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ARTIFICIAL INTELLIGENCE IN CONSTRUCTION PROJECT MANAGEMENT: ADOPTION, IMPACT, AND CHALLENGES IN INDIA'S INFRASTRUCTURE SECTOR

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ABSTRACT

India's construction sector accounts for nearly 9% of national GDP and employs over 50 million people. Despite this scale, the industry is plagued by inefficiencies in planning, cost control, and risk management. As of 2023, over 350 large infrastructure projects were delayed, with cumulative cost overruns surpassing ₹4.6 trillion. In this context, Artificial Intelligence (AI) is emerging as a critical enabler for improving project performance. This study assessed the adoption and impact of AI tools across core project management functions in India's construction sector. A convergent mixed-methods design was used. Quantitative data were collected from 80 construction professionals via a semi-structured survey, while qualitative insights were drawn from 12 key informant interviews with senior project managers in Mumbai, Delhi, Bengaluru, and Hyderabad. Analysis revealed that 72% of firms use AI tools for risk assessment, 65% for project planning, 61% for scheduling, and 59% for cost and budget management. Tools such as BIM 360, ALICE Technologies, nPlan, and Cleopatra Enterprise were most commonly deployed. Findings indicate that AI improves schedule accuracy, enhances real-time risk forecasting, streamlines procurement, and enables predictive quality and safety management. However, challenges persist: 58% of respondents cited integration issues with legacy systems; 51% highlighted the high cost of implementation; and 45% reported organizational resistance, especially in SME and informal labor settings. The study concludes that while AI is progressively reshaping project management in India's construction industry, enhancing planning precision, risk anticipation, cost control, and communication, its full potential remains constrained by structural, financial, and cultural barriers. To fully realize AI's benefits, construction firms must invest in digital infrastructure, workforce training, and stakeholder engagement. Policymakers are urged to provide incentives for SMEs and support standardized frameworks for AI integration. This research provides context-specific insights and practical recommendations to guide scalable, inclusive digital transformation in India's construction industry.

***Keywords**: Artificial Intelligence, Construction Management, India, Project Planning, Risk Assessment, Digital Transformation, BIM*

1. INTRODUCTION

India's construction sector is a vital contributor to the national economy, accounting for approximately 9% of the GDP and employing over 50 million people directly and indirectly (Jha et al.2023). Despite its scale and significance, the sector continues to grapple with persistent inefficiencies, particularly in the realms of project planning, cost control, and risk mitigation. As of 2023, the Ministry of Statistics and Programme Implementation (MoSPI) reported that over 350 large infrastructure projects were delayed, with cumulative cost overruns exceeding ₹4.6 trillion (MoSPI, 2023). These inefficiencies not only result in budgetary wastage and timeline slippages but also compromise safety, quality, and stakeholder satisfaction.

The complexity of modern construction projects—characterized by large budgets, multi-stakeholder coordination, evolving regulatory frameworks, and unforeseen risks—has exposed the limitations of traditional project management approaches (Gilbert, 2024). Manual planning methods, static risk assessment models, and reactive quality control mechanisms are no longer sufficient in today's fast-paced and digitally connected construction landscape (Beghoura, 2024). In response, the construction industry is increasingly exploring Artificial Intelligence (AI) as a transformative enabler (Rane, 2023; Mustapha et al.,2024).

AI-powered tools—spanning machine learning algorithms, predictive analytics, computer vision, natural language processing, and digital twins—are being embedded into project lifecycle functions to enable automation, real-time decision-making, and proactive problem-solving (Taheri-Khosroshahi, 2024; Pantovic et al.,2024). Applications range from automated scheduling, cost estimation, and workforce planning to real-time risk detection, safety compliance, and stakeholder communication (Kapoor, 2024). AI not only improves efficiency but also enhances accuracy, transparency, and adaptability—making it a critical asset for large-scale infrastructure development (Khan, 2024; Olawale, 2024).

