*Proceedings of the 35th European Safety and Reliability & the 33rd Society for Risk Analysis Europe Conference*
*Edited by* Eirik Bjorheim Abrahamsen, Terje Aven, Frederic Bouder, Roger Flage, Marja Ylönen
 *Published by* Research Publishing, Singapore.
doi: 10.3850/978-981-94-3281-3_ESREL-SRA-E2025-P2439-cd

# Challenges and research directions in multi-project, multi-actor infrastructure construction management

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Infrastructure construction programs are often highly complex due to the involvement of multiple projects and actors. The presence of multiple projects introduces interdependencies that necessitate the coordination of schedules, resources, and priorities, as well as the implementation of risk management strategies. Simultaneously, the involvement of multiple actors gives rise to power dynamics, challenges in communication and engagement, and competing interests that must be effectively managed. A systematic literature review is conducted to explore how the challenges associated with managing multiple projects and multiple actors are addressed within the field of infrastructure construction management. Key themes, strengths, and limitations within the literature are identified. Based on this analysis, critical research gaps are outlined, and potential directions for future research are proposed. The main findings highlight six key gaps that may serve as a foundation for future investigations aimed at enhancing the management of infrastructure construction programs.

*Keywords*: Infrastructure construction programs, multiple stakeholders, multiple projects, interdependencies, decision-making, construction management, risk management.

## 1. Introduction

Large infrastructures are essential to society, requiring both the construction of new facilities and the maintenance of existing ones to ensure reliability and safety. However, infrastructure construction involves significant challenges, as initial plans often prove insufficient due to disruptions and unforeseen changes, necessitating mitigation measures and re-planning. These challenges become more complex when multiple projects and stakeholders are involved.

Managing multiple projects entails handling interdependencies—geographical, functional, and temporal—that require careful coordination of schedules, resource allocation, and priorities (Kammouh et al., 2020; Shi et al., 2020). Additionally, effective risk management is crucial to identifying and mitigating potential disruptions (Mok et al., 2015).

The involvement of multiple actors, including residents, government agencies, and infrastructure owners, introduces power dynamics and competing interests. Differences in influence, perspectives, and expertise necessitate clear communication protocols and engagement strategies to ensure collaboration (Yang et al., 2017). Furthermore, balancing stakeholders' interests in decision-making is essential for achieving satisfactory project outcomes (Prebanić and Vukomanović, 2023).

Given these complexities, this study categorizes infrastructure construction programs into two key dimensions: multi-project and multi-actor. The

multi-project dimension concerns the simultaneous execution of interdependent projects, while the multi-actor dimension reflects the diverse stakeholders involved, each with distinct roles and objectives. Figure 1 illustrates the multi-project and multi-actor dimensions. The Venn diagram consists of two intersecting circles, each representing one dimension. The overlap in the center of the diagram represents the intersection where the presence of multiple projects and the involvement of multiple actors occur simultaneously.

Despite increasing recognition of these challenges, limited research explores their integration within infrastructure construction management. A deeper understanding of their interaction is critical to developing effective management strategies. To address this gap, this study conducts a systematic literature review, synthesizing existing research on multi-project and multi-actor complexities in infrastructure construction programs. Key themes, strengths, and limitations are identified, highlighting research opportunities in construction management, stakeholder engagement, and risk assessment.

This paper is structured as follows: Section 2 outlines the methodology for the systematic literature review, Section 3 presents the key findings, and Section 4 summarizes the insights and suggests future research directions.

## 2. Methodology

This study employs a systematic literature review to examine the challenges associated with the multi-project and multi-actor dimensions of complexity in infrastructure construction programs. The review aims to identify research gaps and provide insights for future research.

The search process was conducted using Scopus, Web of Science, and Google Scholar, incorporating keywords such as "multiple projects," "multiple stakeholders," "collaborative," and "coordination." Studies were included if they addressed at least one of these dimensions within infrastructure construction programs, were published in English between 2018 and 2024, and, if outside the construction field, provided relevant insights. The initial search yielded 258 articles, which were screened based on predefined inclusion and exclusion criteria. After removing duplicates and irrelevant studies, 58 articles proceeded to full-text review, leading to the exclusion of eight additional studies. The remaining articles underwent in-depth analysis to synthesize findings and highlight research gaps.

