AI-Driven Project Management Transformation: Strengthening Saudi Arabia's Construction Sector as a Catalyst for Economic Diversification

Abstract

This study investigated the transformative impact of Artificial Intelligence (AI) on project management within Saudi Arabia's construction sector, examining its role as a catalyst for economic diversification under Vision 2030. A qualitative research approach was adopted, utilizing case studies of three flagship projects; NEOM, Qiddiya, and Red Sea Global. The analysis demonstrated that AI integration enhances project planning, risk management, performance monitoring, sustainability optimization, and workforce transformation. Findings reveal that AI-driven practices improve efficiency, reduce cost overruns, strengthen environmental compliance, and facilitate high-skill workforce development, aligning operational outcomes with national strategic objectives. At the macroeconomic level, AI adoption contributes to non-oil GDP growth, industrial diversification, and the creation of knowledge-intensive employment opportunities. Challenges such as digital readiness disparities, high infrastructure costs, and evolving regulatory frameworks remain, underscoring the need for policy intervention and capacity-building initiatives. The study concludes that AI is not merely a technological enhancement but a strategic enabler, positioning Saudi Arabia's construction sector as a key driver of Vision 2030's innovation-led, sustainable, and economically diversified future.

Introduction

The Saudi Arabian Vision 2030 is a transformative national roadmap that was designed to shift dependence of the Kingdom on oil towards a diversified, knowledge based model [1]. The vision 2030 of Saudi Arabia focused on different sectors for national development and growing economy, and construction sector is amongst them which is kept at the centre of vision for becoming a vital contributor in shifting to non-oil economy in the region. The influence of vision 2030 can be observed in the Kingdom's large scale infrastructure programmes which includes the projects like NEOM, The Line, Diriyah Gate, Qiddiya and the Red Sea Development [2]. These projects represent the physical and economic alignment with the goals and outcomes of the vision 2030, where each project require complicated and sophisticated planning, cost management and execution framework for meeting global standards, sustainability and technological advancements along with efficiency. However, due to complications in planning and designing of these projects, the construction sector face challenges like increase in costs, time delays, inefficiencies in resources and management systems due to which productivity and long-term contribution in economic diversification is impacted. On the other hand, emergence of Artificial Intelligence (AI) has brought opportunities for enhancing the outcomes of these projects while reducing inefficiencies and turning them into strategic advantages. It is because AI based project management has increased automation of processes while providing predictive analytics and enhancing decision making by analyzing data at every stage of the project delivery. In this regard, Liu and Hao [3] stated that machine learning algorithms have the ability to make forecasting deviation in schedule while detecting any inconsistencies in project designing and management. Similarly, Jain et al.[4] also noted that machine learning algorithms are supporting construction industry by optimizing procurement and logistics processes. In addition to machine learning algorithms, Building Information Modeling (BIM) with AI integration has been enhancing the coordination between design and construction teams and supporting in reducing delays and reworking. As a result, with AI, ability of project managers has enhanced due to intelligent resource management tools which allow them to allocate labour, materials, and equipment based on real time data. Thus, with the technological advancements an adaptive and efficient project management ecosystem is created that aligns the construction project with the Kingdom's transformation objectives defined in Vision 2030.

The construction industry of Saudi Arabia is estimated $74.11 billion and it is expected to grow by $96.26 bullion by 2030 fueled by vision 2030 [5]. Since, Saudi Arabian construction sector operates in a broader economic transformation, Vision 2030 has brought several projects worth $1.5 trillion where construction industry alone is likely to acquire $950 billion of this total [5]. The Saudi Arabian Vision 2030 is based on three key pillars, thriving economy, vibrant society and an ambitious nation. Therefore, AI driven project management has the potential to support these three key pillars of the Vision 2030 by enhancing the productivity, reducing risks and enhancing innovation in the projects. It is because AI driven project management tools are increasing the ability of construction project managers for efficient utilization of resources and capital while accelerating project completions, and improving costs control, leading to higher returns on investments of construction industry. According to Bhattacharya and Chatterjee [6], technological integration in construction projects supports strengthening of construction supply chain, creating employment opportunities and developing local expertise in digital engineering and analytics.

However, the macroeconomic relevance of the transformation due to Kingdom's Vision 2030, is beyond, operational efficiency, because construction industry acts as a multiplier for connected sectors like transportation, logistics, finance and manufacturing [7]. Therefore, improvements in the construction management with AI adoption can contribute in wider economic growth, employment creating and increased participation of private sector in the diversification of Saudi economy. Despite, Vision 2030 promising these developments, the implementation of AI is the infrastructural construction projects of Saudi construction industry is in its early stage [8]. It is because the industry demonstrated different levels of digital readiness, where many firms in the industry are still relying on the conventional project management practices. At the same time, there are several barriers that are hindering adoption of AI in construction projects such as limited technical expertise, resistance to change, regulatory ambiguity, and data fragmentation. Thus, addressing these challenges need coordinated policies, institutional capacity building and investments in digital infrastructure for which professional bodies need to integrate AI driven project management competencies into engineering and management education and skills development to ensure future workforce has required digital and analytical skills.

85   The aim of this study is to examine the strategic role of AI in transformation of project
86 management for strengthening Saudi Arabian construction sector as a key influencer for
87 economic diversification under Vision 2030. For this purpose, the study exploresthe potential of
88 AI for enhancing project performance, and support sustainable development and contributes in
89 macroeconomic transformation of the Kingdom. The findings of this study aim to inform
90 decision makers, policy makers and industry leaders on the opportunities framework that
91 connects technological innovation with the Kingdom's long term developmental agenda. The
92 study addresses four research questions that guide analysis and findings:

93 1. What methods are used to integrate Artificial Intelligence techniques into project
94   management practices within major Saudi construction megaprojects, including NEOM,
95   Qiddiya, and Red Sea Global?

96 2. What measurable project-level outcomes arise from AI-driven project management, with
97   attention to planning accuracy, cost control, risk mitigation, and sustainability
98   performance?

99 3. Which organizational and institutional enablers and barriers determine scale and pace of
100   AI adoption across Saudi construction firms?

101 4. In what ways do AI-driven project management transformations contribute to
102   macroeconomic objectives associated with Vision 2030, including non-oil economic
103   growth, local capability development, and sustainable development?

104 **Research Contributions**

105   The study offers several contributions for the project management especially for the
106 construction industry. Firstly, it provides a synthesis of AI applications in project management
107 within three nationally significant construction programs. Further, it develops a conceptual
108 pathway that links AI adoption at project level to sectoral and macroeconomic outcomes relevant
109 to Vision 2030. Additionally, the study delivers focused policy and managerial
110 recommendations aimed at accelerating equitable AI diffusion across the national construction
111 sector, covering data governance, workforce capability development, procurement practice, and
112 digital infrastructure priorities.

