

A Systematic Review of the Current State of Artificial Intelligence Adoption in South Africa's AEC Sector

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Abstract

This study investigates the current state of artificial intelligence (AI) adoption within South Africa's Architecture, Engineering, and Construction (AEC) sector, with a focus on its implementation, associated barriers, and enabling factors. While AI holds significant potential to boost productivity, reduce costs, and drive innovation, its adoption remains limited due to financial constraints, inadequate digital infrastructure, and a shortage of skilled professionals. To ensure a comprehensive assessment of AI adoption trends, a systematic review was conducted using the PRISMA methodology to refine relevant literature. Additionally, bibliometric analysis was performed using VOSviewer to explore citation networks, key authors, and research clusters. The study also employed keyword co-occurrence analysis to map prominent themes related to AI integration. Findings reveal that AI use is largely limited to machine learning and predictive analytics, with advanced applications such as robotics and natural language processing significantly underutilized. The study highlights the urgent need for policy reforms, enhanced digital infrastructure, and targeted training initiatives to promote widespread AI adoption and improve competitiveness across South Africa's AEC industry.

Keywords: Artificial Intelligence, South Africa, Construction Industry, AI Integration, AEC

1. Introduction

The rapid growth of artificial intelligence (AI) has the potential to revolutionize the architecture, engineering, and construction (AEC) industry by enhancing efficiency, reducing costs, and improving decision-making (Abioye, et al., 2022; Pan & Zhang, 2021). However, AI adoption in South Africa's AEC sector remains inconsistent due to persistent barriers such as financial constraints, limited digital infrastructure, a shortage of skilled professionals, and inadequate policy frameworks (Felemban et al., 2024). These challenges are particularly acute in developing regions, where the AEC industry continues to grapple with project delays, cost overruns, and operational inefficiencies (Deng et al., 2022; Wang, et al., 2020). Despite the global momentum in AI-driven innovation, there is limited research specifically exploring the extent, barriers, and enablers of AI integration. This study addresses this critical gap by conducting a systematic review and bibliometric analysis to assess the current state of AI adoption in the local AEC sector (Balli & Guven, 2022; Rafsanjani & Nabizadeh, 2023).

2. Literature Review

This section provides a thorough review of the literature on AI adoption in the AEC industry, with a focus on South Africa. It begins by looking at global trends in the industry's use of AI and emphasizing how it may increase project efficiency, safety, and cost-effectiveness. This section provides a thorough review of the literature on AI adoption in the AEC industry,

focusing on South Africa. It begins by examining global trends in the industry's use of AI and emphasizes how it may enhance project efficiency, safety, and cost-effectiveness. The chapter then shifts to the South African context, discussing the challenges facing the sector, the current state of AI integration, and opportunities for further AI adoption.

2.1. AI Adoption in the AEC Industry

Despite its significant economic contribution, the AEC sector has traditionally lagged in digital adoption due to its reliance on conventional methods and fragmented project structures (Felemban et al., 2024; Pan & Zhang, 2021). However, AI technologies are increasingly recognized for their potential to revolutionize the industry by improving efficiency in project management, cost control, safety, and productivity (Li, et al., 2025). Machine learning algorithms can analyse historical data to predict project delays and budget overruns, allowing proactive risk mitigation (Darko, et al., 2020). AI-powered solutions also enhance on-site safety by identifying hazards and enabling real-time data analysis to prevent accidents (Deng et al., 2022). In many developing regions, however, limited access to advanced technology and infrastructure slows AI adoption, while more developed countries benefit from tools like predictive analytics and automation. Financial constraints, a shortage of skilled professionals, and outdated systems further hinder widespread integration. Bridging this gap requires investment in training, improved funding, and supportive policies to ensure AI's benefits are accessible across the global AEC sector.

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2.2. The State of AI Adoption in South Africa's AEC Sector

AI adoption in South Africa's AEC sector is advancing unevenly, with larger firms leading in areas like project management, resource optimization, and predictive analytics to reduce risks and delays (Deng et al., 2022). While these advancements improve efficiency, they are often limited to select projects, and broader industry adoption remains slow. SMEs, which make up a large portion of the sector, face challenges such as high costs, limited skills, and outdated infrastructure, especially in rural areas (Abioye, et al., 2022). A lack of a unified AI strategy further hinders widespread integration (Bilal , et al., 2016).

