
| RESEARCH ARTICLE

Artificial Intelligence in Project Management: A Systematic Review of Applications, Challenges, and Future Directions

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| ABSTRACT

Artificial intelligence (AI) has emerged as a transformative technology in project management, offering advanced capabilities for data-driven decision-making, predictive analytics, and process automation. This study presents a systematic literature review of AI applications in project management, focusing on peer-reviewed journal articles published between 2015 and 2021. A total of 25 relevant studies were selected following PRISMA guidelines and analyzed using both thematic and bibliometric approaches. The findings reveal that AI is predominantly applied in areas such as project scheduling, cost estimation, risk management, safety monitoring, and project portfolio selection, with a strong concentration in construction project management. Machine learning and deep learning techniques are widely used, enabling enhanced prediction accuracy and real-time monitoring. The thematic analysis highlights key benefits, including improved efficiency, better decision-making, and enhanced safety performance. However, significant challenges remain, particularly related to data quality, model interpretability, organizational readiness, and ethical concerns. The bibliometric analysis further demonstrates that research in this field is structured around four main dimensions: AI techniques, application domains, performance outcomes, and emerging challenges. A temporal shift from traditional optimization methods to advanced data-driven approaches is also observed. This study contributes to the existing literature by providing a comprehensive synthesis of AI applications in project management and identifying critical research gaps. The findings suggest that future research should focus on explainable AI, integration with emerging technologies such as digital twins and IoT, and the development of human–AI collaborative systems to enhance project management practices.

| KEYWORDS

Artificial intelligence, project management, machine learning, systematic review, bibliometric analysis, construction management

| ARTICLE INFORMATION

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1. Introduction

Project management has traditionally relied on human expertise, heuristic decision-making, and deterministic planning tools. However, the increasing complexity, uncertainty, and data intensity of modern projects have exposed the limitations of conventional approaches. In response, organizations are increasingly turning to AI to enhance decision-making, improve efficiency, and enable predictive capabilities across project lifecycles.

AI, encompassing techniques such as machine learning (ML), deep learning (DL), natural language processing (NLP), and fuzzy logic, has demonstrated significant potential in transforming project management practices. These technologies enable the analysis of large and complex datasets, facilitating more accurate forecasting, risk assessment, and resource optimization (Abioye et al., 2021; Xu et al., 2021). In particular, AI has gained traction in domains such as construction project management, where data-rich environments provide opportunities for advanced analytics and automation (Pan & Zhang, 2021). Recent studies highlight that AI applications in project management extend to areas such as schedule prediction, cost estimation, safety

monitoring, and portfolio selection (Egwim et al., 2021; Tavana et al., 2015; Fang et al., 2020). Furthermore, the integration of AI with emerging technologies such as Building Information Modeling (BIM) and digital twins has enabled real-time monitoring and intelligent control of project processes (Pan & Zhang, 2021). These developments indicate a shift toward data-driven and intelligent project management systems.

Despite these advancements, the adoption of AI in project management remains uneven and faces several challenges. Issues related to data quality, model interpretability, organizational readiness, and ethical concerns continue to hinder widespread implementation (Akinosho et al., 2020; An et al., 2021; Abioye et al., 2021). Moreover, existing research is fragmented, with many studies focusing on specific applications rather than providing a holistic understanding of AI's role in project management. Given these gaps, there is a need for a comprehensive synthesis of the literature to better understand the current state, challenges, and future directions of AI in project management. Therefore, this study aims to systematically review the existing body of knowledge and address the following research questions:

1. What are the key applications of AI in project management?
2. What benefits does AI provide in improving project performance?
3. What challenges and limitations affect AI adoption in project management?
4. What are the future research directions in this domain?

By addressing these questions, this study contributes to both academic research and practice by providing a structured overview of AI's evolving role in project management.

2. Literature Review

2.1 Overview of AI in Project Management

The application of AI in project management has gained increasing attention over the past decade, driven by advances in computational power, data availability, and algorithmic development. AI is broadly defined as the capability of machines to perform tasks that typically require human intelligence, including learning, reasoning, and decision-making.

