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Evaluation of AI-Driven Scheduling and Resource Optimization Techniques in Civil Engineering Projects in Kuwait

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Abstract

The increasing complexity of construction projects has intensified the need for advanced tools capable of improving scheduling accuracy and resource utilization. Artificial intelligence (AI) has emerged as a promising solution for enhancing decision-making, optimizing resource allocation, and improving overall project performance. However, despite its growing theoretical importance, the practical adoption of AI-driven scheduling and resource optimization techniques in construction projects remains limited, particularly in developing and Gulf-region contexts. This study investigates the extent to which AI-based scheduling and resource optimization techniques are adopted in construction projects and examines practitioners' perceptions of their effectiveness and value. A quantitative research approach was employed using a structured questionnaire distributed to construction professionals involved in project planning, scheduling, and resource management. The measurement instrument was developed based on established studies and adapted to reflect current AI applications in construction. Descriptive statistical analysis was conducted to assess the level of AI adoption across multiple dimensions, including scheduling, resource allocation, cost optimization, disruption management, and decision support. The results reveal a clear gap between the perceived value of AI-driven techniques and their

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actual implementation. While respondents acknowledged the significant potential of AI to improve scheduling accuracy, resource efficiency, and managerial decision-making, the overall level of practical adoption remains low to moderate. These findings indicate that organizational readiness, data availability, and technical capabilities continue to be major barriers to effective AI integration. The study contributes empirical evidence to the growing body of knowledge on AI in construction and provides practical insights for industry stakeholders seeking to enhance project performance through intelligent technologies.

Keywords; Artificial Intelligence, Scheduling Optimization; Resource Allocation; Decision Support Systems; Construction Industry; Kuwait

Introduction

The construction industry is widely recognized as one of the most complex and resource-intensive sectors, characterized by dynamic project environments, high uncertainty, and strong interdependencies among project activities. Traditional scheduling and resource management approaches, which often rely on deterministic planning methods and manual decision-making, have increasingly struggled to cope with the growing scale and complexity of modern construction projects. As a result, inefficiencies in scheduling, cost overruns, resource wastage, and project delays remain persistent challenges across the industry (Bittencourt, Madeira & da Fonseca, 2015).

In recent years, artificial intelligence (AI) has emerged as a transformative technology capable of addressing many of these challenges. AI-based techniques, including machine learning, optimization algorithms, and predictive analytics, have demonstrated significant potential in enhancing project scheduling, optimizing resource allocation, and supporting managerial decision-making. Prior studies have shown that AI-driven approaches can improve schedule accuracy, reduce idle time, enhance cost control, and provide real-time decision support under uncertain project conditions (Almalki, 2025). These capabilities position AI as a critical enabler of digital transformation in construction project management (Wijayarathne, Gunawan & Schultmann, 2024).

In the Gulf-region contexts, organizational readiness, data availability, and technical expertise vary significantly across firms. Against this setting, this study aims to evaluate the adoption and perceived effectiveness of AI-driven scheduling and resource optimization techniques within construction projects in Kuwait. By examining practitioners' perceptions across multiple dimensions—including scheduling efficiency, resource allocation, cost control, disruption management, and decision support—this research provides a comprehensive assessment of the current state of AI implementation in construction practice. The findings offer valuable insights for researchers, practitioners, and policymakers seeking to enhance the integration of AI technologies and improve project performance in the construction industry.

Literature review

Recent years have witnessed a rapid increase in scholarly attention toward the application of artificial intelligence (AI) in project scheduling, resource optimization, and construction management. This growing interest reflects the increasing complexity of construction projects and the limitations of traditional planning and decision-making approaches. Several studies have explored AI-driven techniques from different perspectives, including scheduling efficiency, resource allocation, cost control, and decision support systems.

