Evaluating Digital Transformation Adoption on Sustainability Outcomes in Construction Projects in the UAE

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ABSTRACT

The construction industry in the United Arab Emirates (UAE) is undergoing rapid transformation driven by digital innovation and sustainability imperatives. This study evaluates the impact of digital transformation adoption on sustainability outcomes in construction projects. By integrating advanced technologies such as Building Information Modeling (BIM), Internet of Things (IoT), and data analytics, organizations aim to improve environmental, economic, and social performance. This study employed a quantitative, hypothesis-driven survey design under a positivist paradigm and deductive approach, guided by the Technology–Organization–Environment (TOE) framework. The population comprised contractors involved in sustainable construction projects in the UAE, based on licensed and classified construction firms listed by the UAE Ministry of Infrastructure Development. The sample size determination based on a population of 11,676 contractors, the required sample size was 371 respondents. Data were collected through a structured questionnaire survey, distributed electronically to targeted contractor managers, supported by official access to company lists and facilitated through the licensing sector to enhance reach and participation. The study analyzed data using Partial Least Squares Structural Equation Modelling (PLS-SEM) via SmartPLS. Findings indicate that digital transformation enhances sustainability outcomes and identifies key drivers and barriers within the UAE context. The findings provide insights for practitioners and policymakers seeking to align digital initiatives with sustainable development goals.

Keywords: – Digital Transformation, Sustainability Outcomes, Contractors, UAE

INTRODUCTION

The construction industry remains a crucial driver of global economic growth and development, accounting for approximately 13% of the world's GDP in 2025 (Hummieda et al., 2023). In the United Arab Emirates (UAE), the sector plays an even more significant role, serving as a backbone for the nation's economic diversification strategies (Hummieda et al., 2023). With a market value exceeding $101 billion in 2025, the UAE construction industry is well-positioned to support national initiatives such as UAE Vision 2030, UAE Centennial 2071, and the Green Agenda 2030, which collectively aim to promote sustainable development, improve quality of life, and reduce dependence on oil revenues (Abiodun et al., 2023; Ahmad, 2024). These national strategies underscore the growing emphasis on smart infrastructure and green building practices, placing increasing pressure on the construction industry to adopt digital transformation tools and innovative project management methodologies that align with global sustainability goals (Alami & El Idrissi, 2022; Alassafi et al., 2024).

In the context of the UAE's construction industry, digital transformation has introduced innovative tools and processes that enhance project management efficiency, reduce costs, and improve overall project outcomes (Dabash, 2023). The adoption of Building Information Modeling (BIM), for example, has revolutionized how construction projects are planned, designed, and executed, offering a collaborative platform that integrates various stakeholders throughout the project lifecycle.

The UAE construction sector plays a pivotal role in national development, contributing significantly to economic growth and infrastructure expansion (Alassafi et al., 2024). However, the industry faces increasing pressure to address sustainability challenges, including resource consumption, carbon emissions, and waste generation. Digital transformation (DT) has emerged as a powerful enabler for improving construction efficiency and sustainability. Technologies such as BIM, cloud computing, artificial intelligence, and smart sensors are reshaping project planning, execution, and monitoring.

This study is particularly relevant in the context of the UAE's broader sustainability and innovation agenda. As the nation continues to invest in sustainable infrastructure and smart cities, the construction sector must evolve to meet these expectations (Hummieda et al., 2023). Digital transformation plays a crucial role in achieving these goals, enabling contractors to reduce waste, optimize resource use, and enhance project performance. For instance, IoT-enabled smart sensors can monitor energy consumption in real-time, allowing for better resource management and reducing a building's carbon footprint (Alassafi et al., 2024). One of the key targets under the UAE Energy Strategy 2050 includes achieving 40% improvement in building energy efficiency by 2050, a goal that is contingent on digital-enabled monitoring and operational control technologies (Hummieda et al., 2023). However, without widespread adoption of these technologies, the industry will struggle to meet the ambitious targets set by the UAE government.

This study aimed to develop a conceptual framework that evaluating digital transformation adoption on sustainability outcomes in construction projects in the UAE.

Theoretical Literature and Hypothesis Development

This study is grounded in: Resource-Based View (RBV): Digital capabilities as strategic assets that improve sustainability performance.

