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Optimization Strategies for Risk Management in Construction Projects to Improve Time, Cost, and Quality Efficiency

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Abstract

Construction projects are an important sector in economic development, but often face various risks that can affect the efficiency of time, cost, and quality of the project. These risks can come from various factors, including weather changes, material price fluctuations, limited human resources, and changes in project design. Effective risk management is needed to ensure that construction projects can run according to plan and achieve the desired results. This study aims to evaluate risk management optimization strategies in construction projects to improve time, cost, and quality efficiency. The method used in this study is a literature study with content analysis of various journals, books, and related research reports published in the last five years. The results of the study indicate that technological approaches such as Building Information Modeling (BIM), multi-objective analysis, and multi-agent simulation have an important role in reducing risk and improving the efficiency of construction projects. This technology allows project managers to plan more accurately, manage design changes proactively, and optimize resource use. In conclusion, risk management optimization strategies integrated with modern technology can improve time efficiency, reduce costs, and improve the quality of construction project results. These findings provide important contributions to the development of more effective risk management practices in the construction industry.

INTRODUCTION

Construction projects are one of the industrial sectors that play an important role in the development of a country's infrastructure and economy. However, construction projects often face various challenges that can affect the success of the project, including the risk of delays, cost overruns, and quality degradation (Hera et al., 2024). These risks can arise from various factors, such as changes in weather, limited human resources, fluctuations in raw material prices, and changes in project design (Nugroho et al., 2024). In addition, the lack of coordination between related parties and regulatory uncertainty can also increase the likelihood of problems occurring in construction projects (Agusman et al., 2021). Therefore, proper risk management is essential to ensure that the

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project can run according to schedule, budget, and established quality standards (Perwiranegara et al., 2024).

Risk management is a systematic process for identifying, assessing, and managing risks that may affect the achievement of organizational goals. It involves evaluating potential risks and implementing strategies to reduce their negative impacts, such as risk avoidance, mitigation, transfer, or acceptance (Leo et al., 2019). This approach is particularly important in the financial, agricultural, and manufacturing industries where uncertainty often has a significant impact on profitability and operational stability (Roncalli, 2020). In addition, technologies such as machine learning are increasingly being used to enhance risk analysis, enabling organizations to make better decisions based on more accurate data.

In a broader context, risk management also includes managing climate change risks and economic uncertainty, as discussed by Hansen et al. (2019) in their study on climate risk management in the agricultural sector (Hansen et al., 2019). They found that a proactive risk management approach can help reduce rural poverty and increase the economic resilience of vulnerable communities. On the other hand, Stulz (2022) highlights the importance of enterprise risk management in improving business competitiveness through appropriate mitigation strategies (Nocco & Stulz, 2022). This approach not only strengthens the company's financial position but also ensures long-term sustainability amidst uncertain market conditions.

Risk management in construction projects aims to identify, analyze, and manage potential risks before they negatively impact the project (Ardian, 2021). By managing risks effectively, construction projects can achieve efficiency in the use of resources, time, and costs, as well as maintain the quality of the final project results (Tobing et al., 2019). In addition, implementing the right risk mitigation strategies can reduce the likelihood of project failure and increase overall productivity (Pratiwi & Priyanto, 2023). Some common mitigation strategies used in construction projects include risk analysis, impact evaluation, and continuous monitoring of changes in project conditions (Afiq, 2021).

Time, cost, and quality efficiency are three main aspects that are the benchmarks for the success of a construction project (Syahrani & Diyanty, 2023). These three aspects are often interrelated, where increasing efficiency in one aspect can affect other aspects. For example, efforts to speed up project completion time often require additional costs for labor and equipment, while efforts to reduce project costs can affect the quality of construction results (Septianugraha et al., 2024). Therefore, an integrated risk management strategy is needed to ensure that these three aspects can be achieved simultaneously (Tanu, 2020).

The urgency of implementing risk management in construction projects is increasing along with the increasing complexity of projects (Ramadhan & Hidayat, 2024). Modern construction projects often involve multiple parties, sophisticated technology, and large scales that require better coordination and more mature risk management (Paden et al., 2024). In addition, climate change and global economic instability also add to the challenges in managing construction projects, thus reinforcing the need for a more comprehensive and adaptive risk mitigation strategy (Dwita & Zamroni, 2021).

