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CHALLENGES IN IMPLEMENTING ARTIFICIAL INTELLIGENCE IN CONSTRUCTION PROJECT MANAGEMENT: A LITERATURE REVIEW ON THE IMPACT OF WORLD WARS, TRADE WARS, AND TECHNOLOGICAL WARS

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ABSTRACT

The implementation of Artificial Intelligence (AI) in construction project management faces various challenges influenced by external factors such as trade wars, technological warfare, and global geopolitics. With the rapid development of AI technology in recent years, the construction sector has begun to adopt this technology to enhance project efficiency and quality. However, despite the benefits that AI offers, the construction industry still faces technical, regulatory, and political barriers that need to be addressed for optimal implementation. This study aims to identify and analyze these challenges through a Systematic Literature Review (SLR) method. The main focus of this research is to explore how trade wars and technological warfare influence the adoption and development of AI in construction project management. Additionally, the study examines the impact of global policy shifts triggered by world wars on technological innovation and the application of AI in the construction sector. Through this research, a deeper understanding of how geopolitical tensions and global technological competition affect AI adoption in the construction industry is expected to be gained. The findings are also expected to provide practical recommendations for mitigating the challenges faced, enabling the construction sector to fully leverage AI's potential.

Keyword: Artificial Intelligence, Construction Project Management, Trade Wars, Technological Warfare, Geopolitics, Technology Implementation

INTRODUCTION

The implementation of artificial intelligence (AI) in construction project management has accelerated in recent years, driven by the need for efficiency, safety, and sustainability [1][2][3][4][5][6][7][8][9][10][11]. However, the impact of world wars, trade wars, and technological wars on this process is complex and multifaceted. While direct research explicitly linking these types of conflicts to AI adoption in construction is limited, the literature provides valuable insights into how global disruptions, technological competition, and regulatory shifts shape the pace and nature of AI integration. Wars and conflicts often act as catalysts for technological innovation, but they can also introduce barriers such as resource constraints, regulatory uncertainty, and ethical dilemmas [12][7][4]. Trade wars and technological competition, in particular, influence the global flow of knowledge, supply chains, and investment in digital transformation, affecting the construction sector's ability to adopt advanced AI solutions [5][9][4]. This review synthesizes findings from recent literature to elucidate the indirect but significant ways in which wars and global conflicts have shaped, and continue to shape, the implementation of AI in construction project management.

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RESEARCH METHOD

In this study, we employed a systematic literature review to provide a structured and in-depth overview of the current knowledge and understanding of the research topic. Systematic literature reviews play a crucial role in critically analyzing and synthesizing existing research. Therefore, our review process is based on Mayring's process model [13]. This process involves four sequential steps: material collection, descriptive analysis, category selection, and material evaluation [14], as illustrated in Figure 1.

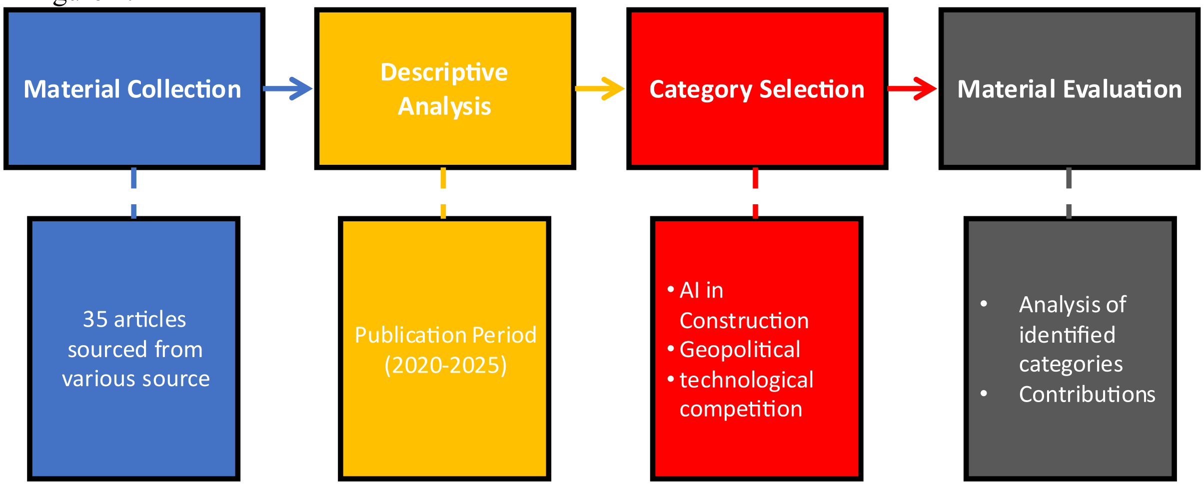

Figure 1. Application of Mayring's process.

