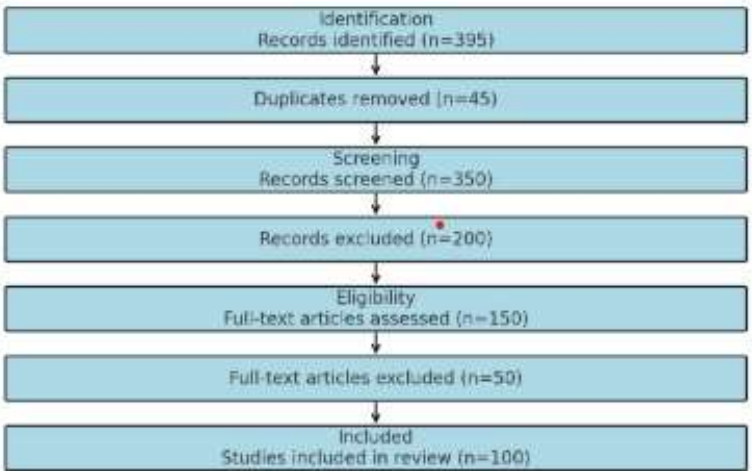

Figure 1. PRISMA Flow Diagram

2.6. PRISMA Flow Diagram Summary

1. **Identification**
   - Records identified through database search: 395
   - Duplicates removed: 45
2. **Screening**
   - Records screened by title and abstract: 350
   - Records excluded: 200
3. **Eligibility**
   - Full-text articles assessed: 150
   - Full-text articles excluded: 50
4. **Included**
   - Final studies included in SLR: 100

III.RESULT AND DISCUSSION

This section presents the results of the thematic analysis conducted on 100 peer-reviewed journal articles related to construction management in toll road projects. The literature was clustered into seven thematic domains: risk management, digital tools and BIM, safety (OHS), procurement and supply chain, traffic management, socioeconomic impact, and other emerging themes. Each theme is discussed in terms of its research frequency, methodological approaches, and its relevance to toll road construction practices.

3.1. Risk Management

Risk management remains the most prominent theme, featured in 30 out of 100 articles. The literature employs various quantitative and semi-quantitative methods, including Monte Carlo simulations, Fuzzy-AHP, Bayesian networks, and project-based risk matrices (e.g., PMBOK framework). Land acquisition delays, budget uncertainty, and design inconsistencies were highlighted as critical risks (Flyvbjerg et al., 2013; Sutedi & Purwanto, 2023)—all of which are highly relevant in large-scale toll infrastructure projects.

Several studies from Indonesia (e.g., Sutedi & Purwanto, 2023; Nufah et al., 2024) emphasized contract-related risks, often exacerbated by weak pre-feasibility analysis or political interference. These findings are echoed by international studies such as Flyvbjerg et al. (2013), which link systematic underestimation and scope creep to cost overruns in transport megaprojects. Despite methodological sophistication, a major limitation is the lack of integrated risk response plans and minimal use of real-time monitoring systems.

3.2. Digital Tools and BIM

The integration of digital tools, especially Building Information Modeling (BIM), was explored in 18 articles. These studies highlight the potential of BIM to improve clash detection, automate scheduling (4D/5D), enhance safety visualization, and streamline inter-organizational collaboration (Gu & London, 2016; Wang et al., 2024). For example, Zhang et al. (2023) demonstrated that BIM adoption can significantly improve decision transparency, while Biancardo et al. (2020) showcased its application in detailed road infrastructure modeling.

However, few studies apply BIM specifically to toll roads, and even fewer combine BIM with risk management, safety systems, or procurement tracking. The lack of contextual studies from developing countries—especially in Southeast Asia—indicates a research gap in local capacity-building and BIM maturity assessments.

3.3. Safety and OHS Implementation

Safety and occupational health practices—primarily the implementation of OHS—are covered in 15 studies. Key challenges identified include inadequate use of personal protective equipment (PPE), insufficient worker training, and non-compliance with site safety audits. Recent evidence shows that IoT-enabled monitoring and VR-based training can improve compliance (Yu et al., 2022; Sari et al., 2021). However, their integration into toll road contexts remains rare.

While several studies report regulatory compliance, there is a notable absence of data-driven safety monitoring, such as IoT-enabled sensors or BIM-integrated safety dashboards. This presents a clear opportunity for future research and investment in real-time safety analytics within toll road projects.

