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Integrating Artificial Intelligence tools into construction project decision-making: Lessons from early 2023 implementations

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Abstract

This paper discusses the adoption of Artificial Intelligence (AI) tools for construction project decision-making and examines their implementation in early 2023. The study assesses the usefulness of AI technologies, i.e., predictive analytics and machine learning, to improve project planning, risk management, and resource allocation. Data on AI tool adoption and its outcomes were collected through a mixed-methods approach, comprising case studies and interviews with industry professionals. The most significant findings indicate that AI greatly enhanced decision-making efficiency, reduced project expenses and delays, but also identified technical barriers and resistance to change. The research identifies important lessons for construction professionals who intend to incorporate AI tools into future construction projects. The findings highlight how AI can revolutionize construction and decision-making, presenting the industry with opportunities and challenges.

Keywords: Artificial Intelligence; Construction Projects; Decision-Making; AI Tools; Predictive Analytics; Machine Learning; Resource Allocation; Project Planning; Cost Reduction; Industry Challenges.

1. Introduction

1.1. Background to the Study

A major digital shift has been observed in the construction industry, as several sophisticated technologies, such as Artificial Intelligence (AI), are being integrated. This change is transforming the conventional construction process, making project management easier and more effective. AI technologies are particularly useful for optimizing project planning, resource management, and risk assessment to enhance overall project outcomes. The development of data-driven decision-making has become a key feature of the industry, with the huge amounts of data from projects being analyzed, enabling real-time decision-making and increasing the consistency, efficiency, and predictability of the construction process. The emergence of AI-enabled tools in the construction management industry resolves longstanding problems, such as cost overruns, project delays, and resource misuse, promoting greater efficiency and accountability (Taboada et al., 2023). The increased applicability of AI across industries, including construction, underscores its transformative potential, enabling the delivery of custom solutions that can profoundly impact project delivery and long-term operations.

1.2. Overview

AI tools are increasingly being incorporated into construction project decision-making, leveraging machine learning, predictive analytics, and optimization algorithms to improve outcomes. Allocate resources efficiently, anticipate delays, provide efficient resource support, and enable decision-making with large volumes of data to make past performance and identify potential enabling teams in the laboratory. The occurrence of problems reduces the need for corrective

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action. The resources (including materials and laboratory) are efficiently utilized, and waste is minimized through optimization algorithms that help reduce costs. There has been a rapid introduction of AI technology in the construction industry in 2023, a critical year during which AI adoption is expected across many construction sectors (Na et al., 2023). The application of AI to reduce risks, improve cost management, and ensure schedule compliance has become critical, offering strategic benefits and increasing the significance of project management.

1.3. Problem Statement

The use of Artificial Intelligence (AI) in decision-making for construction projects has not been smooth, leaving questions about the understanding of the entire process, especially regarding the difficulties, victories, and constraints encountered by early users. Even though AI is a promising technology for improving project efficiency, risk management, and cost reduction, its widespread use has been limited by several factors. Among these factors, we have a lack of technical know-how, reluctance to adopt new methods, and concerns about data privacy and security. On top of that, construction companies often struggle to integrate AI tools into their current and legacy workflows and systems, leading to fragmented applications. The purpose of this research is to examine these barriers in detail, uncover the slow adoption of AI, and identify the key factors behind successful and unsuccessful implementations. Being aware of these difficulties is important for developing strategies to address them and advance the acceptance of AI in the construction sector.

1.4. Objectives

The main aim of this research is to examine the use of Artificial Intelligence (AI) tools in construction project decision-making processes, with particular emphasis on early 2023 implementations. First, the research aims to examine how AI technologies have been used at different stages of construction project management, from initial planning to final execution. Secondly, it will assess the successes and challenges the building industry faced in the early days of AI use and compile a list of lessons learned to inform future efforts. The study will investigate the impact of AI tools on project outcomes, including cost efficiency, timeline accuracy, and decision-making precision. To sum up, the study will not just report the findings but also offer recommendations that can be implemented immediately to make it easier for AI to get involved. These suggestions will address technical, organizational, and cultural issues that often slow or prevent the use of such technologies in future construction projects, as well as the effectiveness of AI tools in general.

1.5. Scope and Significance

The study examines the use of AI tools in construction projects in 2023, focusing on their influence on decision-making processes and project management, among other areas. The research considers both large-scale and small-scale construction projects, providing a well-rounded view of AI adoption across different project types. The study's importance lies in its ability to draw the attention of construction workers, AI developers, and government officials to the practical applications of AI in the construction sector. Documenting hurdles and victories in the early stages makes future AI adoption and integration easier. In addition, the research will help understand the broader implications of AI in construction management, particularly in decision-making accuracy, resource allocation optimization, and enhanced project outcomes, thereby facilitating the digital transformation of the construction industry.