2.3. Barriers of AI Adoption in South Africa's AEC Sector

AI adoption in South Africa's AEC sector is hindered by several key challenges, with financial constraints being the most prominent, particularly for smaller firms that struggle to invest in AI without immediate returns (Abioye, et al., 2022). Limited digital infrastructure, especially in rural areas with unreliable connectivity and outdated systems, further restricts implementation (Darko, et al., 2020). A significant skills gap in AI, data analytics, and machine learning also persists, as the industry lacks sufficient digital education and training (Felemban et al., 2024). Additionally, unclear policies and regulations, including data privacy concerns and the absence of AI ethics guidelines, create further hesitation among stakeholders (Ikudayisi et al., 2023). Addressing these challenges requires proactive government intervention. Targeted policies, including funding for digital infrastructure, tax incentives, and AI adoption programs tailored for SMEs, can help ease financial barriers and promote wider implementation. Investments in AI-related education and training will also be crucial in bridging the skills gap, ensuring that firms of all sizes can harness AI's potential (Bilal , et al., 2016). Without these efforts, AI adoption may remain concentrated within larger firms, deepening industry inequalities and limiting overall growth and innovation.

2.4. Enablers of AI Adoption in South Africa's AEC Sector

Despite existing challenges, several enablers have the potential to accelerate the adoption of AI within South Africa's AEC sector. The gradual enhancement of digital infrastructure, particularly in urban regions, has facilitated improved internet connectivity and cloud computing capabilities, thereby creating a supportive environment for AI integration and data-driven decision-making (Abioye, et al., 2022; Onososen & Musonda , 2022). Collaborative efforts among government entities, industry stakeholders, and academic institutions are essential in addressing the skills shortage through the implementation of AI-specific training programmes and the revision of construction-related curricula (Felemban et al., 2024).

Moreover, governmental support in the form of tax incentives, subsidies, and grant funding can reduce financial barriers, particularly for small and medium-sized enterprises. Strategic investments in both technological infrastructure and human capital development are critical for fostering long-term growth, enhancing operational efficiency, and improving the global competitiveness of the sector. By leveraging these enablers, the South African AEC industry may be better positioned to harness the transformative potential of AI technologies in a sustainable and inclusive manner.

3. Research Methodology

This section describes the research methodology, highlighting that the study is part of a broader project. While the overall research follows a positivist approach, this paper specifically focuses on a qualitative literature review. It includes bibliometric analysis using VOSviewer software to identify trends, factors, and barriers affecting AI adoption in South Africa's AEC sector, providing both qualitative insights and objective data analysis for a comprehensive understanding of the subject matter under investigation.

3.1. Research Design

The research design adopted in this study is qualitative and exploratory, whilst focusing on synthesizing existing literature knowledge related to AI adoption in the AEC industry, particularly in the South African context. The systematic literature review provides a structured and transparent framework for gathering relevant studies on AI adoption, barriers, and enablers (Petticrew & Roberts, 2006). Bibliometric analysis supplements the review, analysing the frequency, citation patterns, and relationships between key articles to uncover trends in AI research within the AEC sector (Moed, 2005).

3.2. Data Collection

To ensure a rigorous and systematic approach to data collection, a structured methodology was adopted to identify, screen, and select relevant studies on AI adoption in South Africa's AEC sector. The process involved searching academic databases and other sources using keywords such as "Artificial Intelligence," "AI adoption," "AEC sector," "Architecture, Engineering, Construction," "South Africa," "Barriers to AI," "Enablers of AI," "Machine learning," "Predictive analytics," and "Digital infrastructure."

