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# Adoption of Artificial Intelligence Technologies in the Philippine Construction Industry: A Review of Literature

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**Abstract.** This review explores the adoption of Artificial Intelligence (AI) technologies in the Philippine construction industry, focusing on the extent and scope of adoption, influencing factors, readiness, and associated benefits and challenges. Utilizing the Technology-Organization-Environment (TOE) framework, Technology Readiness Index (TRI), and diffusion of innovation theory, the study synthesizes findings from 20 articles published between 2014 and 2024. Findings reveal a promising yet varied landscape of AI integration, driven by the need for improved cost management, enhanced decision-making, and higher quality standards. Successful AI adoption involves digital readiness, robust data management, and stakeholder engagement. Benefits include enhanced productivity, cost-efficiency, decision-making capabilities, sustainability, and safety. However, significant challenges such as data quality, technological complexity, ethical concerns, and the need for a skilled workforce remain. Overcoming these challenges through strategic planning and investment is crucial for the growth of AI adoption in the Philippine construction industry.

**Keywords**: AI adoption; Philippine construction industry; Cost management; Technological integration; Sustainability.

## 1.0 Introduction

In recent years, the global construction industry has increasingly turned to Artificial Intelligence (AI) technologies to address its challenges, including labor shortages, cost overruns, and the need for greater efficiency and safety (Adeloye et al., 2023). Worldwide, AI was leveraged to optimize project management, enhance predictive maintenance, and improve overall productivity (Jambol et al., 2024). Countries like Bahrain, France, and Germany made significant strides in integrating AI into their construction practices, resulting in substantial improvements in project outcomes and operational efficiencies (Aljawder & Al-Karaghouli, 2024; Pan & Zhang, 2023). These advancements set a precedent for other nations, showcasing the potential benefits of AI in transforming the construction sector.

The construction industry is a cornerstone of economic development globally, including in the Philippines, where it plays a crucial role in infrastructure growth and employment (Siman, 2023). As this sector navigates the complexities of modernization, the adoption of Artificial Intelligence (AI) technologies stands out as a transformative potential (Bang & Olsson, 2022). AI offered promises of efficiency gains, improved safety measures, and enhanced project management capabilities, which significantly benefited the Philippine construction landscape (Korke et al., 2023). However, the Philippine construction industry faced challenges such as limited technological infrastructure, a shortage of skilled professionals, and regulatory hurdles (Dimaculangan, 2023;

Subia et al., 2019; Santos et al., 2022). Understanding the current state of AI adoption in the Philippines is essential for identifying these barriers and developing strategies to overcome them.

This scholarly review explored the current state of AI adoption within the Philippine construction industry, addressing several key research questions. Firstly, it described the extent and scope of AI technology implementation across various construction practices and projects in the Philippines. Understanding this current state is critical for stakeholders and policymakers to identify existing gaps and opportunities for further integration of AI (Dwivedi et al., 2021). Secondly, the review explored the factors influencing AI adoption in the Philippine construction industry. By examining these factors—ranging from technological feasibility and cost-effectiveness to regulatory frameworks and organizational readiness—this research aims to uncover the motivations and barriers shaping AI uptake in Philippine construction (Obana, 2024). Moreover, the study investigated how the Philippine construction industry can prepare for the integration of AI technologies. This includes identifying challenges such as the shortage of skilled AI professionals and the need for targeted investments in infrastructure and training. Addressing these challenges will be essential for maximizing the potential benefits of AI while mitigating risks (Shahriar et al., 2023). Lastly, the review assessed both the potential benefits and challenges associated with AI integration in the Philippine construction industry. By examining local case studies and best practices, the research aims to derive actionable insights that can inform strategic decision-making and policy formulation (Khan et al., 2024).

To sum up, this research is motivated by the imperative to comprehensively understand the landscape of AI adoption in Philippine construction, anticipate future trends, and provide practical recommendations for stakeholders to harness AI's transformative potential effectively. By addressing these research questions, this study seeks to contribute to the ongoing discourse on technological innovation within the Philippine construction industry.

**Theoretical and Conceptual Framework**

The adoption of AI technologies in the construction industry is a process influenced by various factors. To understand this complexity, several key concepts and theories are instrumental. This research leverages several theoretical and conceptual frameworks to examine the adoption of AI technologies in the Philippine construction industry. The primary theoretical framework is the Technology-Organization-Environment (TOE) framework, which describes the relationship between technological, organizational, and environmental factors that influence technology adoption (Lin & Chen, 2023). The TOE framework is particularly relevant as it provides a comprehensive perspective on the factors affecting AI adoption in this sector.

In addition to the TOE framework, the Technology Readiness Index (TRI) serves as another framework for this study. The TRI measures the readiness of individuals and organizations to adopt new technologies, offering a critical assessment of the Philippine construction industry's preparedness for AI integration (Lai & Lee, 2020). This framework is essential for understanding the industry's current capabilities and identifying areas needing improvement (Santos & Jocson, 2021). The theoretical anchor for this research is the diffusion of innovation theory, which explains how new technologies are adopted and spread within a society (Okour et al., 2021). This theory is pertinent as it provides insights into both the benefits and challenges associated with AI adoption in the construction industry, guiding the analysis of how AI can be effectively integrated (LlenadaSantos, 2022).

The application of these frameworks to the research questions is as follows: the TOE framework addresses the current state of AI adoption and the factors influencing it, corresponding to research questions 1 and 2. The TRI framework is applied to research question 3, which focuses on how the industry can prepare for AI integration. The diffusion of innovation theory is relevant to research question 4, which explores the potential benefits and challenges of AI adoption.