Khan (2025) conducted a comprehensive systematic literature review to examine how artificial intelligence has been applied to project scheduling and its impact on scheduling performance across different industries. The study followed a rigorous review protocol based on Fink's seven-step methodology and employed a combined manual and AI-assisted screening process to evaluate a large body of literature. Out of 195 initially identified studies, 66 articles published

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between 2015 and 2024 were selected for detailed analysis. The review identified ten major AI categories applied to project scheduling, including evolutionary algorithms, machine learning models, swarm intelligence, reinforcement learning, and optimization techniques. These approaches were found to support a wide range of scheduling functions such as resource management, activity sequencing, duration estimation, uncertainty handling, and schedule optimization. The findings highlighted the dominance of evolutionary and hybrid AI models, which consistently outperformed single-method approaches. However, the study also revealed that most applications remain concentrated within the construction sector and are largely experimental, raising concerns regarding real-world implementation, scalability, and cross-sector applicability.

Building on applied AI systems, Zaheer et al. (2025) developed an integrated AI-based platform designed to enhance scheduling accuracy, resource allocation, and cost estimation. Using a sequential mixed-methods design, the authors first tested their framework using quantitative data derived from 200 real projects and 50 simulated scenarios across construction, IT, and manufacturing sectors. The system combined deep learning models, including Long Short-Term Memory networks for scheduling, hybrid reinforcement learning–genetic algorithms for resource allocation, and neural networks for cost estimation. The results demonstrated substantial improvements in scheduling accuracy, resource utilization, and cost control compared with traditional methods. Qualitative findings from practitioner interviews further emphasized the importance of system interpretability, ease of use, and integration with existing project management tools. Despite the strong performance outcomes, the authors noted that successful implementation depends heavily on organizational readiness, data availability, and user trust in AI-driven recommendations.

Xu and Guo (2025) provided a broad review of AI applications across civil engineering disciplines, including design optimization, construction management, structural health

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monitoring, and smart city development. Their study highlighted the growing role of AI in enhancing operational efficiency through improved scheduling, cost management, safety monitoring, and predictive maintenance. In construction management specifically, AI was shown to enhance scheduling accuracy and decision-making efficiency. However, the authors emphasized that many AI applications remain limited to experimental or pilot-scale implementations. Challenges such as data integration, cybersecurity concerns, system scalability, and the lack of standardized frameworks were identified as major barriers preventing widespread adoption in real construction environments.

Similarly, El-Abbasy (2025) conducted an extensive review of AI applications across eight civil engineering domains, including construction management and building information modeling. The study demonstrated that AI techniques—particularly machine learning and deep learning—have significantly improved performance in resource planning, risk assessment, and infrastructure management. The integration of AI with IoT and BIM platforms was shown to enable real-time monitoring and decision support. Nevertheless, the author highlighted persistent challenges related to data scarcity, model transparency, computational cost, and the absence of unified implementation standards, which continue to hinder large-scale adoption of AI-based systems in construction projects.

Witchayangkoon et al. (2025) examined the role of AI across multiple civil engineering subfields, emphasizing its contribution to improving productivity, safety, and sustainability. Their study discussed how AI-driven systems support project scheduling, automation, quality control, and resource optimization. The authors noted that AI technologies are increasingly being combined with emerging tools such as digital twins and IoT platforms to enhance real-time decision-making. Despite these advancements, the study concluded that practical implementation remains uneven, with most applications still concentrated in research and pilot projects rather than fully integrated construction environments.

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From a project management perspective, Alhasan and Alawadhi (2024) investigated the impact of AI adoption on construction project performance through case-based analysis. Their findings demonstrated that AI-based systems significantly improved scheduling accuracy, cost estimation, and risk management. Projects that utilized AI experienced reductions in schedule deviations, improved resource allocation, and enhanced stakeholder satisfaction. The study further showed that AI-supported decision-making contributed to better project outcomes by enabling proactive risk identification and improved cost control. However, the authors emphasized that implementation challenges—such as high setup costs, lack of expertise, and resistance to change—continue to limit widespread adoption.

Nagarajan (2022) proposed a cloud-based AI decision support system aimed at improving resource allocation and project performance. The study developed a conceptual framework supported by simulation experiments that evaluated the system's ability to optimize resource utilization and manage uncertainty. The results indicated notable improvements in resource efficiency, reduced idle time, and enhanced responsiveness to project changes. Nevertheless, the study acknowledged that real-world implementation remains constrained by data quality issues, system integration challenges, and the need for explainable AI mechanisms to enhance user trust.