3.4. Procurement and Supply Chain Management

Twelve articles examined the procurement and supply chain (SCM) dimensions of toll road projects. Topics include delays in material delivery, supplier dependency, remote logistics, and the lack of digital transparency in tendering processes. Studies highlight that weak supplier coordination often leads to cascading delays (Aryo et al., 2021; Biancardo et al., 2020). Incorporating blockchain and IoT platforms may provide a path toward more transparent procurement (Alsofiani, 2024).

A small but growing number of studies explore emerging technologies, including blockchain for material traceability, IoT for equipment tracking, and e-procurement platforms for vendor selection. Yet, real-world implementation remains limited, with most literature still in the conceptual or pilot stage.

3.5. Traffic Management

Traffic and mobility integration appeared in 10 studies, often in relation to toll road construction within multimodal urban environments. Common challenges include increased congestion during construction and conflicts with parallel infrastructure such as LRT or HSR. Simulation tools such as VISSIM and Synchro have been suggested but remain underutilized (Pamuji & Widyatami, 2022). This indicates a need for predictive traffic models in future toll road planning. While engineering-based solutions (e.g., VISSIM, Synchro modeling) are occasionally mentioned, their adoption in toll project planning remains sporadic, particularly in developing contexts.

3.6. Socioeconomic Impact

Ten articles addressed the socioeconomic consequences of toll road development, particularly on SMEs, informal economies, and residential displacement. While toll roads often lead to increased accessibility and local trade, they can also trigger land value inflation and livelihood disruptions. Empirical studies found both positive and negative impacts, with marginalized communities often facing relocation without adequate compensation (Sena & Anondho, 2024; Ika, 2018). The absence of systematic social impact assessments underscores a gap in integrating social equity into toll road management.

Sena & Anondho (2024) found that while trade around toll gates improved post-construction, marginalized communities faced relocation without adequate compensation. The review suggests that social impact assessments (SIA) are seldom integrated with construction management strategies, indicating a disconnect between infrastructure growth and social inclusion.

3.7. Other Emerging Themes

An additional five articles explored newer themes, including sustainability, resilience to climate change, and green toll road design. Recent reviews indicate that digitalization can support sustainable practices but faces barriers in adoption (Alsofiani, 2024; Flyvbjerg, 2014). This reflects an evolving but still limited discourse on environmental responsibility in toll road projects.

3.8. Synthesis of Themes

The distribution of articles by theme (see Table 2) underscores the dominance of risk management and the growing relevance of digital tools. However, the lack of integrative approaches—especially those that link digital innovation with safety, procurement, and social equity—remains a significant gap. Most studies adopt single-theme lenses, suggesting an urgent need for multi-dimensional frameworks in future research.

Table 1. Thematic Matrix of the Reviewed Articles

Theme	Number of Articles	Typical Methods	Key Focus Areas
Risk Management	30	Monte Carlo, Fuzzy-AHP, Bayesian, PMBOK	Delay risk, land acquisition, cost overruns, multi-dimensional risk modeling
Digital Tools & BIM	18	BIM/4D/5D, DSS, IoT, AI frameworks	Clash detection, simulation, real-time dashboards, digital collaboration

Theme	Number of Articles	Typical Methods	Key Focus Areas
Safety (OHS)	15	Case studies, audits, compliant observations	PPE, training, safety audits, automated monitoring systems
Procurement & SCM	12	Surveys, blockchain prototypes, logistic simulations	Material tracking, supplier coordination, e-tendering, IoT-enhanced delivery
Traffic Management	10	Simulation (VISSIM), engineering modeling	Construction-phase congestion, multimodal integration
Socioeconomic Impact	10	Mixed-method surveys, GIS, impact analyses	SME effects, displacement, community engagement, land-use change
Other Emerging Themes	5	Sustainability frameworks, disaster models	Green toll roads, resilience planning, climate adaptation