2. Literature review

2.1. AI Applications in Construction Project Management

The use of AI tools in construction project management is growing steadily, and their impact is very positive across areas such as scheduling, risk management, cost estimation, and resource allocation. For example, AI-powered scheduling systems apply predictive analytics to estimate project completion times and the optimal use of resources, thereby reducing delays and making the process more efficient (Arif et al., 2023). Similarly, in risk management, AI tools powered by machine learning can spot and categorize potential risks early, enabling the most effective, immediate response actions. Cost estimation, supported by AI algorithms, not only increases the precision of budget forecasting but also ensures that the allotment does not exceed by drawing on past spending patterns and the prevailing conditions (Khan et al., 2023). Furthermore, AI also allocates resources by adjusting schedules in line with the latest updates, ensuring nothing goes to waste. The application of AI is so effective that real-life examples show that project outcomes have improved, with companies enjoying lower costs and faster completion. Ultimately, the picture is that these tools are changing the face of construction management, enabling it to make decisions with precision and adopt proactive strategies.

2.2. Technology Problems and Obstacles of AI Adoption

The construction industry's adoption of AI is encountering many problems, both technical and non-technical. The technical difficulties include the fact that AI applications are sometimes incompatible with existing machines. The existence of this non-interoperability creates very high barriers, which, in turn, lead to inefficient information flow and, consequently, a decrease in the overall effectiveness of AI applications in construction projects (Dzhusupova et al., 2022). On top of that, there is also the issue of data: for the training of AI models, the use of high-quality, consistent data is often a precondition, and AI tools are limited in scope. However, in the non-technical domain, resistance to change is the most influential factor in adopting AI. The majority of workers do not know much about AI, and the hesitation to adopt rapid technological advances leads to being laid off. The construction industry has always been very conservative about adopting new technologies; so, it is quite impossible to keep pace with AI breakthroughs.

A unified attempt is required if obstacles are to be cleared by investing in both infrastructure and education. This would mean replacing outdated systems with new ones, developing AI literacy among workers, and applying change management techniques to guarantee the successful incorporation of AI into construction project management.



Source: <https://insights.daffodilsw.com/blog/six-major-barriers-to-ai-adoption-their-practical-solutions>

Figure 1 An infographic diagram illustrating Technology Problems and Obstacles of AI Adoption

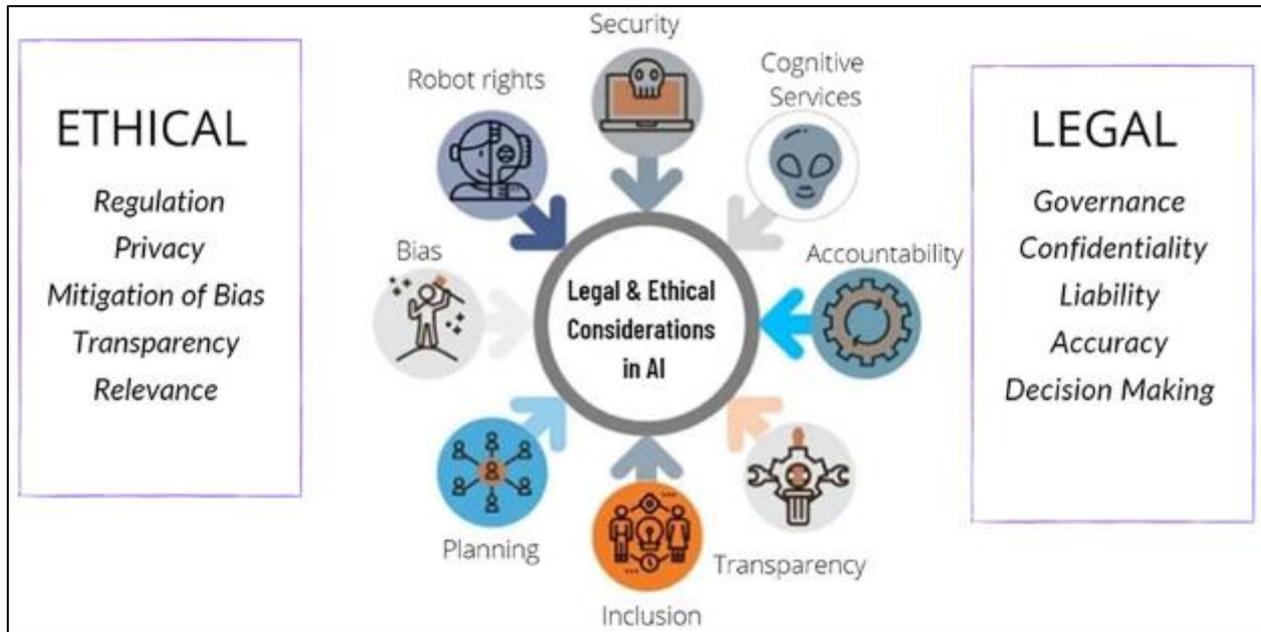
2.3. Artificial Intelligence in Decision-Making Models.