This search aimed to gather peer-reviewed, high-quality literature that aligned with the research objectives. Following the identification of 160 records, the PRISMA methodology was applied to refine the data systematically (Figure 1). After removing duplicates, the screening phase resulted in the exclusion

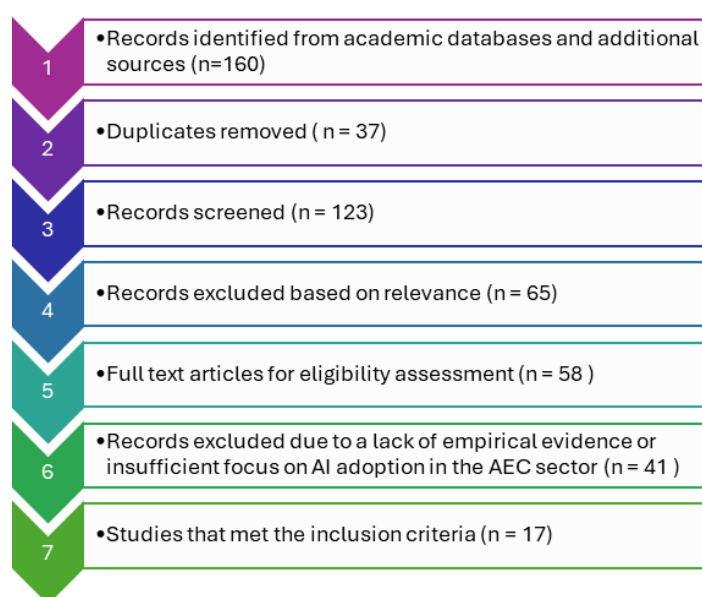


Figure 7: PRISMA flowchart displaying data collection process

of 65 records based on relevance, peer-review status, and alignment with the research objectives. The remaining 58 full-text articles were assessed for eligibility, with 41 excluded due to a lack of empirical evidence or insufficient focus on AI adoption in the AEC sector. Ultimately, 17 studies published between 2017 and 2024 met the inclusion criteria and were incorporated into the systematic literature review and bibliometric analysis, providing valuable insights into the trends, barriers, and enablers of AI adoption in South Africa's AEC industry.

The inclusion of 17 publications reflects the early stage of the current master's research, which aims to provide a foundational understanding of AI adoption in South Africa's AEC industry. As this paper is part of a broader project, the limited sample size ensures a focused analysis, with plans to expand the review as the research progresses, enhancing its depth and scope.

3.3. Data Analysis

Bibliometric analysis was conducted using VOS viewer software to map relationships between key articles and identify significant trends in the literature. Citation networks and keyword frequency analysis highlighted influential studies and knowledge gaps, helping to track the development of AI-related research within the AEC sector (Van Eck & Waltman, 2010). This approach provided a clear framework for categorizing and interpreting the findings.

3.4. Justification of the Methodology

The positivist approach is suitable for this research as it seeks to analyse objective, existing data to draw conclusions about AI adoption in South Africa's AEC industry. By employing a systematic literature review and bibliometric analysis, the study synthesizes the current body of knowledge and identifies patterns

without requiring primary data collection. This approach aligns with the study's aim to explore the current state of AI integration in the sector (Petticrew & Roberts, 2006). The use of VOS viewer enhances the reliability of the findings by offering a structured, data-driven method for identifying trends and relationships within the literature.

3.5. Limitations of the Methodology

The limitations of this study include the reliance on published literature, which may not fully reflect real-time developments in AI adoption. The scope of available studies may also not capture all regional challenges or the specific experiences of industry practitioners. Additionally, the study is constrained using secondary data, limiting the ability to explore firsthand experiences of AI implementation by AEC professionals. Despite these limitations, the findings offer valuable insights into trends, barriers, and enablers of AI adoption in South Africa's AEC industry.

4. Findings and Discussion

This chapter presents the key findings from a bibliometric analysis of AI adoption in the AEC sector, highlighting an increase in publications and the growing recognition of AI's potential. Key themes include barriers to AI adoption, technological enablers, and regulatory concerns in South Africa. The findings emphasize the interdisciplinary nature of AI research in the AEC industry and stress the need for strategic approaches to address challenges and promote wider adoption in the sector.