113 **Literature Review**

114 **Conceptual Foundation of Project Management in Construction**

115   Project management is considered an important aspect of effective construction delivery,
116 ensuring alignment between design, planning, resource utilization, and objectives defined by the
117 client. In the construction sector, project management is integrated with scope, time, cost,
118 quality, safety, and stakeholder expectations in a structured framework which enables
119 predictability and accountability in a project [9]. In addition, [10] and [11]have emphasized that
120 construction projects differ from other industrial projects due to their large scale, complexity,
121 and dynamic stakeholder interactions. Similarly, success of project management depends on
122 systematic planning, real-time monitoring, and adaptive mechanisms that respond to
123 uncertainties observed in construction processes[12]. Moreover, traditional project management
124 practices in construction have largely relied on methods like Critical Path Method (CPM), Gantt
125 scheduling, and cost structuring [13]. Although these tools have the potential to support large
126 infrastructure programs, they often fail to accommodate the level of uncertainty,
127 interdependency, and data intensity present in modern construction projects [14]. At the same
128 time, human error, ambiguous communication, and fixed decision-making models frequently
129 result in schedule delays and cost overruns [15]. As a result, this problem becomes visible in
130 countries like Saudi Arabia, where megaprojects under Vision 2030 operate under tight timelines
131 and high performance expectations. It is because modern construction projects demand agile,
132 technology-driven project management frameworks that integrate data analytics and digital
133 intelligence to achieve desired outcomes [16]. The conceptual foundation of project management
134 has therefore evolved from a process-oriented discipline toward a data-driven and predictive
135 system capable of learning from prior project data [17]. In addition, Ajayi[18] highlighted the
136 growing importance of digital ecosystems where information flows seamlessly between
137 stakeholders through cloud-based platforms, real-time dashboards, and integrated modeling
138 environments. This transformation created the foundation for AI to enhance construction project
139 management while ensuring their timely completion.

140   However, in the Saudi context, the transition carries economic and strategic significance
141 because Vision 2030 places strong emphasis on efficiency, sustainability, and innovation within
142 the construction sector as a driver of economic diversification [19]. The application of advanced
143 project management methodologies supported by AI created a mechanism to achieve these
144 policy goals. Therefore, scholars from regional development agencies indicate that improved
145 project management maturity directly contributes to higher investment returns and faster

146 infrastructure delivery. Consequently, redefining the conceptual framework of project
147 management from traditional control to intelligent automation aligns both operational practice
148 and national strategy.

Evolution of Artificial Intelligence in Project Management

150 AI has evolved from theoretical computer science into a critical enabler of decision-
151 making and automation across industries, including construction [20]. Its integration into project
152 management represents a paradigm shift from human-centered control toward intelligent, data-
153 driven optimization to enhance outcomes of ongoing processes. According to Narne[21], AI
154 applications such as machine learning, natural language processing, predictive analytics, and
155 computer vision now support planning, scheduling, and resource allocation with unprecedented
156 accuracy. These technologies transform traditional project management from reactive oversight
157 to proactive intelligence that mitigate and reduces risks, identifies inefficiencies, and
158 continuously improves performance of construction projects. The adoption of AI in project
159 management has followed a structured progression over the last decade [22]. Initially,
160 automation was limited to repetitive data tasks such as document management or schedule
161 tracking but with the introduction of predictive algorithms, project management is now capable
162 of forecasting project performance based on historical data.Violos et al.[23] also noted that
163 recent advancements have moved further toward cognitive systems that reflects human judgment
164 and optimize real-time decision-making. For construction projects, where uncertainty,
165 complexity, and scale dominate, AI-driven project management has the potential to offer
166 adaptive models capable of analyzing large data sets from sensors, drones, and BIM systems to
167 support instantaneous adjustments in scope, budget, and timelines in the project.

168 Globally, integration of AI into project management is now aligned with broader digital
169 transformation initiatives for optimizing processes and completing projects on time and within
170 defined scope. Paul et al. [24] indicate that organizations implementing AI-supported project
171 systems experience higher efficiency, better cost control, and improved safety outcomes. Despite
172 potential benefits of AI, construction industry is relatively slower in adopting digital
173 technologies, but has started leveraging AI through platforms that integrate predictive modeling,
174 image recognition, and automated reporting [25]. For instance, construction industry is
175 leveraging AI-enabled systems for detecting deviations in construction progress through site
176 imagery, predict potential delays, and recommending corrective actions before performance is

177 impacted. However, in Saudi Arabia, the evolution of AI within project management is gaining
178 policy-level recognition where establishment of the Saudi Data and AI Authority (SDAIA) and
179 the National Strategy for Data and Artificial Intelligence (NSDAI) underscores the government's
180 commitment to embedding AI within key economic sectors, including construction. At the same
181 time, Vision 2030 emphasizes digital transformation as a strategic enabler of national
182 competitiveness and the evolution of AI in project management serves both operational and
183 macroeconomic purposes. While enhancing construction performance while fostering
184 innovation, knowledge transfer, and high-value employment. The Kingdom's approach positions
185 AI not merely as a technological tool but as a catalyst for systemic efficiency and sustainable
186 economic diversification.

187 **AI Applications in Construction Management**

188 The application of AI in construction management is extended across multiple project
189 phases, while enhancing accuracy, efficiency, and control in the project. According to Van
190 Hoang[26], AI tools integrate with BIM, Internet of Things (IoT) devices, and predictive
191 analytics platforms to create intelligent ecosystems that continuously monitor project variables
192 and adjust strategies accordingly. At the same time,in design and planning, AI algorithms
193 process large quantities of architectural and engineering data to optimize layouts, detect design
194 conflicts, and evaluate constructability [27]. Thus through generative design, AI systems explore
195 different configurations to identify solutions for balancing cost, performance, and sustainability,
196 capabilities particularly relevant to Saudi Arabia's sustainability-driven Vision 2030 initiatives.
197 In project scheduling and cost estimation, AI enhances forecasting precision so that project
198 remains under predefined measures [28]. Machine learning models trained on historical project
199 data predict potential time and budget deviations with greater reliability than traditional methods
200 [29]. In addition,predictive analytics platforms identify early warning indicators of schedule
201 slippage or cost escalation, allowing project managers to intervene before critical thresholds are
202 reached. These capabilities have the ability to reduce uncertainty and strengthen accountability in
203 large-scale projects such as NEOM or Qiddiya, where even minor inefficiencies can lead to
204 substantial economic consequences.

205 Moreover, risk management is an important area in construction project management
206 where integration of AI is significantly influencing by analyzing patterns in the project
207 documentation, performance of project and teams, and real time data for reducing the impacts of

208   potential risks [30]. This proactive approach enables construction managers to implement
209   preventive measures, thereby reducing safety incidents and operational disruptions. At the same
210   time, AI is also supporting predictive maintenance of equipment and infrastructure, optimizing
211   lifecycle costs and minimizing unplanned disturbance in the construction projects [31]. In
212   construction execution and monitoring, AI utilizes computer vision and drone-based imaging for
213   progress tracking and site safety inspections. Due to which systems automatically compare on-
214   site visuals with BIM data to detect deviations, material shortages, or non-compliance. Whereas,
215   natural language processing facilitates intelligent document control and stakeholder
216   communication through automated reporting and contract analysis. According to Qudus[32], AI-
217   based resource management platforms integrate labor, materials, and machinery data to enhance
218   allocation efficiency, reducing waste and delays.

219   **Benefits and Measurable Outcomes of AI Integration**

220   With the integration of AI in construction project management has generated several
221   measureable improvements in performance, efficiency and sustainability. Sanusi[33] also noted
222   that AI has significantly reduced cost increase, project delays and enhanced quality of
223   construction projects due to data driven decision making. Moreover, AI enhances productivity by
224   automating repetitive administrative and analytical tasks that traditionally consume large
225   portions of project time. Whereas, AI-supported automation can improve labor productivity by
226   20–30% across complex construction programs [34]. In addition, intelligent scheduling and
227   resource optimization tools reduce idle time for labor and equipment, leading to significant cost
228   savings and profit maximization. These improvements directly influence project performance
229   indicators such as earned value, cost performance index (CPI), and schedule performance index
230   (SPI), translating operational efficiency into measurable financial gains for the investors in
231   construction projects. Beyond operational performance, AI contributes to enhanced safety and
232   sustainability outcomes where its image recognition systems monitor site conditions and detect
233   safety hazards in real time, preventing incidents and reducing liability exposure [35]. At the same
234   time, predictive maintenance powered by AI extends the lifespan of machinery and infrastructure
235   assets, lowering total lifecycle costs and minimizing environmental impact. These outcomes
236   align with Vision 2030's environmental and sustainability objectives, emphasizing reduced
237   waste and energy-efficient construction practices.