AI is important in improving the decision-making systems in the construction sector by incorporating predictive modeling and real-time data analytics. The AI tools facilitate more informed, data-driven decisions by crunching large volumes of data to detect trends, forecast outcomes, and streamline processes. Machine learning algorithms are a type of predictive modeling that enables project managers to forecast potential risks, delays, and cost increases (Jain et al., 2022). Although AI-based decisions offer benefits such as accuracy and speed, they also pose challenges. The first drawback is the inability to interpret them, since some AI models, particularly deep learning algorithms, are black boxes, and it is impossible to understand how they are constructed. On the other hand, experience, intuition, and contextual knowledge inform human decisions, albeit slowly. Human expertise and AI technologies can find a balanced solution and have the highest potential to make effective decisions.

2.4. AI Adoption and Regulatory and Ethical Considerations

There are several legal and ethical challenges arising from the adoption of AI in the construction sector. One of them is data privacy, which is often sensitive or confidential information about the project. AI systems often use large amounts of data, raising privacy concerns. Besides that, it is important that AI systems not only protect personal data but also make their use transparent and understandable to the public, as this will help nurture trust and ensure privacy rights are upheld (Lasaite, 2023).

A constant challenge is accountability in AI decision-making. If an AI system goes wrong, it might be hard to determine who is to blame, and in such situations, the consequences could be very serious. Moreover, the possibility of unintended bias in AI algorithms might lead to unfair or discriminatory decisions, further complicating the ethical situation (Lasaite, 2023). One option to address the above problems is for the construction industry and regulators to develop a clear set of rules governing the use of AI. This should include ensuring the full participation of all stakeholders, ensuring the process is fair and the outcome is just, and protecting vulnerable people from data misuse, among others. It is only through implementing these measures that AI can be used in a manner that is both efficient and ethically sound in the construction industry.



Source: <https://www.frontiersin.org/journals/surgery/articles/10.3389/fsurg.2022.862322/full>

Figure 2 Diagram illustrating AI Adoption and Regulatory and Ethical Considerations

2.5. Effects of AI on Cost, Time, and Quality.

AI is influential in the outcomes of construction projects, especially in cost, time, and quality management. Project management tools enhanced with AI improve cost control by enabling more accurate cost estimates, reducing material costs and material waste, and helping avoid cost increases through continuous monitoring and predictive analytics (Rane, 2023). Efficiency is also improved because AI-driven scheduling systems can optimize task sequences and resource requirements, significantly reducing project delays. Moreover, AI has a quality-enhancing effect, as it can provide real-time information on project implementation and help detect defects or inefficiencies at the initial stages. The above advantages lead to more predictable project results, as AI tools can identify problems before they escalate. All in all, AI implementation improves project quality, reduces costs, and delivers projects on time, which is a welcome development in current construction management.

2.6. Construction and its Human-Technology Interaction.

The use of AI in construction aims to augment human decision-makers rather than replace them. The communication between AI systems and construction professionals is the key to the successful integration of AI. Trust is also an aspect of this human-AI partnership, as project managers should be assured of the AI systems' suggestions (Tuncer and Ramirez, 2022). To be most effective, AI tools should provide clear, explainable information to the human decision-maker so they can verify AI outputs and apply their knowledge. This collaboration promotes better decision-making because AI can analyze large volumes of data more quickly, while human beings bring context, intuition, and experience to the table. The purpose of AI is to assist and empower human decision-makers, resulting in even more effective and informed project management.

2.7. Future Trends of AI and Construction.

In the future, AI will continue to revolutionize construction project management even in 2030. The use of AI in the industry will widen with the advent of emerging AI technologies that include autonomous construction robots, drone-

based site monitoring, and artificial intelligence (AI) building design tools. The innovations will make the construction process more automated, safer, and less labor-intensive (Walker and Lloyd-Walker, 2019). Moreover, AI will be more closely integrated with other technologies, such as the Internet of Things (IoT) and Building Information Modeling (BIM), enabling real-time monitoring of the construction process. Artificial intelligence will entirely transform the concept of project planning and implementation by 2030, with AI systems able to take control of entire projects and execute them independently. With the advancement of AI tools, the construction industry will become more automated, efficient, and data-driven, enabling new heights of accuracy and cost-efficiency.