Several review studies emphasize the growing importance of AI in project-based industries. For instance, Abioye et al. (2021) highlight the expanding role of AI in construction, noting its potential to improve productivity, safety, and sustainability. Similarly, Xu et al. (2021) identify a shift from traditional statistical methods to data-driven AI approaches, particularly deep learning, which has enabled more sophisticated analysis of complex project data.

Although the majority of AI applications are concentrated in construction and engineering, the underlying principles are applicable across various project management domains. The literature suggests that AI is gradually transforming project management into a more predictive and adaptive discipline, capable of responding to dynamic project environments.

2.2 Applications of AI in Project Management

AI has been applied across multiple project management functions, with significant contributions in planning, monitoring, risk management, and decision support. One of the most widely studied applications is project scheduling and delay prediction. ML models have been used to analyze historical project data and predict potential delays, improving planning accuracy and enabling proactive interventions (Egwim et al., 2021). Similarly, AI techniques have been applied in cost estimation and tendering, where DL models can predict profitability and optimize bidding strategies (Bilal & Oyedele, 2020). Another important area is project portfolio selection, where AI-based approaches such as fuzzy logic and hybrid decision models support the evaluation of multiple competing projects under uncertainty (Tavana et al., 2015; Tavana et al., 2019; Zolfaghari & Mousavi, 2021). These methods enhance decision-making by incorporating both quantitative and qualitative criteria.

AI has also played a critical role in risk and safety management. Computer vision and DL techniques are increasingly used to monitor construction sites, detect unsafe behaviors, and analyze accident data (Fang et al., 2018; Fang et al., 2020; Zhong et al., 2020). These applications enable real-time risk identification and improve safety performance. Furthermore, the integration of AI with BIM and digital twin technologies has enabled advanced project monitoring and control. AI-driven digital twins enable real-time data analysis and predictive maintenance, enhancing project performance and reducing uncertainty (Pan & Zhang, 2021).

2.3 AI Techniques in Project Management

The literature reveals a wide range of AI techniques applied to project management, reflecting the field's evolution. Early studies primarily utilized fuzzy logic, expert systems, and multi-criteria decision-making methods for project evaluation and selection (Tavana et al., 2015). While effective at handling uncertainty, these methods are limited in their ability to process large, complex datasets. More recent research has shifted toward ML and DL approaches, which offer greater flexibility and predictive accuracy (Xu et al., 2021). Deep learning models, including CNNs, have been widely used in computer vision applications, such as safety monitoring and object detection (Fang et al., 2018).

In addition, NLP has been applied to analyze textual data, such as safety reports and project documentation, enabling automated classification and knowledge extraction (Zhong et al., 2020). The use of big data analytics and data mining techniques further enhances AI systems' ability to extract insights from large datasets (Yan et al., 2020). Overall, the literature indicates a trend toward hybrid AI approaches that combine multiple techniques to improve performance and address complex project management problems.

2.4 Benefits of AI in Project Management

The adoption of AI in project management offers several advantages. First, AI improves decision-making quality by providing data-driven insights and reducing reliance on subjective judgment (El Khatib & Al Falasi, 2021). Second, AI enhances project efficiency and productivity by automating repetitive tasks and optimizing resource allocation (Pan & Zhang, 2021). AI also contributes to improved risk management and safety performance. Real-time monitoring systems enable early detection of hazards, reducing accidents and improving compliance (Fang et al., 2020). Additionally, predictive models allow for better management of project uncertainties, leading to improved project outcomes. Moreover, AI facilitates knowledge discovery and organizational learning by analyzing historical project data and identifying patterns that can inform future projects (Bilal & Oyedele, 2020).

2.5 Challenges and Research Gaps

Despite its potential, implementing AI in project management faces several challenges. One of the primary issues is data quality and availability. AI models require large volumes of high-quality data, which are often lacking in project environments (Akinosho et al., 2020). The absence of standardized data formats further complicates data integration. Another significant challenge is the lack of transparency and interpretability of AI models. Many advanced models, particularly deep learning systems, operate as "black boxes," making it difficult for practitioners to understand and trust their outputs (An et al., 2021). Organizational barriers, including lack of expertise, resistance to change, and high implementation costs, also hinder AI adoption (Abioye et al., 2021). Additionally, ethical concerns related to data privacy and security remain underexplored in the literature. Importantly, the existing body of research is highly fragmented, with limited integration between AI technologies and project management theory. This highlights the need for more holistic and interdisciplinary approaches.