To structure the analysis, studies were categorized into three groups: those addressing only the multi-project dimension, those focusing solely on the multi-actor dimension, and those integrating both. The multi-project category includes studies examining the coordination of simultaneous projects, integration of interdependencies, scheduling strategies, resource allocation, and risk assessment. The multi-actor category comprises studies on stakeholder influence, engagement strategies, communication protocols, and decision-making approaches. The final category focuses on research that integrates both dimensions, exploring communication strategies, engagement mechanisms, and decision-making processes that balance project interdependencies with stakeholder interests.

## 3. Results from literature review

Following the categorization outlined in Section 2, this section presents insights derived from the literature, structured according to the multi-project, multi-actor, and multi-project and multi-actor dimensions of complexity in infrastructure construction programs.

The multi-project dimension has gained increasing attention, particularly in decision-making methods. A recurring theme is scheduling optimization, with studies proposing models for selecting and scheduling projects under constraints. For instance, Miralinaghi et al. (2020) introduce a bi-level model for urban road project selection, while Hosseinian and Baradaran (2023), Maher et al. (2021), Bayesteh et al. (2024) Peng et al.

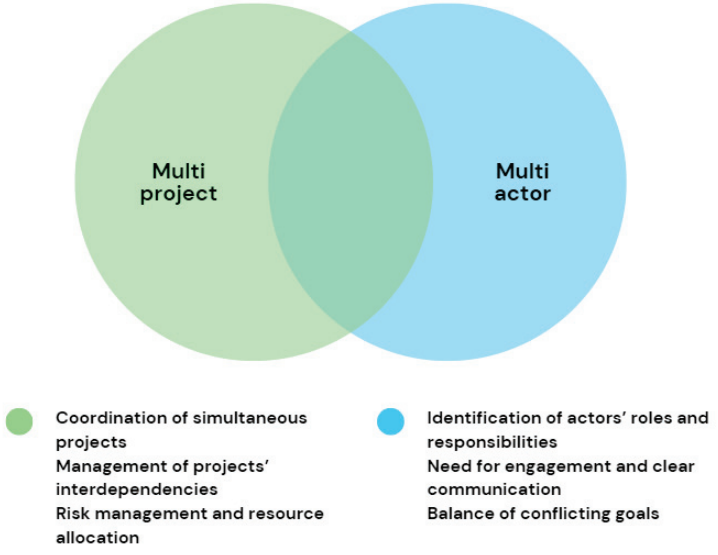


Fig. 1. Venn diagram illustrating the multi-project and multi-actor dimensions

(2024) and Taheri Amiri et al. (2018) present alternative formulations for multi-project scheduling considering different objectives such as time, cost, or quality. Another key area is project interdependencies, which are essential for understanding the interconnected nature of multi-project environments. With this regard, studies have proposed frameworks addressing risk assessment across multiple projects (Li et al., 2019) and decision-making for risk response strategies (Zhang et al., 2023). Despite these advancements, significant gaps remain. Research on re-scheduling methods is limited, with most studies focusing on initial scheduling rather than adapting to delays or disruptions (Hosseinian and Baradaran, 2023; Taheri Amiri et al., 2018; Maher et al., 2021). Additionally, project interdependencies are often treated as static rather than dynamic (Li et al., 2019). However, because they frequently change over time, it is necessary to model the interdependencies dynamically. Moreover, the literature prioritizes time and cost optimization (Hosseinian and Baradaran, 2023; Miralinaghi et al., 2020; Taheri Amiri et al., 2018), whereas broader objectives such as quality, safety, and sustainability require further integration.

The multi-actor dimension has been widely explored, particularly in stakeholder engagement and decision-making. Many studies emphasize behavioral factors influencing decision-making, such as stakeholders' motivations to collaborate in construction projects (Li et al., 2024; Abdul Nabi et al., 2023), as well as how the behavioral factors influence interactions among stakeholders (Tan and Hong, 2021), and how collaboration affects project performance (Abdul Nabi et al., 2023). Other studies propose models to account for stakeholder preferences in decision-making processes, such as the bi-level optimization model for site layout planning introduced by Song et al. (2019), and the preference-based optimization method introduced by Zhilyaev et al. (2022). Conflict resolution strategies have also been studied, including frameworks based on Game Theory and conflict analysis (Kandel et al., 2023; Yu et al., 2019). Stakeholder engagement and communica-