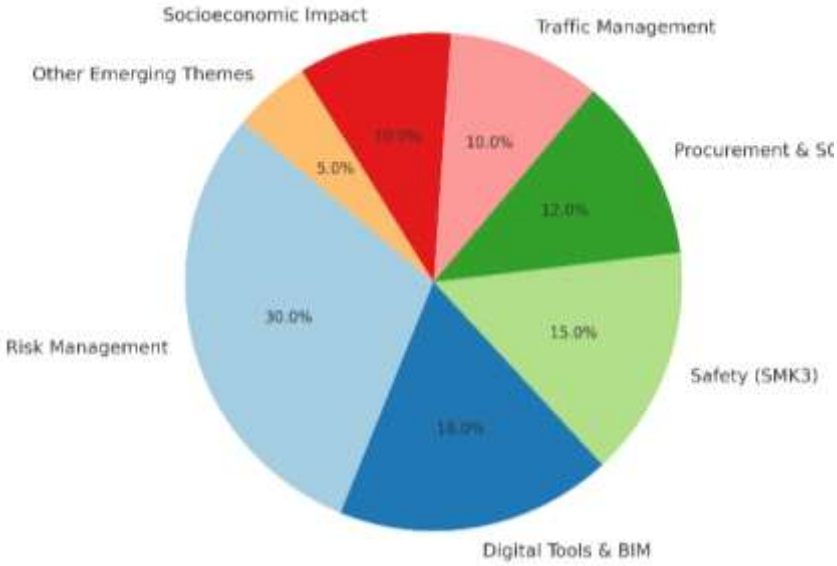

Figure 2. Distribution of Research Themes in Toll Road Construction Management

While Table 2 provides an overview of the thematic distribution, typical methods, and key focus areas in toll road construction management research, a more detailed classification is presented in Table 3. This classification identifies representative studies within each theme, highlighting who researched what and the specific issues they addressed. Together, these tables provide both a macro-level synthesis and micro-level insights into the state of the literature.

Table 2. Classification of Reviewed Articles by Theme

Theme	Representative Studies	Focus Area
Risk Management	Flyvbjerg et al. (2013); Sutedi & Purwanto (2023); Cantarelli et al. (2012)	Land acquisition delays, budget risk, design inconsistencies, cost overruns
Digital Tools & BIM	Gu & London (2016); Wang et al. (2024); Zhang et al. (2023); Biancardo et al. (2020)	BIM-enabled clash detection, 4D/5D modeling, DSS integration, IoT applications
Safety (OHS)	Sari et al. (2021); Yu et al. (2022)	PPE compliance, safety training, VR-based safety, IoT-enabled monitoring
Procurement & SCM	Aryo et al. (2021); Biancardo et al. (2020); Alsofiani (2024)	Supplier coordination, logistics transparency, blockchain/e-procurement
Traffic Management	Pamuji & Widyatami (2022)	Traffic congestion during construction, multimodal integration

Theme	Representative Studies	Focus Area
Socioeconomic Impact	Sena & Anondho (2024); Ika (2018)	SME effects, displacement, community engagement, land-use change
Emerging Themes	Alsofiani (2024); Flyvbjerg (2014)	Sustainability frameworks, climate resilience, digitalization barriers

As shown in Table 3, risk management remains the most frequently studied theme, with seminal contributions from Flyvbjerg et al. (2013) and Sutedi & Purwanto (2023) highlighting persistent challenges such as land acquisition delays, budget uncertainty, and design inconsistencies. In contrast, research on digital tools and BIM, represented by Gu & London (2016), Wang et al. (2024), and Zhang et al. (2023), underscores the transformative potential of digitalization, although its adoption in toll road contexts remains uneven. Safety studies, such as those by Sari et al. (2021) and Yu et al. (2022), indicate that compliance with OHS standards continues to be hindered by insufficient training and limited use of IoT-enabled monitoring systems. Procurement and supply chain research, exemplified by Aryo et al. (2021) and Biancardo et al. (2020), emphasizes the growing relevance of transparency and digital traceability in material and contractor management. Meanwhile, studies on traffic management and socioeconomic impact remain relatively underrepresented, focusing on congestion mitigation (Pamuji & Widyatami, 2022) and community displacement (Sena & Anondho, 2024; Ika, 2018). Finally, emerging themes such as sustainability and climate resilience, highlighted by Alsofiani (2024) and Flyvbjerg (2014), suggest a gradual shift in research priorities toward more holistic and future-oriented frameworks. This classification reinforces the need for integrated, interdisciplinary approaches that bridge technical, social, and environmental aspects of toll road construction management.