238   **Barriers to AI Adoption in Construction**

239   Despite its transformative potential, AI adoption within the construction industry faces a
240   series of persistent barriers that hinder its effective implementation in construction projects [36].
241   These challenges include technical, organizational, economic, and regulatory domains,
242   particularly within emerging markets such as Saudi Arabia. Similarly, fragmented nature of the
243   construction industry, due to involvement of multiple subcontractors, complex supply chains,
244   and project-specific contracts, often leads to data inconsistency and limited interoperability
245   between digital systems [37]. Therefore, absence of standardized data frameworks restricts the
246   ability of AI algorithms to process information efficiently, reducing predictive accuracy and
247   limiting automation outcomes. Moreover, technical challenges emerge from the quality available
248   data because AI relies on extensive, clean datasets for model training and continuous learning
249   [38]. At the same time, construction projects suffer from incomplete, unstructured, or
250   inconsistent data collected through manual processes. This deficiency weakens the reliability of
251   predictive models and complicates their integration with existing BIM and enterprise resource
252   systems. Additionally, the lack of digital infrastructure in smaller construction firms constrains
253   their ability to implement advanced AI solutions, reinforcing inequality in technological adoption
254   across the sector.

255   Moreover, organizational barriers represent another significant constraint for integration
256   of AI in construction projects where resistance to change, inadequate digital skills, and limited
257   management commitment often reduces the process of AI integration. According to Piras et al.
258   [39], many project managers perceive AI as a complex or non-essential investment rather than a
259   strategic necessity. The construction workforce traditionally values experiential decision-making,
260   making cultural adaptation toward data-driven management difficult. Moreover, the shortage of
261   trained professionals capable of operating and maintaining AI systems intensifies the
262   dependency on foreign expertise, which conflicts with Saudi Arabia's Vision 2030 target of
263   enhancing national workforce competency. In addition to these barriers, economic barriers also
264   hinder the process of AI integration in the projects because its integration requires high initial
265   costs for obtaining software licenses, hardware acquisition, and staff training. These economic
266   challenges particularly impact on small and medium sized organisations which are a major
267   element of Saudi construction market and lack sufficient financial resources for this type of
268   transformation [40]. Similarly, regulatory and ethical challenges further complicate the adoption
269   process where issues like data ownership, cybersecurity and accountability is still

9

270 underdeveloped in construction governance frameworks [41]. However, in Saudi Arabia, SDAIA

271 has initiated national data governance standards but its translation into industry specific protocols

272 is still in the process. Therefore, ensuring compliance, privacy protection, and clear liability

273 allocation for AI-driven decisions are critical prerequisites for scaling adoption.

274 **Research Gaps**

275 Current studies in the Saudi context emphasize digital readiness and technical feasibility

276 but rarely examine the intersection between AI-driven project management and national

277 economic objectives. There is limited empirical evidence evaluating AI integration and its

278 influences on macro-level outcomes such as GDP contribution, job creation in high-technology

279 fields, and local capability development [42]. Similarly, few frameworks exist that link micro-

280 level construction project performance with macroeconomic indicators of Vision 2030. This gap

281 highlights the need for an integrated analytical model that captures both the project-level and

282 national-level implications of AI-driven transformation. Furthermore, AI-related construction

283 researches relies on theoretical models developed in Western or industrialized economies, which

284 may not fully capture the socio-economic and institutional realities of Saudi Arabia. There is a

285 need to contextualize existing adoption theories such as Resource Based View within the unique

286 policy environment, labor structure, and cultural dynamics of the Kingdom's construction

287 industry.

288 **Methodology**

289 The research adopted qualitative methodology to explore the transformative influence of

290 AI on project management within Saudi Arabia's construction sector and its contribution to

291 economic diversification under Vision 2030. From the available methodological approaches like

292 quantitative, mixed methods, and qualitative, the qualitative approach was most suitable because

293 the study seeks to interpret, understand, and explain complex socio-technical interactions rather

294 than quantify relationships. On the other hand, quantitative methods, although useful for

295 measuring relationship between variables, was likely to fail to capture the dynamic institutional,

296 cultural, and strategic factors that shape AI adoption in the Saudi construction context. A mixed-

297 method approach was also considered but as the study's objectives emphasize conceptual depth,

298 policy alignment, and contextual understanding rather than numerical generalization, it was not

299 selected by the author. Moreover, multiple research strategies such as ethnography, grounded

300 theory, phenomenology, and case study design were evaluated. The case study approach was

301 selected as the most appropriate strategy because it enabled examination of AI-driven project
302 management transformation through real-world examples that reflect Saudi Arabia's ongoing
303 national projects. This approach supported contextual exploration of implementation of AI tools
304 in complex, high-value construction environments, and their influence on managerial decisions,
305 productivity, and macroeconomic objectives. The case study design provided an opportunity to
306 analyze data from existing projects such as NEOM, Qiddiya, and Red Sea Global, that have the
307 principles of Vision 2030 through digital innovation and advanced project governance.

308   The study relied on secondary data, gathered from scholarly publications, policy reports,
309 industry analyses, and official documents published between 2019 and 2025. Primary data
310 collection through interviews or surveys was not considered because of the availability of
311 credible secondary sources that has documented AI integration in Saudi Arabia's construction
312 sector. Thus, secondary data allowed broader coverage across different megaprojects and policy
313 frameworks, which was essential for capturing the macroeconomic implications of digital
314 transformation. For data analysis, content analysis technique was applied to extract, organize,
315 and interpret recurring patterns and relationships from the collected data. Due to this method,
316 systematic identification of themes such as digital capability development, AI-enabled project
317 control, risk prediction, and sustainability performance, was made.

Figure 1 Conceptual Framework Linking AI-Driven Project Management to Vision 2030 Outcomes

Figure 1 illustrates the analytical pathway connecting AI technologies to project-management transformations, project-level performance improvements, sectoral productivity gains, and macroeconomic diversification outcomes aligned with Vision 2030.

Findings and Analysis

Overview of Case Studies

The findings of this study are based on secondary data derived from three strategic megaprojects that represent Saudi Arabia's construction transformation under Vision 2030, NEOM, Qiddiya, and Red Sea Global. These projects were selected using purposive criteria, focusing on their scale, digital maturity, and direct alignment with national economic diversification goals. At the same time, each project functions as a construction venture and experimentation for digital integration, sustainability innovation, and AI-enabled project management practices that symbolize Saudi Arabia's transition toward a knowledge-based economy.

NEOM, a major project and reflection of Kingdom's Vision 2030, is a $500 billion futuristic smart city initiative designed to embody AI-driven governance and cognitive urbanism [43]. The project's digital core relies on advanced construction management systems integrating AI, BIM, and IoT technologies for real-time coordination and predictive analytics. Its cognitive city framework is likely to demonstrates AI-based tools can automate infrastructure design, simulate construction outcomes, and optimize resource efficiency. NEOM project provides an exemplary case of showing that AI is redefining project planning, control, and sustainability in large-scale construction.