Material Collection

Journal articles for this study were gathered through structured keyword searches across various databases, including MDPI, Scopus, and IT Con. The search focused on the application of artificial intelligence (AI) in project management, utilizing diverse keyword combinations such as "artificial intelligence AND construction" and "world wars, trade wars & technological wars on AI implementation in construction project management".

The initial criteria restricted the selection to peer-reviewed journal articles written in English. Following this initial search, a four-stage filtering process was employed: language verification, abstract review, a Semantic Relevance Review, and full-text analysis. As illustrated in Figure 2, this rigorous selection process ultimately yielded 35 relevant articles for further analysis in the research.

Data Analysis

This study's data analysis utilizes a mixed-methods approach, integrating qualitative content analysis with quantitative visualization techniques. The foundational methodology rests on K. O'Halloran 's [15] definition, which posits content analysis as a rigorous research method providing a systematic and objective mechanism for deriving valid inferences from verbal, visual, or written data to accurately describe and measure specific phenomena.

The selection of this integrated methodology was deliberate, designed to effectively transition complex, text-based insights into structured, quantifiable data, thereby significantly enhancing the clarity of interpretation. Specifically, the research systematically extracted and collated findings from a corpus of 35 scholarly articles. These extracted findings were subsequently categorized and quantified through bar charts to construct a comprehensive profile of the influence of Artificial Intelligence (AI) across three intersecting domains: Construction, Geopolitics, and technological competition.

This meticulous profiling serves to address the primary research question, which investigates the extent to which global conflicts—including world wars, trade wars, and technology wars—exacerbate or redefine the challenges associated with implementing AI in construction project management. Based on a focused review of the selected literature and a careful analysis of the collected data, a distinct taxonomy of implementation challenges for artificial intelligence within construction project management was systematically identified and established across the entire body of evidence.

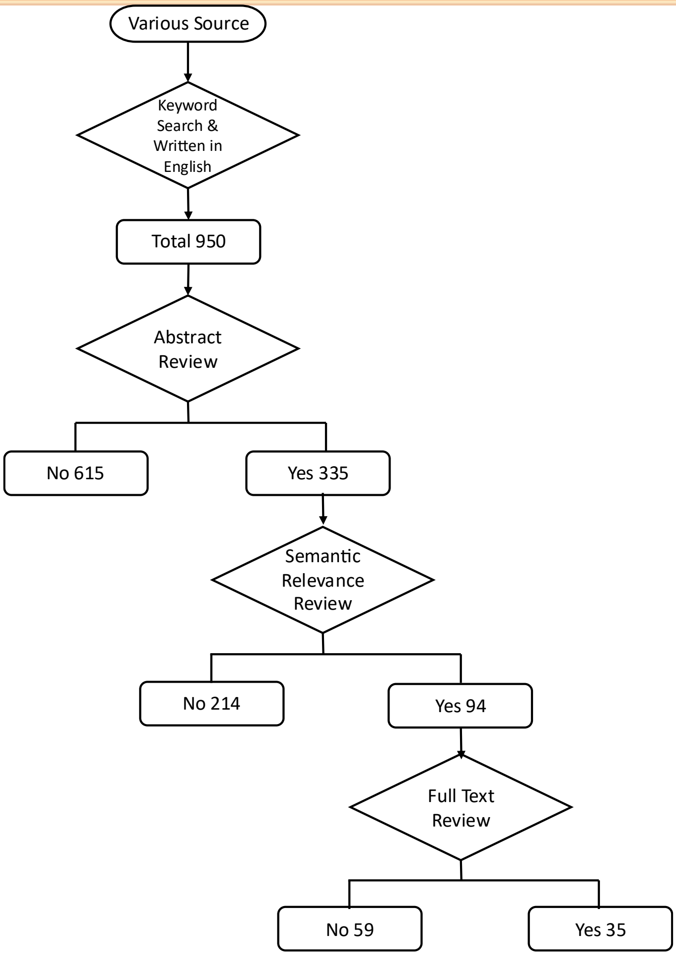

Figure 2. Literature search and selection process.