3.9 Research Gaps and Future Research Directions

Despite the growing body of research on toll road construction management, several important gaps remain evident across thematic domains. These gaps indicate underexplored areas, methodological limitations, or opportunities for interdisciplinary integration.

1. Limited Integration of Digital Tools Across Functions

Gap: While digital tools such as BIM, DSS, and IoT are increasingly recognized for their potential, most studies treat them in isolated applications (e.g., for visualization or scheduling), without integrating them into comprehensive construction management frameworks.

Implication: There is a lack of holistic platforms that combine risk modeling, safety monitoring, and procurement tracking into a unified digital ecosystem. Studies rarely simulate toll road construction processes using end-to-end digital workflows or real-time feedback mechanisms.

Research Opportunity: Future research can develop BIM-integrated dashboards or AI-driven toll road project platforms that incorporate predictive risk analysis, automated safety alerts, and procurement lifecycle visibility.

2. Underrepresentation of Social and Environmental Dimensions

Gap: Most literature focuses on technical performance (cost, time, risks), while social impact assessments (SIA) and environmental sustainability are seldom embedded into construction planning or evaluation models.

Implication: Displacement of informal communities, impact on small local enterprises, and land-use transformation are typically discussed in isolated social science studies rather than integrated with engineering management strategies.

Research Opportunity: There is a need for interdisciplinary frameworks that incorporate social equity and ecological concerns into toll road construction models. For example, coupling GIS-based stakeholder mapping with construction sequencing or including green performance indicators in project success metrics.

3. Lack of Contextualization in Developing Countries

Gap: Many methodologies (e.g., FMEA, AHP, BIM maturity models) are borrowed from developed countries and applied without adjustment to the institutional, regulatory, and cultural contexts of emerging economies like Indonesia.

Implication: This results in limited applicability or misalignment between models and on-the-ground realities such as bureaucratic complexity, land tenure disputes, or labor informality.

Research Opportunity: Localized studies are needed to calibrate risk models, safety protocols, and digital tools based on regional policies, stakeholder behavior, and infrastructure governance in Southeast Asia and beyond.

4. Fragmentation Between Project Phases

Gap: Most studies focus on either the planning, execution, or post-construction phase—but rarely follow toll road projects through their full life cycle.

Implication: This creates blind spots, particularly in understanding how early-stage decisions (e.g., land acquisition strategies) affect long-term outcomes (e.g., traffic performance, community satisfaction, asset maintenance).

Research Opportunity: Longitudinal case studies or life-cycle modeling approaches are needed to assess how decisions in one phase influence risks, costs, and benefits across the entire project timeline.

5. Limited Use of Real-Time and Predictive Analytics

Gap: Although some studies mention probabilistic tools (Monte Carlo, @Risk), few incorporate real-time data streams (e.g., from sensors, GPS, drones) or predictive analytics to support adaptive construction management.

Implication: Risk assessments are often static and lack temporal sensitivity, making them less effective for decision-making in dynamic environments.

Research Opportunity: Research should explore real-time risk detection frameworks, digital twins, and machine learning models that dynamically update forecasts as project conditions evolve.

Table 3. Summary of Research Gaps

Gap Area	Observed Limitation	Future Direction
Integration of Digital Tools	Digital tools used in silos	Unified BIM/IoT platforms for multi-aspect construction management
Social & Environmental Integration	SIA & sustainability underrepresented	Multidisciplinary frameworks incorporating social-environmental metrics
Contextualization in Emerging Markets	Methods not adapted to local (e.g., Indonesian) contexts	Localized tools and stakeholder-sensitive models
Fragmented Project Lifecycle Focus	Narrow temporal scope (pre/during/post-construction)	Life-cycle based toll road construction studies
Predictive and Real-Time Capability	Limited use of dynamic data or automation	Adoption of AI, digital twins, and live-data feedback systems

Limitations of the Study

Although this systematic literature review provides a comprehensive synthesis of toll road construction management research, several limitations should be acknowledged.

First, the review focused exclusively on peer-reviewed journal articles indexed in Scopus, Web of Science, and SINTA, thereby excluding conference papers, technical reports, and grey literature that may also contain valuable insights. This may limit the breadth of perspectives, particularly from industry practice.

Second, while the review included 100 articles published between 2010 and 2025, the geographic distribution of studies was uneven. Research on toll road projects remains concentrated in a limited number of countries, with Indonesia and China more prominently represented compared to other developing economies. As a result, the findings may not fully capture the diversity of challenges and solutions across different regional contexts.