3. Research Methodology

3.1 Research Design

This study adopts a systematic literature review (SLR) approach to examine the applications, challenges, and future directions of AI in project management. The SLR method ensures a transparent, reproducible, and comprehensive process for identifying, evaluating, and synthesizing existing research. The review is conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

3.2 Data Sources and Search Strategy

A structured search was conducted across major academic databases, including:

- Scopus
- Web of Science (WoS)
- ScienceDirect (Elsevier)
- IEEE Xplore
- SpringerLink

The search focused on peer-reviewed journal articles published between 2015 and 2021, ensuring coverage of recent developments in AI technologies. The following search string was used and adapted for each database:

("Artificial Intelligence" OR "Machine Learning" OR "Deep Learning" OR "AI") AND ("Project Management" OR "Project Planning" OR "Project Scheduling" OR "Project Risk Management")

3.3 Inclusion and Exclusion Criteria

To ensure relevance and quality, the following criteria were applied:

Inclusion Criteria

- Peer-reviewed journal articles
- Published between 2015 and 2021
- Written in English
- Studies focusing on AI applications in project management or closely related domains (e.g., construction project management, portfolio management)
- Articles with empirical, theoretical, or review contributions

Exclusion Criteria

- Conference papers, book chapters, editorials, and theses
- Articles not directly related to project management
- Studies without clear AI-related methodologies
- Duplicate records

3.4 Study Selection Process

The study selection process followed the PRISMA framework and consisted of four stages:

- Identification: Initial search yielded a large number of records across databases.
- Screening: Titles and abstracts were reviewed to remove irrelevant studies.
- Eligibility: Full-text articles were assessed against inclusion/exclusion criteria.
- Inclusion: A final set of 25 relevant articles was selected for detailed analysis.

3.5 Data Extraction and Coding

A structured data extraction form was developed to systematically collect relevant information from each article. The following key variables were extracted:

- Author(s) and year
- Study objective
- AI techniques used (e.g., ML, DL, NLP, fuzzy logic)
- Application area (e.g., scheduling, risk management, safety, decision-making)
- Key findings
- Identified challenges
- Suggested future research directions

The extracted data were organized into a literature review matrix (Excel sheet) to facilitate comparison and synthesis.

3.6 Data Analysis and Synthesis

A thematic analysis approach was used to synthesize the findings. The selected studies were categorized into major themes, including:

- AI applications in project management
- AI techniques and tools
- Benefits and performance improvements

- Challenges and limitations
- Future research directions

This thematic classification enabled the identification of research trends, gaps, and emerging opportunities in the field.

3.7 Reliability and Validity

To ensure the reliability and validity of the review:

- A systematic and replicable search strategy was applied
- Clear inclusion and exclusion criteria were defined
- Multiple databases were used to reduce selection bias
- Data extraction was conducted consistently using a predefined framework

3.8 Limitations of the Methodology

Despite efforts to ensure rigor, some limitations exist:

- The review is limited to English-language publications
- Only journal articles were included, excluding conference proceedings
- The time range (2015–2021) may omit earlier foundational studies

4. Critical Discussion of AI in Project Management

The integration of AI into project management represents a significant paradigm shift from traditional, experience-driven practices toward data-driven, predictive, and automated decision-making systems. The synthesis of the 25 selected studies reveals not only the growing adoption of AI but also critical tensions between technological potential and practical implementation. The thematic distribution of the reviewed studies is summarized in Figure 1. ● Green = Strong coverage; ● Yellow = Moderate coverage; ● Red = Limited coverage