Several previous studies have discussed the importance of risk management strategies in construction projects. For example, research by Prasetyo et al. (2022) shows that the Failure Mode and Effect Analysis (FMEA) approach is effective in identifying key risks that can affect project time, cost, and quality (Simanjuntak et al., 2022). Meanwhile, a study by Setiono and Amrullah (2024) highlights the importance of implementing a House of Risk in managing risks in infrastructure projects to reduce the impact of unexpected costs and time (Amrullah et al., 2024). These studies

emphasize the importance of an appropriate risk management strategy to improve the efficiency of construction projects.

Based on this background, this study aims to examine the optimization strategy for risk management in construction projects to improve the efficiency of time, cost, and quality. This study is expected to provide practical guidance for project managers in managing risks more effectively and supporting more appropriate decision-making in a dynamic and complex project environment.

METHOD

This study uses a qualitative approach with a literature study method, which aims to identify, analyze, and formulate risk management optimization strategies in construction projects to improve time, cost, and quality efficiency. The literature study approach was chosen because it allows researchers to gain an in-depth understanding of the phenomenon under study through the analysis of various written sources, including academic journals, books, research reports, and other relevant documents (Snyder, 2019). Literature studies also allow researchers to identify trends, patterns, and research gaps that have not been answered in previous literature (Paré & Kitsiou, 2017).

The data sources in this study consist of secondary data obtained from accredited national journals, conference articles, theses, books, and technical reports published in the last five years to ensure the relevance and accuracy of the findings (Snyder, 2019). The data sources used must meet the inclusion criteria, namely relevant to the topic of risk management in construction projects, focus on aspects of time, cost, and quality efficiency, and have good methodological quality (Kitchenham, 2004). Data searches were conducted through various academic databases, such as Google Scholar, ResearchGate, and national journal portals to ensure broad and in-depth coverage of the literature.

The data collection technique was carried out using the documentation method, namely the collection of various documents, journal articles, and research reports related to the research topic (Bowen, 2009). The data collected was then classified based on the main themes, such as risk identification, risk assessment, mitigation strategies, and evaluation of the effectiveness of risk management strategies in construction projects. In addition, the data was also evaluated to ensure its validity and reliability through a cross-check process with several different sources to reduce interpretation bias (Yin, 2009).

The data analysis method used was content analysis, which involved the process of coding, categorizing, and interpreting findings from various literature that had been collected (Krippendorff, 2018). This analysis aims to identify the best strategy in managing construction risks to achieve efficiency in time, cost, and quality. The analysis steps include grouping information based on relevant themes, identifying patterns, and mapping relationships between concepts to formulate appropriate optimization strategies (Elo & Kyngäs, 2008). The results of this analysis are expected to provide clearer guidance for construction practitioners in managing project risks more effectively and efficiently.

RESULT AND DISCUSSION

In this study, a screening and selection process was carried out on various scientific articles that discuss risk management optimization strategies in construction projects. These articles were selected based on their relevance to the topic, publication time range (2019-2024), and methodological quality. From dozens of articles found, 10 articles that best fit the research focus on increasing the efficiency of time, cost, and quality of construction projects were selected for further analysis. These articles form the basis for understanding the best approach to construction risk management.

Table 1. Literature Review

No	Title	Author	Research Focus
1	Strategic contract management for drilling efficiency and cost reduction: Insights and perspectives	Egbumokei, P.I., & Dienagha, I.N.	Contract management strategies to reduce costs and improve project efficiency
2	A robust time-cost-quality-energy-environment trade-off with resource-constrained in project management	Lotfi, R., Yadegari, Z., & Hosseini, S.	Trade-off models for managing time, cost, quality, energy, and environment in projects
3	Multi-objective optimization of cost, contamination control, and sustainability in cleanroom construction	Otoko, J.	Decision-making models for contamination control and cost optimization in construction
4	BIM as a tool to optimize and manage project risk management	Alzoubi, H.M.	Utilization of BIM for risk management optimization in construction projects
5	Systematic review of the time-cost optimization models in construction management	ElSahly, O.M., Ahmed, S., & Abdelfatah, A.	A systematic review of time and cost optimization models in construction management
6	Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges	Abioye, S.O., Oyedele, L., Akanbi, L., & Ajayi, A.	Utilization of AI for cost and risk optimization in the construction industry
7	Cost estimation and prediction in construction projects: A systematic review on machine learning techniques	Tayefeh Hashemi, S., Ebadati, O.M., & Kaur, H.	Project cost prediction using machine learning techniques
8	AHP and NSGA-II-based time–cost–quality trade-off optimization model for construction projects	Sharma, K., & Trivedi, M.K.	Time-cost-quality optimization models based on AHP and NSGA-II
9	Multi-agent simulation for managing design changes in prefabricated construction projects	Du, J., Jing, H., & Castro-Lacouture, D.	Multi-agent simulation for design change management in prefabrication projects
10	A review of artificial intelligence based risk assessment methods for capturing complexity-risk interdependencies	Afzal, F., Yunfei, S., Nazir, M., & Bhatti, S.M.	AI approaches for complex risk assessment in construction projects