While global research has extensively examined the theoretical promise of AI in construction, empirical studies exploring how AI is being adopted across end-to-end project management functions in the Indian context remain limited. Most available literature focuses narrowly on AI's role in planning or risk alone (e.g.,

Yigitcanlar et al.,2020; Baryannis, 2019; Sharma et al.,2022), overlooking its broader integration into functions such as procurement, communication, quality assurance, and human resource management. Moreover, there is a lack of comprehensive analysis that evaluates both the benefits and practical challenges—such as cost of implementation, digital maturity, and organizational resistance—associated with AI deployment in Indian construction firms.

This study seeks to address this gap by conducting a mixed-methods investigation into the use of AI tools across the full spectrum of project management domains in the Indian construction sector. It examines the actual tools being used, their specific applications, the perceived outcomes, and the barriers to their adoption, thereby offering a holistic view of AI's role in driving construction project success. The findings aim to contribute actionable insights for practitioners, policymakers, and technology developers looking to enable smarter, more resilient infrastructure delivery in India and similar emerging market contexts.

2. METHODOLOGY

This study adopted a convergent mixed-methods design to comprehensively explore the impact of AI-powered tools across multiple domains of project management within India's construction sector. The decision to employ this design was informed by the complex and multidimensional nature of the research objectives, which required both statistical insight and contextual understanding. By collecting and analyzing both quantitative and qualitative data concurrently, the approach facilitated a deeper interpretation of how AI technologies are being applied in real-world construction projects. This design was particularly appropriate for a phenomenon such as AI integration, which affects both measurable project outcomes and subjective managerial practices.

2.1 Quantitative Component

The quantitative component of the study involved administering a **semi-structured questionnaire** to 80 construction professionals, including project planners, engineers, quantity surveyors, procurement officers, and site managers. Participants were drawn from both public and private sector construction projects across Mumbai, Delhi NCR, Bengaluru, and Hyderabad—urban hubs known for their concentration of large-scale, technology-integrated infrastructure development. The questionnaire was organized into five thematic sections reflecting the core functions of project management: planning, risk assessment, cost and time control, quality and safety management, and stakeholder communication. While the majority of questions were closed-ended and designed using a 5-point Likert scale to quantitatively assess the use and effectiveness of AI tools (such as BIM platforms, predictive analytics software, and automated scheduling systems), the instrument also included **open-ended prompts** that invited respondents to elaborate on their experiences, challenges, and contextual factors influencing AI implementation. This semi-structured format allowed the researchers to capture both standardized metrics and different perspectives within a single instrument. The questionnaire was pilot-tested with five construction professionals to evaluate clarity, content relevance, and flow. Revisions were made accordingly to enhance interpretability. Reliability testing using Cronbach's alpha produced a coefficient of 0.82, indicating high internal consistency across the scaled items.

2.2 Qualitative Component

To complement the survey findings, the qualitative component of the study employed semi-structured interviews with 12 senior professionals, including project managers, construction consultants, and digital transformation leads. These interviews focused on metro rail projects, urban road works, and high-rise residential and commercial developments—sectors that are increasingly adopting AI-driven workflows. The interviews explored the real-world implementation of AI tools, the decision-making processes behind their selection, the organizational readiness for digital transformation, and the perceived impact on overall project performance. Each interview lasted between 45 and 60 minutes and was conducted either in person or via video conferencing platforms such as Zoom, depending on the participant's availability. The interviews were audio-recorded with the participants' consent and transcribed verbatim to preserve accuracy and ensure the integrity of the data.

2.3 Sampling Strategy

A purposive sampling approach was employed to identify suitable participants for both the survey and the interviews. Selection criteria included a minimum of three years of professional experience in project management or a closely related field, direct involvement in a project where AI-based tools were implemented, and representation from diverse project roles and firm types. This sampling strategy ensured that the data collected was both relevant and sufficiently diverse to reflect the range of experiences and perceptions within the sector. The purposive nature of the sample helped focus the research on informed voices, thereby enhancing the richness and validity of the results.