Study (Author, Year)	AI Applications	AI Techniques	Benefits	Challenges	Future Directions
Gil Ruiz et al. (2021)	Yellow	Red	Red	Yellow	Red
Pan & Zhang (2021a)	Green	Green	Green	Green	Green
El Khatib & Al Falasi (2021)	Red	Yellow	Red	Yellow	Yellow
Pan & Zhang (2021b)	Red	Yellow	Red	Yellow	Yellow
An et al. (2021)	Red	Red	Green	Red	Red
Abdirad & Mathur (2021)	Red	Yellow	Red	Red	Yellow
Egwim et al. (2021)	Green	Green	Red	Red	Green
Xu et al. (2021)	Red	Red	Red	Yellow	Yellow
Abioye et al. (2021)	Green	Yellow	Red	Green	Yellow
Pham et al. (2021)	Red	Yellow	Green	Red	Red
Khallaf & Khallaf (2021)	Red	Red	Red	Yellow	Green
Zolfaghari & Mousavi (2021)	Yellow	Green	Green	Red	Yellow
Tavana et al. (2019)	Red	Red	Yellow	Yellow	Red
Bilal & Oyedele (2020)	Red	Yellow	Red	Green	Red
Yan et al. (2020)	Red	Red	Yellow	Green	Green
Akinosho et al. (2020)	Yellow	Red	Red	Red	Yellow
Fang et al. (2020a)	Red	Red	Green	Green	Red
Zhong et al. (2020)	Yellow	Green	Yellow	Yellow	Red
Fang et al. (2020b)	Green	Yellow	Yellow	Red	Red
Martinez et al. (2019)	Red	Yellow	Yellow	Green	Yellow
Zhong et al. (2019)	Green	Red	Red	Yellow	Yellow
Ayhan & Tokdemir (2019)	Red	Yellow	Red	Yellow	Green
Fang et al. (2018)	Red	Yellow	Green	Green	Red
Kim et al. (2019)	Green	Green	Yellow	Yellow	Green
Tavana et al. (2015)	Red	Green	Yellow	Red	Green

Figure 1. Traffic light matrix summarizing the extent of coverage of key themes (AI applications, techniques, benefits, challenges, and future directions) across the selected studies (2015–2021).

4.1 Bibliometric Analysis of Keyword Co-occurrence

To complement the thematic analysis, a bibliometric keyword co-occurrence analysis was conducted to explore the intellectual structure and evolution of research on AI in project management. The analysis was based on a normalized keyword dataset derived from the 25 selected studies, ensuring consistency in terminology and reducing redundancy across similar terms.

4.1.1 Keyword Co-occurrence Network

The keyword co-occurrence network (Figure 4a) illustrates the relationships among key concepts within the literature. The network is centered around AI and project management, indicating their foundational role in the field. Strong linkages are observed between ML, DL, and construction management, reflecting the dominant methodological and application focus of existing research.

A major cluster is associated with construction-related applications, including safety management, computer vision, and monitoring. This suggests that AI research in project management is heavily concentrated in construction environments, where data availability and operational complexity provide fertile ground for AI implementation. Another cluster highlights decision-support and optimization approaches, represented by keywords such as project portfolio selection, fuzzy logic, and decision making. These studies emphasize the use of AI to support strategic planning and resource allocation under uncertainty. Additionally, emerging technologies such as building information modeling, digital twin, and data mining form an important sub-cluster, indicating a shift toward integrated and intelligent project management systems.