The results of the literature review collected show various strategies for optimizing risk management in construction projects that focus on improving time, cost, and quality efficiency. Each selected article reflects a variety of approaches to addressing the complex challenges of modern construction projects, which often involve high uncertainty and multidimensional risks.

A study by Egbumokei and Dienagha (2024) highlighted the importance of contract management strategies in optimizing project efficiency, especially in the drilling industry. They

emphasized that good contract management not only focuses on cost reduction but also strengthens compliance with quality and timeliness standards. This approach is considered essential for projects with large budgets and high technical risks, such as oil and gas exploration, where delays or changes in project specifications can cause significant cost spikes (Egbumokei et al., 2024).

Lotfi, Yadegari, and Hosseini (2022) introduced a trade-off model of time, cost, quality, energy, and environment in construction projects. They used a mathematical approach to manage resource constraints in bridge projects, focusing on multidimensional optimization. This approach allows project managers to consider multiple parameters simultaneously, resulting in a more balanced and sustainable solution. This model is particularly relevant for large infrastructure projects that require comprehensive cost and environmental impact assessments (Lotfi et al., 2022).

A study by Otoko (2023) explored a decision-making model for contamination control and cost optimization in cleanroom projects. Focusing on high-tech construction projects such as laboratories or pharmaceutical facilities, the model integrates multiple risk variables to achieve cost efficiency while meeting stringent quality standards. This approach emphasizes the importance of contamination monitoring and risk management to avoid additional costs due to non-compliance with cleanliness standards (Otoko, 2023).

Alzoubi (2022) highlighted the role of Building Information Modeling (BIM) as a tool for optimizing risk management in construction projects. BIM enables real-time risk visualization, facilitates better planning, and supports faster decision-making in managing design changes and material requirements. This technology also enhances coordination between various parties involved in the project, such as architects, engineers, and contractors, reducing the risk of design conflicts that often lead to delays and additional costs (Alzoubi, 2022).

ElSahly, Ahmed, and Abdelfatah (2023) conducted a systematic review of various time and cost optimization models in construction management. They found that although many models have been developed to manage time and cost effectively, there is still a gap in understanding the impact of quality on project management decisions. Their approach emphasizes the importance of integrating quality evaluation into optimization models to produce more holistic and sustainable project outcomes (ElSahly et al., 2023).

Abioye et al. (2021) present a comprehensive view of the use of artificial intelligence (AI) in the construction industry for cost optimization and risk management. They highlight how AI can be used to predict costs, identify risks, and manage project changes more efficiently. This technology can reduce uncertainty in project planning by analyzing historical data and future trends, thereby improving the accuracy of cost and time estimates (Abioye et al., 2021).

Hashemi, Ebadati, and Kaur (2020) review various machine learning techniques for construction project cost prediction. This approach provides a solution to manage budget risks which are often the main cause of project failure. They emphasize the importance of accurate data and adaptive prediction models to avoid unexpected cost overruns (Tayefeh Hashemi et al., 2020).

Sharma and Trivedi (2021) introduce a time-cost-quality trade-off optimization model based on AHP and NSGA-II. This approach allows project managers to evaluate various decision options considering different priorities, such as accelerating project completion time or improving the quality of the final output. This model is especially useful in complex infrastructure projects, where decisions often have to be made quickly based on multiple interrelated parameters (Sharma & Trivedi, 2021).