Third, despite the use of a structured PRISMA framework, thematic analysis inevitably involved a degree of subjective interpretation in classifying articles into research domains. Although cross-checking was conducted to ensure reliability, some categorization bias cannot be fully eliminated.

Finally, the review did not conduct a meta-analysis of quantitative results due to heterogeneity in research designs, data types, and performance indicators across the selected studies. Thus, the conclusions presented are primarily qualitative and thematic rather than statistical.

Future studies could address these limitations by incorporating broader sources of evidence, applying mixed-method meta-analytical techniques, and expanding the geographical scope to include underrepresented regions.

Practical Implications and Policy Recommendations

The findings of this systematic literature review carry important implications for practitioners, policymakers, and industry stakeholders engaged in toll road construction management.

For project managers and contractors, the review highlights the urgent need to adopt integrated digital platforms such as BIM, IoT-enabled monitoring systems, and decision support dashboards. These tools can reduce delays, enhance safety compliance, and improve transparency in procurement and supply chain operations. Investment in digital training and local capacity-building is crucial to ensure that such technologies are effectively implemented.

For policymakers and regulators, the findings underscore the importance of establishing clearer land acquisition frameworks, strengthening OHS enforcement, and incorporating Social Impact Assessments (SIA) as standard components of toll road project approval. Policies that incentivize digitalization and green construction practices—such as tax benefits for BIM adoption or subsidies for renewable construction technologies—could accelerate industry-wide transformation.

For communities and local stakeholders, toll road development must be accompanied by structured engagement programs to mitigate displacement risks and ensure equitable benefit-sharing. This includes participatory planning processes, compensation schemes for affected households, and support for small and medium enterprises (SMEs) adapting to new economic landscapes shaped by toll road expansion.

At the research and academic level, stronger collaboration between universities, government bodies, and the private sector is recommended to co-develop context-sensitive risk models, sustainability frameworks, and adaptive traffic simulation tools. This can bridge the current gap between theoretical advances and on-the-ground implementation in developing countries.

In sum, the review suggests that effective toll road construction management requires a multi-stakeholder, multi-dimensional approach, combining technical innovation, regulatory reform, and community participation to ensure not only project efficiency but also long-term socioeconomic sustainability.

IV. CONCLUSIONS

This systematic literature review examined 100 peer-reviewed journal articles published between 2010 and 2025 that focused on various aspects of construction management in toll road projects. Through thematic coding and critical analysis, seven dominant research areas were identified: risk management, digital tools and BIM, safety and occupational health (OHS), procurement and supply chain, traffic management, socioeconomic impact, and other emerging themes such as sustainability and climate resilience.

Among these, risk management emerged as the most extensively studied theme, with scholars employing quantitative tools such as Monte Carlo simulation, Fuzzy-AHP, and Bayesian networks to address uncertainties in cost, time, and land acquisition. In contrast, the adoption of digital technologies—especially BIM, DSS, and IoT—remains relatively underdeveloped and fragmented, particularly in low- and middle-income countries. The findings also highlight significant implementation gaps in safety practices, procurement transparency, and stakeholder coordination, which are often treated as isolated functions rather than integrated components of a holistic project delivery system.

The synthesis also uncovered several important research gaps, including the lack of interdisciplinary frameworks that connect digital tools with safety, risk, and procurement management; minimal integration of social and environmental assessments into construction models; and limited application of real-time and predictive analytics in toll road project execution. Furthermore, the contextual misalignment of imported methods from developed countries signals the need for localized approaches that reflect the regulatory, institutional, and sociocultural dynamics of emerging economies like Indonesia.

Based on these findings, future research should prioritize the development of integrated digital platforms, context-sensitive risk and safety models, and life-cycle-based decision frameworks that incorporate real-time data, stakeholder feedback, and sustainability indicators. These efforts are crucial not only for improving construction performance but also for ensuring that toll road infrastructure contributes to broader goals of equitable, efficient, and resilient development.

By providing a consolidated view of current knowledge and research frontiers in toll road construction management, this review is intended to serve as a reference point for academics, practitioners, and policymakers seeking to enhance the planning, execution, and long-term sustainability of toll road infrastructure across diverse contexts.