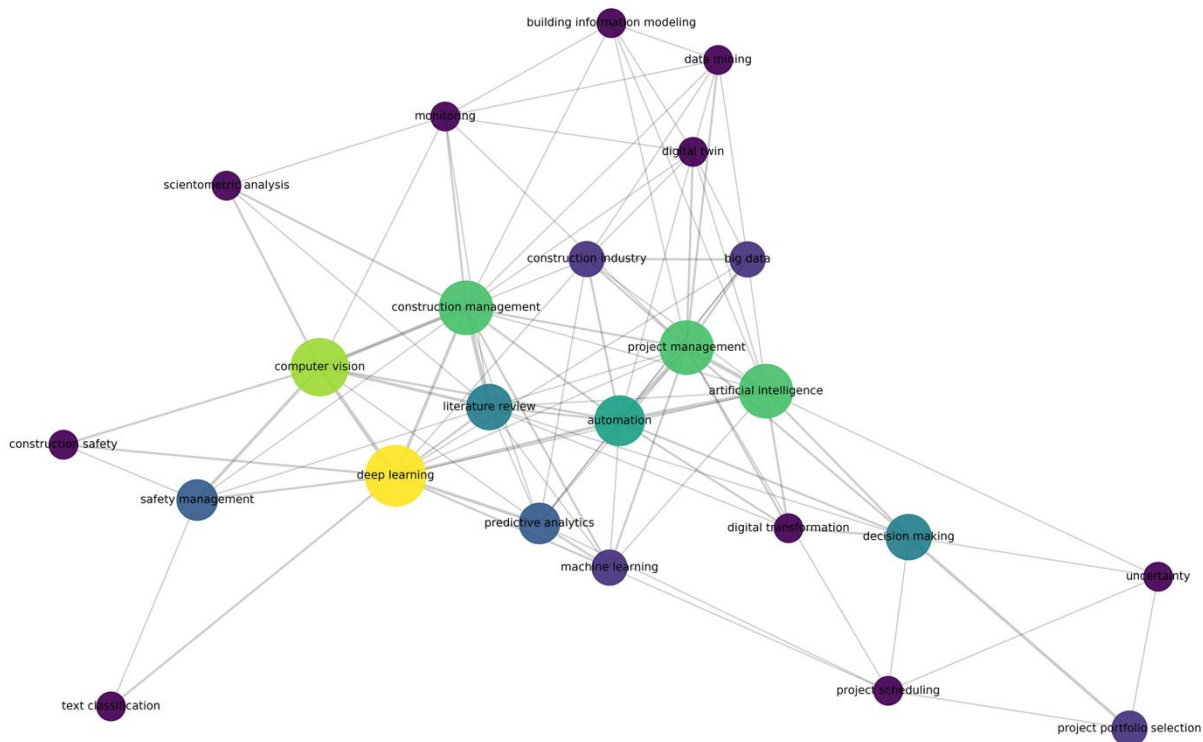


Figure 2. Keyword co-occurrence network of AI in project management based on the 25 selected studies. Node size represents keyword frequency, while link thickness indicates co-occurrence strength between keywords.

4.1.2 Keyword Density Analysis

The density map (Figure 3) identifies the most prominent research areas based on keyword frequency. The highest-density regions are concentrated around artificial intelligence, project management, ML, and DL, confirming their central importance in the literature. High-density areas are also observed for construction management and safety management, further reinforcing the dominance of construction-focused applications. In contrast, keywords related to explainable AI, data quality, and organizational challenges appear in lower-density regions, indicating that these topics are relatively underexplored despite their importance.