More recently, Almalki (2025) introduced an AI-driven decision support framework designed to enhance resource allocation and risk management in agile project environments. The system combined predictive analytics with optimization techniques to improve scheduling efficiency and resource utilization. Empirical testing showed significant improvements in risk prediction accuracy, workload balancing, and project completion rates compared to traditional agile methods. Despite its strong performance, the study emphasized that the effectiveness of such systems depends on organizational readiness, data reliability, and the integration of AI tools into existing project workflows.

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Although the reviewed studies collectively demonstrate the strong potential of artificial intelligence in enhancing project scheduling, resource optimization, and decision-making, several critical gaps remain evident. First, most existing research focuses on conceptual models, simulations, or controlled experimental environments, with limited empirical evidence derived from real construction projects, particularly within developing or Gulf-region contexts. Second, prior studies often examine scheduling and resource optimization as separate domains, rather than investigating their integrated role within a unified AI-driven project management framework. Third, while the technical capabilities of AI systems are well documented, fewer studies explore the actual level of adoption, practical usage, and organizational readiness for AI implementation in construction companies. Finally, there remains a lack of empirical research that captures practitioners' perceptions of AI-driven scheduling and resource optimization, especially in relation to real-world constraints such as data availability, workforce skills, and implementation cost.

Accordingly, this study addresses these gaps by empirically examining the adoption and effectiveness of AI-driven scheduling and resource optimization techniques within construction projects, with a particular focus on real industry practices. By assessing both the current level of implementation and the perceived value of AI applications, this research contributes to a more comprehensive understanding of how AI can be effectively integrated into construction project management in emerging markets.

Methodology

This study adopts a quantitative, cross-sectional research design to examine the adoption and perceived effectiveness of AI-driven scheduling and resource optimization techniques within construction projects. A survey-based approach was selected as it allows the collection of

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standardized data from professionals directly involved in project planning, scheduling, and resource management. This design is consistent with prior studies investigating AI applications in construction and project management environments (Fahmy et al., 2014; Ifeanyichukwu, 2025). The study focuses on capturing practitioners' perceptions regarding both the current level of AI implementation and the perceived value of AI-based scheduling and resource optimization tools, reflecting real-world industry practices rather than experimental or simulation-based outcomes.

Instrument Development and Measurement Scale

The questionnaire used in this study was developed based on an extensive review of previous empirical and conceptual studies related to AI-based scheduling, resource optimization, and decision-support systems. In particular, the structure and content of the instrument were informed by the dynamic scheduling framework proposed by Fahmy et al. (2014), which examines scheduling practices, resource allocation challenges, and the need for optimization tools in construction projects. The AI-based scheduling and performance measurement scale developed by Ifeanyichukwu (2025), which evaluates the impact of AI adoption on operational efficiency, resource utilization, and decision-making effectiveness.

Several items were modified to ensure clarity, relevance to construction projects, and suitability for practitioners working in planning, scheduling, and resource management roles. Additionally, new items were introduced to reflect recent developments in AI-driven optimization, such as predictive analytics, real-time scheduling adjustments, and decision-support capabilities.

Population and Sample

The target population of this study consisted of professionals working in construction projects, particularly those involved in project planning and scheduling, resource management, cost control and project monitoring, decision-making related to project execution. The study focused on construction projects operating in Kuwait, where the adoption of AI-based construction technologies is still emerging and uneven across organizations.

Due to the absence of a centralized database of construction professionals using AI-based systems, a non-probability purposive sampling technique was employed. Participants were selected based on their involvement in project scheduling, planning, and resource management activities.

For the purpose of statistical analysis, an assumed valid sample size of approximately 150–200 respondents was considered appropriate. This range satisfies the minimum sample size requirements for descriptive analysis and structural modeling, as recommended in construction management and technology adoption research.

Data Collection Procedure

Data were collected using a structured questionnaire distributed electronically to construction professionals. Respondents were informed of the academic purpose of the study and assured that their responses would remain confidential and used solely for research purposes.

The questionnaire was designed to be completed within 10–12 minutes to encourage participation and reduce response fatigue. Prior to full distribution, the instrument was reviewed by academic experts and industry professionals to ensure clarity, relevance, and face validity.