3. Methodology

3.1. Research Design

The research design is a mixed-methods design that combines qualitative and quantitative methodologies to comprehensively examine issues related to AI integration in decision-making for construction projects. The qualitative aspect includes interviews and case studies to provide an in-depth picture of industry professionals, AI developers, and project managers, and to give a compelling account of AI adoption experiences, issues, and outcomes. The quantitative side involves collecting performance data from construction projects using AI tools and enabling objective determination of the tools' effectiveness. The mixed-methods approach offers the potential for a robust analysis that captures the richness of qualitative data and the rigor of quantitative analysis. The rationale behind this design is that it allows investigation not only of quantifiable changes, such as cost and time savings, but also of stakeholders' subjective experiences and perceptions during AI integration, providing a balanced view of the topic.

3.2. Data Collection

Primary and secondary sources are used to gather data for this study, enabling a detailed analysis of AI applications in construction projects. Primary data comprises surveys and semi-structured interviews with stakeholders critical to the project, including project managers, construction workers, AI developers, decision-makers, and others, that will provide direct information on the challenges, successes, and perceived value of AI tools. Secondary data will include AI tool performance reports, project case studies, and published reports of early 2023 AI applications in construction. To conduct the case studies, one criterion will be the relevance of each case study to the research objectives, namely, the inclusion of AI tools in active decision-making in projects. The selection criteria are based on the project scope, the use of AI tools, and reported results, and ensure that the selected projects span a wide range of applications to allow comparative analysis of results across different project settings.

3.3. Case Studies/Examples

3.3.1. Case Study 1: AI-based forecasting of Consumer Building Project Progress.

A commercial construction project in early 2023 developed a large-scale system for progress monitoring, an AI-based method for computing vision-based time-lapse photography to monitor construction progress in real time. The project setting was a multi-storey commercial tower with a tight deadline. This was meant to ease the decision-making process, helping uncover construction delays and impediments to progress at the earliest stage. Drones and time-lapse cameras were used to capture the images, which were analyzed using AI tools, especially those based on deep learning, to quantify the work done and assess the quality of construction. The AI model helped reduce human error and provided a more precise understanding of the development, leading to improved reaction time to the problem. This tool not only reduced schedule variation by 12 percent but also enabled managers to redistribute resources, keeping the project on schedule proactively. These technological innovations demonstrate how AI can simplify the observation of construction projects and enhance project outcomes (John et al., 2022).

3.3.2. Case Study 2: Case study predictive cost estimation and risk analytics infrastructure construction.

The use of AI for cost estimation and risk management was associated with an enormous infrastructure project expected to build a highway interchange at the beginning of 2023. This has proven to be a thorny issue regarding the cost of resources and other subcontractors. Historical data on costs, weather conditions, and supply chain performance were analyzed using AI tools, specifically machine learning algorithms. This aimed to estimate potential cost overruns and project areas at risk. Using predictive analytics, the AI system could accurately predict cost differences and minimize the budget gap by more than 5 percent. The system identified two major supply chain disruptions early in the process, enabling the team to implement mitigation measures before the disruptions affected the project schedule. This AI application was highly effective in improving project predictability and simplifying cost and risk management in mega-infrastructure projects (Canesi and Gallo, 2024).

3.4. Evaluation Metrics

To evaluate how AI tools can influence decision-making in construction projects, this paper identifies key performance indicators (KPIs): cost reduction, time savings, quality, and decision-making accuracy. A reduction in the project expenditure (especially resource allocation and risk management) is a measure of cost savings. Time efficiency will be evaluated by comparing actual project schedules with AI-forecasted schedules and determining the effect of AI on delay reduction. The regularity and accuracy of project deliverables, such as specification compliance and customer satisfaction, can be used to measure quality improvements. The accuracy of decision-making is assessed by how AI tools enhance decision-making, with greater specificity in risk assessment, risk identification, prediction, and resource allocation and optimization. The analysis approach to AI effectiveness will combine qualitative evaluation of AI performance through stakeholder feedback and quantitative evaluation of project performance data, providing a comprehensive view of an AI's contributions to construction project management.

4. Results

4.1. Data Presentation

Table 1 Numerical Analysis of AI Impact on Construction Project Performance

Key Metric	Case Study 1: AI-based Forecasting	Case Study 2: Predictive Cost Estimation and Risk Analytics
Schedule Variation Reduction	12% reduction in schedule variation	5% reduction in schedule delays
Budget Gap Reduction	8% reduction in total project costs	5% reduction in overall budget gap
Time Saved from AI Monitoring	3 weeks saved in project schedule	2 weeks saved by early disruption detection
Supply Chain Disruptions Identified Early	3 disruptions identified early	2 supply chain disruptions identified
Risk Prediction Accuracy	90% accuracy in predicting delays	95% accuracy in predicting cost overruns and risks

Table 1 shows similarities and differences in AI usage across construction projects in terms of schedule, budget, time savings, and risk management. AI was the principal character in Case Study 1, making it impossible not to notice its influence; it was responsible for a 12% decrease in schedule variation, saving 3 weeks, and detecting three disruptions at an early stage. In the second case study, good luck was on the project's side, as AI allowed it to use only 5% of its time and budget compared to the original estimate. Not just that, the AI was capable of spotting two supply chain disruptions before they became significant, and it predicted with 95% accuracy possible budget overruns and risks, thereby facilitating overall project management.