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2.4 Data Analysis
Quantitative data were coded and analyzed using IBM SPSS Statistics Version 27. Descriptive statistics were employed to summarize the level of AI adoption, frequency of use across project functions, perceived benefits, and common challenges. Further analyses, including cross-tabulations and Pearson's correlation tests, were conducted to identify associations between the use of AI tools and improvements in project performance metrics. For the qualitative data, thematic analysis was carried out using NVivo 12 software, following Braun and Clarke's six-step framework. Interview transcripts were repeatedly read and manually coded to identify significant patterns, which were then categorized into themes such as tool effectiveness, digital maturity, resistance to change, and skill gaps. These themes were compared with quantitative results to establish points of convergence and divergence, allowing for a richer and more detailed interpretation of the findings.

2.5 Ethical Considerations
Ethical approval for this study was obtained from the Thames University Institutional Review Board at All participants were fully informed about the objectives of the study, and written consent was obtained prior to data collection. Participants were assured of anonymity and confidentiality, and were informed that their participation was voluntary, with the option to withdraw at any stage. All collected data were securely stored and used exclusively for academic purposes in compliance with research ethics protocols.

3. FINDINGS
This section presents evidence from both the survey and interviews on the adoption of AI tools across core project management functions. Each theme integrates statistical observations and qualitative insights, while also addressing the practical challenges encountered by construction firms in India.

3.1 AI in Project Planning
Approximately 65% of respondents reported using AI-enhanced planning tools such as Autodesk BIM 360, PlanRadar, and ALICE Technologies for clash detection, schedule sequencing, and construction simulation. A key informant—a planner working on a metro rail project in Delhi—noted, "We've reduced planning errors by almost 30% since switching to BIM integrated with AI—automated scheduling alone saved weeks."

These findings show that AI is transforming planning from a static task into a more dynamic and data-driven process. Firms benefit from reduced errors, improved visualization, and faster iteration. However, several organizations faced integration challenges when attempting to merge AI platforms with traditional project scheduling tools. As one planning consultant explained, "Training our senior engineers to adopt AI-driven BIM tools took months and slowed down early implementation. Most were used to manual methods."

3.2 AI in Risk Assessment
AI-powered predictive analytics tools were used by 72% of the participants to identify risks related to budget overruns, construction delays, and safety concerns. Tools such as nPlan, Smartvid.io, and Oracle Construction Intelligence Cloud were commonly deployed.

A risk manager involved in a national highway project shared, "nPlan has helped us identify potential overruns and interruptions by comparing our schedule with thousands of historic projects."

These tools allow project teams to model disruptions and test risk mitigation strategies. Nonetheless, several firms noted that AI risk models require clean and extensive historical data, which many projects in India—particularly small and medium ones—lack. As one site engineer observed, "The software only works well when fed reliable, up-to-date data, which we didn't always have."

3.3 AI in Cost and Budget Management
According to the study findings 59% of surveyed firms reported using cost estimation and monitoring tools such as Cleopatra Enterprise, Procore AI, and 1build. These tools allowed for real-time budget tracking, inflation prediction, and detection of anomalies in spending.

A cost estimator from Mumbai commented, "We use Cleopatra AI to predict bulk material cost swings—it's been more accurate than traditional spreadsheets."

Although these systems improved cost discipline and forecasting accuracy, smaller firms expressed concern about affordability. Others found the tools less adaptable to informal vendor pricing, with one project accountant noting that "most AI systems struggle to work with fluctuating rates from small suppliers not listed in formal databases."

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3.4 AI in Time and Schedule Management

Approximately 61% of firms integrated AI tools such as ALICE Technologies, Primavera AI, and OpenSpace.ai for real-time scheduling, progress tracking, and delay modeling. A planning engineer stated, "With ALICE, we've created multiple recovery scenarios after delays—something manual Gantt charts just couldn't handle."

These tools have enhanced schedule flexibility and response time, helping firms stay on track despite site-level disruptions. However, implementation was not without difficulty. "Setting up ALICE to reflect our procurement logistics was labor-intensive," admitted one operations manager, "and even then, it missed some site-specific variables we had to adjust manually."