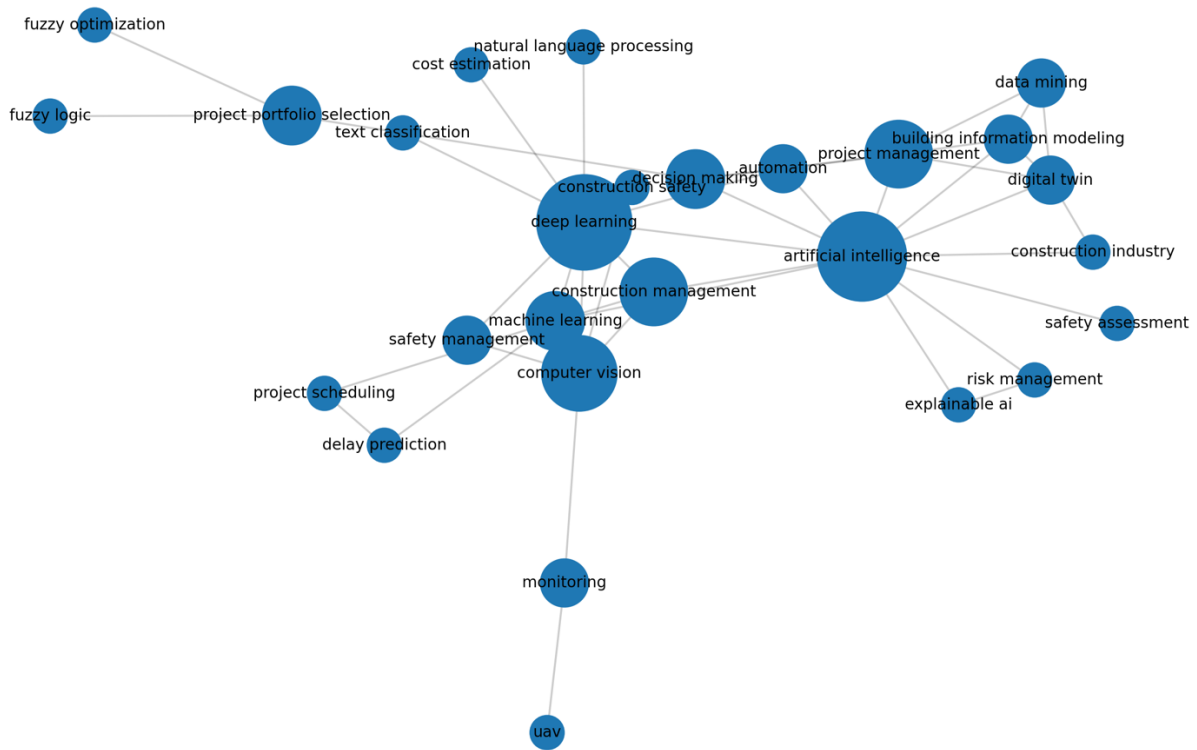


Figure 3. Keyword density map of AI in project management research. Larger nodes indicate higher keyword frequency, highlighting dominant research areas within the selected studies.

4.1.3 Temporal Evolution of Research Themes

The overlay visualization (Figure 4) provides insights into the temporal evolution of research themes between 2015 and 2021. Earlier studies are primarily associated with traditional decision-support techniques, such as fuzzy logic, project portfolio selection, and multi-criteria decision-making approaches. These methods laid the foundation for handling uncertainty in project environments. More recent studies show a clear shift toward advanced AI techniques, including deep learning, computer vision, and natural language processing. These approaches enable the analysis of unstructured data and support real-time monitoring and predictive analytics. Furthermore, the emergence of keywords such as digital twin and building information modeling reflects a growing interest in integrated and data-driven project management systems. At the same time, newer concepts such as explainable AI and human–AI collaboration indicate increasing attention to transparency, trust, and the socio-technical aspects of AI adoption.

4.1.4 Synthesis of Bibliometric Findings

Overall, the bibliometric analysis reveals that research on AI in project management is structured around four main dimensions:

- Core concepts: AI and project management
- AI techniques: ML, DL, computer vision
- Application domains: construction management, safety, scheduling, and cost estimation
- Emerging challenges and future directions: explainability, data quality, and human–AI collaboration

The findings confirm a transition from rule-based and optimization-driven approaches toward data-driven, intelligent, and integrated systems. However, the relatively low prominence of keywords related to governance, ethics, and organizational readiness suggests important gaps that warrant further investigation.