tion strategies emerge as another critical area, with studies highlighting structured approaches to enhance communication and engagement (Baharuddin et al., 2021; Herrera and Castañeda, 2024). However, key gaps persist. Most studies focus on a limited number of stakeholders, failing to capture the complexity of real-world projects that usually involve a broader set of stakeholders (Song et al., 2019; Tan and Hong, 2021). Furthermore, while some research incorporates behavioral and cultural factors, many rely on rational decision-making models, overlooking psychological and social dynamics (Kandel et al., 2023). Another limitation is the emphasis on early project phases, with limited attention to engagement strategies throughout execution (Baharuddin et al., 2021; Song et al., 2019). This gap is critical, as it is essential to provide solutions that can support the entire project execution.

An emerging research area integrates both multi-project and multi-actor dimensions, addressing their interdependencies. Stakeholder coordination is a key focus, with studies proposing collaborative frameworks for managing interdependent infrastructures (Gordan et al., 2024). Interdependencies, both across projects and actors, have been explored, are also explored. For instance, Tee et al. (2019) explore the potential of modular design and integrating practices to better manage interdependencies, while Malla and Delhi (2022) identify the main barriers to interdependencies management. Resilience has gained attention as well, with risk assessment strategies for critical infrastructures (Gordan et al., 2024) and emergency management frameworks (Feletti et al., 2022). Additionally, behavioral and organizational factors, like the establishment of team identity and employment of incentives to enhance stakeholder engagement (Haiyirete et al., 2024; Tee et al., 2019), are increasingly recognized as essential to overcome the challenges generated by the presence of multiple projects and multiple actors. Decision-making models integrating multiple projects and stakeholders have also been proposed, such as the bi-level optimization model for infrastructure fund allocation presented by Saad et al. (2018). However, research gaps remain. Many studies focus on a limited number of actors, despite the broader sets of stakeholders that characterize real-world projects (Haiyirete et al., 2024). Moreover, while behavioral factors are acknowledged, their full complexity is often underexplored (Haiyirete et al., 2024). Prioritization mechanisms for both actors and projects are also lacking, limiting their applicability in real-world decision-making (Saad et al., 2018). Furthermore, while early-phase decision-making is well studied, frameworks for re-scheduling that integrate both interdependencies and stakeholder preferences remain underdeveloped. This gap is crucial, as delays, disruptions, and changing stakeholders' preferences often generate the need to adjust projects' schedules.

To further illustrate the main themes identified, a term map was developed using VOSViewer, as shown in Fig. 2. The map visualizes the academic landscape, highlighting key research areas and their interconnections, offering insights into how these themes are integrated within infrastructure construction programs.

## 4. Conclusion

This study examined recent advancements in infrastructure construction management through a systematic literature review, categorizing studies into *multi-project*, *multi-actor*, and *multi-project and multi-actor* dimensions. Common themes included interdependency management, conflict resolution, and stakeholder engagement. However, several critical gaps remain:

- **Dynamic interdependencies**: Existing studies treat interdependencies as static, despite their evolving nature. Future research should capture their changing impact on project outcomes.
- **Broader stakeholder representation**: A