RESULT AND DISCUSSION

Historical and Geopolitical Context

While direct empirical investigations specifically establishing the relationship between large-scale global conflicts (such as the World Wars) and the rate of Artificial Intelligence (AI) adoption within the modern construction environment remain markedly limited, the historical literature and sociotechnical analyses consistently underscore the role of major military conflicts as a primary driver and potent accelerator of technical innovation. This acceleration stems from the critical wartime imperatives for resource efficiency and production speed, significantly impacting the evolution of both construction methodologies and project management paradigms. Nevertheless, it is crucial to recognize that the translation of emergent technological capabilities forged during conflict periods into the structured implementation of AI in post-war civil practice is not an automatic process. This adoption window is critically mediated by a series of macroeconomic and institutional post-conflict variables. These determining factors include the pace and nature of national economic recovery, industry-wide regulatory reforms, and fundamental strategic shifts in the investment and operational priorities of the construction sector [1][11]. Therefore, while conflicts set the innovative stage, the subsequent socio-economic conditions and policy frameworks ultimately govern the actual pace of AI integration.

Trade Wars and Technological Competition

The global landscape of Artificial Intelligence (AI) implementation is profoundly shaped by geopolitical tensions, particularly the intensifying trade wars and technological competition among major powers. These dynamics exert a direct and complex influence by fundamentally altering the configuration of global supply chains, establishing differential access to critical digital technologies, and simultaneously eroding or strengthening multilateral cooperation mechanisms [6] [9][4].

Specifically, the deployment of political instruments, such as the imposition of tariffs, stringent export controls, and protracted intellectual property disputes, acts as a significant impediment. These barriers increase operational costs and technological uncertainty, thereby slowing the pace of AI tool adoption, especially in economies that rely heavily on the importation of advanced hardware, software, and specialized foreign expertise [6] [9].

However, the reverse effect—a competitive stimulus—is equally crucial. The pressure generated by technological competition often compels nation-states to prioritize self-sufficiency and digital sovereignty. This pressure accelerates domestic innovation, necessitates massive strategic investment in indigenous AI research and development, and actively promotes the rapid adoption of digital transformation initiatives. Notable examples include the aggressive push for industry frameworks such as Construction 4.0 and the sophisticated development and deployment of digital twin technologies [6] [6][9][4]. Therefore, while trade friction creates barriers, the underlying technological race simultaneously acts as a powerful catalyst for localized AI advancement.

AI Adoption Drivers and Barriers in Construction

The strategic adoption of Artificial Intelligence (AI) within the Architecture, Engineering, and Construction (AEC) sector is consistently driven by three overarching industry imperatives. Firstly, there is a fundamental need for enhanced safety protocols by leveraging AI for real-time hazard detection, risk prediction, and proactive site monitoring, thereby reducing incident rates and improving compliance. Secondly, AI offers unprecedented opportunities for optimizing operational efficiency through automated project scheduling, resource allocation, and predictive maintenance, leading to significant reductions in time and cost overruns. Finally, the growing global focus on environmental responsibility mandates the use of AI to promote long-term project sustainability, optimizing material usage and improving energy consumption modeling [3][2][1][7][4][9].

However, despite these compelling benefits, the path to widespread AI integration is fraught with significant systemic and contextual barriers. Pervasive challenges include deep-seated organizational resistance to change and a critical lack of technically skilled labor capable of deploying and maintaining complex AI systems. Furthermore, external factors such as regulatory uncertainty regarding data ownership and algorithmic accountability, coupled with emerging ethical concerns related to surveillance and bias, complicate implementation. These inherent obstacles are often acutely amplified and exacerbated, particularly during periods of geopolitical conflict or acute macroeconomic instability, where investment in new technologies is curtailed and risk aversion dominates decision-making [12][7][4][9].

Nevertheless, industry stakeholders identify the synergistic integration of AI with other disruptive technologies as a crucial pathway for overcoming several existing adoption hurdles. For instance, pairing AI-driven analytics with real-time data streams from the Internet of Things (IoT) sensors and the complex fabrication capabilities of 3D printing offers a robust framework for autonomous construction processes. This integration, while holding great promise, simultaneously introduces new layers of technical and logistical complexity. Chief among these new challenges are issues concerning system interoperability—ensuring seamless communication between diverse hardware and software platforms—and establishing stringent, robust data security and privacy architectures to manage the vast quantities of sensitive project data generated [9][16][4].