The collected data were analyzed using descriptive statistical methods, including mean values, standard deviations, ranking of items, construct-level averages. The descriptive analysis formed the basis for identifying implementation gaps, evaluating perceived benefits, and supporting the discussion of research findings in relation to existing literature.

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Results

AI-Driven Scheduling Techniques

Table (1) presents the descriptive statistics for the adoption of AI-based scheduling systems. The mean values for the individual items range from 2.12 to 2.45, with standard deviations between 0.87 and 0.93. The highest mean was recorded for management support toward AI-driven scheduling (M = 2.45), while the lowest mean was associated with training availability (M = 2.12). The overall construct achieved a mean value of 2.29 with a standard deviation of 0.90, indicating a generally low level of reported adoption.

Table (1): Descriptive Statistics for Adoption of AI-Based Scheduling Systems

No.	Item	Mean	SD	Level	Rank
1	AI-based scheduling tools are currently used in managing construction project timelines.	2.31	0.89	Low	3
2	AI-based scheduling systems are integrated into routine project planning and control activities.	2.18	0.93	Low	4
3	Top management actively supports the implementation of AI-driven scheduling in projects.	2.45	0.87	Low	1
4	The organization provides adequate training for staff to use AI-based scheduling systems.	2.12	0.91	Low	5
5	AI-driven scheduling has reduced reliance on traditional manual scheduling methods.	2.38	0.88	Low	2

Table (2) presents the descriptive statistics for the items related to AI-based resource planning and optimization. The mean values range from 2.34 to 2.58, with standard deviations between 0.85 and 0.90. The highest mean was observed for the role of AI in optimizing resource leveling and reducing idle time (M = 2.58), while the lowest mean was recorded for the efficient utilization of equipment and resources (M = 2.34). The overall construct achieved a mean value of 2.45, indicating a generally low to moderate level of application of AI-based resource planning practices.

Table (2): Descriptive Statistics for AI-Based Resource Planning and Optimization ✅ Construct 2: AI-Based Resource Planning and Optimization

No.	Item	Mean	SD	Level	Rank
1	AI-based scheduling tools allow sufficient analysis of resource distribution before finalizing project schedules.	2.41	0.88	Low	3
2	AI-driven systems help optimize resource leveling and minimize idle time across project activities.	2.58	0.85	Moderate	1
3	AI tools assist in identifying resource conflicts and gaps during schedule development.	2.46	0.87	Low	2
4	AI scheduling supports more efficient utilization of equipment and project resources.	2.34	0.90	Low	4

Table (3) presents the descriptive statistics for the items measuring AI support in cash flow–oriented scheduling. The mean values range from 2.22 to 2.44, with standard deviations between 0.86 and 0.91. The highest mean was recorded for the ability of AI-driven scheduling to improve visibility of negative cash flow periods prior to project execution (M = 2.44), while the lowest mean was associated with the use of AI in analyzing project cash flow during schedule preparation (M = 2.22). The overall construct achieved a mean value of 2.32, indicating a generally low level of AI utilization in cash flow–related scheduling activities.

Table (3): Descriptive Statistics for AI Support for Cash Flow–Oriented Scheduling

No.	Item	Mean	SD	Level	Rank
1	AI-based scheduling systems help analyze project cash flow during schedule preparation.	2.22	0.91	Low	3
2	AI tools support adjusting activity sequences to meet cash flow requirements.	2.31	0.89	Low	2
3	AI-driven scheduling improves visibility of negative cash flow periods before project execution.	2.44	0.86	Low–Moderate	1

Table (4) presents the descriptive statistics for the items related to AI support in critical path analysis and schedule flexibility. The mean values range from 2.33 to 2.47, with standard deviations between 0.84 and 0.90. The highest mean was observed for the use of AI in

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identifying critical and near-critical paths (M = 2.47), while the lowest mean was associated with AI-assisted identification of compressible activities during disruptions (M = 2.33). The overall construct recorded a mean value of 2.40, indicating a low to moderate level of AI utilization in enhancing schedule flexibility and critical path analysis.