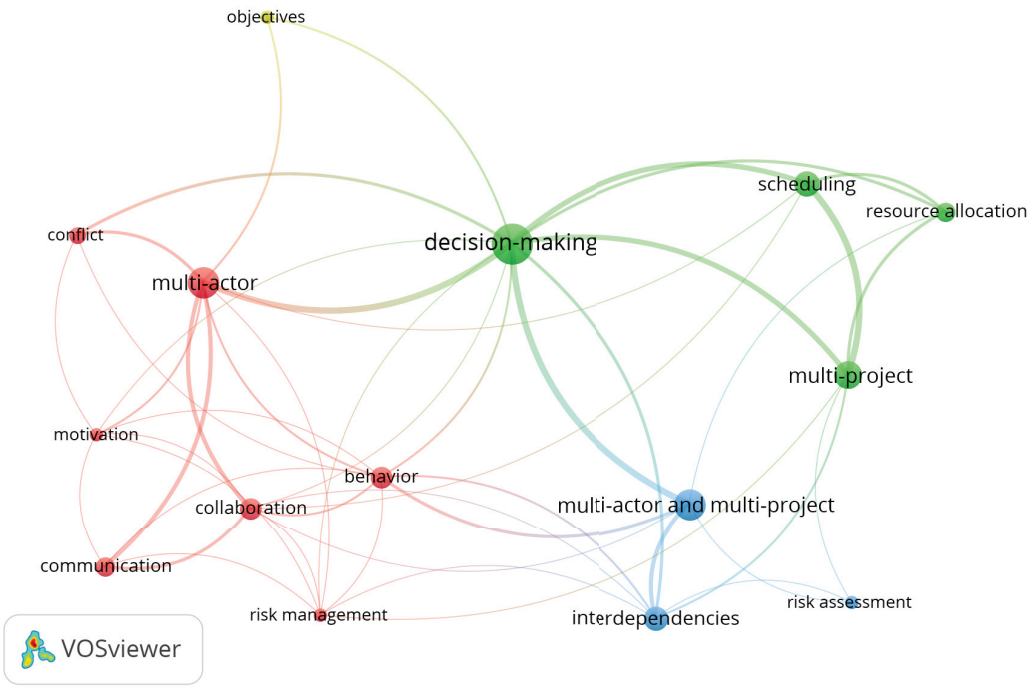


Fig. 2. Term map developed using VOSViewer to visualize the main themes identified in the literature on infrastructure construction programs.

limited set of stakeholders is currently included when addressing the presence of multiple actors in infrastructure construction programs.

- **Behavioral and cultural factors**: Limited attention is given to psychological and cultural influences on stakeholder engagement and collaboration.
- **Broader decision objectives**: Research prioritizes time and cost over quality, safety, and sustainability, overlooking their role in multi-stakeholder decision-making.
- **Prioritization mechanisms**: The literature lacks frameworks for ranking projects and stakeholders, despite their practical relevance.
- **Continuity across project phases**: Existing studies focus on specific phases, but adaptable decision-making and engagement strategies are needed throughout project execution.

Addressing these gaps will enhance the adaptability and effectiveness of infrastructure project management.

**Acknowledgement**

This publication is part of the project Logiquay with file number NWA.1431.20.005 of the research programme Urbiquay which is financed by the Dutch Research Council (NWO) under the grant https://www.nwo.nl/en/projects/nwa143120005.

## References

Abdul Nabi, M., A. Elsayegh, and I. H. El-adaway (2023). Understanding collaboration requirements for modular construction and their cascading failure impact on project performance. *Journal of Management in Engineering 39*(6), 04023043.

Baharuddin, H. E. A., N. S. M. Azizi, and I. Piri (2021). Improving early stakeholder engagement process: An empirical study of rapid transit railway of malaysian project. *International Journal of Sustainable Construction Engineering and Technology 12*(5), 279–285.

Bayesteh, A., M. Lu, and P. Lakshminarasimhan (2024). Planning municipal drainage infrastructure maintenance operations with finite available crews: pragmatic optimization approach. *Journal of Civil Engineering and Management 30*(8), 708–719.

Feletti, G., M. Piraina, B. Petrenj, and P. Trucco (2022). Collaborative capability building for critical infrastructure resilience: assessment and selection of good practices. *Environment Systems and Decisions 42*(2), 207–233.

Gordan, M., D. A. Kountche, D. McCrum, S. Schauer, S. König, S. Delannoy, L. Connolly, M. Iacob, N. G. Durante, Y. Shekhawat, et al. (2024). Protecting critical infrastructure against cascading effects: The precinct approach. *Resilient Cities and Structures 3*(3), 1–19.

Haiyirete, X., X. Gan, and J. Wang (2024). Research on safety decision-making behavior in megaprojects. *Systems 12*(8), 315.

Herrera, R. F. and K. Castañeda (2024, 12). Development of a collaborative design management system for enhancing building project efficiency. *Revista Ingeniería de Construcción 39*, 1–12.

Hosseinian, A. H. and V. Baradaran (2023). A two-phase approach for solving the multi-skill resource-constrained multi-project scheduling problem: a case study in construction industry. *Engineering, Construction and Architectural Management 30*(1), 321–363.

Kammouh, O., M. Nogal, M. Bruijne, R. Binnekamp, and A. R. M. Wolfert (2020). Interdependent infrastructure interventions optimization: An integrative systems thinking approach. In *30th European Safety and Reliability Conference, ESREL 2020 and 15th Probabilistic Safety Assessment and Management Conference, PSAM*, pp. 1175–1182.