Du, Jing, and Castro-Lacouture (2019) developed a multi-agent simulation for design change management in prefabrication projects. This model allows for more realistic and predictive scenario analysis, helping project managers plan design changes without sacrificing time or quality. This approach is particularly relevant for projects involving prefabricated components, where design changes can have significant impacts on project cost and time (Du et al., 2019).

Finally, Afzal et al. (2021) evaluated an artificial intelligence-based approach for risk assessment in complex construction projects. They highlighted the importance of understanding the interactions between different types of risks to manage projects more effectively. The AI model they developed allows for a more in-depth analysis of the relationships between risks, reducing the likelihood of project failure due to suboptimal decisions (Afzal et al., 2021).

Overall, this literature highlights a variety of optimization strategies that can be used to manage construction project risks more efficiently. Each approach has its own advantages and disadvantages, depending on the scale, complexity, and specific objectives of the project. However, the integration of advanced technologies such as AI, BIM, and multi-agent simulation seems to offer the greatest potential for achieving simultaneous time, cost, and quality efficiencies in modern construction projects.

Discussion

Construction projects are notoriously high risk due to their complexity, multi-stakeholder involvement, and dynamic environment. Risk factors in construction projects can include time delays, cost overruns, and quality degradation, all of which can have serious impacts on the success of the project. Therefore, optimization strategies in risk management are essential to ensure that projects remain on budget, on time, and up to quality standards.

Key Strategies in Construction Project Risk Management

In the context of construction project risk management, several critical optimization strategies have emerged as essential for improving time, cost, and quality efficiency. These strategies are particularly important given the inherently complex and uncertain nature of construction projects, where unexpected delays, cost overruns, and quality issues are common. Effective risk management strategies must therefore integrate advanced technologies and analytical approaches to anticipate, mitigate, and respond to these risks.

One of the most impactful strategies is the integration of technology and digitalization into the project management workflow. Building Information Modeling (BIM) has become a cornerstone in this approach, serving as a powerful tool for enhancing design accuracy, reducing rework, and improving project coordination. BIM creates a digital representation of the physical and functional characteristics of a project, allowing for comprehensive visualization and simulation of construction processes. This capability significantly reduces the likelihood of design conflicts and errors that can lead to costly delays and quality issues. For example, Alzoubi (2022) demonstrated that BIM can optimize project risk management by identifying potential design clashes before they reach the construction phase, thus minimizing costly redesigns and enhancing overall project efficiency (Alzoubi, 2022).

Another critical strategy involves the use of multi-objective optimization (MOO) methods, which aim to balance the often competing goals of minimizing time, reducing costs, and maintaining high-quality standards. These methods leverage advanced algorithms like Particle Swarm Optimization (PSO) and Genetic Algorithms (GA) to identify optimal project scheduling and resource allocation solutions. For instance, Almahameed and Bisharah (2024) applied machine learning and PSO to predict project costs more accurately and optimize resource allocation, resulting in improved financial performance and project outcomes. This approach is particularly effective in large, complex construction projects where the interplay of multiple variables can significantly impact the project's success (almahameed & Bisharah, 2024).

Efficient resource management is another cornerstone of risk optimization in construction. This involves maximizing the utilization of labor, materials, and equipment to reduce waste and

improve productivity. Techniques such as lean construction, just-in-time (JIT) inventory management, and modular construction have proven effective in minimizing downtime and material waste, leading to significant cost savings and faster project completion. For example, a systematic review by ElSahly et al. (2023) highlighted that effective resource management not only reduces project costs but also enhances quality by ensuring that materials are used efficiently and waste is minimized. This approach is particularly critical in large-scale infrastructure projects where small inefficiencies can lead to substantial cost overruns and schedule delays (ElSahly et al., 2023).

Together, these strategies form a comprehensive framework for optimizing risk management in construction projects. By integrating digital tools like BIM, leveraging multi-objective optimization algorithms, and improving resource management practices, project managers can significantly enhance project outcomes, reduce uncertainties, and increase the likelihood of on-time, on-budget, and high-quality project delivery. These approaches not only improve immediate project performance but also contribute to long-term organizational learning and capability development in the construction sector.