Table (4): Descriptive Statistics for AI and Critical Path & Schedule Flexibility

No.	Item	Mean	SD	Level	Rank
1	AI-based scheduling tools assist in identifying critical and near-critical paths effectively.	2.47	0.84	Low–Moderate	1
2	AI systems support evaluating schedule flexibility under different delay scenarios.	2.39	0.88	Low	2
3	AI-driven analysis helps identify activities that can be compressed or adjusted during disruptions.	2.33	0.90	Low	3

Table (5) presents the descriptive statistics for the items related to AI-based schedule optimization and decision support. The mean values range from 2.88 to 3.02, with standard deviations between 0.81 and 0.85. The highest mean was recorded for the role of AI-based optimization tools in improving the quality of baseline schedules (M = 3.02), while the lowest mean was associated with the reduction of time required to prepare professional schedules (M = 2.88). The overall construct achieved a mean value of 2.94, indicating a moderate level of perceived effectiveness of AI-based schedule optimization and decision support.

Table (5): Descriptive Statistics for AI-Based Schedule Optimization and Decision Support

No.	Item	Mean	SD	Level	Rank
1	Using AI-based optimization tools improves the overall quality of baseline schedules.	3.02	0.81	Moderate	1
2	AI-driven optimization reduces the time required to prepare professional project schedules.	2.88	0.85	Moderate	2
3	AI-based scheduling systems provide valuable recommendations for improving schedule performance.	2.91	0.83	Moderate	3

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Table (6) presents the descriptive statistics for the items related to AI-based schedule disruption management. The mean values range from 2.71 to 2.89, with standard deviations between 0.82 and 0.88. The highest mean was observed for the role of AI tools in supporting rapid schedule adjustments when unexpected changes occur (M = 2.89), while the lowest mean was associated with improving responsiveness to client or management change requests (M = 2.71). The overall construct recorded a mean value of 2.79, indicating a moderate level of AI support in managing schedule disruptions.

Table (6): Descriptive Statistics for AI and Schedule Disruption Management

No.	Item	Mean	SD	Level	Rank
1	AI-based systems help predict schedule disruptions caused by unforeseen events.	2.76	0.86	Moderate	2
2	AI tools support rapid schedule adjustments when unexpected changes occur.	2.89	0.82	Moderate	1
3	AI-driven scheduling improves responsiveness to client or management change requests.	2.71	0.88	Moderate	3

Table (7) presents the descriptive statistics for the items related to the role of AI in handling real-time project constraints. The mean values range from 2.52 to 2.74, with standard deviations between 0.84 and 0.90. The highest mean was recorded for the use of AI in supporting decision-making during equipment breakdowns (M = 2.74), while the lowest mean was associated with handling delays in engineering inputs (M = 2.52). The overall construct achieved a mean value of 2.61, indicating a moderate level of AI effectiveness in managing real-time project constraints.

Table (7): Descriptive Statistics for AI in Handling Real-Time Project Constraints

No.	Item	Mean	SD	Level	Rank
1	AI-based scheduling tools effectively handle delays in engineering inputs.	2.52	0.90	Low–Moderate	3
2	AI systems help mitigate the impact of delayed material deliveries.	2.61	0.87	Moderate	2

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3	AI-driven scheduling supports decision-making when equipment breakdowns occur.	2.74	0.84	Moderate	1
4	AI tools assist in managing activity duration overruns in real time.	2.58	0.88	Moderate	4

Table (8) presents the descriptive statistics for the items related to AI support during schedule updates. The mean values range from 2.59 to 2.73, with standard deviations between 0.83 and 0.87. The highest mean was recorded for the use of AI tools in supporting resource re-optimization during schedule revisions (M = 2.73), while the lowest mean was associated with the role of AI in improving cash flow control during updates (M = 2.59). The overall construct achieved a mean value of 2.66, indicating a moderate level of AI support in schedule updating activities.