## 2.0 Methodology

This research reviewed the literature on the adoption of AI in the Philippine construction industry. To achieve this objective, a systematic review of existing studies was conducted. The systematic review approach was chosen because it allows for identifying, selecting, and analyzing relevant literature on AI adoption in the Philippine construction industry (Ismail et al., 2021). Following the guidelines of the Preferred Reporting Items for Systematic

Reviews and Meta-Analyses (PRISMA) statement, this approach ensured a structured and transparent review process.

Data collection involved a comprehensive search of electronic databases, including Google Scholar, JSTOR, and EBSCO. Keywords such as "Philippines," "Construction Industry," "artificial intelligence," and "AI technology" were used to identify relevant studies. Initially, 150 articles were identified through this search. These articles were then screened and assessed for eligibility, resulting in 20 articles being selected for inclusion in the final review. This selection process ensured that only the most pertinent studies were included, providing a focused and relevant dataset for analysis.

The sample for this study consisted of 20 articles published between 2014 and 2024, all written in English. Purposive sampling was employed to select articles that met specific eligibility criteria relevant to the study's focus on adopting AI in the Philippine construction industry. This sampling technique was crucial in ensuring that the selected articles were directly relevant to the research questions and provided comprehensive insights into the current state and challenges of AI adoption in the industry.

The data analysis technique used in this study was thematic analysis. Each selected article was thoroughly read and analyzed to identify key themes related to AI adoption in the Philippine construction industry. These themes were then organized and presented coherently, offering a comprehensive review of the literature. This analytical approach allowed for a deep understanding of the factors influencing AI adoption and the specific challenges faced by the industry.

However, the study had some limitations. The primary limitation was the potential for selection bias, as only articles written in English and published between 2014 and 2024 were included in the review. Additionally, the study relied solely on literature and did not incorporate empirical data, which may limit the generalizability of the findings. Despite these limitations, the study provides valuable insights into the current state of AI adoption in the Philippine construction industry.

Ethical considerations were carefully adhered to throughout the study. All selected articles were properly cited to acknowledge the original authors' contributions and avoid plagiarism. Any potential conflicts of interest were disclosed to maintain transparency. Since the study did not involve human participants, ethical approval was not required, and the review process adhered to standard ethical guidelines for literature reviews.

## 3.0 Results and Discussion

### 3.1 Current State of AI Adoption

Adopting AI technologies in the Philippine construction industry transforms various sector aspects, significantly improving efficiency, accuracy, sustainability, and safety, as shown in Table 1. One key area of impact is cost estimation and budgeting. AI, particularly Artificial Neural Networks (ANN), provides accurate cost predictions and enhances budgeting methods. This is crucial for financial planning and project success, as shown in studies by Roxas et al. (2019) and Allam et al. Roxas & Ongpeng (2014) and Gante et al. (2022) further highlight how ANN models improve structural cost estimation and road construction cost forecasting, benefiting financial management in construction projects.

In project management and performance, AI technologies enable predictive modeling, which enhances decision-making and project outcomes. According to Fernandez et al. (2021) and Lim et al. (2021), AI is used in predictive modeling and construction management, especially in low-cost housing projects. This leads to more efficient processes and better project performance, improving timelines, resource allocation, and overall productivity in the construction industry. Sustainability and environmental impact are also critical areas where AI is making substantial contributions. AI improves green building ratings and integrates sustainable materials into construction projects, as noted by Lat et al. (2022) and Silva et al. (2020). Additionally, Cataldo et al. (2022) discuss the role of AI in sustainable supply chain management (SSCM), promoting sustainability throughout the construction supply chain. These advancements help the industry adopt more environmentally friendly practices and comply with global sustainability standards.

**Table 1.** Identified sub-themes in the current state of AI adoption

| Sub-themes | Applications | Related Literature |
|---|---|---|
| AI in Cost Estimation and Budgeting | Accurate cost predictions and budgeting improvements | Roxas et al. (2019); Allam et al.; Roxas & Ongpeng (2014); Gante et al. (2022); Lim et al. (2021) |
| AI in Project Management and Performance | Predictive modeling and construction management | Fernandez et al. (2021); Lim et al. (2021) |
| AI in Sustainability and Environmental Impact | Green building ratings, sustainability improvements, and SSCM | Lat et al. (2022); Silva et al. (2020); Cataldo et al. (2022) |
| AI in Safety and Compliance | Safety technologies and PPE compliance detection | Magon & Imbang (2022); Reyes et al. (2022) |
| AI in Material and Structural Optimization | Optimizing concrete properties and 3D printing | Silva et al. (2020); Nebrida (2022); Alejandrino et al. (2020) |
| AI in Geotechnical and Structural Analysis | Soil profiling, geotechnical analysis, and structural health monitoring | Galupino & Dungca (2022); Villanueva et al. (2022) |
| AI in Efficiency and Documentation | Enhancing supply chain efficiency and problem documentation | Encabo (2023); Pusod & Villaverde (2021) |

Safety and compliance are crucial for the construction industry, and AI technologies significantly enhance these aspects. Magon & Imbang (2022) and Reyes et al. (2022) report on the development of AI-driven safety technologies and the use of Convolutional Neural Networks (CNN) for detecting personal protective equipment (PPE) compliance. These innovations help mitigate risks and ensure worker safety on construction sites, addressing one of the industry's most pressing concerns. AI also proves invaluable in material and structural optimization. It optimizes concrete properties for better material efficiency and environmental sustainability, as highlighted by Silva et al. (2020). The integration of AI in 3D printing, discussed by Nebrida (2022) and Alejandrino et al. (2020), further enhances material efficiency and automates building processes, representing a significant technological advancement in construction practices.