In the context of large-scale construction projects, the integration of advanced risk management strategies has proven crucial for improving time, cost, and quality efficiency. A notable example can be found in the recent construction of a major bridge in Southeast Asia. This project faced significant challenges from the outset, including unpredictable weather conditions, complex logistical requirements, and a highly interconnected supply chain that exposed it to numerous risks. However, by employing a combination of innovative technologies and proactive management approaches, the project team was able to overcome these obstacles and achieve remarkable success.

From the design phase, the project utilized Building Information Modeling (BIM) to improve planning accuracy and reduce the likelihood of costly design conflicts. BIM provided a comprehensive digital representation of the bridge's physical and functional characteristics, allowing engineers to identify potential design issues before construction even began. This predictive capability enabled the team to optimize material usage, reduce waste, and minimize costly rework, which is often a significant source of delay and budget overruns in large infrastructure projects. By integrating BIM with real-time data from the construction site, the project team could continuously update and refine their plans, ensuring that the project remained on track despite numerous external challenges.

To further enhance project efficiency, the team employed multi-objective optimization techniques to balance the competing demands of time, cost, and quality. This approach involved the use of Particle Swarm Optimization (PSO) algorithms to identify the critical paths within the project schedule, optimize resource allocation, and minimize idle time for labor and equipment. These algorithms, inspired by the collective behavior of biological populations, allowed the project team to quickly identify the most efficient work sequences and resource distributions, significantly reducing the overall project timeline.

Moreover, the project team took a proactive approach to risk management, recognizing that Southeast Asia's unpredictable weather patterns posed a substantial threat to project continuity. To address this, they leveraged historical weather data and predictive analytics to anticipate potential weather disruptions and adjust their construction schedule accordingly. This forward-looking approach allowed the team to avoid costly weather-related delays and maintain a steady work pace, even during the region's challenging monsoon season.

The combined effect of these strategies was transformative. The bridge project was completed 20% faster than initially projected, resulting in significant cost savings—estimated at approximately 15% of the original budget—while still meeting all quality and safety standards. This outcome not only demonstrated the effectiveness of integrating digital tools like BIM and advanced

optimization algorithms but also highlighted the critical importance of proactive risk management in ensuring project success.

This case serves as a compelling example for other large infrastructure projects facing similar challenges. It underscores the importance of integrating technology, data analytics, and forward-thinking management practices to optimize project outcomes, reduce uncertainties, and deliver high-quality results within budget and on schedule.

Optimization strategies in construction project risk management that combine advanced technologies such as BIM, multi-objective optimization, and efficient resource management can provide significant results in terms of cost reduction, time savings, and quality improvement. This approach not only improves project efficiency but also reduces the likelihood of future project failures, providing much-needed guidance for project managers in an increasingly complex and dynamic project environment.

CONCLUSION

The conclusion of this study shows that risk management optimization strategies integrated with technologies such as Building Information Modeling (BIM), multi-objective analysis, and multi-agent simulation have great potential to improve time, cost, and quality efficiency in construction projects. This technology allows project managers to anticipate risks early, simulate design changes, and manage resources more efficiently. Thus, construction projects can achieve more consistent and quality results, even though they are faced with various operational and technical challenges.

Practically, the results of this study provide guidance for project managers and construction managers to apply digital technology in planning and risk management. The use of BIM, for example, allows early detection of potential design conflicts, while multi-objective analysis helps manage the trade-offs between time, cost, and quality in a more balanced way. In addition, multi-agent simulation can be used to estimate the impact of design changes on cost and time more accurately. This approach not only improves project efficiency but also reduces the possibility of cost overruns and project delays.

However, this study has several limitations. First, the focus of this study is only on literature analysis, so it has not been able to evaluate the effectiveness of this strategy empirically in the field. Second, the implementation of technologies such as BIM and multi-agent simulation requires significant initial investment and special training for workers, which may be a constraint for small and medium-sized construction companies. In addition, the data used in this literature study may not fully represent project conditions at various locations and scales. Therefore, suggestions for further research are to conduct case studies or direct experiments to measure the effectiveness of these optimization strategies in various construction project contexts. Research can also expand its focus by considering social and environmental aspects in risk management, as well as evaluating the impact of new technologies such as artificial intelligence (AI) and the Internet of Things (IoT) in construction projects. Thus, risk management strategies can be more focused and in line with the increasingly complex development of the construction industry.