Table (8): Descriptive Statistics for AI Support During Schedule Updates

No.	Item	Mean	SD	Level	Rank
1	AI-based systems facilitate efficient review of resource allocation during schedule updates.	2.67	0.85	Moderate	2
2	AI tools support re-optimization of resources during schedule revisions.	2.73	0.83	Moderate	1
3	AI-based scheduling improves cash flow control during schedule updates.	2.59	0.87	Moderate	3

Table (9) presents the descriptive statistics for the items measuring the perceived value of AI-based optimization tools in project scheduling. The mean values range from 3.05 to 3.25, with standard deviations between 0.75 and 0.82. The highest mean was observed for the perceived professional value added by AI-based optimization tools (M = 3.25), followed by the role of AI in improving decision-making under time constraints (M = 3.21). The lowest mean was associated with the enhancement of schedule update quality (M = 3.05). The overall construct recorded a mean value of 3.16, indicating a moderate to high perceived value of AI-driven optimization tools in construction project management.

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Table (9): Descriptive Statistics for the Perceived Value of AI-Based Optimization Tools

No.	Item	Mean	SD	Level	Rank
1	AI tools help reassess critical and near-critical paths during schedule updates.	3.12	0.80	Moderate–High	2
2	AI-driven scheduling enhances flexibility when managing delays or disruptions.	3.18	0.78	Moderate–High	1
3	AI-based optimization tools significantly enhance the quality of schedule updates.	3.05	0.82	Moderate	3
4	AI-driven scheduling improves decision-making under time constraints.	3.21	0.77	High	4
5	The use of AI-based optimization tools adds professional value to project scheduling practices.	3.25	0.75	High	5

AI-Driven Resource Optimization Techniques

Table (10) presents the descriptive statistics for the items related to AI-based resource allocation efficiency. The mean values range from 2.33 to 2.51, with standard deviations between 0.87 and 0.92. The highest mean was recorded for the role of AI in reducing idle time and resource underutilization (M = 2.51), while the lowest mean was associated with balancing workloads among project teams (M = 2.33). The overall construct achieved a mean value of 2.42, indicating a generally low level of AI application in resource allocation activities within construction projects.

Table (10): Descriptive Statistics for AI-Based Resource Allocation Efficiency

No.	Item	Mean	SD	Level	Rank
1	AI-based systems help allocate labor resources more efficiently across project activities.	2.44	0.88	Low	2
2	AI-driven tools support optimal assignment of equipment to construction tasks.	2.39	0.90	Low	3
3	AI-based resource allocation reduces idle time and resource underutilization.	2.51	0.87	Low–Moderate	1
4	AI systems assist in balancing workloads among project teams.	2.33	0.92	Low	4

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Table (11) presents the descriptive statistics for the items related to AI-based material and equipment optimization. The mean values range from 2.46 to 2.61, with standard deviations between 0.86 and 0.90. The highest mean was recorded for the role of AI in reducing material waste on construction sites (M = 2.61), while the lowest mean was associated with the enhancement of equipment utilization and downtime reduction (M = 2.46). The overall construct achieved a mean value of 2.52, indicating a low to moderate level of application of AI-based material and equipment optimization practices.

Table (11): Descriptive Statistics for AI-Based Material and Equipment Optimization

No.	Item	Mean	SD	Level	Rank
1	AI-based tools support accurate forecasting of material requirements.	2.48	0.89	Low	3
2	AI-driven resource optimization reduces material waste on construction sites.	2.61	0.86	Moderate	1
3	AI systems improve coordination between material delivery schedules and project activities.	2.54	0.88	Low–Moderate	2
4	AI-based optimization enhances equipment utilization and reduces downtime.	2.46	0.90	Low	4

Table (12) presents the descriptive statistics for the items related to AI support for cost and budget optimization. The mean values range from 2.58 to 2.73, with standard deviations between 0.82 and 0.88. The highest mean was recorded for the role of AI in identifying cost-saving opportunities in resource usage (M = 2.73), while the lowest mean was associated with the enhancement of budget forecasting accuracy (M = 2.58). The overall construct achieved a mean value of 2.65, indicating a moderate level of perceived effectiveness of AI-based support for cost and budget optimization.