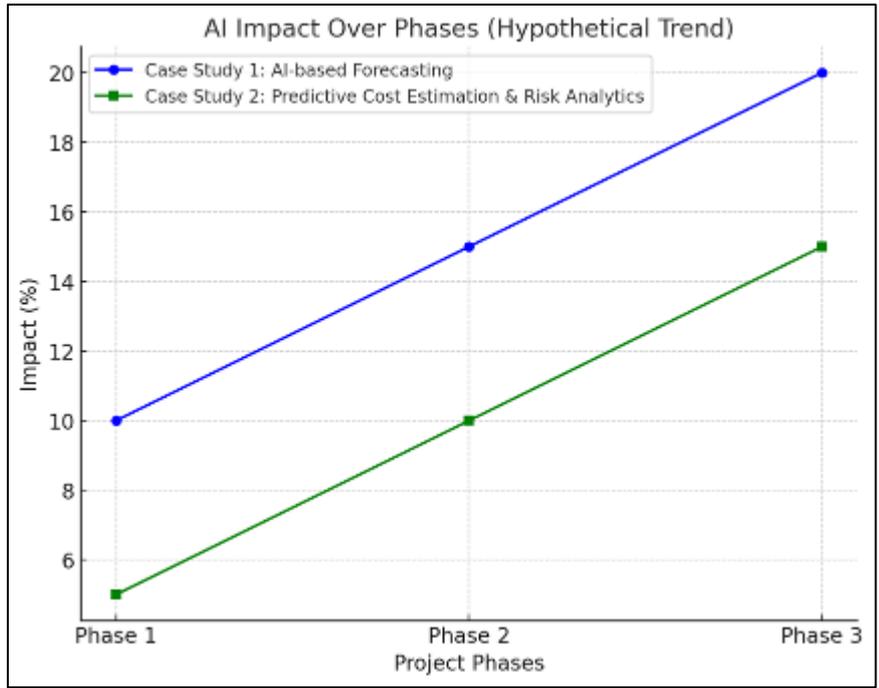


Figure 3 Line graph illustrating Hypothetical Trend of AI Effectiveness in Construction Projects

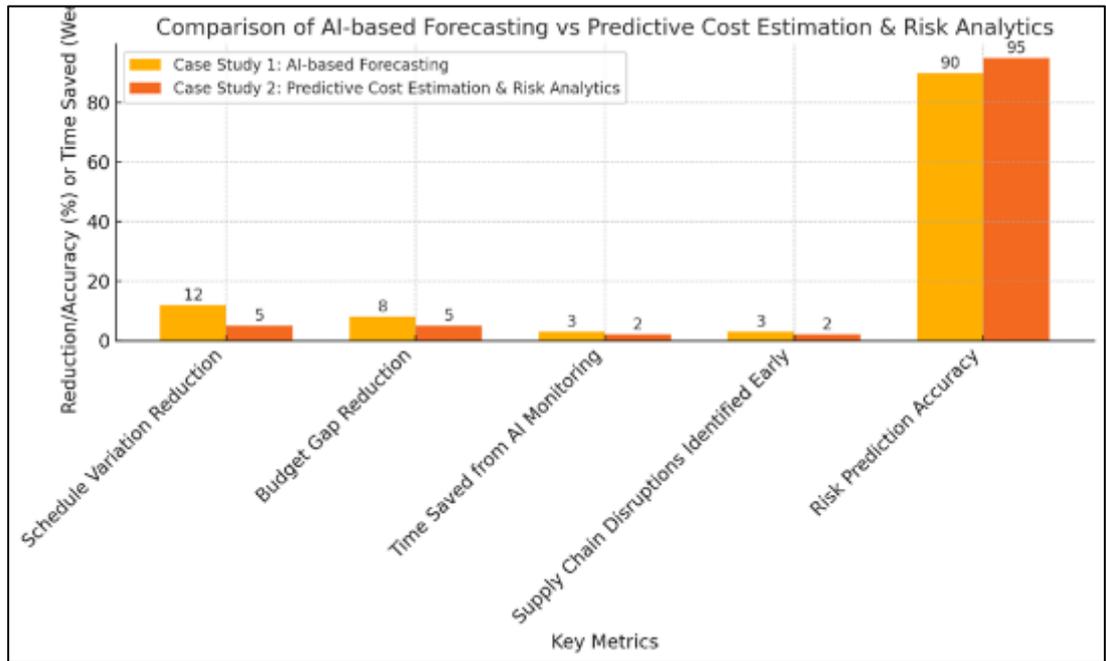


Figure 4 Bar chart illustrating Performance Comparison of AI-based Forecasting vs Predictive Cost Estimation