Similarly, Qiddiya, envisioned as Saudi Arabia's capital of entertainment and culture, is a different and complementary aspect of AI-enabled project delivery [44]. The project's implementation strategy emphasizes AI-supported schedule optimization, supply chain management, and safety monitoring. AI platforms have been integrated to assess construction sequence impacts, reduce logistical bottlenecks, and monitor workforce productivity through digital dashboards. The project's scale and diversity make it an ideal case for understanding contribution of AI to organizational coordination and adaptive management practices within complex multi-stakeholder environments.

In addition, Red Sea Global serves a benchmark for sustainable and environmentally conscious construction supported by AI. The project utilizes predictive algorithms to minimize ecological disturbance and optimize material use while maintaining high-quality standards. Through AI-driven sustainability analytics, the project monitors energy consumption, water use, and carbon emissions across construction phases. It demonstrates contribution and influence of AI in achieving Vision 2030's sustainability objectives while ensuring operational excellence. These three projects illustrate distinct yet interconnected facets of AI integration in project management becuase NEOM focuses on digital urbanism, Qiddiya on organizational efficiency, and Red Sea Global on sustainability and environmental intelligence. Their selection ensures comprehensive representation of the major dimensions of project management such as technological, managerial, and economic, through which AI-driven project management transformation supports Saudi Arabia's economic diversification and innovation goals.

Table 1 Summary of AI Integration across Saudi Vision 2030 Construction Megaprojects

Project	Primary AI Applications Observed	Level of Digital	Documented or Reported Outcomes

		Maturity	
NEOM	Predictive analytics for planning, digital twin integration, autonomous site monitoring, AI-driven design coordination, and sustainability modeling	High	Increased project schedule accuracy, proactive risk identification, improved interdepartmental coordination, enhanced carbon and energy modeling accuracy
Qiddiya	Machine-learning scheduling systems, computer-vision safety compliance, AI-assisted procurement analytics, IoT-based asset monitoring	Medium–High	Reduction in work delays, higher safety compliance rate, supply-chain optimization, improved material traceability
Red Sea Global	Environmental impact prediction through AI, real-time energy-efficiency optimization, autonomous drone inspection, and predictive maintenance of utilities	Medium–High	Reduction of material waste by more than 20%, energy cost savings, enhanced environmental compliance, improved maintenance scheduling

363   Table 1 presents comparative evidence of AI adoption across NEOM, Qiddiya, and Red
364   Sea Global, illustrating varying maturity levels, implementation domains, and measurable
365   outcomes aligned with Vision 2030 objectives.

366   **AI Integration in Project Planning and Control**

367   The adoption of AI in project planning and control within Saudi Arabia's construction
368   megaprojects has become a defining feature of the country's technological transformation under
369   Vision 2030. Across NEOM, Qiddiya, and Red Sea Global, AI systems are used to enhance
370   predictive planning accuracy, automate scheduling, optimize resource utilization, and improve
371   coordination among multiple stakeholders. At NEOM, AI is embedded within the project's
372   digital management infrastructure through predictive analytics platforms and BIM integration.
373   The NEOM project's Cognitive Digital Twin framework allows real-time visualization of
374   construction progress, enabling project managers to simulate potential delays, budget
375   fluctuations, and risk scenarios before they materialize. In addition, AI algorithms analyze

millions of construction variables to recommend optimized scheduling and procurement sequences, ensuring that critical path activities are executed efficiently [45]. These AI capabilities align directly with Vision 2030's digital governance objective, emphasizing transparency, automation, and intelligent decision-making in infrastructure development. On the other hand, Qiddiya demonstrates AI's role in multi-stakeholder project coordination and control. AI-powered dashboards and scheduling algorithms manage interdependencies between contractors, monitor resource allocation, and provide dynamic progress forecasting. The project employs machine learning systems to predict schedule deviations and automatically generate corrective action plans. Such practices have significantly reduced project rework and idle time while enhancing synchronization between design, procurement, and on-site construction activities. While the literature on AI in project management confirms that predictive control models enhance planning reliability and minimize uncertainty by continuously analyzing historical and live project data [30].Similarly, Red Sea Global has implemented AI-driven systems for integrated project delivery because AI platforms are managing workforce deployment, logistics scheduling, and environmental compliance, ensuring real-time control across geographically dispersed project sites. Data from AI sensors and drones feed into centralized control centers that track project milestones and flag anomalies. This aligns with the findings of Obiuto et al. [46], who emphasized that AI-based predictive monitoring enhances cost control and schedule adherence in large-scale construction projects. Through these applications, Red Sea Global is likely to demonstrate the synergy between digital technology, project governance, and sustainable development practices. The use of AI in planning and control across these projects reveals a consistent pattern: data-driven automation improves accuracy, accountability, and performance visibility. Thus, showing that AI is likely to become an essential enabler of project governance and strategic efficiency within the Kingdom's construction sector.

AI-Driven Risk and Performance Management

Risk and performance management represent two of the most critical dimensions of project success in Saudi Arabia's construction megaprojects, and AI has become instrumental in reshaping the ways these functions are executed. In traditional project environments, risk monitoring depended on static assessments and manual reporting, which often failed to anticipate interconnected threats. Through AI, risk management has evolved into a predictive, continuous,

and data-responsive discipline. The integration of machine learning and advanced analytics across NEOM, Qiddiya, and Red Sea Global illustrates AI systems have the potential to transform uncertainty into measurable, manageable parameters that directly enhance project performance and accountability. In NEOM project, AI-driven analytics form the strength of its risk governance framework where predictive algorithms model external and internal variables, ranging from supply chain disruptions to workforce productivity fluctuations, produce early-warning signals for project managers. These predictive insights enable proactive mitigation rather than reactive correction, minimizing time and cost overruns. Therefore, predictive modeling exemplifies the transition from traditional deterministic planning to dynamic probabilistic forecasting, reinforcing managerial confidence and decision precision. In Qiddiya, AI applications focus on operational and safety risk management in which the project uses computer vision and real-time monitoring tools to assess on-site safety compliance, identify unsafe behaviors, and automatically trigger alerts to supervisors [47]. Machine learning models analyze incident patterns to predict high-risk zones, contributing to a significant reduction in workplace accidents. These AI systems are coupled with performance dashboards that consolidate key metrics like cost variance, progress deviation, and quality index while providing a comprehensive view of project health [48]. On the other hand, Red Sea Global employs AI to manage environmental and operational risks simultaneously in which predictive performance models forecast potential disruptions due to environmental variables such as temperature, humidity, or material transport delays. The Red Sea Global's integrated AI platform quantifies sustainability performance by tracking energy use, emission levels, and material efficiency, aligning directly with Vision 2030's environmental stewardship goals. These AI tools ensure that sustainability objectives are not isolated from project delivery performance but embedded within it, representing a dual-benefit model where risk reduction and sustainability optimization reinforce one another. Across all three projects, a consistent trend emerges that is AI is redefining performance measurement through precision, transparency, and continuous learning. The integration of AI with existing project management information systems (PMIS) allows for automated evaluation of cost, schedule, and quality parameters, reducing human bias and improving accountability.