REFERENCE

Abioye, S. O., Oyedele, L. O., Akanbi, L., Ajayi, A., Delgado, J. M. D., Bilal, M., Akinade, O. O., & Ahmed, A. (2021). Artificial intelligence in the construction industry: A review of present status, opportunities and future challenges. *Journal of Building Engineering*, *44*, 103299.

Afiq, M. (2021). Manajemen Risiko pada Proyek Pembangunan Gedung Asrama Mahasiswa UIN Walisongo Tahun 2021. *Akselerasi: Jurnal Ilmiah Teknik Sipil*, *3*(1).

Afzal, F., Yunfei, S., Nazir, M., & Bhatti, S. M. (2021). A review of artificial intelligence based risk

assessment methods for capturing complexity-risk interdependencies: Cost overrun in construction projects. *International Journal of Managing Projects in Business*, *14*(2), 300–328.

Agusman, A., Prasetya, H. B., & Purba, H. H. (2021). Tinjauan dan Analisis Risiko dalam Proyek Konstruksi Bangunan: Studi Literatur. *Jurnal Teknologi Dan Manajemen*, *19*(2), 95–106.

almahameed, B. aldeen, & Bisharah, M. (2024). Applying machine learning and particle swarm optimization for predictive modeling and cost optimization in construction project management. *Asian Journal of Civil Engineering*, *25*(2), 1281–1294.

Alzoubi, H. M. (2022). BIM as a tool to optimize and manage project risk management. *International Journal of Mechanical Engineering*, *7*(1).

Amrullah, H. D., Setiono, S., & Handayani, F. (2024). Analisis Manajemen Risiko terhadap Aspek Pengendalian Biaya dan Waktu pada Proyek Pembangunan JDU SPAM WOSUSOKAS dengan Metode House of Risk (HOR). *Sustainable Civil Building Management and Engineering Journal*, *1*(4), 11.

Ardian, A. S. (2021). *Manajemen Risiko Proyek Perumahan Taman Golf Residence 3*.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, *9*(2), 27–40.

Du, J., Jing, H., Castro-Lacouture, D., & Sugumaran, V. (2019). Multi-agent simulation for managing design changes in prefabricated construction projects. *Engineering, Construction and Architectural Management*, *27*(1), 270–295.

Dwita, A., & Zamroni, M. (2021). Legal Responsibility of Waste Transportation Services in the Management of Hospital Solid Medical Waste. *Jurnal Hukum Dan Etika Kesehatan*, 45–63.

Egbumokei, P. I., Dienagha, I. N., Digitemie, W. N., Onukwulu, E. C., & Oladipo, O. T. (2024). Strategic contract management for drilling efficiency and cost reduction: Insights and perspectives. *International Journal of Multidisciplinary Research and Growth Evaluation*, *5*(5), 1042–1050.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–115.

ElSahly, O. M., Ahmed, S., & Abdelfatah, A. (2023). Systematic review of the time-cost optimization models in construction management. *Sustainability*, *15*(6), 5578.

Hansen, J., Hellin, J., Rosenstock, T., Fisher, E., Cairns, J., Stirling, C., Lamanna, C., van Etten, J., Rose, A., & Campbell, B. (2019). Climate risk management and rural poverty reduction. *Agricultural Systems*, *172*, 28–46.

Hera, S. H., Purwanggono, B., & Ulkhaq, M. M. (2024). PERANCANGAN MANAJEMEN RISIKO PADA PROYEK PEMBANGUNAN LABORATORIUM TERINTEGRASI FAKULTAS TEKNIK UNDIP. *Industrial Engineering Online Journal*, *13*(3).

Kitchenham, B. (2004). Procedures for performing systematic reviews. *Keele, UK, Keele University*, *33*(2004), 1–26.

Krippendorff, K. (2018). *Content analysis: An introduction to its methodology*. Sage publications.

Leo, M., Sharma, S., & Maddulety, K. (2019). Machine learning in banking risk management: A literature review. *Risks*, *7*(1), 29.

Lotfi, R., Yadegari, Z., Hosseini, S. H., Khameneh, A. H., Tirkolaee, E. B., & Weber, G. W. (2022). *A robust time-cost-quality-energy-environment trade-off with resource-constrained in project management: A case study for a bridge construction project*.