Indirect Impacts: Supply Chains, Labor, and Regulation

Global conflicts and persistent trade disruptions exert substantial indirect, yet profoundly consequential effects on construction project management by fundamentally destabilizing three core operational pillars: global supply chains, labor market dynamics, and the consistency of regulatory frameworks. Specifically, volatility stemming from international geopolitical instability directly precipitates severe supply chain fragmentation. This fragmentation manifests as highly unpredictable material delays, significant and rapid cost inflation for critical inputs, and a corrosive inability to reliably guarantee procurement timelines. Concurrently, these macro-environmental shifts induce acute pressure on construction labor markets, characterized by heightened skills shortages, restrictive migration policies, or sharp increases in wage demands, thereby undermining project staffing efficiency and productivity targets. Furthermore, the ensuing economic uncertainty often compels governmental bodies to swiftly revise trade protocols, safety mandates, or environmental compliance requirements, introducing complex, unforeseen regulatory hurdles that substantially deviate from original project baselines. These synergistic macro-environmental pressures culminate in project extensions, substantial budget overruns, and heightened execution complexity, which invariably complicates the seamless and timely integration of advanced digital solutions like Artificial Intelligence (AI) and Machine Learning, particularly within large-scale, globally dependent project portfolios. Paradoxically, periods defined by systemic crisis and elevated operational risk often function as non-negotiable catalysts for accelerated digital transformation. These crises compel construction firms to execute strategic investments in automation, predictive analytics, and AI technologies—not merely for marginal efficiency gains, but as a fundamental imperative to establish proactive risk mitigation, overcome pervasive resource constraints, bolster organizational resilience, and secure a sustainable competitive advantage in an increasingly volatile operational landscape [4][5][6][9].

Table 1. Comparison of key studies on the impact of wars and global conflicts on AI implementation in construction project management.

Paper	Focus	Methodology	Key Results	Conflict Linkage
[1]	AI in AEC industry	Scientometric analysis	Identifies trends, gaps, and future directions in AI adoption	Highlights post-conflict innovation surges
[4]	Intelligent construction	Quantitative & qualitative review	Summarizes digital transformation strategies and challenges	Discusses impact of global disruptions
[5]	Construction 4.0	Comparative analysis	Reviews digital and AI technologies in construction	Examines effects of technological competition
[9]	3D printing, AI, IoT integration	Explorative review	Assesses benefits and barriers to tech adoption	Notes regulatory and trade barriers
[7]	AI for sustainability & safety	Review	Evaluates AI/ML/DL for operational challenges	Considers ethical and regulatory impacts

Discussion

The existing body of literature suggests that the influence of large-scale geopolitical events, such as historical world wars, on the specific adoption of Artificial Intelligence (AI) within construction project management is predominantly indirect, mediated through complex pathways. While global conflicts have historically served as significant accelerators for broad technological innovation, their impact on the tailored implementation of AI tools in the construction sector is largely filtered by the resulting post-conflict economic landscapes and regulatory environments [1][4]. Put differently, major wars established the enabling conditions (such as massive infrastructure rebuilding investments and new institutional frameworks) rather than directly driving the immediate deployment of modern AI technologies.

In contrast, contemporary forms of global rivalry, notably trade wars and intense technological competition, demonstrate a more immediate and direct impact on the digitization trajectory of the construction industry. These forms of conflict fundamentally reshape access to technology (e.g., through export sanctions or restrictions), influence investment flows (diverting capital towards domestic or deemed-secure markets), and consequently determine the overall pace of digital transformation within the industry [5][9][4].

Although the evidence concerning the broader impacts of global disruptions on digital transformation is generally considered strong, the literature identifies a significant gap in establishing direct causal links between specific instances of warfare (whether global or regional) and the precise rate of AI adoption in the construction sector. More substantial and immediate impediments to successful AI integration are recognized as being internal and ethical in nature, encompassing crucial regulatory hurdles, concerns over data ethics and governance, and especially, the challenges related to workforce readiness and skill gaps [12][7][9]. These barriers are often exacerbated and become more intractable in regions currently grappling with sustained economic instability or ongoing conflict. The prevailing research thus underscores that to successfully advance AI integration in construction project management, the focus must shift toward cultivating operational resilience, enhancing organizational and technological adaptability, and fostering sustained international collaboration[4][5][6].

Table 2. Key claims and support evidence identified in these papers.