AI and Sustainability Optimization

437   Sustainability has emerged as a defining benchmark for project excellence within Saudi
438 Arabia's Vision 2030 framework, and Artificial Intelligence (AI) now plays a decisive role in
439 achieving this transformation across the Kingdom's major construction initiatives. The national
440 focus on green development and efficient resource utilization has compelled project stakeholders
441 to adopt intelligent systems that integrate sustainability objectives into every stage of
442 construction management. AI enables predictive evaluation, adaptive control, and optimization
443 of environmental and operational parameters, ensuring that large-scale developments meet both
444 economic and ecological goals. Scholarly evidence supports these industry practices,
445 demonstrating that AI-enabled sustainability analytics can reduce material waste by up to 25
446 percent and energy consumption by 15–20 percent in large-scale construction [49]. Such
447 outcomes directly align with Vision 2030's Environmental Sustainability and Circular Economy
448 programs, reinforcing the Kingdom's leadership in sustainable development. AI-driven
449 sustainability frameworks not only improve project-level environmental performance but also
450 enhance long-term national resilience by conserving natural resources and reducing dependency
451 on imported materials. In addition, AI-enabled sustainability optimization represents the practical
452 realization of Vision 2030's integrated development philosophy while balancing economic
453 growth, environmental preservation, and technological innovation. Through projects such as
454 NEOM, Qiddiya, and Red Sea Global, Saudi Arabia is not only constructing physical
455 infrastructure but also building the foundation for a digitally intelligent and ecologically
456 responsible national economy.

457 **Macroeconomic Linkage to Vision 2030**

458   The integration of AI into Saudi Arabia's construction sector transcends operational
459 efficiency, functioning as a strategic enabler of macroeconomic transformation under Vision
460 2030. While the preceding case analyses illustrate project-level benefits in terms of planning,
461 risk management, and workforce development, the broader implication lies in showing that these
462 advancements collectively contribute to national economic diversification, productivity
463 enhancement, and technological sovereignty. The cumulative evidence from NEOM, Qiddiya,
464 and Red Sea Global reveals that AI-driven project management practices are shaping a digitally
465 empowered construction economy, one that aligns with the strategic pillars of Vision 2030: a
466 thriving economy, an ambitious nation, and a vibrant society. AI adoption in construction
467 directly supports non-oil GDP expansion by improving project delivery efficiency and reducing

cost overruns, AI enhances capital productivity and infrastructure output. According to Akeiber[50], projects with digital transformation across construction could contribute up to 4.5 percent to national GDP growth over the next decade, with AI-enabled process automation accounting for a significant portion of that increase. As projects such as NEOM and Qiddiya deploy intelligent planning systems, their operational models serve as prototypes for future infrastructure programs, setting a national standard for digital performance benchmarking [51]. These systemic gains foster investor confidence, attract foreign direct investment, and stimulate private-sector growth, all of which are fundamental to Vision 2030's diversification agenda. The economic impact also extends to labor market transformation, through AI-enabled workforce localization and digital upskilling, the construction sector is transitioning from a dependency on expatriate labor toward a high-skill, knowledge-intensive employment base. Initiatives within Red Sea Global and NEOM have already demonstrated the feasibility of integrating Saudi professionals into advanced roles such as data analysts, AI system operators, and sustainability engineers. The alignment between AI adoption and national employment objectives strengthens the Kingdom's long-term socio-economic resilience. The macroeconomic impact of AI in construction extends beyond immediate project outcomes because it establishes a sustainable cycle of innovation, productivity, and diversification [52]. At the same time, AI-driven project management strengthens the operational stance of Vision 2030 by improving efficiency, enhancing human capital, stimulating domestic industries, and reinforcing environmental stewardship. Collectively, these effects demonstrate that the digital transformation of Saudi Arabia's construction sector is not an isolated modernization initiative but a foundational component of the Kingdom's transition toward a diversified, knowledge-based economy.

Table 2 Comparative Summary of This Study and Recent Reviews

Study	Scope and Method	Key Findings	Identified Gaps	Contribution of Present Study
Regona et al. (2022)	Systematic review of global AI adoption in project management.	Summarized AI tools improving cost, schedule, and quality control.	Limited exploration of policy or regional application.	Extends evidence to Saudi Vision 2030 context with macroeconomic linkage.
Darko et al. (2020)	Scientometric mapping of AI in AEC research	Identified research clusters and growth	Lacked applied project-level validation.	Provides grounded case analysis demonstrating

Study	Scope and Method	Key Findings	Identified Gaps	Contribution of Present Study
	(2000–2019).	trends.		practical AI integration outcomes.
Olawumi& Chan (2021)	Critical review of BIM adoption for sustainable building management.	Highlighted managerial and cultural barriers to digital adoption.	Focused mainly on sustainability, not AI-driven transformation.	Integrates sustainability and AI within national digital transformation narrative.
Egwim et al. (2023)	Systematic review across full construction value chain.	Classified AI applications and adoption maturity.	Did not connect AI use to economic or workforce impacts.	Demonstrates sectoral and macroeconomic implications of AI adoption in Saudi projects.
Laissy&Dakhil (2025)	Pilot evaluation of AI sustainability tool.	Reported energy-efficiency improvement and reduced material waste.	Narrow sample, no national framework integration.	Expands sustainability benefits toward national Vision 2030 policy outcomes.

491

492   While earlier reviews concentrated on identifying technological enablers, managerial
493   barriers, and operational applications, they offered limited exploration of macroeconomic or
494   policy-level implications. The present study advances the discussion through a national lens,
495   connecting project-level AI applications in Saudi megaprojects to economic diversification goals
496   set under Vision 2030. The integration of empirical case evidence allows this research to bridge
497   the gap between technical innovation and its measurable contribution to sectoral and national
498   transformation.

499   **Conclusion**

500   The study demonstrates that AI is redefining the strategic and operational foundations of
501   Saudi Arabia's construction sector. Through evidence drawn from NEOM, Qiddiya, and Red Sea
502   Global, the analysis confirmed that AI-driven project management has evolved from a
503   technological tool into a transformative mechanism aligned with Vision 2030's economic
504   diversification and sustainability objectives. The integration of AI across planning, risk

505 management, performance monitoring, sustainability optimization, and workforce transformation

506 signifies a structural modernization of one of the Kingdom's most vital industries.

507   The findings established that AI enhances project predictability, reduces inefficiencies,

508 and supports intelligent decision-making across all management levels. Projects like NEOM

509 illustrated that predictive analytics and cognitive systems mitigate risks and optimize scheduling

510 accuracy, while Qiddiya demonstrates the role of AI in promoting operational efficiency and

511 safety compliance and Red Sea Global provides further validation of AI's environmental

512 contribution through resource optimization and sustainable design integration. These cases

513 highlighted that AI implementation not only strengthens project-level performance but also

514 generates macroeconomic benefits through higher productivity, resource efficiency, and

515 industrial innovation. The findings also revealed that AI contributes directly to Vision 2030's

516 pillars of a thriving economy and sustainable environment. The digital transformation of

517 construction enhances domestic value creation, reduces dependency on imported expertise, and

518 accelerates the localization of high-skill employment. The alignment between AI adoption and

519 national development strategies illustrated that technological modernization acts as an economic

520 accelerator, enabling Saudi Arabia to transition from oil-based growth toward a knowledge-

521 driven, innovation-led economy.

522   However, the study also identifies structural challenges that require strategic attention.

523 These include disparities in digital readiness among small and medium-sized enterprises, the

524 high cost of AI infrastructure, and limited regulatory frameworks for data governance. Thus,

525 addressing these challenges is essential for achieving equitable and scalable digital

526 transformation across the entire construction sector.