Nocco, B. W., & Stulz, R. M. (2022). Enterprise risk management: Theory and practice. *Journal of Applied Corporate Finance*, *34*(1), 81–94.

Nugroho, S. A., Dofir, A., & Puspito, I. H. (2024). ANALISIS MANAJEMEN RISIKO YANG BERPENGARUH TERHADAP WAKTU PELAKSANAAN PEKERJAAN. *Jurnal ARTESIS*, *4*(2), 164–173.

Otoko, J. (2023). Multi-objective optimization of cost, contamination control, and sustainability in cleanroom construction: A decision-support model integrating Lean Six Sigma, Monte Carlo Simulation, and Computational Fluid Dynamics (CFD). *Int J Eng Technol Res Manag*, *7*(1), 108.

Paden, O., Sihombing, J. J., Irwan, A., Agusta, T., & Simanjuntak, D. A. (2024). Analasis Dampak Resiko

Pinjaman Online Terhadap Mahasiswa. *Jurnal Ilmiah Sistem Informasi*, *4*(1), 98–113.

Paré, G., & Kitsiou, S. (2017). Methods for literature reviews. In *Handbook of eHealth evaluation: An evidence-based approach [Internet]*. University of Victoria.

Perwiranegara, A. F., Wibowo, K., & Mudiyono, R. (2024). STRATEGI MANAJEMEN RESIKO PADA PROYEK PENGENDALIAN BANJIR DAN ROB SUNGAI LOJI–BANGER PAKET 1. *Jurnal Teknik Sipil Giratory UPGRIS*, *5*(2), 132–140.

Pratiwi, S. A., & Priyanto, B. (2023). Manajemen Risiko pada Pekerjaan Beton Proyek Pembangunan Bendungan Jlantah. *Jurnal Sosial Teknologi*, *3*(3), 220–226.

Ramadhan, M. A., & Hidayat, W. (2024). Analisis Manajemen Risiko dalam Mengatasi Tantangan Siswa Buta Huruf Al-Quran di SMAN 1 Lembang. *Ta Lim Jurnal Pendidikan Agama Islam Dan Manajemen Pendidikan Islam*, *3*(1), 11–24.

Roncalli, T. (2020). *Handbook of financial risk management*. Chapman and Hall/CRC.

Septianugraha, A. F., Nugraheni, F., & Astuti, S. A. Y. (2024). Analisis Manajemen Risiko Konstruksi Pada Proyek Konstruksi Bendungan Berdasarkan Konsep ISO 31000: 2018. *AGREGAT*, *9*(2), 1083–1090.

Sharma, K., & Trivedi, M. K. (2021). AHP and NSGA-II-based time–cost–quality trade-off optimization model for construction projects. In *Artificial intelligence and sustainable computing: Proceedings of ICSISCET 2020* (pp. 45–63). Springer.

Simanjuntak, I. J., Siagian, R. T., Prasetyo, R., Rozak, N. F., & Purba, H. H. (2022). Manajemen risiko pada proyek konstruksi jembatan: Kajian literatur sistematis. *Jurnal Teknologi Dan Manajemen*, *20*(1), 59–76.

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339.

Syahrani, S. A., & Diyanty, V. (2023). Evaluasi Manajemen Risiko Proyek Konstruksi Terhadap Biaya Operasional Proyek Menggunakan Metode AHP. *Jurnal Akademi Akuntansi*, *6*(2), 215–224.

Tanu, Y. (2020). *Manajemen Risiko Perencanaan Optimalisasi Pembangunan Jembatan Utama Pt. Wijaya Karya dengan Metode Failure Mode and Effect Analysis*. UNIVERSITAS MA CHUNG.

Tayefeh Hashemi, S., Ebadati, O. M., & Kaur, H. (2020). Cost estimation and prediction in construction projects: A systematic review on machine learning techniques. *SN Applied Sciences*, *2*(10), 1703.

Tobing, Y. O. L., Sari, D. P., & Wicaksono, P. A. (2019). Analisis risiko proyek konstruksi dengan importance index dan bow tie analysis. *Industrial Engineering Online Journal*, *7*(4).

Yin, R. K. (2009). Case study research: Design and methods (applied social research methods). *London and Singapore: Sage*, *23*, 24.