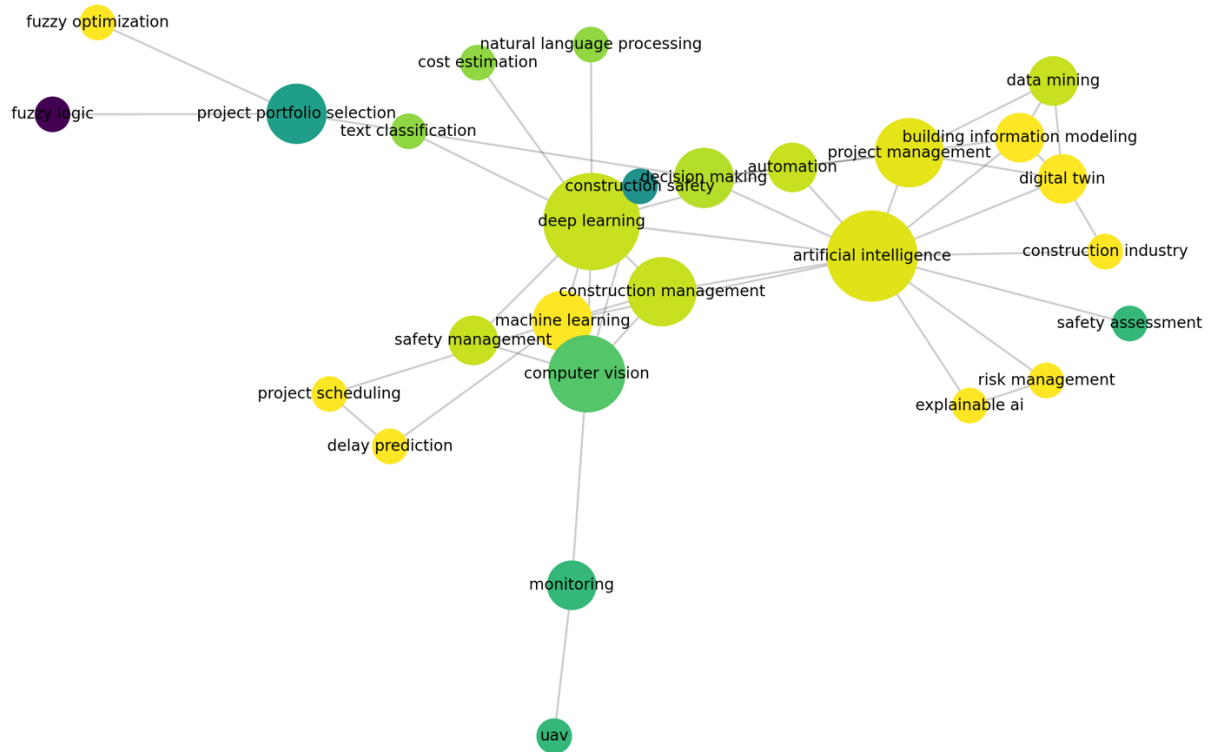


Figure 4. Keyword overlay visualization showing the temporal evolution of research themes in AI in project management (2015–2021). Node shading reflects the average publication year of each keyword.

4.2 From Functional Support to Intelligent Project Ecosystems

A key insight emerging from the literature is the transition of AI from a supportive analytical tool to a core enabler of intelligent project ecosystems. Early applications of AI were largely confined to isolated functions such as project portfolio selection and scheduling optimization, typically relying on fuzzy logic and decision-support models (Tavana et al., 2015). While these approaches improved decision consistency, they remained limited in scalability and adaptability. In contrast, recent studies demonstrate a shift toward integrated AI-driven systems, particularly within construction project management. The convergence of AI with Building Information Modeling (BIM) and digital twin technologies has enabled real-time monitoring, predictive control, and continuous feedback loops (Pan & Zhang, 2021). This evolution suggests that project management is moving toward cyber-physical systems, where AI not only supports decisions but actively shapes project execution.

However, this transformation remains uneven across industries. Most empirical applications are concentrated in construction, indicating a sectoral imbalance and raising concerns about the generalizability of findings to other project-based domains such as IT or healthcare.

4.3 Dominance of Data-Driven Techniques and the Rise of DL

The reviewed studies highlight a clear methodological evolution from rule-based and fuzzy systems to ML and DL approaches. DL, in particular, has demonstrated superior capabilities in handling unstructured data, such as images and textual reports, enabling advanced applications in safety monitoring and risk analysis (Fang et al., 2020; Zhong et al., 2020).

This shift reflects the increasing availability of large datasets and computational power. However, it also introduces new challenges. DL models are often data-intensive and computationally expensive, limiting their applicability in resource-constrained project environments. Moreover, the dominance of data-driven approaches risks overlooking contextual and human factors, which remain central to project management.

Critically, the literature reveals a lack of balance between technical sophistication and managerial relevance. While many studies focus on improving model accuracy, fewer address how these models can be effectively integrated into real-world project workflows.

4.4 Value Creation: Efficiency, Predictability, and Safety

AI contributes to project management by enhancing efficiency, predictability, and safety performance. Predictive analytics enables early identification of delays and cost overruns, allowing proactive interventions (Egwim et al., 2021). Similarly, AI-driven safety systems, particularly those based on computer vision, facilitate real-time hazard detection and behavioral monitoring, significantly improving workplace safety (Fang et al., 2020).

Furthermore, AI enhances decision-making quality by reducing reliance on subjective judgment and enabling evidence-based planning (El Khatib & Al Falasi, 2021). This is particularly valuable in complex, high-uncertainty projects where traditional methods often fall short. However, the extent of these benefits depends on data availability and system integration. Without reliable data and seamless integration into project workflows, the potential efficiency gains of AI remain largely theoretical.

4.5 Persistent Barriers: Data, Trust, and Organizational Readiness

Despite its potential, the adoption of AI in project management is constrained by several persistent barriers.

Data Challenges: Data-related issues represent the most significant limitation. Many projects suffer from fragmented, incomplete, or low-quality data, which undermines the performance of AI models (Akinosho et al., 2020). Additionally, the lack of standardized data formats limits interoperability across systems.