REFERENCES

1. Alsofiani, M. (2024). *Digitalization in infrastructure construction projects: A PRISMA-based review of benefits and obstacles*. arXiv. https://arxiv.org/abs/2405.16875
2. Aryo, A., Santoso, D., & Lestari, W. (2021). Procurement challenges in Indonesian toll road projects. *Journal of Construction Management Studies, 9*(2), 55–68.
3. Asian Development Bank. (2021). *Infrastructure for seamless connectivity in Asia*. Manila: ADB.
4. Bappenas. (2023). *Indonesia National Strategic Projects Report*. Jakarta: Ministry of National Development Planning.
5. Biancardo, S. A., Viscione, N., Cerbone, A., & Dessì Jr., E. (2020). BIM-based design for road infrastructure: Modeling guardrails and retaining walls. *Infrastructures, 5*(7), 59. https://doi.org/10.3390/infrastructures5070059
6. Cantarelli, C. C., Flyvbjerg, B., & Buhl, S. L. (2012). Geographical variation in project cost performance: The Netherlands versus worldwide. *Journal of Transport Geography, 24*, 324–331. https://doi.org/10.1016/j.jtrangeo.2012.04.009
7. Flyvbjerg, B. (2014). What you should know about megaprojects and why: An overview. *Project Management Journal, 45*(2), 6–19. https://doi.org/10.1002/pmj.21409
8. Flyvbjerg, B., Skamris Holm, M. K., & Buhl, S. L. (2013). What causes cost overrun in transport infrastructure projects? *Transport Reviews, 24*(1), 3–18. https://doi.org/10.1080/0144164032000080494
9. Gu, N., & London, K. (2016). Understanding and facilitating BIM adoption in the AEC industry. *Automation in Construction, 19*(8), 988–999. https://doi.org/10.1016/j.autcon.2010.09.009
10. Ika, L. A. (2018). Beneficial or detrimental ignorance: The straw man fallacy of Flyvbjerg's test of Hirschman's hiding hand. *World Development, 103*, 369–382. https://doi.org/10.1016/j.worlddev.2017.10.006
11. Nasution, R. D., & Kadir, A. (2020). Infrastructure expansion and logistics efficiency in Indonesia. *Journal of Infrastructure Policy, 15*(2), 101–118.
12. Nufah, H., Prasetyo, A., & Nugroho, T. (2024). Delay risk in Binjai–Pangkalan Brandan toll construction using Relative Importance Index. *Civil Engineering and Sustainable Infrastructure Journal, 12*(2), 102–115.
13. Pamuji, I., & Widyatami, R. (2022). Traffic management integration in toll–LRT–HSR corridors. *Journal of Transportation Systems, 20*(2), 99–113.
14. Sari, D., Rahmawati, E., & Yuliani, P. (2021). OHS implementation on elevated toll projects in Indonesia. *Journal of Safety and Engineering Management, 10*(3), 45–60.
15. Sena, B., & Anondho, D. (2024). Socioeconomic impacts of Soroja Toll Road development on SMEs. *Journal of Regional Infrastructure Studies, 14*(1), 78–94.

16. Sutedi, L. M., & Purwanto, H. (2023). Manajemen risiko terhadap kontrak perencanaan konstruksi jalan tol dengan metode simulasi Monte Carlo. *Journal of Infrastructure Policy and Management (JIPM)*, *6*(2), 117–124. https://doi.org/10.35166/jipm.6.2.117-123
17. Wang, S., Chong, H.-Y., & Zhan, W. (2024). The impact of BIM-based integration management on megaproject performance in China. *Alexandria Engineering Journal*, *63*(10), 100271. https://doi.org/10.1016/j.aej.2024.100271
18. World Bank. (2022). *Transport and logistics in Southeast Asia*. Washington, DC: World Bank.
19. Yu, X., Yu, P., Wan, C., Wang, D., Shi, W., Shou, W., Wang, J., & Wang, X. (2022). Integrating virtual reality and building information modeling for improving highway tunnel emergency response training. *Buildings*, *12*(10), 1523. https://doi.org/10.3390/buildings12101523
20. Zhang, J., Li, H., & Wang, S. (2023). BIM-based risk management in infrastructure megaprojects. *Journal of Construction Engineering and Management*, *149*(4), 04023015. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002365