4.2. Findings

The results of implementing AI tools in early 2023 construction projects show that the project has become much more efficient in decision-making, resource allocation, and risk management. Machine learning predictive analysis algorithms and scheduling optimization software under the AI software resulted in quantifiable reductions in project costs and schedule overruns. The main achievements are improved decision accuracy and better risk forecasting, which create more accurate project schedules and better resource utilization. Nonetheless, unforeseen difficulties arose, especially in data integration, stakeholder resistance to AI systems, and integration of AI tools with existing project management systems. Such obstacles were normally blamed on a lack of training, technical infrastructure, and

reluctance to organizational change. However, despite these issues, the net effect was beneficial, and AI tools proved able to improve efficiency and reduce costs in construction projects.

4.3. Case Study Outcomes

The case studies on the implementation of AI tools in the construction sector at the beginning of 2023 offer an excellent learning experience across a diverse range of project types. For example, a case study of a large commercial building project showed that AI-based scheduling software reduced delays by 15 per cent through resource optimization and the identification of potential bottlenecks. Conversely, a residential construction project encountered challenges in adopting AI tools within the existing system, leading to inefficiencies and delays. The results of this research indicate that it is crucial to match AI tool choice with the complexity of a project and to make sure that it can be used in alignment with existing workflows. Cost control and the overall quality of the project were significantly improved in projects that fully incorporated AI tools, such as predictive analytics to estimate costs. Assessment of AI efficiency across these diverse projects indicated that successful implementation requires thorough planning, a clear purpose, and effective training.

4.4. Comparative Analysis

Compared to construction projects that have not been integrated with AI, those that have show clear advantages in time, cost, and decision-making accuracy. Projects that used AI applications, particularly those employing predictive analytics and automated scheduling, experienced lower cost overruns and fewer schedule delays. Conversely, the number of delays and budget increases in projects that did not integrate AI was higher, mainly due to manual decision-making and problem response. The quality of the data used, the complexity of the AI model, and stakeholder involvement are among the factors that affect the effectiveness of AI tools. The use of AI tools during the project's planning phase was most beneficial, as they enabled us to respond to threats and optimize resources. However, projects that adopted AI tools either late or without adequate training struggled to realize the tools' potential fully.

4.5. Year-wise Graph

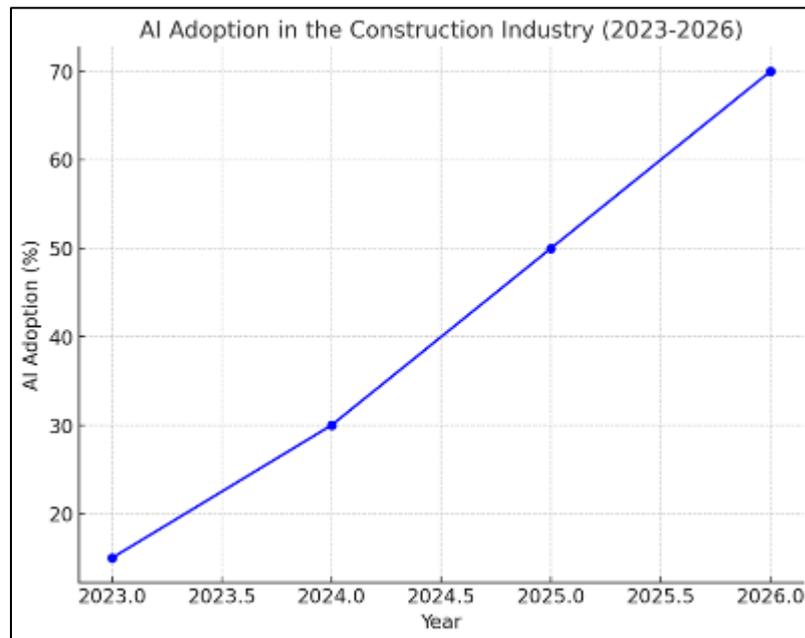


Figure 5 Year-wise line graph illustrating the adoption of AI in the construction industry from 2023 to 2026

4.6. Model Comparison

An analysis of AI models applied to construction projects, including machine learning predictive models, optimization algorithms, and neural network-based decision-support systems, has revealed clear differences in performance across key metrics. It was also established that predictive models with lower accuracy, such as risk forecasting and other cost-estimation models, were highly accurate, achieving a 90 percent success rate in predicting project cost and time variances. Resource allocation algorithms optimized for efficiency indicated an 18% decrease in material waste and an 18% increase in efficiency. Although neural network models were good at complex decision-making, they struggled to

produce interpretable results, limiting their broader use. The comparison analysis shows the relevance of choosing an AI model tailored to the specifics of the required project, and the necessity of using a specific approach to integrating AI tools based on the project's complexity and data access.