AI benefits geotechnical and structural analysis through advanced soil profiling and structural health monitoring. Studies by Galupino and Dungca (2022) and Villanueva et al. (2022) demonstrate machine learning for soil profiling and deep learning for crack detection, ensuring construction projects' structural integrity and safety. These applications improve the accuracy of geotechnical assessments and facilitate proactive maintenance of structures. Lastly, AI enhances efficiency and documentation within the construction industry. Encabo (2023) notes that AI improves supply chain efficiency, leading to streamlined operations and better resource utilization. Pusod and Villaverde (2021) emphasize the role of AI in documenting construction problems, which enhances project management and workflow efficiency. These improvements reduce delays, minimize costs, and ensure smoother project execution.

### 3.2 Factors Influencing AI Adoption

Various factors influence the adoption of AI technologies in the Philippine construction industry, each with significant implications for the sector's growth and development, as shown in Table 2. Cost and Operational Efficiency are major drivers of AI adoption. Studies by Encabo (2023) and Nebrida (2022) highlight AI's potential to reduce operational costs and boost productivity. Accurate cost estimation, as discussed by Roxas et al. (2019) and Allam et al., is crucial for efficient project planning and execution. Construction companies must invest in AI technologies to stay competitive by managing costs effectively and enhancing overall efficiency.

In Project Management and Decision-Making, AI enables more efficient project planning and accurate decision-making, especially in complex projects like road construction (Gante et al., 2022). Pusod and Villaverde (2021) note that AI can reduce delays and solve construction problems more effectively. This suggests that adopting AI can lead to more timely project completions and improved problem-solving capabilities, which are vital for maintaining project schedules and budgets.

**Table 2**. Identified sub-themes in the current state of AI adoption

| Sub-themes | Factors | Related Literature |
|---|---|---|
| Cost and Operational Efficiency | Operational cost benefits, accurate cost estimation | Encabo (2023); Nebrida (2022); Roxas et al. (2019); Allam et al. |
| Project Management and Decision-Making | Efficient project planning, accurate decision-making, delay reduction, problem solving | Gante et al. (2022); Pusod & Villaverde (2021) |
| Quality and Performance Improvement | High-quality project outputs, socio-economic progress, workmanship, policy development | Fernandez et al. (2021); Lim et al. (2021) |
| Safety and Regulatory Compliance | Safety enhancements, regulatory compliance, deep learning advancements | Magon & Imbang (2022); Reyes et al. (2022) |
| Sustainability and Environmental Impact | Sustainable material use, urbanization, environmental concerns, energy efficiency | Manahan Malasan et al. (2021); Lat et al. (2022) |
| Technological and Data Challenges | Data completeness and quality, technology limitations | Roxas et al. (2019); Galupino & Dungca (2022); Alejandrino et al. (2020) |
| Ethical and Skill Considerations | Ethical concerns, skill requirements | Nebrida & Oliveros (2023); Cataldo et al. (2022) |

Quality and Performance Improvement is another area where AI plays a crucial role. Fernandez et al. (2021) and Lim et al. (2021) emphasize the need for high-quality project outputs and the socio-economic progress driven by AI adoption. Addressing workmanship defects and developing policy guidelines to support AI implementation is essential for enhancing construction quality. Embracing AI can lead to higher-quality constructions that meet industry standards and societal needs. Safety and Regulatory Compliance are also critical. AI technologies enhance safety regulations and ensure compliance, particularly through advancements like deep learning for PPE compliance (Magon & Imbang, 2022; Reyes et al., 2022). This implies that AI can significantly reduce workplace accidents and ensure adherence to safety standards, crucial for worker safety and legal compliance.

In Sustainability and Environmental Impact, AI adoption is driven by the need for sustainable material use and addressing environmental concerns (Manahan Malasan et al., 2021; Lat et al., 2022). AI helps manage urbanization challenges and improve energy efficiency. AI can support the construction industry's efforts to become more sustainable and environmentally friendly, aligning with global sustainability goals. However, the industry faces Technological and Data Challenges. Ensuring data completeness and quality is a significant hurdle, as Roxas et al. (2019) and Galupino & Dungca (2022) highlight. Current AI technologies also have inherent limitations (Alejandrino et al., 2020). Overcoming these challenges requires substantial investment in technology and data infrastructure. Companies must prioritize data management and technological upgrades to leverage AI's benefits fully.

Lastly, Ethical and Skill Considerations are crucial for AI adoption. Ethical concerns related to AI use must be addressed, as noted by Nebrida and Oliveros (2023). Additionally, there is a need for skilled personnel to manage and implement AI technologies effectively (Cataldo et al., 2022). The construction industry must invest in training and education to develop the necessary skills and address ethical issues, ensuring responsible and effective AI implementation. Overall, the identified factors affecting the adoption of artificial intelligence in the construction industry were encompassed by the technological, organizational, and environmental factors that influence technology adoption according to the TOE framework (Lin & Chen, 2023).