4.1. Citation Networks and Key Authors

The citation network analysis demonstrated distinct clusters of influential authors in the domain of AI adoption within the AEC sector. Key contributors, such

as Oyedele, Lukmon, and Abioye, Sofiat, formed a prominent cluster, reflecting their foundational impact on the field. Other notable clusters include contributions by authors like Ahmed, Ashraf, and Akambi, Lukman, who have significantly shaped discussions on interdisciplinary applications of AI in construction. Interdisciplinary collaborations were evident, with connections spanning fields such as construction management, data science, and digital transformation (Figure 2). The network also highlighted emerging contributors, such as Schoeman, Franz, and Deng, Yichuan, who form smaller, yet pivotal clusters. These patterns underscore a growing emphasis on global and collaborative approaches to AI research in construction, providing a comprehensive perspective on technological advancements in the sector.

benefits. Meanwhile, the blue cluster centres on "AI adoption," "framework," "factors," and "South Africa," reflecting research addressing the local context and strategies to enhance adoption.

The purple cluster highlights organizational and regulatory considerations through terms like "organisation," "policy," and "maturity," while the yellow cluster explores conceptual and strategic discussions, with keywords like "concept," "advantage," and "digital technology." The interconnectedness between clusters, such as the link between "barrier" and "AI adoption," underscores the interplay between challenges and strategic interventions.