Claim	Evidence Strength	Reasoning	Papers
Global conflicts and trade wars indirectly shape AI adoption in construction via supply chains, regulation, and investment.	Strong	Multiple reviews and analyses show consistent indirect effects, though direct causal studies are limited.	[1], [4], [6], [5], [9]
Technological competition can accelerate domestic AI innovation in construction.	Moderate	Evidence from Construction 4.0 and digital twin adoption supports this, but context-dependent.	[4], [5], [6]
Ethical, regulatory, and workforce barriers are exacerbated during conflicts, slowing AI implementation.	Moderate	Systematic reviews highlight these barriers, especially in unstable regions.	[7], [9], [12]
Direct research linking world wars to current AI adoption in construction is lacking.	Weak	Literature reviews note the absence of direct studies, relying on historical analogies.	[1], [4]
Integration of AI with IoT and 3D printing offers resilience but faces regulatory and technical challenges.	Moderate	Explorative reviews and case studies support this, but real-world validation is limited.	[4], [9], [16]
Wars can act as both catalysts and barriers for technological adoption, depending on context.	Moderate	Historical and theoretical analyses suggest mixed impacts, with context-specific outcomes.	[4], [5], [16]

CONCLUSION

Conclusion

The prevailing body of literature indicates a compelling, though often indirect, relationship between global conflicts—specifically encompassing world wars, trade hostilities, and technological arms races—and the subsequent implementation and adoption of Artificial Intelligence (AI) within the domain of construction project management. These geopolitical disruptions have not acted as singular, direct causes, but rather as powerful forces mediating through several critical pathways. These pathways include the acceleration or deceleration of technological innovation, the shaping of regulatory and legislative environments (particularly concerning data security and technology transfer), the vulnerability and subsequent restructuring of global supply chains, and the fluctuation and redirection of investment patterns toward digitalization initiatives.

While empirical research establishing a direct, linear causality between specific global conflicts and AI adoption rates remains limited, the cumulative evidence strongly suggests that such worldwide upheavals operate under a dualistic mechanism. They function simultaneously as significant barriers (e.g., introducing economic uncertainty and trade restrictions that stifle investment) and as potent catalysts (e.g., creating an urgent mandate for efficiency, autonomy, and digital resilience). Consequently, the ultimate impact of these conflicts on the digital transformation of the construction industry is highly contingent upon the specific regional context, the implemented policy frameworks, and the inherent resilience and adaptability demonstrated by individual firms and the sector as a whole.

Research Gaps

The rapid growth of interest in Artificial Intelligence (AI) within the construction sector is not paralleled by robust empirical research, particularly concerning the disruptive role of war and global conflicts on its adoption. Existing studies largely address broader digital transformation frameworks, resulting in a lacuna regarding the conflict-specific pressures that either impede or catalyze the implementation of AI technologies.

Table 3. Matrix of research topics, highlighting gaps in direct conflict impact studies.

Topic / Attribute	Direct Conflict Impact	Regulatory Barriers	Supply Chain Disruption	Workforce Adaptation	Tech Integration (AI+IoT/3DP)
AI Adoption Trends	2	5	4	3	4
Digital Transformation	1	6	5	2	3
Construction 4.0	GAP	3	2	1	2
Ethics & Regulation	GAP	7	2	2	1
Case Studies	GAP	1	1	GAP	GAP

Open Research Questions

Future research should focus on empirically investigating the direct and indirect impacts of wars and global conflicts on AI adoption in construction, as well as developing frameworks for resilience and adaptation in the face of such disruptions.

Table 4. Open research questions for future investigation on the impact of wars on AI in construction.

Question	Why
How do world wars, trade wars, and technological wars directly affect the pace and nature of AI adoption in construction project management?	There is a lack of empirical studies directly linking conflicts to AI implementation, making it crucial to understand these relationships for future resilience.
What strategies can construction firms employ to mitigate the negative impacts of global conflicts on digital transformation and AI integration?	Identifying effective strategies will help firms maintain competitiveness and project continuity during periods of disruption.
How do regulatory and ethical challenges evolve in the construction sector during and after major global conflicts?	Understanding these dynamics is essential for developing adaptive policies and ensuring responsible AI adoption in volatile environments.

In conclusion, while wars and global conflicts have shaped the landscape for AI implementation in construction project management, significant research gaps remain, particularly regarding direct causal impacts and adaptive strategies for resilience.