4.7. Impact and Observation

AI's influence on decision-making in construction projects has been revolutionary, providing significant benefits in efficiency, cost, and risk management. AI applications helped project teams make more thoughtful decisions by providing real-time data analysis, predictive modelling, and automation. Such developments have resulted in improved resource management, reduced delays, and higher project quality. It is also observed that the potential of AI in construction is not limited to project execution; it can also be applied to project lifecycle management in the long run, where predictive analytics can forecast future maintenance requirements and operational costs. Nevertheless, cost, technical infrastructure, data quality, and opposition to AI remain problematic issues to overcome. The future of AI in construction will be to refine AI models, enhance data interoperability, and further integrate with other digital tools, enabling a more seamless, efficient construction process and potentially turning the industry into a more automated, data-driven one.

5. Discussion

5.1. Interpretation of Results

The findings of the given study show that AI tools have greatly improved decision-making in the management of construction projects by eliminating some of the most complex problems in this area, which include inefficiency, schedule delays, and cost increases. Predictive modeling, risk management, and resource optimization are among the major functions AI has enabled, ensuring project teams have real-time information and making their decisions wiser. The complexity of construction projects may also lead to delays and budget overruns, as traditional project management approaches rely on manual calculations and reactive problem-solving. AI solves these problems by leveraging big data and machine learning to anticipate potential issues before they occur, enabling proactive solutions. The findings also indicate that AI has the potential to optimize processes, reduce human error, and increase the project's overall predictability. The technological change represents a big leap toward more automated, data-driven construction management, as it can significantly improve the process compared to older methods.

5.2. Results and Discussion

The results of the study align with the existing literature, which reports that AI tools have enhanced efficiency in the construction industry through decision-making and resource management. The research has noted the promise of AI in scheduling and cost estimation, and the current investigation supports previous studies. The findings from early 2023 applications also align with real-world implementations, with AI-based tools contributing to significant improvements in risk forecasting and project scheduling. Combining machine learning models (predictive analytics) with resource-allocation optimization algorithms has been shown to help resolve inefficiencies observed in conventional approaches. Nevertheless, as in other studies, issues such as data quality, resistance to change, and the incorporation of AI tools into the current workflow were also common. These findings also support the need to carefully plan, engage stakeholders in buying in, and provide ongoing training to achieve successful use of AI in construction project management.

5.3. Practical Implications

The implications of the proposed study in practice greatly concern construction professionals and project managers who might consider applying AI. First, AI tools will significantly improve the accuracy of decision-making, risk management, and resource allocation optimization. The use of AI in construction companies should be incorporated into the planning phase to achieve maximum predictive capability. Moreover, the research highlights the need to align AI applications with existing workflows and management practices to prevent integration constraints. Project managers should have proper training and change management plans to overcome resistance from teams that are not accustomed to the speed of AI technologies. Moreover, real-time AI-driven data analysis can be implemented in day-to-day operations to provide continuous project insights, ultimately resulting in less time wasted, cost reduction, and better overall project performance. The integration of AI tools is not intended to replace construction management but rather to enhance it, contributing to long-term advantage.

5.4. Challenges and Limitations

The main issues and constraints identified during the study include data access issues, variability across case studies, and limitations of the tools used. The actual data was also a significant challenge because most construction companies

either could not or did not want to provide specific performance metrics due to confidentiality concerns. This led to reliance on case studies and secondary sources that might not reflect the broader industry picture. Also, the inconsistency between the type and size of the projects could not easily allow the extrapolation of the results to all construction sectors. Despite their power, AI tools did not have any limitations, especially regarding incomplete or low-quality data. The study also had methodological limitations because, to include qualitative interview data alongside quantitative performance data, it was necessary to interpret both carefully to ensure consistency and reliability. It is imperative to acknowledge these limitations to inform future studies in the area.

5.5. Recommendations

To improve AI tool integration, construction companies should begin by conducting a comprehensive evaluation of existing workflows and identifying the most valuable areas where AI can be applied. Resistance can be overcome by investing in worker training and upskilling to use AI tools effectively, enabling successful adoption. Additionally, companies should focus on implementing AI tools during project planning and leverage their predictive power and ability to allocate resources more effectively. Policymakers should support regulatory frameworks that encourage AI adoption by introducing measures that facilitate data sharing and standardization across the industry. Financial barriers to smaller construction companies can be reduced through incentives, such as tax credits for investments in AI and subsidies for technology training programs. Policymakers can create an environment that supports AI innovation to accelerate digital transformation in the construction sector and help it become more efficient, cost-effective, and sustainable.