Overall, the analysis underscores an interdisciplinary

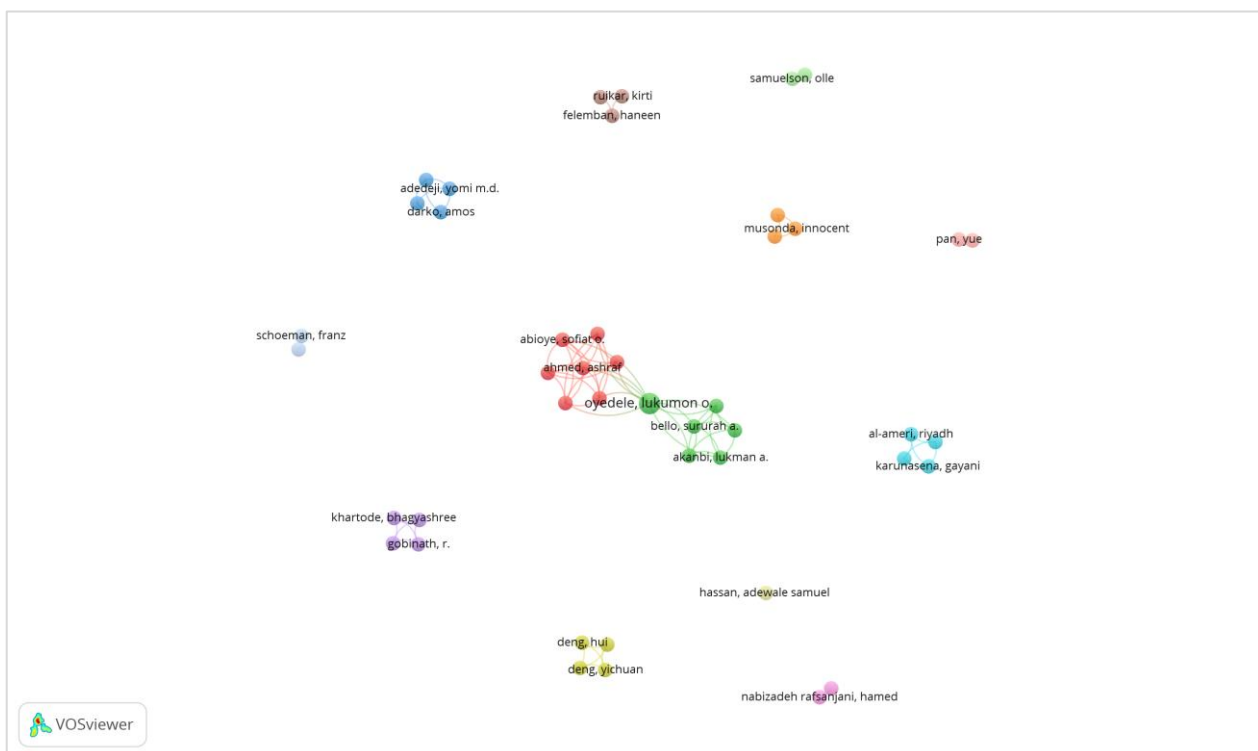


Figure 2: Citation Networks and Key Authors

4.2. Co-occurrence of key words

The co-occurrence of keywords in bibliometric analysis highlights the central themes and interconnected trends within AI adoption research in the AEC sector. The VOS viewer-generated map reveals distinct clusters representing recurring topics displayed in Figure 3 on the next page.

The red cluster emphasizes foundational themes like "AEC industry," "automation," "AI application," and "information," showcasing the role of AI in revolutionizing construction processes and project workflows. The green cluster focuses on challenges and facilitators, with keywords such as "barrier," "enabler," "efficiency," and "safety," pointing to discussions on overcoming obstacles and leveraging technological

approach that integrates technological, organizational, and policy-related dimensions. It also highlights a dual focus on addressing region-specific challenges, such as those in South Africa, while incorporating global insights into the adoption of AI in construction. This visualization provides a comprehensive understanding of the trends and gaps in the current research landscape. The bibliometric analysis using VOS viewer has provided valuable insights into the current state of AI adoption in South Africa's AEC sector. The findings indicate a growing body of literature that identifies key barriers, enablers, and trends shaping the adoption of AI technologies. Despite significant advances in AI adoption in certain sectors, there remains a need for more localized research, strategic policy interventions,

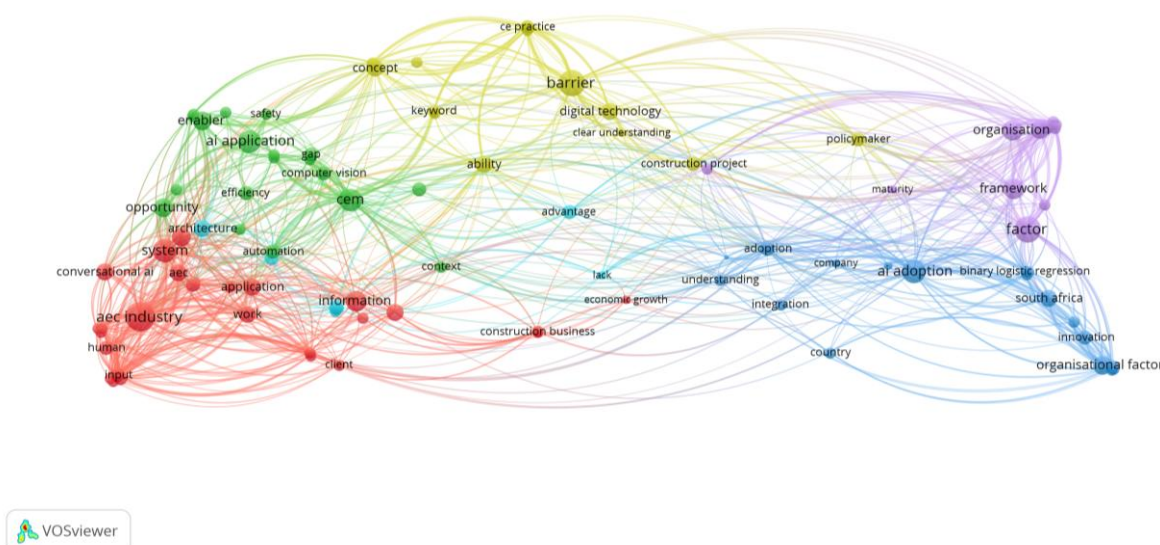


Figure 3: Co-occurrence of key words

and investments in digital infrastructure to support widespread AI integration in South Africa's construction industry.