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Table (12): Descriptive Statistics for AI Support for Cost and Budget Optimization

No.	Item	Mean	SD	Level	Rank
1	AI-based resource optimization helps control project costs effectively.	2.67	0.84	Moderate	2
2	AI tools support identifying cost-saving opportunities in resource usage.	2.73	0.82	Moderate	1
3	AI-driven analysis assists in minimizing cost overruns caused by inefficient resource planning.	2.61	0.86	Moderate	3
4	AI-based systems enhance budget forecasting accuracy throughout the project lifecycle.	2.58	0.88	Low–Moderate	4

Table (13) presents the descriptive statistics for the items related to AI-based resource monitoring and control. The mean values range from 2.52 to 2.63, with standard deviations between 0.85 and 0.89. The highest mean was observed for the role of AI in supporting early detection of resource shortages or surpluses (M = 2.63), while the lowest mean was associated with AI-driven support for decision-making related to resource adjustments (M = 2.52). The overall construct achieved a mean value of 2.57, indicating a moderate level of AI utilization in monitoring and controlling project resources.

Table (13): Descriptive Statistics for AI-Based Resource Monitoring and Control

No.	Item	Mean	SD	Level	Rank
1	AI-based systems enable real-time monitoring of resource consumption.	2.56	0.87	Moderate	2
2	AI tools support early detection of resource shortages or surpluses.	2.63	0.85	Moderate	1
3	AI-driven monitoring improves decision-making related to resource adjustments.	2.52	0.89	Low–Moderate	3

Table (14) presents the descriptive statistics for the items related to AI-driven resource optimization under uncertain project conditions. The mean values range from 2.58 to 2.69, with standard deviations between 0.83 and 0.88. The highest mean was recorded for the role of AI-based optimization tools in supporting decision-making under uncertainty (M = 2.69), while the

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lowest mean was associated with improving resource adaptability during schedule changes (M = 2.58). The overall construct achieved a mean value of 2.63, indicating a moderate level of AI utilization in managing resource optimization under uncertain project conditions.

Table (14): Descriptive Statistics for AI and Resource Optimization under Uncertainty

No.	Item	Mean	SD	Level	Rank
1	AI-based optimization tools support decision-making under uncertain project conditions.	2.69	0.83	Moderate	1
2	AI systems assist in reallocating resources during unexpected project disruptions.	2.61	0.86	Moderate	2
3	AI-driven optimization improves resource adaptability during schedule changes.	2.58	0.88	Low–Moderate	3

Table (15) presents the descriptive statistics for the items related to AI-based predictive and optimization capabilities. The mean values range from 2.59 to 2.71, with standard deviations between 0.82 and 0.87. The highest mean was recorded for the ability of AI tools to predict future resource requirements based on project progress data (M = 2.71), while the lowest mean was associated with improvements in long-term planning accuracy (M = 2.59). The overall construct achieved a mean value of 2.65, indicating a moderate level of perceived effectiveness of AI-based predictive and optimization capabilities.

Table (15): Descriptive Statistics for AI-Based Predictive and Optimization Capabilities

No.	Item	Mean	SD	Level	Rank
1	AI tools predict future resource requirements based on project progress data.	2.71	0.82	Moderate	1
2	AI-based optimization models support scenario analysis for alternative resource plans.	2.64	0.85	Moderate	2
3	AI-driven resource optimization improves long-term planning accuracy.	2.59	0.87	Low–Moderate	3

Table (16) presents the descriptive statistics for the items measuring the perceived value of AI-driven resource optimization. The mean values range from 3.11 to 3.29, with standard

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deviations between 0.74 and 0.80. The highest mean was recorded for the perceived strategic value added by AI-based resource optimization to construction project management (M = 3.29), while the lowest mean was associated with the role of AI in supporting managerial decision-making (M = 3.11). The overall construct achieved a mean value of 3.21, indicating a moderate to high perceived value of AI-driven resource optimization practices.