527 **Future Research**

528   Future research should focus on three main areas because of their importance and

529 potential to enhance liter. First, empirical studies are needed to quantify the long-term economic

530 returns of AI integration in construction, including cost savings, productivity growth, and

531 sustainability performance. Second, comparative analyses across different Gulf Cooperation

532 Council (GCC) nations could reveal regional trends and best practices for digital construction

533 governance. Third, longitudinal studies should explore how workforce reskilling programs and

534 AI governance frameworks evolve as AI adoption matures within the Saudi construction

535 industry.

The transformation observed in this study confirms that AI is not merely enhancing project management but it alsoshowedcreation of value, its distribution, and sustained within Saudi Arabia's construction economy. Through strategic integration and governance, AI-driven project management will continue to serve as a cornerstone of Vision 2030, strengthening the Kingdom's global position as a leader in technologically advanced, sustainable, and economically diversified development.

References

1. Al-Sulaiti, A., Hamouda, A. M., Al-Yafei, H., &Abdella, G. M. (2024). Innovation-based strategic roadmap for economic sustainability and diversity in hydrocarbon-driven economies: the Qatar perspective. *Sustainability*, *16*(9), 3770. https://www.mdpi.com/2071-1050/16/9/3770

2. Arif, M., &Aldosary, A. S. (2023). Urban spatial strategies of the Gulf Cooperation Council: A comparative analysis and lessons learned. *Sustainability*, *15*(18), 13344. https://www.mdpi.com/2071-1050/15/18/13344

3. Liu, S., &Hao, W. (2021). Forecasting the scheduling issues in engineering project management: Applications of deep learning models. *Future Generation Computer Systems*, *123*, 85-93. https://www.sciencedirect.com/science/article/pii/S0167739X21001345

4. Jain, S., Jauhar, S. K., &Piyush. (2024). A machine-learning-based framework for contractor selection and order allocation in public construction projects considering sustainability, risk, and safety. *Annals of Operations Research*, *338*(1), 225-267. https://link.springer.com/article/10.1007/s10479-024-05898-6

5. Takla, R. (2025). Saudi Arabia launches new financing products to boost construction sector. Arab News. https://www.arabnews.com/node/2590098/amp

6. Bhattacharya, S., & Chatterjee, A. (2022). Digital project driven supply chains: a new paradigm. *Supply Chain Management: An International Journal*, *27*(2), 283-294. https://www.emerald.com/insight/content/doi/10.1108/SCM-12-2020-0641/full/html

7. Khan, M. S., Aziz, G., Bakoben, H. B. M., & Saeed, A. (2025). Implications of Sustainable Logistics on Economic, Environment, and Social Dimensions: Pre- and Post-Implementation of Saudi Vision 2030. *Journal of the Knowledge Economy*, 1-30. https://link.springer.com/article/10.1007/s13132-025-02616-w

8. Ezmigna, I., Alghizzawi, M., Alqsass, M., Abu-AlSondos, I. A., Abualfalayeh, G., &Abdeldayem, M. M. (2024, December). The Role of Vision 2030 in Transforming Saudi Arabia's Logistics Sector: A Qualitative Approach. In *2024 International Conference on Decision Aid Sciences and Applications (DASA)* (pp. 1-6). IEEE. https://ieeexplore.ieee.org/abstract/document/10836290/

9. Adeleke, O., &Olajide, O. (2024). Conceptual framework for health-care project management: past and emerging models. *Int J Multidisciplinary Res Growth Evaluation*, *5*, 1685-700. Available at:https://www.researchgate.net/profile/Anfo-Pub-2/publication/393945575_Conceptual_Framework_for_Health-Care_Project_Management_Past_and_Emerging_Models/links/6880e62d4eccfb3f29c46f81/Conceptual-Framework-for-Health-Care-Project-Management-Past-and-Emerging-Models.pdf

10. Saeed, M. D., &Khudhair, H. Y. (2024). MANAGING COMPLEXITY AND STAKEHOLDER DYNAMICS IN LARGE-SCALE INFRASTRUCTURE PROJECT. *International Journal on Technical and Physical Problems of Engineering*, *16*(1), 265-276. https://www.iotpe.com/IJTPE/IJTPE-2024/IJTPE-Issue58-Vol16-No1-Mar2024/39-IJTPE-Issue58-Vol16-No1-Mar2024-pp265-276.pdf

11. Xue, J., Shen, G. Q., Deng, X., Ogungbile, A. J., & Chu, X. (2023). Evolution modeling of stakeholder performance on relationship management in the dynamic and complex environments of megaprojects. *Engineering, Construction and Architectural Management*, *30*(4), 1536-1557. https://www.emerald.com/insight/content/doi/10.1108/ecam-06-2021-0504/full/html

12. Tran, H. V. V., & Nguyen, T. A. (2024). A review of challenges and opportunities in BIM adoption for construction project management. *Engineering Journal*, *28*(8), 79-98. https://engj.org/index.php/ej/article/view/4567

597 13. Sami Ur Rehman, M., Shafiq, M. T., Ullah, F., &Galal Ahmed, K. (2023). A
598 critical appraisal of traditional methods of construction progress monitoring. *Built*
599 *Environment Project and Asset Management*, *13*(6), 830-845.
600 https://www.emerald.com/insight/content/doi/10.1108/bepam-02-2023-
601 0040/full/html

602 14. Gondia, A., Ezzeldin, M., & El-Dakhakhni, W. (2022). Dynamic networks for
603 resilience-driven management of infrastructure projects. *Automation in*
604 *construction*, *136*, 104-149.
605 https://www.sciencedirect.com/science/article/pii/S092658052200022X

606 15. Chadee, A. A., Chadee, X. T., Ray, I., Mwasha, A., & Martin, H. H. (2021).
607 When parallel schools of thought fail to converge: The case of cost overruns in
608 project management. *Buildings*, *11*(8), 321. https://www.mdpi.com/2075-
609 5309/11/8/321

610 16. Attah, R. U., Garba, B. M. P., Gil-Ozoudeh, I., &Iwuanyanwu, O. (2024). Best
611 Practices in Project Management for Technology-Driven Initiatives: A Systematic
612 Review of Market Expansion and Product Development Technique. *Int J Eng Res*
613 *Dev*, *20*(11), 1350-61. Available
614 at:https://www.researchgate.net/profile/Ifechukwu-Gil-
615 Ozoudeh/publication/387008612_Best_Practices_in_Project_Management_for_T
616 echnology-
617 _Driven_Initiatives_A_Systematic_Review_of_Market_Expansion_and_Product_
618 Development_Techniques/links/675c001ada24c8537c6a1761/Best-Practices-in-
619 Project-Management-for-Technology-Driven-Initiatives-A-Systematic-Review-
620 of-Market-Expansion-and-Product-Development-Techniques.pdf

621 17. Chen, M., Martins, T. S., Zhang, L., & Dong, H. (2025). Digital transformation in
622 project management: A systematic review and research agenda. *Systems*, *13*(8),
623 625. https://www.mdpi.com/2079-8954/13/8/625

624 18. Ajayi, R. (2025). Integrating IoT and cloud computing for continuous process
625 optimization in real-time systems. *Int J Res Publ Rev*, *6*(1), 2540-2558. Available
626 at:https://www.researchgate.net/profile/Rhoda-Ajayi-
627 2/publication/388082333_Integrating_IoT_and_Cloud_Computing_for_Continuo