REFERENCES

[1] A. Darko, A. Chan, M. Adabre, D. Edwards, M. Hosseini, and E. Ameyaw, "Artificial intelligence in the AEC industry: Scientometric analysis and visualization of research activities," *Autom. Constr.*, vol. 112, p. 103081, 2020, doi: 10.1016/j.autcon.2020.103081.

[2] T. D. Akinosho *et al.*, "Deep learning in the construction industry: A review of present status and

future innovations," *J. Build. Eng.*, vol. 32, 2020, doi: 10.1016/j.jobe.2020.101827.

[3] A. Waqar, "Intelligent decision support systems in construction engineering: An artificial intelligence and machine learning approaches," *Expert Syst. Appl.*, vol. 249, p. 123503, 2024, doi: 10.1016/j.eswa.2024.123503.

[4] L. Zhang, Y. Li, Y. Pan, and L. Ding, "Advanced informatic technologies for intelligent construction: A review," *Eng. Appl. Artif. Intell.*, vol. 137, p. 109104, 2024, doi: 10.1016/j.engappai.2024.109104.

[5] N. Perrier *et al.*, "Construction 4.0: a Comparative Analysis of Research and Practice," *J. Inf. Technol. Constr.*, vol. 24, no. January, pp. 16–39, 2024, doi: 10.36680/j.itcon.2024.002.

[6] R. Taiwo *et al.*, "Generative AI in the Construction Industry: A State-of-the-art Analysis," 2024, [Online]. Available: http://arxiv.org/abs/2402.09939

[7] E. Z. Gill, D. Cardone, and A. Amelio, "Revolutionizing the construction industry by cutting edge artificial intelligence approaches: a review," *Front. Artif. Intell.*, vol. 7, 2024, doi: 10.3389/frai.2024.1474932.

[8] C. Wang, L. Song, Z. Yuan, and J.-S. Fan, "State-of-the-art AI-based computational analysis in civil engineering," *J. Ind. Inf. Integr.*, vol. 33, p. 100470, 2023, doi: 10.1016/j.jii.2023.100470.

[9] B. S. Alotaibi *et al.*, "Assimilation of 3D printing, Artificial Intelligence (AI) and Internet of Things (IoT) for the construction of eco-friendly intelligent homes: An explorative review," *Heliyon*, vol. 10, 2024, doi: 10.1016/j.heliyon.2024.e36846.

[10] H. Liu, H. Su, L. Sun, and D. Dias-Da-Costa, "State-of-the-art review on the use of AI-enhanced computational mechanics in geotechnical engineering," *Artif. Intell. Rev.*, vol. 57, p. 196, 2024, doi: 10.1007/s10462-024-10836-w.

[11] L. Filho *et al.*, "Deploying digitalisation and artificial intelligence in sustainable development research," *Environ. Dev. Sustain.*, vol. 25, pp. 4957–4988, 2022, doi: 10.1007/s10668-022-02252-3.

[12] C.-J. Liang, T.-H. Le, Y. Ham, B. Mantha, M. Cheng, and J. Lin, "Ethics of Artificial Intelligence and Robotics in the Architecture, Engineering, and Construction Industry," *ArXiv*, vol. abs/2310.0, 2023, doi: 10.1016/j.autcon.2024.105369.

[13] S. Seuring and M. Müller, "From a literature review to a conceptual framework for sustainable supply chain management," *J. Clean. Prod.*, vol. 16, no. 15, pp. 1699–1710, 2008, doi: https://doi.org/10.1016/j.jclepro.2008.04.020.

[14] Y. Adebayo, P. Udoh, X. B. Kamudyariwa, and O. A. Osobajo, "Artificial Intelligence in Construction Project Management: A Structured Literature Review of Its Evolution in Application and Future Trends," *Digital*, vol. 5, no. 3, pp. 1–21, 2025, doi: 10.3390/digital5030026.

[15] K. O'Halloran, S. Tan, D.-S. Pham, J. Bateman, and A. Vande Moere, "A Digital Mixed Methods Research Design: Integrating Multimodal Analysis With Data Mining and Information Visualization for Big Data Analytics," *J. Mix. Methods Res.*, vol. 12, pp. 11–30, 2018, doi: 10.1177/1558689816651015.

[16] M. Alahi *et al.*, "Integration of IoT-Enabled Technologies and Artificial Intelligence (AI) for Smart City Scenario: Recent Advancements and Future Trends," *Sensors (Basel).*, vol. 23, 2023, doi: 10.3390/s23115206.