Digital Transformation in Construction

Refers to the integration of digital technologies into various aspects of an organization, fundamentally changing how it operates and delivers value to its stakeholders. In the construction industry, digital transformation involves adopting tools such as Building Information Modeling (BIM), project management software, Internet of Things (IoT) devices, and other technologies that enhance collaboration, improve decision-making, and streamline project management processes (Alassafi et al., 2024; Ahmad, 2024). However, digital transformation is not merely about implementing new technologies it also requires cultural and organizational change, with a shift in mindset toward embracing innovation, agility, and continuous improvement (Ali Mohamad et al., 2023; Alieva & Powell, 2023). This transformation aims to increase efficiency, reduce costs, and improve the overall quality and sustainability of construction projects, aligning with the growing emphasis on green building practices and smart infrastructure development across the UAE (Kolasani, 2023; Alami & El Idrissi, 2022).

The construction industry in the United Arab Emirates (UAE) is undergoing a profound transformation as it seeks to integrate digital technologies into traditional project management practices. Despite the recognized benefits of digital transformation, such as enhanced efficiency, improved communication, and optimized resource management, its adoption among contractors remains inconsistent and slow, with studies indicating that only 45% have fully integrated digital tools while the remaining 55% either partially adopted or continue to rely on manual processes (Oke et al., 2023). This adoption lag becomes more apparent when compared to sectors like healthcare and energy in the UAE, which have seen faster digital uptake due to dedicated policy incentives and targeted funding (Alami & El Idrissi, 2022).This gap in adoption, driven by a combination of organizational, technological, and environmental factors, poses significant challenges to the industry's growth and to achieving sustainability goals defined by national strategies such as the UAE Green Agenda 2030, Energy Strategy 2050, and Vision 2021.

Economically, the UAE remains one of the fastest-growing economies in the MENA region, with the construction sector playing a pivotal role in national development. In recent years, construction-related activities have contributed over 8% to the UAE's GDP, with the industry valued at approximately $101 billion in 2023(Hummieda et al., 2023). This growth is expected to continue, fueled by significant infrastructure projects tied to the UAE Vision 2021, Expo 2020 legacy projects, and the UAE Centennial 2071 Plan

(Abiodun et al., 2023). However, while these projects offer ample opportunities for innovation, contractors often continue to rely on traditional project management methodologies due to institutional inertia, limited technological readiness, and a lack of incentivizing regulatory mechanisms (Adebowale & Agumba, 2023).

Sustainability in Construction Projects

Sustainable facilities are buildings and infrastructure projects designed, constructed, and operated in ways that minimize their environmental impact, optimize resource use, and enhance the well-being of occupants and the surrounding community. These facilities incorporate principles of sustainability across various stages of their lifecycle, from the selection of materials to energy efficiency measures and waste management strategies. In the UAE, sustainable facilities are often guided by stringent government regulations and standards, such as the Estidama Pearl Rating System, which aims to promote sustainable development in alignment with the country's environmental goals (Hamani, 2019). The concept of sustainable facilities also includes the use of smart technologies and data-driven approaches to monitor and optimize building performance over time (Mohamed Hashim et al., 2022).In the UAE, sustainability initiatives are aligned with national visions such as UAE Vision 2030 and green building regulations.

Influence of Digital Transformation on Sustainability Outcomes

Empirical research strongly supports the hypothesis that the adoption of digital transformation enhances the sustainability of construction projects. Alizadehsalehi & Yitmen (2023) show that digital tools like BIM, IoT, and smart sensors enable real-time tracking of materials, energy use, and project progress, significantly reducing waste and improving resource optimization. Digital transformation facilitates the design and execution of sustainable construction practices, allowing firms to meet environmental standards and regulatory requirements. Ahmad (2024) highlights how AI-driven predictive models can forecast resource needs and energy consumption, leading to more efficient construction practices. Moreover, Abiodun et al. (2023) argue that digital adoption in construction aligns directly with sustainability goals by streamlining workflows and minimizing environmental footprints. Therefore, it is hypothesized that digital transformation adoption directly contributes to improving the sustainability of construction projects by enhancing energy efficiency, reducing waste, and optimizing resource use.

Digital transformation is not just a technological upgrade, it is a strategic shift that alters how construction projects are designed, managed, and delivered. In this study, digital transformation refers to the integration of digital technologies into core project operations, including planning, resource management, monitoring, and stakeholder communication. The adoption of such technologies has a direct and measurable impact on project sustainability, encompassing environmental, economic, and social dimensions (Mohamed Hashim et al., 2022). Technologies like BIM enhance project visualization and coordination, reducing rework and material waste. IoT devices allow real-time monitoring of energy use and environmental impact, while AI and data analytics enable smarter scheduling and resource optimization. Collectively, these tools contribute to the three pillars of sustainability: reducing the environmental footprint, improving economic efficiency, and enhancing worker safety and well-being (Alassafi et al., 2024). In this context, digital transformation becomes an enabler of sustainability by embedding performance monitoring and continuous improvement into everyday operations.