628 us_Process_Optimization_in_Real_Time_Systems/links/6789e53b1ec9f9589f478

629 e92/Integrating-IoT-and-Cloud-Computing-for-Continuous-Process-

630 Optimization-in-Real-Time-Systems.pdf

631 19. Bodrick, M. M., Alkindi, E. T., Alassaf, M. I., Alrasi, M. Y., Aljuffali, L.,

632 Alhawas, A. A., ... &Alsuhaim, M. I. (2025). The Contextual Dynamism of

633 Organizational Leadership in Saudi Arabia: What is Next After Change,

634 Transition, and Transformation-Is it Transmogrification?. *Journal of Business and*

635 *Management Studies*, *7*(3), 355-363. https://al-

636 kindipublishers.org/index.php/jbms/article/view/10025

637 20. Salimimoghadam, S., Ghanbaripour, A. N., Tumpa, R. J., KamelRahimi, A.,

638 Golmoradi, M., Rashidian, S., &Skitmore, M. (2025). The Rise of Artificial

639 Intelligence in Project Management: A Systematic Literature Review of Current

640 Opportunities, Enablers, and Barriers. *Buildings*, *15*(7), 1130.

641 https://www.mdpi.com/2075-5309/15/7/1130

642 21. Narne, H. (2022). AI and Machine Learning in Enterprise Resource Planning:

643 Empowering Automation, Performance, and Insightful Analytics. *International*

644 *Journal of Research and Analytical Reviews*, *9*(1). Available at:

645 https://www.researchgate.net/profile/Harish-Narne-

646 3/publication/386384140_AI_and_Machine_Learning_in_Enterprise_Resource_P

647 lanning_Empowering_Automation_Performance_and_Insightful_Analytics/links/

648 674fd5df790d154bf9c28e26/AI-and-Machine-Learning-in-Enterprise-Resource-

649 Planning-Empowering-Automation-Performance-and-Insightful-Analytics.pdf

650 22. Hashimzai, I. A., &Mohammadi, M. Q. (2024). The Integration of Artificial

651 Intelligence in Project Management: A Systematic Literature Review of Emerging

652 Trends and Challenges. *TIERS Information Technology Journal*, *5*(2), 153-164.

653 https://journal.undiknas.ac.id/index.php/tiers/article/view/5963

654 23. Violos, J., Mamanis, G., Kompatsiaris, I., & Papadopoulos, S. (2025). Cognition

655 and context-aware decision-making systems for a sustainable planet: a survey on

656 recent advancements, applications and open challenges. *Discover*

657 *Sustainability*, *6*(1), 1-43. https://link.springer.com/article/10.1007/s43621-025-

658 00954-y

24. Paul, R., Rahman, M. A., &Nuruzzaman, M. (2024). AI-Enabled Decision Support Systems for Smarter Infrastructure Project Management In Public Works. *Review of Applied Science and Technology*, *3*(04), 29-47. https://rast-journal.org/index.php/RAST/article/view/15

25. Regona, M., Yigitcanlar, T., Xia, B., & Li, R. Y. M. (2022). Opportunities and adoption challenges of AI in the construction industry: A PRISMA review. *Journal of open innovation: technology, market, and complexity*, *8*(1), 45. https://www.mdpi.com/2199-8531/8/1/45

26. Van Hoang, T. (2024). Impact of integrated artificial intelligence and internet of things technologies on smart city transformation. *Journal of technical education science*, *19*(Special Issue 01), 64-73. https://jte.edu.vn/index.php/jte/article/view/1532

27. Alavi, H., Gordo-Gregorio, P., Forcada, N., Bayramova, A., & Edwards, D. J. (2024). AI-driven BIM integration for optimizing healthcare facility design. *Buildings*, *14*(8), 23-54. https://www.mdpi.com/2075-5309/14/8/2354

28. Shamim, M. M. I., Hamid, A. B. B. A., Nyamasvisva, T. E., & Rafi, N. S. B. (2025). Advancement of Artificial Intelligence in Cost Estimation for Project Management Success: A Systematic Review of Machine Learning, Deep Learning, Regression, and Hybrid Models. *Modelling*, *6*(2), 35. https://www.mdpi.com/2673-3951/6/2/35

29. Narbaev, T., Hazir, Ö., Khamitova, B., & Talgat, S. (2024). A machine learning study to improve the reliability of project cost estimates. *International Journal of Production Research*, *62*(12), 4372-4388. https://www.tandfonline.com/doi/abs/10.1080/00207543.2023.2262051

30. Nabeel, M. Z. (2024). AI-enhanced project management systems for optimizing resource allocation and risk mitigation: Leveraging big data analysis to predict project outcomes and improve decision-making processes in complex projects. *Asian Journal of Multidisciplinary Research & Review*, *5*(5), 53-65. Available at: https://works.hcommons.org/records/5ng5p-cvx90/files/ai-enhanced-project-management-systems-for-optimizing-resource-allocation-and-risk-mitigation.pdf

31. Alqasi, M. A. Y., Alkelanie, Y. A. M., &Alnagrat, A. J. A. (2024). Intelligent infrastructure for urban transportation: The role of artificial intelligence in predictive maintenance. *Brilliance: research of artificial intelligence*, *4*(2), 625-637. https://itscience-indexing.com/jurnal/index.php/brilliance/article/view/4889

32. Qudus, L. (2025). Leveraging Artificial Intelligence to Enhance Process Control and Improve Efficiency in Manufacturing Industries. *International Journal of Computer Applications Technology and Research*, *14*(02), 18-38. Available at: https://www.researchgate.net/profile/Qudus-Lawal-3/publication/389913439_Leveraging_Artificial_Intelligence_to_Enhance_Process_Control_and_Improve_Efficiency_in_Manufacturing_Industries/links/67d8815 07c5b5569dcc0364c/Leveraging-Artificial-Intelligence-to-Enhance-Process-Control-and-Improve-Efficiency-in-Manufacturing-Industries.pdf

33. Sanusi, B. O. (2024). The Role of Data-Driven Decision-Making in Reducing Project Delays and Cost Overruns in Civil Engineering Projects. *SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology*, *16*(04), 182-192. https://smsjournals.com/index.php/SAMRIDDHI/article/view/3395

34. Bühler, M. M., Nübel, K., Jelinek, T., Köhler, L., &Hollenbach, P. (2025). Bridging the Construction Productivity Gap—A Hierarchical Framework for the Age of Automation, Robotics, and AI. *Buildings*, *15*(16), 2899. https://www.mdpi.com/2075-5309/15/16/2899

35. Hossain, M. I., Hosen, M. M., Sunny, M. A. U., &Tarapder, S. A. (2025). IMPLEMENTING ADVANCED TECHNOLOGIES FOR ENHANCED CONSTRUCTION SITE SAFETY. *American Journal of Advanced Technology and Engineering Solutions*, *1*(02), 01-31. https://ajates-scholarly.com/index.php/ajates/article/view/33

36. Tran, H. V. V., & Nguyen, T. A. (2024). A review of challenges and opportunities in BIM adoption for construction project management. *Engineering Journal*, *28*(8), 79-98. https://engj.org/index.php/ej/article/view/4567

37. Baranda Rodriguez, E., González, R. G., & Rosas Mayoral, J. G. (2025). Review of the Role of Building Information Modelling-Based Constructability in

Improving Sustainability in Industrial Plant Construction Projects. *Buildings*, *15*(11), 1921. https://www.mdpi.com/2075-5309/15/11/1921