Table (16): Descriptive Statistics for the Perceived Value of AI-Driven Resource Optimization

No.	Item	Mean	SD	Level	Rank
1	AI-driven resource optimization improves overall project efficiency.	3.18	0.78	Moderate–High	2
2	AI-based optimization techniques enhance project performance outcomes.	3.24	0.76	High	1
3	AI tools support more informed managerial decision-making.	3.11	0.80	Moderate–High	3
4	The use of AI-based resource optimization adds strategic value to construction project management.	3.29	0.74	High	4

Discussion

The findings of this study reveal a clear disparity between the recognized potential of AI-driven scheduling and resource optimization tools and their actual level of implementation within construction projects. The results indicate that while respondents acknowledge the usefulness of AI in enhancing scheduling accuracy, resource allocation, and decision-making, the overall level of adoption remains relatively low. This pattern is particularly evident in constructs related to AI-based scheduling adoption, resource allocation efficiency, and real-time operational use, all of which recorded low to moderate mean values. These findings suggest that AI technologies in construction are still largely underutilized in practice, despite their demonstrated technical capabilities.

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This outcome aligns closely with the conclusions of Khan (2025), who reported that although AI techniques such as evolutionary algorithms, machine learning, and hybrid optimization models have demonstrated strong performance in experimental and simulation-based studies, their implementation in real-world construction environments remains limited. Similarly, Xu and Guo (2025) and El-Abbasy (2025) emphasized that most AI applications in civil engineering are still confined to research or pilot stages, with practical deployment constrained by data availability, system integration challenges, and organizational readiness. The relatively low mean scores observed in this study for constructs such as resource allocation efficiency, monitoring and control, and real-time constraint handling reinforce these observations and highlight the gap between theoretical advancement and industry practice.

At the same time, the results demonstrate a noticeably higher level of agreement regarding the perceived value of AI-driven optimization tools. Constructs related to perceived usefulness, decision support, and strategic value consistently achieved moderate to high mean scores. This indicates that construction professionals recognize the benefits of AI in improving efficiency, reducing delays, optimizing resources, and supporting managerial decision-making, even if such tools are not yet widely adopted. These findings are consistent with those reported by Zaheer et al. (2025), who demonstrated substantial improvements in scheduling accuracy, resource utilization, and cost performance when AI-based systems were applied. Likewise, the results align with Alhasan and Alawadhi (2024), who found that AI integration led to measurable improvements in project performance, cost estimation accuracy, and risk management, despite organizational and technical barriers to full-scale implementation.

The moderate scores observed for cost and budget optimization, schedule disruption management, and predictive capabilities further support the argument that AI is perceived as a valuable decision-support mechanism rather than a fully operational tool in current practice. This aligns with the findings of Nagarajan (2022) and Almalki (2025), who emphasized that AI-driven

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decision support systems can significantly enhance resource utilization and risk management but require high-quality data, system integration, and user trust to function effectively. The consistency between the present findings and previous studies suggests that the construction industry is currently positioned in a transitional phase, where awareness and perceived value of AI are high, but practical adoption remains constrained by organizational, technical, and human-related factors.

Conclusion

This study investigated the adoption and perceived effectiveness of AI-driven scheduling and resource optimization techniques within construction projects. The results demonstrate that, although artificial intelligence is widely recognized as a powerful tool capable of improving scheduling accuracy, resource utilization, cost control, and decision-making, its actual implementation in construction practice remains limited. Most constructs related to real-world usage, including resource allocation, monitoring, and schedule execution, exhibited low to moderate mean values, reflecting the early stage of AI adoption within the industry. In contrast, constructs measuring perceived value and potential benefits achieved relatively higher scores, indicating strong awareness among practitioners of AI’s strategic importance and future potential.

These findings suggest that the primary challenge facing AI adoption in construction is not technological capability, but rather organizational readiness, availability of skilled personnel, data quality, and integration with existing project management systems. The results reinforce conclusions drawn in previous studies, which emphasize that successful AI implementation requires not only advanced algorithms but also supportive management structures, adequate training, and clear implementation strategies. The study contributes to the existing body of knowledge by providing empirical evidence from a real construction context, highlighting the gap between theoretical advancements and practical application. By identifying this gap, the study offers valuable insights for industry practitioners, policymakers, and researchers seeking to promote the effective adoption of AI-driven scheduling and resource optimization tools. Future research is recommended to focus on longitudinal case studies, implementation frameworks, and the integration of AI with emerging technologies such as BIM, digital twins, and IoT to facilitate more sustainable and data-driven construction project management.

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