Furthermore, empirical studies have confirmed that firms undergoing digital transformation report higher levels of project sustainability, especially when supported by organizational alignment and policy frameworks (Ali Mohamad et al., 2023). Therefore, digital transformation is not only a technological outcome but a strategic means to achieve sustainable project goals. Its influence on sustainability is both direct and amplified by the firm's capacity to integrate digital tools into every stage of the construction lifecycle.

H1: The adoption of digital transformation significantly influences sustainability outcomes in construction projects in the UAE.

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Table 1. Relevant studies to the research context

Author/Year	Title	Findings
Dabash, 2023	The Implementation of Agile Project Management Using BIM Influences on the Construction Industry in The UAE Sector.	Demonstrated the positive impact of integrating BIM with Agile methodologies on project efficiency in the UAE.
Khansaheb (2023)	The role of artificial intelligence in enhancing sustainability: The case of UAE smart cities.	Showcased the practical benefits of cloud-based platforms in enhancing construction project management.
El Khatib (2023)	Drafting a digital transformation strategy for project management sector–empirical study on UAE	Highlighted the efficiency and transparency gains from adopting digital tendering processes.
Smart Building Technologies (2024)	Digital Transformation Leading To Sustainability In The Landscape of UAE.	Emphasized the role of smart technologies in promoting sustainability and energy efficiency in construction.

Source(s): The study's authors

The research framework

This framework illustrates the relationships between key factors influencing digital transformation adoption in sustainable construction projects in the UAE. The insights from this framework will support construction firms in developing strategies that align technology investments, leadership practices, and market responses with an innovation-driven culture, ensuring smoother transitions toward digital project management and sustainability. Finally, there are one hypotheses identified in Fig. 1.

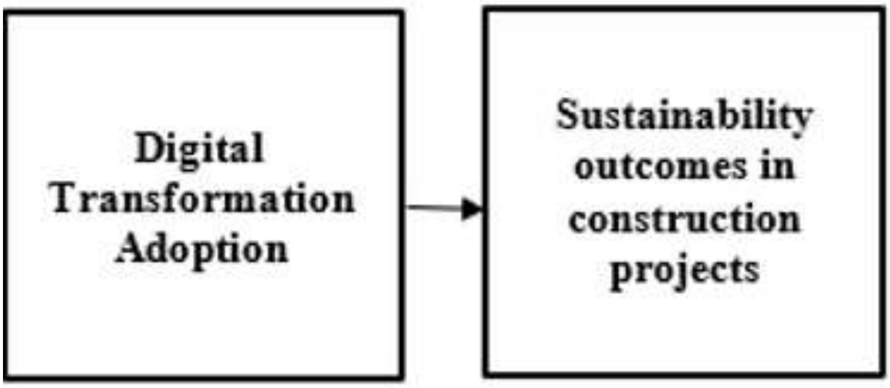

Figure 1. Research Framework

METHODOLOGY

In this research, A total of 500 questionnaires were distributed to contractors operating within the UAE construction industry, representing a cross-section of small, medium, and large enterprises. Out of these, 402 questionnaires were returned, yielding an overall response rate of 80.4%. However, after data screening, 31 questionnaires were identified as incomplete and were therefore excluded from further analysis. Consequently, 371 questionnaires were deemed valid and usable for statistical analysis, representing a usable response rate of 74.2%. The minimum sample size required for generalization was satisfied. Data collection was conducted over a six-week period. The completed responses were downloaded from the online data collection platform and analyzed using Smart PLS for structural equation modeling. The data were initially recorded and organized within the online platform according to the response structure before being exported for statistical analysis.

Demographic analysis

Table 1 shows the respondents profile for those who participated in the research. The results in Table 1 indicate that male respondents formed the majority at 60.9%, while female respondents accounted for 39.1%. This reflects the typical gender distribution within the construction industry, where male professionals tend to dominate operational and technical roles. In terms of age distribution, the majority of respondents (48.5%) were between 36 and 40 years old, followed by 31% aged above 40 years. This suggests that most participants are experienced professionals with substantial exposure to construction management practices and digital technologies. Regarding educational qualifications, a significant portion of the respondents held Master's degrees (60.6%), followed by PhDs (22.4%), Bachelor's degrees (13.7%), and Diplomas (3.2%). This indicates a well-educated workforce that is capable of understanding and implementing digital transformation initiatives within the construction sector. In terms of work experience, nearly half of the respondents (49.1%) had 4–6 years of experience, while 29.1% had more than 6 years. This distribution suggests that most participants possessed considerable practical experience, which enhances the reliability of their responses regarding digital transformation practices and sustainability implementation.