### 3.3 Preparations for AI Adoption

The adoption of AI technologies in the Philippine construction industry stands to revolutionize key aspects, driven by extensive preparation outlined in recent literature, as shown in Table 3. Central to this transformation is integrating Digital Tools and Modeling, such as BIM AI software and MATLAB simulations, highlighted by Nebrida & Oliveros (2023) and Roxas et al. (2019). These tools promise enhanced project visualization, streamlined collaboration, and improved decision-making, addressing longstanding design and project management inefficiencies.

**Table 3.** Identified sub-themes in the preparations for AI adoption

| Sub-themes | Preparation Factors | Related Literature |
|---|---|---|
| Digital Tools and Modeling | Digital modeling, BIM AI software, and MATLAB use | Nebrida & Oliveros (2023); Roxas et al. (2019); Allam et al. |
| Data Collection and Analysis | Comprehensive data collection, analysis of past projects | Roxas et al. (2019); Roxas & Ongpeng (2014); Allam et al.; Gante et al. (2022) |
| Stakeholder Training and Education | Workforce training, stakeholder education, and relations | Nebrida & Oliveros (2023); Fernandez et al. (2021); Encabo (2023) |
| Assessment and Evaluation | Assessment tools, meta-cognitive analysis, policy guidelines | Fernandez et al. (2021); Lim et al. (2021) |
| Algorithm Development and Validation | Algorithm development, statistical tools, model training | Pusod & Villaverde (2021); Silva et al. (2020); Galupino & Dungca (2022); Villanueva et al. (2022) |
| Sustainability and Innovation | Sustainability assessment, green building ratings, innovation mapping | Lat et al. (2022); Magon & Imbang (2022) |
| Practical Applications and On-Site Utility | Practical application development, 3D printing impacts | Villanueva et al. (2022); Nebrida (2022) |
| Financial and Technological Support | Smart technology investment, ML algorithm implementation | Cataldo et al. (2022); Alejandrino et al. (2020) |

Data Collection and Analysis emerge as foundational pillars for AI readiness. Roxas et al. (2019) and Allam et al. emphasize robust data collection methods and advanced analytics using tools like MATLAB. Effective use of historical project data, noted by Gante et al. (2022), enhances predictive capabilities and optimizes cost estimation and resource allocation, thereby reducing project risks and improving efficiency. The importance of Stakeholder Training and Education cannot be overstated in fostering AI adoption. Nebrida and Oliveros (2023) stress the need for workforce training in digital modeling and AI technologies, ensuring stakeholders can leverage these tools effectively. Fernandez et al. (2021) advocate for meta-cognitive analysis and stakeholder education to align expectations and enhance project outcomes. This preparation is crucial for overcoming initial resistance to change and maximizing the benefits of AI integration.

Assessment and Evaluation methodologies, including assessment tools and policy guidelines formulation (Lim et al., 2021), are essential for measuring the impact and success of AI implementations. These frameworks facilitate continuous improvement and ensure AI applications meet industry standards and regulatory requirements, fostering an environment conducive to innovation and sustainable growth. In terms of Algorithm Development and Validation, advancements in machine learning algorithms (Pusod & Villaverde, 2021; Silva et al., 2020) play a pivotal role in predictive modeling and real-time decision support in construction projects. Robust algorithmic frameworks and validation processes are critical for enhancing AI-driven applications' accuracy, reliability, and performance metrics.

Sustainability and Innovation are driving forces behind AI adoption in the construction sector. Lat et al. (2022) highlight AI's role in sustainability assessments and green building ratings, aligning with global environmental initiatives. Magon and Imbang (2022) stress innovation mapping and socioeconomic reviews to identify opportunities for AI-driven advancements that contribute to economic development and environmental stewardship. As discussed by Villanueva et al. (2022) and Nebrida (2022), practical applications and on-site utility underscore the tangible benefits of AI technologies in enhancing construction processes and project outcomes. From optimizing material usage to improving methodologies, these applications illustrate AI's transformative potential in mitigating challenges and advancing industry standards.

However, realizing these benefits hinges on addressing Financial and Technological Support. Cataldo et al. (2022) advocate for strategic investments in smart technologies and financial support, particularly for SMEs, to facilitate widespread AI adoption. Alejandrino et al. (2020) stress the importance of handling large datasets and implementing scalable machine learning algorithms, highlighting the need for robust technological infrastructure to sustain long-term AI integration.

### 3.4 Benefits of AI Adoption

Adopting AI technologies in the Philippine construction sector promises transformative benefits across several critical dimensions, as highlighted by the identified sub-themes in the literature shown in Table 4.

**Table 4.** Identified sub-themes in the benefits of AI adoption

| Sub-themes | Associated Benefits | Related Literature |
|---|---|---|
| Increased Productivity and Efficiency | Increased operational efficiency, enhanced project delivery speed | Nebrida & Oliveros (2023), Encabo (2023), Lim et al. (2021) |
| Improved Cost Management | Reduced operational costs, accurate cost predictions | Roxas et al. (2019), Roxas & Ongpeng (2014), Pusod & Villaverde (2021) |
| Enhanced Decision-Making | Informed decision-making, improved forecasting | Fernandez et al. (2021), Allam et al., Magon & Imbang (2022) |
| Higher Quality and Sustainability | Use of sustainable materials, improved environmental impact assessments | Manahan Malasan et al. (2021), Lat et al. (2022), Silva et al. (2020) |
| Optimization of Processes | Material optimization, production efficiency improvement | Alejandrino et al. (2020), Nebrida (2022) |
| Safety and Compliance | Enhanced safety compliance, protocol integration | Reyes et al. (2022), Galupino & Dungca (2022), Villanueva et al. (2022) |
| Innovation and Technological Advancement | Technological innovation, advancement in construction methods | Gante et al. (2022), Cataldo et al. (2022) |
| Economic Competitiveness | Improved economic competitiveness, alignment with socio-political settings | Magon & Imbang (2022), Cataldo et al. (2022) |
| Environmental Benefits | Environmental sustainability benefits, reduction of carbon footprint | Lat et al. (2022), Nebrida (2022), Silva et al. (2020) |
| Digital Transformation | Adoption of digital methods, efficiency gains through automation | Nebrida & Oliveros (2023), Encabo (2023), Galupino & Dungca (2022) |