3.5 AI in Human Resource Management

Tools like Pymetrics, Eightfold.ai, and Rekruit.ai were used by 45% of firms to conduct skill profiling, schedule shifts, and optimize workforce allocation. According to an HR officer in a Tier-1 contracting firm, "AI helped us build the perfect team composition phase by phase, matching people's core strengths with the project's needs."

These tools supported more effective labor utilization and faster onboarding. However, HR managers expressed concern over algorithmic bias and the exclusion of informal labor characteristics from AI profiles. "It kept recommending candidates with academic profiles but missing out on highly skilled masons who had no formal certification," said one HR coordinator.

3.6 AI in Procurement and Vendor Management

AI tools such as Kreo AI, Scoutbee, and Zycus iSource were reportedly adopted by 41% of firms to streamline procurement processes, analyze vendor performance, and improve tendering decisions. One procurement lead in Hyderabad noted, "We saved nearly 10% on procurement by switching to an AI-suggested alternate vendor during a steel shortage."

These tools helped reduce procurement costs and lead times, especially during material shortages. Still, many firms struggled with database limitations. "Most AI systems could not recognize local suppliers who we rely on heavily," said one procurement officer, "and this affected their effectiveness in our context."

3.7 AI in Quality Control

Computer vision tools like Buildots, Disperse, and OpenSpace.ai were used by 38% of respondents to identify deviations from construction drawings, validate completed work, and ensure site compliance. A site engineer noted, "With OpenSpace AI, we spot errors in finishes and structural joints as soon as they happen—not weeks later."

While the benefits in real-time quality inspection were clear, some challenges related to technical setup were also mentioned. One construction manager said, "These tools require wide-angle coverage and uninterrupted connectivity, which we couldn't always guarantee, especially indoors."

3.8 AI in Safety and Compliance

Safety-related AI systems were used by 34% of firms, including tools such as Smartvid.io Vinnie, Soter Analytics, and Pillar Technologies. These platforms supported PPE compliance, site surveillance, and predictive hazard detection. A safety executive working on a high-rise project shared, "We installed AI cameras from Smartvid.io, and it flagged 90% of the unsafe incidents we previously missed."

Despite improvements in incident detection, some workers expressed discomfort with being constantly monitored. "Many of our workers felt watched, like Big Brother was always looking," one site manager acknowledged. Firms also raised concerns about data privacy policies and how recorded footage might be used outside safety purposes.

3.9 AI in Communication and Stakeholder Management

About 36% of participating firms reported using AI tools such as Slack GPT, Microsoft Power BI with AI, Trello AI, and chatbot systems like Tars to manage communications, produce automated reports, and engage stakeholders. A senior planner explained, "Using Slack's AI summary tools, we compile weekly reports in minutes—it keeps our investors well-informed and saves project managers hours."

While these tools improved the speed and clarity of updates, some stakeholders, particularly in public-sector projects, preferred more traditional modes of communication. "Not all clients were comfortable receiving automated updates—some still insisted on PDFs and in-person briefings," said a project coordinator in Delhi.

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Table 2: AI Applications in Project Management: Benefits, Adoption Rates, and Challenges

Project Function	AI Tools Used	% Adoption	Reported Benefits	Reported Challenges
Planning	Autodesk BIM 360, ALICE Technologies, PlanRadar	65%	Reduced planning errors, improved simulation and scheduling	Integration issues with legacy systems, high training costs
Risk Assessment	nPlan, Smartvid.io, Oracle Construction Intelligence Cloud	72%	Early detection of schedule and cost risks	Requires historical data, difficulty with real-time site input
Cost & Budget Management	Cleopatra Enterprise, Procore AI, 1build	59%	Accurate material cost forecasting, real-time tracking	High cost for SMEs, limited local vendor data
Time & Schedule Management	ALICE Technologies, Primavera AI, OpenSpace.ai	61%	Scenario modeling and improved delay management	Complex configuration, alignment with procurement cycles
Human Resource Management	Pymetrics, Eightfold.ai, Rekruit.ai	45%	Better skill matching, reduced idle time	Algorithm bias, limited informal labor profiling
Procurement & Vendor Management	Kreo AI, Scoutbee, Zycus iSource	41%	Vendor optimization, procurement cost savings	Excludes informal suppliers, data fragmentation
Quality Control	Buildots, Disperse, OpenSpace.ai	38%	Real-time defect detection and compliance	Limited camera access, storage constraints
Safety & Compliance	Smartvid.io Vinnie, Soter Analytics, Pillar Technologies	34%	Real-time alerts for unsafe behaviors and PPE compliance	Worker resistance to surveillance, data privacy concerns
Communication & Stakeholder Mgt.	Slack GPT, Power BI AI, Trello AI, Tars	36%	Faster reporting and improved communication	Client discomfort with automated updates