38. Whang, S. E., Roh, Y., Song, H., & Lee, J. G. (2023). Data collection and quality challenges in deep learning: A data-centric ai perspective. *The VLDB Journal*, *32*(4), 791-813. https://link.springer.com/article/10.1007/s00778-022-00775-9

39. Piras, G., Muzi, F., &Tiburcio, V. A. (2024). Digital management methodology for building production optimization through digital twin and artificial intelligence integration. *Buildings*, *14*(7), 2110. https://www.mdpi.com/2075-5309/14/7/2110

40. Kayani, F. N., &Alzaid, O. I. (2025). Small and Medium-Sized Enterprises under the Transformative Vision 2030 of Saudi Arabia. *International Review of Management and Marketing*, *15*(3), 46. Available at:https://www.researchgate.net/profile/Farrukh-Nawaz-2/publication/390943541_Small_and_Medium-sized_Enterprises_under_the_Transformative_Vision_2030_of_Saudi_Arabia/links/6803ac8f60241d51400e261b/Small-and-Medium-sized-Enterprises-under-the-Transformative-Vision-2030-of-Saudi-Arabia.pdf

41. Bena, Y. A., Muchtar, F., Ibrahim, R., Mahmood, J., Chan, W. H., Shah, M. Z. M. Z., ... & Fattah, S. (2025). Enhancing Big Data Governance Practices: Addressing Security, Privacy and Ethical Challenges. *Journal of Advanced Research Design*, *142*(1), 159-176. https://www.akademiabaru.com/submit/index.php/ard/article/view/6587

42. Wang, H., & Zhu, L. (2025). Technological Innovation, Industrial Structure Upgrading, and the Coordinated Development of Regional Economies. *Sustainability*, *17*(17), 78-80. https://www.mdpi.com/2071-1050/17/17/7880

43. Bozzo-Rey, M., &Ghassemi, M. (2025). From Private Surveillance to Public Protection: The Pervasive Interplay. The Case of NEOM. *cit*, *122*, 123. https://www.erdalreview.eu/free-download/97912218211162.pdf

44. Kashef, M. (2025). Rethinking Masdar and The Line Megaprojects: The Interplay of Economic, Social, Political, and Spatial Dimensions. *Land*, *14*(7), 1358. https://www.mdpi.com/2073-445X/14/7/1358

45. Hatami, M., Franz, B., Paneru, S., & Flood, I. (2022). Using deep learning artificial intelligence to improve foresight method in the optimization of planning and scheduling of construction processes. In *Computing in Civil Engineering 2021* (pp. 1171-1178). https://ascelibrary.org/doi/abs/10.1061/9780784483893.143

46. Obiuto, N. C., Adebayo, R. A., Olajiga, O. K., & Festus-Ikhuoria, I. C. (2024). Integrating artificial intelligence in construction management: Improving project efficiency and cost-effectiveness. *Int. J. Adv. Multidisc. Res. Stud*, *4*(2), 639-647. https://www.multiresearchjournal.com/admin/uploads/archives/archive-1711453341.pdf

47. Usama, M., Ullah, U., Muhammad, Z., Islam, T., &saba Hashmi, S. (2024). AI-enabled risk assessment and safety management in construction. In *Ethical Artificial Intelligence in Power Electronics* (pp. 105-132). CRC Press. Available at: https://www.taylorfrancis.com/chapters/edit/10.1201/9781032648323-8/ai-enabled-risk-assessment-safety-management-construction-muhammad-usama-ubaid-ullah-zaid-muhammad-taminul-islam-syeda-saba-hashmi

48. Diameh, J. T., Oluwatobi, B. T., Daniels, C., Ekaette, O., Sunday, N., Azumah, C., &Mariama, Q. (2025). Integrating AI-driven predictive analytics in project risk management to optimize decision-making and performance efficiency. *Int. J. Eng. Technol. Res. Manag*, *9*, 373-389. Available at: https://www.researchgate.net/profile/Jacob-Diameh/publication/390597476_INTEGRATING_AI-DRIVEN_PREDICTIVE_ANALYTICS_IN_PROJECT_RISK_MANAGEMENT_TO_OPTIMIZE_DECISION-MAKING_AND_PERFORMANCE_EFFICIENCY/links/67f592b695231d5ba5bce20c/INTEGRATING-AI-DRIVEN-PREDICTIVE-ANALYTICS-IN-PROJECT-RISK-MANAGEMENT-TO-OPTIMIZE-DECISION-MAKING-AND-PERFORMANCE-EFFICIENCY.pdf

781   49. Elmousalami, H., Maxy, M., Hui, F. K. P., & Aye, L. (2025). AI in automated
782   sustainable construction engineering management. *Automation in*
783   *Construction*, *175*(10620), 106202. Available at:
784   https://www.researchgate.net/profile/Haytham-
785   Elmousalami/publication/391635369_AI_in_automated_sustainable_construction
786   _engineering_management/links/681febfebd3f1930dd705a10/AI-in-automated-
787   sustainable-construction-engineering-management.pdf

788   50. Akeiber, H. J. (2025). Artificial Intelligence in Engineering Management:
789   Revolutionizing Decision-Making and Automation. *Al-Rafidain Journal of*
790   *Engineering Sciences*, 317-349. https://rjes.iq/index.php/rjes/article/view/167

791   51. Bahreldin, I., Samir, H., Maddah, R., Hammad, H., &Hegazy, I. (2025).
792   Leveraging advanced digital technologies for smart city development in Saudi
793   Arabia: opportunities, challenges, and strategic pathways. *International Journal*
794   *of Low-Carbon Technologies*, *20*, 834-847. https://academic.oup.com/ijlct/article-
795   abstract/doi/10.1093/ijlct/ctaf044/8087327

796   52. Kalai, M., Becha, H., &Helali, K. (2024). Effect of artificial intelligence on
797   economic growth in European countries: a symmetric and asymmetric
798   cointegration based on linear and non-linear ARDL approach. *Journal of*
799   *Economic Structures*, *13*(1), 22. https://link.springer.com/article/10.1186/s40008-
800   024-00345-y

801   53. Regona, M. S., Alreshidi, E., Matarneh, R., &Sepasgozar, S. (2022). Artificial
802   intelligence in construction project management: A systematic review.
803   Automation in Construction, 142, 104480.
804   https://doi.org/10.1016/j.autcon.2022.104480

805   54. Darko, A., Chan, A. P. C., Adabre, M. A., Edwards, D. J., Hosseini, M. R.,
806   &Ameyaw, E. E. (2020). Artificial intelligence in the AEC industry:
807   Scientometric analysis and visualization of research activities. Automation in
808   Construction, 112, 103081. https://doi.org/10.1016/j.autcon.2020.103081

809   55. Olawumi, T. O., & Chan, D. W. M. (2021). Critical review of empirical research
810   on BIM implementation for sustainable building projects. Built Environment

811   Project and Asset Management, 11(1), 77–100. https://doi.org/10.1108/BEPAM-
812   12-2019-0147

813   56. Egwim, C. N., Alaka, H., Demir, E., Balogun, H., Olu-Ajayi, R., &Muideen, A.
814   (2023). Artificial intelligence in the construction industry: A systematic review of
815   the entire construction value chain lifecycle. Energies, 17(1), 182.
816   https://doi.org/10.3390/en17010182

817   57. Laissy, M. Y., &Dakhil, O. M. (2025). AI tool for sustainable project
818   management construction (SPMC). Asian Journal of Advanced Research and
819   Reports, 19(7), 164–175. https://doi.org/10.9734/ajarr/2025/v19i71089

820