4.3. Trends in AI Adoption in the AEC Sector

The bibliometric analysis revealed several key trends in AI adoption within the AEC sector, particularly in South Africa. Initially, the literature on AI adoption in the AEC industry was sparse; however, over the past seven years (from 2017 to 2024), a sharp increase in publications was observed. This surge, with over 17 papers specifically referenced in this study, highlights a growing recognition of AI's potential to enhance operational efficiency, project management, and safety in construction. The increased interest is particularly evident in urban areas with better-developed digital infrastructure, where AI applications such as predictive analytics, project risk management, and resource optimization are gaining traction (Abioye, et al., 2022). However, despite this growth in research, AI adoption in the South African construction sector remains limited, with only a small subset of studies specifically addressing its implementation within the local industry. This gap underscores the need for further investigation into the challenges and opportunities for AI adoption in the region.

4.3.1. Thematic Findings on AI Adoption in South Africa's AEC Sector

A detailed thematic analysis of the reviewed literature provides insights into the key focus areas of AI adoption in South Africa's AEC sector. Table 1 categorizes these findings into major themes, emphasizing the extent of AI adoption, barriers, enablers, applications, economic impact, and policy considerations shaping the sector. Notably, barriers to AI adoption were the most frequently discussed theme, appearing in 11 papers, underscoring financial

constraints, lack of infrastructure, and limited AI expertise as major obstacles. Conversely, enablers of AI adoption, covered in 8 papers, highlight the role of government policies, digital infrastructure investment, and workforce upskilling in facilitating AI integration. The findings further indicate that AI's application in South Africa's AEC sector is mainly focused on predictive analytics, project risk management, and resource optimization, with limited use of advanced technologies such as robotics and natural language processing. Policy and regulatory challenges also remain a critical concern, as identified in 6 papers, emphasizing the need for structured AI governance, ethical considerations, and clearer guidelines to promote adoption. These insights demonstrate that while AI adoption is increasing, its implementation remains uneven, with larger firms leading the way while SMEs struggle due to financial and technical limitations. The data underscores the importance of targeted interventions, including policy reforms, financial incentives, and skills development initiatives, to bridge these gaps and drive AI adoption across the industry.

5. Conclusion and Further Research

This study provides an in-depth analysis of AI adoption in South Africa's AEC sector, identifying key trends, barriers, and enablers. Through a systematic literature review and bibliometric analysis, it reveals that AI usage is largely limited to basic applications like machine learning and predictive analytics, with more advanced technologies such as robotics and natural language processing underutilized. The primary barriers include financial constraints, inadequate digital infrastructure, and a shortage of skilled professionals. The research underscores the importance of strategic policy interventions, investments in digital

Table 3: Thematic Findings on AI Adoption in South Africa's AEC Sector

Theme	Number	Key Findings	Relevance to Study
Extent of AI Adoption in AEC	6	AI is primarily applied in automation, predictive analytics, and project management. More advanced technologies (robotics, NLP) remain underutilized.	Provides insight into the current maturity level of AI in South Africa's AEC industry.
Barriers to AI Adoption	8	Major barriers include financial constraints, lack of digital infrastructure, skills shortages, resistance to change, and regulatory uncertainties.	Identifies key challenges limiting AI adoption and informs policy recommendations.
Enablers of AI Adoption	7	Government policies, investment in digital infrastructure, targeted training programs, and financial incentives are crucial to accelerating AI adoption	Highlights opportunities and strategies to enhance AI integration.
AI Applications in Construction	9	AI is used for construction management, predictive risk analytics, safety monitoring, and resource optimization.	Demonstrates AI's functional role in improving project efficiency.
Economic Impact of AI	7	AI adoption reduces operational costs, improves productivity, and enhances project risk management.	Links AI implementation to financial and efficiency benefits.

infrastructure, and targeted training programs to overcome these challenges.

Further research is necessary to engage directly with industry stakeholders to explore practical implementation challenges and opportunities. Additionally, examining regional disparities in AI adoption and the potential of emerging AI technologies, such as robotics and AI-driven project management tools, could provide deeper insights into the sector's evolving capabilities. Addressing these areas will be critical to driving broader AI adoption, enhancing efficiency, sustainability, and competitiveness in South Africa's AEC sector.

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