One of the primary advantages is Increased Productivity and Efficiency. AI-driven tools, as demonstrated by Nebrida & Oliveros (2023), Encabo (2023), and Lim et al. (2021), significantly enhance operational efficiency and expedite project delivery. AI accelerates project timelines and boosts overall productivity by automating routine tasks, optimizing resource allocation, and streamlining workflows. Moreover, Improved Cost Management emerges as another pivotal benefit. Studies by Roxas et al. (2019), Roxas & Ongpeng (2014), and Pusod & Villaverde (2021) underscore AI's ability to facilitate precise cost predictions and reduce operational expenses. Through advanced analytics and predictive modeling, AI enables better financial planning, risk management, and budget adherence, which is essential for sustainable project execution in the Philippine context.

AI adoption also enhances Decision-Making capabilities within the industry. Fernandez et al. (2021), Allam et al., and Magon and Imbang (2022) highlight AI's role in providing data-driven insights and improving forecasting accuracy. By leveraging real-time data analysis and predictive algorithms, stakeholders can promptly make informed decisions, mitigate risks, and capitalize on opportunities, enhancing project outcomes and stakeholder satisfaction. Integrating AI contributes significantly to Higher Quality and Sustainability practices in construction. Research by Manahan Malasan et al. (2021), Lat et al. (2022), and Silva et al. (2020) emphasizes AI's capacity to promote sustainable construction methods through the use of eco-friendly materials and enhanced environmental impact assessments. AI-driven tools optimize material usage, minimize waste, and facilitate energy-efficient construction practices, aligning with global sustainability goals and regulatory requirements.

Furthermore, AI supports process Optimization by improving material selection, enhancing production efficiency, and optimizing operational workflows, as noted by Alejandrino et al. (2020) and Nebrida (2022). These advancements streamline construction operations and enhance scalability and adaptability to market demands, further driving efficiency gains and cost savings. Regarding Safety and Compliance, AI technologies ensure enhanced safety protocols and regulatory compliance on construction sites. Reyes et al. (2022), Galupino & Dungca (2022), and Villanueva et al. (2022) illustrate AI's capability in real-time safety monitoring, risk prediction, and protocol integration, fostering a safer working environment and reducing accidents.

Moreover, AI adoption stimulates Innovation and Technological Advancement in construction methods. Gante et al. (2022) and Cataldo et al. (2022) emphasize how AI facilitates technological innovation by enabling advanced construction techniques and integrating smart technologies. This innovation enhances project efficiency and positions Philippine construction firms at the forefront of global technological advancements. Economically, AI adoption contributes to Improved Economic Competitiveness by optimizing resource allocation, improving project efficiency, and aligning with socio-political settings, as discussed by Magon & Imbang (2022) and Cataldo et al. (2022). These benefits enhance industry competitiveness, attract investment, and stimulate economic growth, creating opportunities for local businesses and job creation.

Lastly, AI adoption promotes Environmental Benefits by fostering sustainable construction practices and reducing the carbon footprint. Lat et al. (2022), Nebrida (2022), and Silva et al. (2020) highlight how AI enables efficient resource use, minimizes environmental impact, and supports green building initiatives, aligning with global sustainability agendas.

### 3.5 Challenges of AI Adoption

The adoption of AI technologies in the Philippine construction industry presents promising opportunities, alongside several significant challenges that must be addressed to fully realize its potential, as shown in Table 5. Adopting AI technologies in the Philippine construction industry presents promising opportunities alongside several significant challenges that must be addressed to realize its full potential. Ethical and Security Concerns stand out as critical hurdles, as highlighted by Nebrida & Oliveros (2023) and Reyes et al. (2022). Data privacy, algorithm bias, and cybersecurity risks need careful management to ensure ethical use and protect sensitive information, which is essential for maintaining trust and credibility within the industry.

**Table 5.** Identified sub-themes in the challenges of AI adoption

| Sub-themes | Associated Challenges | Related Literature |
|---|---|---|
| Ethical and Security Concerns | Ethical implications, security risks | Nebrida & Oliveros (2023), Reyes et al. (2022) |
| Financial Constraints | Funding challenges, financial investments | Encabo (2023), Cataldo et al. (2022) |
| Data Complexity and Quality | Handling complex data, ensuring data accuracy | Roxas et al. (2019), Gante et al. (2022), Silva et al. (2020) |
| Stakeholder Trust and Acceptance | Building trust, stakeholder acceptance | Roxas et al. (2019), Roxas & Ongpeng (2014) |
| Accuracy and Adaptability of Models | Ensuring model accuracy, adapting models to diverse project conditions | Lim et al. (2021), Galupino & Dungca (2022), Villanueva et al. (2022) |
| Technological Complexity | Managing complex AI technologies, technological risks | Galupino & Dungca (2022), Alejandrino et al. (2020) |
| Policy and Regulatory Challenges | Adhering to policy guidelines, regulatory compliance | Lim et al. (2021), Pusod & Villaverde (2021) |
| Long-term Sustainability | Sustainable integration of AI technologies, longevity of AI solutions | Cataldo et al. (2022), Nebrida (2022) |
| Skills and Workforce Adaptation | Skills gap, workforce training, and adaptation | Encabo (2023), Nebrida & Oliveros (2023) |
| Integration with Existing Systems | Integrating AI with current systems, compatibility issues | Pusod & Villaverde (2021), Silva et al. (2020) |