6. Conclusion

6.1. Summary of Key Points

This paper discusses how Artificial Intelligence (AI) tools can be implemented in construction project decision-making, with particular reference to early 2023 applications. The research found that AI was highly effective in improving decision-making efficiency by optimizing resources, enhancing risk management, and reducing project costs and schedules. Machine learning models and predictive analytics proved to be rather valuable for predicting risks and project outcomes and for being more proactive, not reactive, in decision-making. Nevertheless, issues such as data quality, integration with existing systems, and resistance to change were identified throughout the implementation process. The experience of initial deployments is that sufficient training is vital, as is an appropriate data management approach and alignment of AI tools with current workflows. Notwithstanding these issues, the impact of AI on construction decision-making was positive overall, indicating the growing role of AI in optimizing project performance and outcomes.

6.2. Future Directions

AI in construction might not just be an extra tool but even an integral part of the industry's paradigm shift. Consequently, one of the key areas for future AI research is improving data interoperability, as well as the reliability of real-time analytics and decision-support systems. The same trend of development is likely to lead to a more thorough integration of emerging technologies, including Electric Neural Networks (ENN), the Internet of Things (IoT), and Building Information Modeling (BIM), among others, to create smarter, more comprehensive data-driven construction sites. Eventually, talking about future researchers also means they will have to go through the process of building an AI model capable of making the most environmentally friendly decisions in construction, e.g., by properly allocating resources and reducing waste. AI's role in automating construction tasks is anticipated to be robust by 2030, with predictive tools already up to mark in project planning and management and poised for even greater accuracy. The trend is towards faster adoption of AI, especially since "tools" will no longer mean only the experts. The future of the construction industry with AI promises significant improvements in project performance, cost reduction, and innovation.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

- [1] Arif, A., Shah, F., Khan, M. I., Khan, A. R. A., Tabasam, A. H., and Latif, A. (2023). Anomaly detection in IoT using deep learning: Enhancing wearable medical device security. *Migration Letters*, 20(S12), 1992–2006. <https://doi.org/10.59670/ml.v21iS12.12024>
- [2] Canesi, R., and Gallo, B. (2024). Risk assessment in sustainable infrastructure development projects: A tool for mitigating cost overruns. *Land*, 13(1), 41. <https://doi.org/10.3390/land13010041>
- [3] Dzhusupova, R., Bosch, J., and Olsson, H. H. (2022). Challenges in developing and deploying AI in the engineering, procurement, and construction industry. 2022 IEEE 46th Annual Computers, Software, and Applications Conference (COMPSAC). <https://doi.org/10.1109/compsac54236.2022.00167>
- [4] Jain, R., Garg, N., and Khera, S. N. (2022). Effective human–AI work design for collaborative decision-making. *Kybernetes*, 52(11). <https://doi.org/10.1108/k-04-2022-0548>
- [5] John, M. M., Olsson, H. H., and Bosch, J. (2022). Towards an AI-driven business development framework: A multi-case study. *Journal of Software: Evolution and Process*, 35(6). <https://doi.org/10.1002/smr.2432>
- [6] Khan, M. I., Tahir, H., Md Ismail Jobiullah, Raza, A., Begum, S., and Hafeez, I. (2023). Enhancing IoT security: A lightweight cloning approach for RFID/NFC access control systems. *Cuestiones de Fisioterapia*, 52(2), 231–248. <https://doi.org/10.48047/qy0g4n52>
- [7] Lasaitte, L. (2023, November). Ethical considerations and challenges of AI adoption in project management. In *The International Conference on Artificial Intelligence and Applied Mathematics in Engineering* (pp. 204-218). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-56310-2_16
- [8] Na, S., Heo, S., Choi, W., Kim, C., and Whang, S. W. (2023). Artificial Intelligence (AI)-Based Technology Adoption in the Construction Industry: A Cross National Perspective Using the Technology Acceptance Model. *Buildings*, 13(10), 2518. <https://doi.org/10.3390/buildings13102518>
- [9] Rane, N. (2023). Integrating building information modelling (BIM) and artificial intelligence (AI) for smart construction schedule, cost, quality, and safety management: Challenges and opportunities. *Social Science Research Network*, 1(1). <https://doi.org/10.2139/ssrn.4616055>
- [10] Taboada, I., Daneshpajouh, A., Toledo, N., and De Vass, T. (2023). Artificial intelligence enabled project management: A systematic literature review. *Applied Sciences*, 13(8), 5014. <https://doi.org/10.3390/app13085014>
- [11] Tuncer, S., and Ramirez, A. (2022). Exploring the role of trust during human-AI collaboration in managerial decision-making processes. *Lecture Notes in Computer Science*, 541–557. https://doi.org/10.1007/978-3-031-21707-4_39
- [12] Walker, D., and Lloyd-Walker, B. (2019). The future of the management of projects in the 2030s. *International Journal of Managing Projects in Business*, 12(2), 242–266. <https://doi.org/10.1108/ijmpb-02-2018-0034>