4. DISCUSSION OF FINDINGS

The findings from this study reveal a growing trend in the adoption of AI tools across key project management functions within India's construction sector. Firms are increasingly integrating AI into their workflows to improve planning, risk management, cost control, and communication. These patterns echo global developments in the field, though uniquely shaped by the specific structural and operational realities of the Indian context.

AI-enhanced project planning tools were adopted by 65% of respondents, reflecting a significant shift toward data-driven and simulation-based scheduling. Tools like Autodesk BIM 360 and ALICE Technologies have been instrumental in reducing planning errors and improving construction sequencing. This is consistent with the findings of Rane. (2023), who noted the ability of AI-integrated BIM systems to reduce rework and accelerate design validation. However, Indian firms encountered challenges integrating these tools with older

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legacy systems, a constraint similarly observed by Wijayasekera et al (2022) which highlights the difficulty of transitioning from manual to intelligent planning processes in environments lacking strong digital infrastructure.

Risk assessment emerged as the most widely adopted AI function, with 72% of firms using tools such as nPlan and Smartvid.io. These platforms supported predictive analytics that allowed firms to model potential cost and schedule disruptions before they occurred. The effectiveness of such systems supports the arguments of Pal (2023), who emphasize the predictive power of AI over traditional risk forecasting methods. However, the findings also showed that smaller Indian firms struggled to maintain the digital data pipelines required for reliable model calibration. This affirms Elouataoui's (2024) assertion that data completeness and timeliness are critical enablers of AI accuracy.

Cost and budget management has also benefited from AI integration, with 59% of firms deploying platforms like Cleopatra Enterprise and 1build to forecast costs and manage budgets in real time. These tools contributed to better financial transparency and anomaly detection, consistent with Afzal et al. (2020), who highlighted AI's capacity to reduce cost overruns in large-scale construction. However, adoption in India was less prevalent among SMEs, which reported difficulty affording proprietary AI platforms. Additionally, the inability of current AI tools to capture real-time local market pricing and informal supplier dynamics remains a gap, supporting Moharrak et al's (2022) view that existing AI systems must evolve to reflect market complexity in emerging economies.

Time and schedule management has seen similar progress. With 61% adoption, platforms such as ALICE Technologies and Primavera AI have enabled firms to dynamically model project delays and develop alternative execution paths. These findings are in line with Tupsakhare (2022), who found that AI-enhanced scheduling improves project agility and responsiveness. Nevertheless, implementation complexity was a key concern for Indian firms, as aligning AI-based timelines with actual procurement and labor workflows proved challenging. This indicates a continued need for user-friendly AI systems that accommodate contextual variables more fluidly.

AI adoption in human resource management was reported by 45% of firms, with platforms like Eightfold.ai and Pymetrics used for labor forecasting and task alignment. The study confirms AI's value in streamlining HR operations and improving skill-task matching, consistent with the claims of Zhao (2024). However, issues of bias and limited accommodation for informal labor profiles emerged frequently. AI-driven HR systems were often unable to capture intangible competencies of non-certified workers, a limitation that echoes Pillai and Matus (2020), who argue for more localized and inclusive AI training datasets in the construction sector.