Financial Constraints pose another substantial challenge. Encabo (2023) and Cataldo et al. (2022) underscore the funding challenges and significant financial investments required for implementing AI technologies. Overcoming these barriers requires strategic financial planning, potential partnerships with financial institutions, and demonstrating a clear return on investment to stakeholders. Data Complexity and Quality represent fundamental challenges in AI adoption, as noted by Roxas et al. (2019), Gante et al. (2022), and Silva et al. (2020). Handling large volumes of complex data while ensuring accuracy and reliability is crucial for the effectiveness of AI applications in construction. Robust data management strategies, advanced analytics capabilities, and rigorous validation processes are necessary to mitigate errors and enhance decision-making outcomes.

Building Stakeholder Trust and Acceptance is crucial for successful AI adoption. Roxas et al. (2019) and Roxas & Ongpeng (2014) emphasize the importance of transparency in AI processes and demonstrate tangible benefits to gain acceptance among project managers, contractors, and regulatory bodies. Effective communication and addressing concerns proactively can help mitigate resistance to technological change. Ensuring the Accuracy and Adaptability of Models is another challenge, particularly in diverse project conditions and environments, highlighted by Lim et al. (2021), Galupino & Dungca (2022), and Villanueva et al. (2022). AI models must be continuously refined and adapted to specific project requirements to maintain reliability and effectiveness in decision-making processes.

Technological Complexity presents challenges in managing advanced AI technologies and addressing associated risks, as Galupino & Dungca (2022) and Alejandrino et al. (2020) noted. This includes understanding and mitigating technological risks, ensuring system compatibility, and integrating AI seamlessly into existing workflows without disrupting operations. Addressing Policy and Regulatory Challenges is crucial for navigating legal frameworks and compliance requirements, as Lim et al. (2021) and Pusod & Villaverde (2021) highlighted. Adhering to evolving policies and regulations governing AI adoption in construction ensures legal compliance and minimizes regulatory risks.

Long-term Sustainability of AI solutions requires sustainable integration and ongoing maintenance, as Cataldo et al. (2022) and Nebrida (2022) emphasize. Ensuring the longevity and scalability of AI implementations involves strategic planning, resource allocation, and adaptation to technological advancements over time. Moreover, Skills and Workforce Adaptation presents challenges due to the skills gap and the need for workforce training in AI technologies, as noted by Encabo (2023) and Nebrida and Oliveros (2023). Upskilling the workforce, fostering a culture of innovation, and investing in continuous education are essential for maximizing the benefits of AI adoption and driving industry-wide transformation. Finally, Integration with Existing Systems involves overcoming compatibility issues and ensuring seamless integration of AI technologies with current construction systems, highlighted by Pusod & Villaverde (2021) and Silva et al. (2020). Careful planning, technical expertise, and phased implementation strategies can minimize disruptions and optimize operational efficiency.

## 4.0 Conclusions

The current state of AI adoption in the Philippine construction industry reveals a promising yet varied landscape. Technologies such as 3D printing, predictive modeling, and machine learning are being integrated to enhance project delivery and operational efficiency. Despite these advancements, the adoption rate varies across different sectors and organizations, reflecting a nascent stage of AI integration in the industry. Continued efforts to embrace these technologies can position the industry to meet modern challenges better and capitalize on opportunities for innovation and growth.

Several factors influence the adoption of AI in the Philippine construction sector. Key drivers include improved cost management, enhanced decision-making, and higher quality standards. However, financial constraints, data complexity, and stakeholder trust present significant barriers. Understanding and addressing these factors is essential for creating a conducive environment for AI adoption, ultimately leading to more efficient and effective construction processes. Preparation for AI adoption involves several critical steps. Digital readiness, including workforce training and data management, is paramount. Stakeholder engagement and developing robust technological frameworks are also crucial to ensure smooth integration and functionality. By focusing on these preparatory measures, the construction industry can harness AI's full potential, driving significant improvements and fostering a culture of innovation and continuous improvement.

The benefits of AI adoption in the Philippine construction industry are manifold. AI technologies enhance productivity, cost-efficiency, and decision-making capabilities while promoting sustainability and safety. These advancements improve the quality of construction projects and contribute to economic competitiveness and environmental stewardship. By leveraging these benefits, the industry can set a path for leadership in the global construction landscape, achieving higher standards and greater operational success. Despite the potential benefits, the challenges of AI adoption must be addressed to realize its full potential. Data quality, technological complexity, ethical concerns, and the need for a skilled workforce pose significant hurdles. Overcoming these obstacles through strategic planning, stakeholder engagement, and investment in technology and human resources will pave the way for sustainable growth and innovation in the sector. By tackling these challenges head-on, the Philippine construction industry can enhance its competitiveness and contribute to broader socio-economic progress.