Lack of Explainability and Trust: The “black-box” nature of many AI models, particularly deep learning, raises concerns about transparency and accountability. Project managers may be reluctant to rely on systems whose decision logic is not easily interpretable (An et al., 2021). This highlights the need for explainable AI (XAI) approaches that bridge the gap between technical complexity and managerial trust.

Organizational and Cultural Barriers: AI adoption is not solely a technical issue but also an organizational one. Resistance to change, lack of AI expertise, and high implementation costs hinder adoption (Abioye et al., 2021). Moreover, existing project management practices are often not designed to accommodate AI-driven processes, creating a mismatch between technology and organizational structures.

Ethical and Privacy Concerns: The use of AI, particularly in safety monitoring through surveillance technologies, raises concerns about privacy, data security, and worker autonomy. These issues are insufficiently addressed in the current literature, indicating a critical research gap.

4.6 Fragmentation of Research and Lack of Theoretical Integration

A critical limitation of the existing body of research is its fragmented nature. Most studies focus on specific applications or techniques without developing a unified theoretical framework for AI in project management. This results in a lack of conceptual clarity regarding:

- The role of AI in decision-making hierarchies
- The interaction between human and AI agents
- The impact of AI on project governance and performance

Furthermore, there is limited cross-disciplinary integration between project management theory and AI research, which restricts the development of holistic solutions.

4.7 Toward Human–AI Collaboration and Intelligent Project Management

The future of AI in project management lies not in full automation but in human–AI collaboration. Rather than replacing project managers, AI should augment their capabilities by providing insights, predictions, and decision support.

Emerging research suggests the need for:

- Explainable and interpretable AI systems
- Integration of AI with IoT, digital twins, and blockchain
- Development of standardized datasets and benchmarking frameworks
- Expansion of AI applications beyond construction into diverse industries

Importantly, future studies should focus on the socio-technical dimensions of AI adoption, including user acceptance, organizational change, and ethical governance.

4.8 Synthesis and Research Implications

Overall, the literature indicates that AI has the potential to fundamentally transform project management into a predictive, adaptive, and intelligent discipline. However, this transformation is constrained by technical, organizational, and ethical challenges.

This study contributes by:

- Highlighting the evolution of AI applications in project management
- Identifying critical gaps in theory and practice
- Emphasizing the importance of human-centered AI integration

The findings suggest that future research should move beyond isolated technical applications toward integrated, theory-driven, and context-aware AI solutions.

5. Conclusion

This study has systematically reviewed and analyzed the application of artificial intelligence in project management, providing a comprehensive understanding of its current state, challenges, and future directions. The findings indicate that AI is rapidly transforming project management into a more data-driven, predictive, and intelligent discipline, particularly within construction-related contexts. The results demonstrate that AI techniques, especially ML and DL, are increasingly being used to enhance key project management functions, including scheduling, cost estimation, risk assessment, and safety monitoring. These technologies enable improved decision-making, increased efficiency, and better project performance. The integration of AI with emerging technologies such as BIM and digital twins further underscores the shift toward intelligent, interconnected project management systems. However, the study also identifies several critical challenges that must be addressed to fully realize the potential of AI. Issues related to data quality, lack of standardization, model interpretability, and organizational readiness remain significant barriers to adoption. Additionally, ethical concerns such as data privacy and transparency require further attention.

The bibliometric analysis confirms that the field is evolving from traditional decision-support approaches toward advanced AI-driven systems, with increasing emphasis on real-time analytics and automation. Despite this progress, research remains fragmented and heavily concentrated in specific domains, particularly construction, indicating the need for broader cross-industry applications.

This study makes both theoretical and practical contributions by synthesizing existing knowledge and highlighting key research gaps. From a theoretical perspective, it underscores the need for integrating AI research with project management theory. From a practical perspective, it provides insights for practitioners seeking to adopt AI technologies in project environments. Future research should focus on developing explainable and trustworthy AI systems, establishing standardized datasets, and exploring human-AI collaboration frameworks. Expanding AI applications beyond construction into other industries will also be essential for advancing the field. Ultimately, the successful integration of AI into project management will depend on balancing technological innovation with organizational and human factors.

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