Procurement and vendor management also saw AI deployment in 41% of firms. Systems like Scoutbee and Zycus iSource supported vendor scoring and predictive bidding strategies. These results align with Nida (2025), who describe AI's effectiveness in optimizing procurement decisions. Yet, Indian firms emphasized that many regional and informal suppliers remain invisible to AI systems due to poor data integration, thereby constraining AI's utility in fragmented supply chains. These findings confirm that procurement AI must be adapted to work within decentralized vendor ecosystems typical of emerging markets.

Quality control improvements through AI were reported by 38% of participants, particularly through the use of computer vision tools like OpenSpace.ai and Buildots. These systems allowed for automated inspection and reduced response time to deviations. Similar observations were made by Fan (2023), who demonstrated that AI enhances construction precision and defect management. However, Indian users pointed out that visual data capture was sometimes limited by camera placement and bandwidth availability, suggesting infrastructure readiness continues to shape the effectiveness of visual AI applications.

Safety and compliance monitoring through AI tools such as Smartvid.io Vinnie and Soter Analytics was adopted by 34% of respondents. These tools improved real-time identification of unsafe behavior, confirming Fiegler-Rudol et al (2025) conclusion that AI enhances occupational safety performance. Nonetheless, ethical concerns and worker resistance to constant surveillance emerged as a barrier. These sentiments reflect broader debates in the literature on AI ethics and worker privacy, reinforcing the need for balanced adoption strategies that incorporate both technological efficiency and human dignity.

In terms of stakeholder communication and reporting, AI usage was reported by 36% of firms. Chatbots and platforms like Slack GPT and Power BI AI were used to generate reports and communicate progress updates. These findings support Mensah (2023), who emphasized AI's potential in improving project transparency and reporting accuracy. However, the resistance of some clients—particularly in public-sector projects—to accept

AI-generated summaries indicates that human trust in machine outputs is still evolving. This insight aligns with Dwivedi et al. (2023), who argue that stakeholder digital readiness is a key determinant of AI success.

Overall, the findings of this study demonstrate that AI tools are producing measurable improvements in operational efficiency, forecasting accuracy, and project visibility across the Indian construction sector. However, the full benefits of AI remain constrained by legacy systems, inconsistent digital capacity, affordability issues for SMEs, and gaps in user acceptance. This study contributes to the global literature by offering India-specific insights and highlighting the dual need for technical advancement and contextual adaptation to make AI an inclusive tool for sustainable project delivery.

5. CONCLUSION

This study set out to examine the impact of AI-powered tools on project management in the Indian construction sector, focusing specifically on planning, risk assessment, budgeting, scheduling, procurement, quality control, safety, workforce coordination, and stakeholder communication. The evidence presented, drawn from both quantitative surveys and qualitative interviews, underscores the transformative potential of AI technologies across all phases of project execution.

Findings revealed that AI tools are being widely adopted, with notable successes in areas such as predictive risk modeling, dynamic scheduling, real-time quality inspection, and automated reporting. These tools have enabled firms to improve decision-making, reduce manual workloads, and enhance both operational agility and stakeholder transparency. The ability to simulate scenarios, predict disruptions, and align labor and procurement plans more precisely has led to measurable efficiency gains for firms equipped with the resources and digital infrastructure to implement these technologies effectively.

However, the study also uncovered several key challenges impeding the full realization of AI's potential. These include integration issues with legacy systems, limited access to high-quality data, the high cost of AI deployment for small and medium enterprises (SMEs), and cultural resistance to automation—particularly in safety monitoring and communication. In addition, many AI systems were found to be ill-equipped to handle the complexities of India's informal labor and procurement ecosystems.

Overall, the study concludes that while AI is undeniably reshaping project management in India's construction industry, its success depends on more than technological readiness. Realizing the full benefits of AI will require investments in data infrastructure, inclusive algorithm design, workforce training, and stakeholder sensitization. The findings contribute new context-specific insights to the global discourse on AI in construction and offer a valuable foundation for both practitioners and policymakers working to scale up AI adoption in emerging markets like India.

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