Future studies could explore the longitudinal impact of adopting AI in the construction industry. Further investigation into the effectiveness of AI tools and technological applications in improving the efficiency of construction methods can also yield innovative approaches that enhance the adoption of AI. Additionally, comparative studies across different construction methods, including traditional and AI approaches, would provide insights into the advantages and disadvantages of adopting or integrating AI with the current construction practices.

## 5.0 Contributions of Authors

The authors confirm the equal contribution in each part of this work. All authors reviewed and approved the final version of this work.

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## 7.0 Conflict of Interests

All authors declare that they have no conflicts of interest.

## 8.0 References

Adeloye, A. O., Diekola, O., Delvin, K., & Gbenga, C. (2023). Applications of Artificial Intelligence (AI) in the construction industry: A review of Observational Studies. Applied Sciences Research Periodicals, 1(4), 28-38.

Alejandrino, J. D., Concepcion, R. S., Lauguico, S. C., Tobias, R. R., Venancio, L., Macasaet, D., ... & Dadios, E. P. (2020). A machine learning approach of lattice infill pattern for increasing material efficiency in additive manufacturing processes. Int. J. Mech. Eng. Robot. Res, 9(9), 1253-1263. https://doi.org/10.18178/ijmerr.9.9.1253-1263

Aljawder, A., & Al-Karaghouli, W. (2024). The adoption of technology management principles and artificial intelligence for a sustainable lean construction industry in the case of Bahrain. Journal of Decision Systems, 33(2), 263-292. https://doi.org/10.1080/12460125.2022.2075529

Allam, J., Dayag, R. M., Fronda, J. C., Tumaliuan, J. A., & Abana, E. Predicting Road Construction Project Costs In Municipalities Through Artificial Neural Network Modeling.

Bang, S., & Olsson, N. (2022). Artificial intelligence in construction projects: a systematic scoping review. https://doi.org/10.32738/JEPPM-2022-0021

Cataldo, I., Banaitis, A., Samadhiya, A., Banaitienė, N., Kumar, A., & Luthra, S. (2022). Sustainable supply chain management in construction: An exploratory review for future research. Journal of Civil Engineering and Management, 28(7), 536-553. https://doi.org/10.3846/jcem.2022.17

Dimaculangan, E. (2023). Issues and challenges in the Philippine construction industry: An opportunity for BIM adoption. Bitlis Eren University Journal of Science and Technology, 13(2), 93-119. https://doi.org/10.17678/beuscitech.1279862

Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., Eirug, A., Galanos, V., Ilavarasan, V., Janssen, M., Jones, P., Kar, A.K., Kizgin, H., Kronemann, B., Lal, B., Lucini, B., Medaglia, R., & Williams, M. D. (2021). Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. International Journal of Information Management, 57, 101994. https://doi.org/10.1016/j.ijinfomgt.2019.08.002

Encabo, P. L. (2023, August). Artificial intelligence in supply chain: Status and constraints–The Philippine experience. In AIP Conference Proceedings (Vol. 2823, No. 1). AIP Publishing. https://doi.org/10.1063/5.0162493

Fernandez, J., Silva, D. L., & De Jesus, K. L. M. (2021). Hybrid Neural–Based Model for Predicting the Construction Project Performance of High–Rise Building Projects in Metro Manila, Philippines. In Modern Management based on Big Data II and Machine Learning and Intelligent Systems III (pp. 274-281). IOS Press. https://doi.org/10.3233/FAIA210258

Galupino, J., & Dungca, J. (2022). Estimating Ground Elevation using Borehole Information: A Case of Metro Manila, Philippines. https://doi.org/10.5109/5909058

Galupino, J., & Dungca, J. (2022). Machine learning models to generate a subsurface soil profile: A case of Makati City, Philippines. GEOMATE Journal, 23(95), 57-64.

Gante, D. V., Silva, D. L., & Leopoldo, M. P. (2022). Forecasting construction cost using artificial neural network for road projects in the department of public works and highways region XI. In Modern Management based on Big Data III (pp. 64-71). IOS Press. https://doi.org/10.3233/FAIA220084

Ismail, S. N., Ramli, A., & Aziz, H. A. (2021). Influencing factors on safety culture in mining industry: A systematic literature review approach. Resources Policy, 74, 102250. https://doi.org/10.1016/j.resourpol.2021.102250

Jambol, D. D., Sofoluwe, O. O., Ukato, A., & Ochulor, O. J. (2024). Transforming equipment management in oil and gas with AI-driven predictive maintenance. Computer Science & IT Research Journal, 5(5), 1090-1112. https://doi.org/10.51594/csitrj.v5i5.1117

Khan, R., Usman, M., & Moinuddin, M. (2024). From Raw Data to Actionable Insights: Navigating the World of Data Analytics. International Journal of Advanced Engineering Technologies and Innovations, 1(4), 142-166.

Korke, P., Gobinath, R., Shewale, M., & Khartode, B. (2023). Role of Artificial Intelligence in Construction Project Management. In E3S Web of Conferences (Vol. 405, p. 04012). EDP Sciences. https://doi.org/10.1051/e3sconf/202340504012

Lai, Y. L., & Lee, J. (2020). Integration of technology readiness index (TRI) into the technology acceptance model (TAM) for explaining behavior in adoption of BIM. Asian Education Studies, 5(2), 10. https://doi.org/10.20849/aes.v5i2.816

Lat, K. C. A., Silva, D. L., & de Jesus, K. L. M. (2022, January). Neural network-based approach for identifying the influence of factors affecting the green building rating of a rural housing construction. In 2022 International Conference on Management Engineering, Software Engineering and Service Sciences (ICMSS) (pp. 36-43). IEEE.