Kandel, M. A., M. S. Eid, and A. Elhakeem (2023). Game theory approach to decision-making analysis of dispute resolution. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction 15*(4), 04523032.

Li, J., J. Zhang, and W. Suo (2019). Risk assessment in cross-border transport infrastructure projects: A fuzzy hybrid method considering dual interdependent effects. *Information Sciences 488*, 140–157.

Li, Y., P. Xiang, P. W. Chan, and J. Zhang (2024). Examining owners' and contractors' motivations to participate in collaborative risk management of mega infrastructure projects. *International Journal of Project Management 42*(5), 102614.

Maher, G., O. Abd-El-Raouf, A. Kafafy, and N. EL-Hefnawy (2021). Decomposition methodology to support complex decisions in construction application. *IAENG International Journal of Computer Science 48*(3).

Malla, V. and V. S. K. Delhi (2022). Determining interconnectedness of barriers to interface management in large construction projects. *Construction Economics and Building 22*(2), 69–101.

Miralinaghi, M., S. E. Seilabi, S. Chen, Y.-T. Hsu, and S. Labi (2020). Optimizing the selection and scheduling of multi-class projects using a stackelberg framework. *European Journal of Operational Research 286*(2), 508–522.

Mok, K. Y., G. Q. Shen, and J. Yang (2015). Stakeholder management studies in mega construction projects: A review and future directions. *International Journal of Project Management 33*(2), 446–457.

Peng, Y., M. Xu, G. Li, and A. Chen (2024). Sequencing post-disruption concurrent restoration via a network flow approach. *Transportation Research Part D: Transport and Environment*, 104234.

Prebanić, K. R. and M. Vukomanović (2023). Exploring stakeholder engagement process as the success factor for infrastructure projects. *Buildings 13*(7), 1785.

Saad, D. A., H. Mansour, and H. Osman (2018). Concurrent bilevel multi-objective optimisation of renewal funding decisions for large-scale infrastructure networks. *Structure and Infrastructure Engineering 14*(5), 594–603.

Shi, Q., M. Hertogh, M. Bosch-Rekveldt, J. Zhu, and Z. Sheng (2020, 05). Exploring decision-making complexity in major infrastructure projects: A case study from china. *Project Management Journal 51*, 875697282091920.

Song, X., F. Pena-Mora, C. Shen, Z. Zhang, and J. Xu (2019). Modelling the effect of multi-stakeholder interactions on construction site layout planning using agent-based decentralized optimization. *Automation in construction 107*, 102927.

Taheri Amiri, M. J., F. Haghighi, E. Eshtehardian, and O. Abessi (2018). Multi-project time-cost optimization in critical chain with resource constraints. *KSCE Journal of Civil Engineering 22*, 3738–3752.

Tan, R. and K. Hong (2021). Research on extreme dispute decisions of large-scale engineering projects from the perspective of multidimensional preferences. *Mathematics 9*(22), 2940.

Tee, R., A. Davies, and J. Whyte (2019). Modular designs and integrating practices: Managing collaboration through coordination and cooperation. *Research policy 48*(1), 51–61.

Yang, J., K. C. Goh, G. Shen, L. Dezhi, and T. Yig-

itcanlar (2017). Transforming communication and decision making practices for sustainable renewal of urban transport infrastructure. In G. Q. Shen, P. S. Brandon, and P. Lombardi (Eds.), *Future challenges in evaluating and managing sustainable development in the built environment*, pp. 285–305. United Kingdom: Wiley-Blackwell.

Yu, T., X. Liang, G. Q. Shen, Q. Shi, and G. Wang (2019). An optimization model for managing stakeholder conflicts in urban redevelopment projects in china. *Journal of Cleaner Production 212*, 537–547.

Zhang, X., M. Goh, S. Bai, Z. Wang, and Q. Wang (2023). Project risk response decision making under uncertain project interdependencies. *IEEE Transactions on Engineering Management 71*, 7364–7378.

Zhilyaev, D., R. Binnekamp, and A. Wolfert (2022, 04). Best fit for common purpose: A multi-stakeholder design optimization methodology for construction management. *Buildings 12*, 527.