Lim, R. U., Silva, D. L., & De Jesus, K. L. M. (2021). Mitigating Construction Deficiencies: An Impact Analysis for Low-Cost Housing Developments Utilizing Artificial Neural Network. In Modern Management based on Big Data II and Machine Learning and Intelligent Systems III (pp. 241-247). IOS Press. https://doi.org/10.3233/FAIA210254

Lin, C. H., & Chen, W. H. (2023). A technology-organization-environment (TOE) framework based on scientometry for understanding the risk factors in sustainable water resources management. Water Resources Management, 37(15), 5849-5869.

LlenadaSantos, J. V. (2022). Comparative Analysis of Mobile Applications for its Integration in College Mathematics Subjects. EDUCATIO: Journal of Education, 6(4), 324-345.

Magon, S. A., & Imbang, G. A. (2022, December). The future of the Philippine safety industry through scenario building. In 2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM) (pp. 1-6). IEEE.

Manahan Malasan, C., S. Villaverde, B., L. Silva, D., & M. de Jesus, K. L. (2021, December). Artificial neural network with sensitivity analysis: Predicting the flexural strength of concrete pavement using locally sourced dilapidated concrete as partial replacement. In Proceedings of the 2021 5th International Conference on Computer Science and Artificial Intelligence (pp. 408-414). https://doi.org/10.1145/3507548.3507611

Nebrida, J. (2022). Automated onsite construction: 3d printing technology. Journal of Engineering Research and Reports.

Nebrida, J. A., & Oliveros, O. (2023). Artificial Intelligence Utilized in 3D Printing Construction Technology. Asian Journal of Advanced Research and Reports, 17(4), 20-25. https://doi.org/10.9734/ajarr/2023/v17i4476

Obana, L. R. (2024). Collaboration of Artificial Intelligence and Project Management.

Okour, M. K., Chong, C. W., & Abdel Fattah, F. A. M. (2021). Knowledge management systems usage: application of diffusion of innovation theory. Global Knowledge, Memory and Communication, 70(8/9), 756-776. https://doi.org/10.1108/GKMC-08-2020-0117

Pan, Y., & Zhang, L. (2023). Integrating BIM and AI for smart construction management: Current status and future directions. Archives of Computational Methods in Engineering, 30(2), 1081-1110.

Pusod, M. G. M., & Villaverde, B. S. (2021). Solution suggesting application model to minimize delays and cost overrun for low to midrise building construction in pampanga. Civ. Eng. Archit, 9(6), 1920-1937.

Reyes, R. C., Sevilla, R. V., Zapanta, G. S., Merin, J. V., & Maaliw, R. R. (2022, July). Safety gear compliance detection using data augmentation-assisted transfer learning in construction work environment. In 2022 IEEE International Conference on Electronics, Computing and Communication Technologies (CONECCT) (pp. 1-6). IEEE.

Roxas, C. L. C., & Ongpeng, J. M. C. (2014, March). An artificial neural network approach to structural cost estimation of building projects in the Philippines. In DLSU Research Congress (Vol. 2, No. 2, pp. 1-8). De La Salle University–Manila.

Roxas, C. L. C., Roxas, N. R., Cristobal, J., Hao, S. E., Rabino, R. M., & Revalde, F. (2019, November). Modeling road construction project cost in the Philippines using the artificial neural network approach. In 2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM) (pp. 1-5). IEEE.

Shahriar, S., Allana, S., Hazratifard, S. M., & Dara, R. (2023). A survey of privacy risks and mitigation strategies in the Artificial Intelligence life cycle. IEEE Access, 11, 61829-61854.

Santos, J., & Jocson, J. (2021). A Comparative Analysis of Productivity Improvement Techniques in Educational Institution of Holy Cross College. Canadian Journal of Educational and Social Studies, 1(1), 14-32. https://doi.org/10.53103/cjess.v1i1.2

Santos, J. V. L., Lansangan, R. M. B., Marcos, E. V., Florencondia, N. B., & Cabrera, F. S. (2022). Effective Leadership Style of Engineering Managers in the Government Construction Agency: National Irrigation Administration–UPRIIS Division V. https://doi.org/10.47191/etj/v7i1.04

Silva, D. L., de Jesus, K. L. M., Villaverde, B. S., & Adina, E. M. (2020, February). Hybrid artificial neural network and genetic algorithm model for multi-objective strength optimization of concrete with Surkhi and buntal fiber. In Proceedings of the 2020 12th International Conference on Computer and Automation Engineering (pp. 47-51).

Siman, B. P. (2023). A Critical Analysis of the Philippine Construction Industry: Current Trends, Forecast, and Business Focus for Engineering Design Firms. International Journal of Multidisciplinary: Applied Business and Education Research, 4(8), 2691-2699. https://doi.org/10.11594/ijmaber.04.08.01

Subia, E. G. S., Jocson, E. J. C., & Florencondia, E. N. T. (2019). Flood prevention and mitigation initiatives towards a flood-free city. American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS), 58(1), 215-224.

Villanueva, A., Balba, J. K. B., Beceril, C. D., Belza, J. L. G., Tagle, R. I. P., Venal, M. C. A., & Rosales, M. M. (2022, June). Crack detection and classification for reinforced concrete structures using deep learning. In 2022 2nd International Conference on Intelligent Technologies (CONIT) (pp. 1-6). IEEE.