Table 1. Profile of Respondents (N = 371)

Demographic Variable	Category	Frequency	Percent (%)
Gender	Male	226	60.9
	Female	145	39.1
	Total	371	100
Age	20–25 years	9	2.4
	26–35 years	67	18.1
	36–40 years	180	48.5
	> 40 years	115	31
	Total	371	100
Education	Diploma	12	3.2
	Bachelor's	51	13.7
	Master's	225	60.6
	PhD	83	22.4
	Total	371	100
Experience	1–3 years	81	21.8
	4–6 years	182	49.1
	> 6 years	108	29.1
	Total	371	100

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Measurement Model Evaluation

The research model analysis includes a detailed evaluation of the measurement model to ensure the constructs meet the criteria for reliability and validity. The process incorporates assessments of factor loadings, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) to confirm that the measurement indicators adequately represent their respective constructs. The Cronbach's alpha values for all constructs exceed 0.70, ranging from 0.864 (DT) to 0.894 (SO), confirming excellent internal consistency (Nunnally & Bernstein, 1994). Similarly, the Composite Reliability (CR) values fall between 0.866 and 0.894, well above the 0.70 benchmark, suggesting that the items consistently measure their underlying constructs with minimal error variance (Hair et al., 2019; Sarstedt et al., 2022).. The Average Variance Extracted (AVE) values provide further evidence of convergent validity. Digital Transformation (DT = 0.759) and Sustainability Outcomes (SO = 0.596) exceed the 0.50 threshold (Fornell & Larcker, 1981), indicating that more than 50% of the variance in their indicators is explained by the latent construct, again exceeding the threshold for acceptable convergent validity. All retained items demonstrated solid loading values, further supporting the unidimensionality and internal reliability of the construct. These improvements are further summarized in Table 2, which displays the loadings, Cronbach's alpha, CR, and AVE values for each construct in the final model.

Table 2. Construct Reliability and Validity - Final Model measurements

	Loading	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
DT1	0.882	0.894	0.894	0.759
DT2	0.880			
DT3	0.879			
DT4	0.842			
SO1	0.744	0.864	0.866	0.596
SO2	0.800			
SO3	0.790			
SO4	0.807			
SO5	0.773			
SO6	0.714			

CR= Composite Reliability; AVE= Average Variance Extracted

Discriminate Validity

As displayed in Table 3, all HTMT values are below the conservative threshold of 0.85, confirming satisfactory discriminant validity across the constructs. The highest HTMT value is observed between Digital Transformation (DT) and between Sustainability Outcomes, (SO) which is within the acceptable limit (Tornatzky & Fleischer, 1990). Meanwhile, weaker correlations such as between Digital Transformation (DT) (0. 424), and between Sustainability Outcomes, (SO) (0.320), demonstrate adequate construct differentiation, ensuring that each latent variable captures a unique conceptual dimension. These results confirm that the constructs do not exhibit multicollinearity or conceptual redundancy, thus fulfilling the discriminant validity requirement. The measurement model therefore satisfies the conditions of both convergent and discriminant validity, providing a solid foundation for subsequent structural model testing and hypothesis evaluation.

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Table 3.The heterotrait-monotrait ratio of correlations (HTMT)

	DT	SO
DT	0.424	
SO	0.172	0.320

DT: Digital Transformation; SO: Sustainability Outcomes

Hypotheses Testing

Testing hypotheses is the most important test in the current research since it shows whether or not the goals of the research were met. The direct effect test effect test will be used to examine the hypothesis. The following Fig. 2 shows the results of the direct effect test followed by some explanations. Through the use of PLS-SEM, the research's hypothesis have been verified. A good match is suggested by the statistical finding. This is a hypothesis in the entire model. The t-value is taken into account when evaluating the structural relationships between the variables that have been identified for this research. In, the authors state that for a t-value to be deemed statistically significant, it must be 1.96 or above (one-tailed). The direct effect test, one sort of hypothesis testing, was employed in this research.

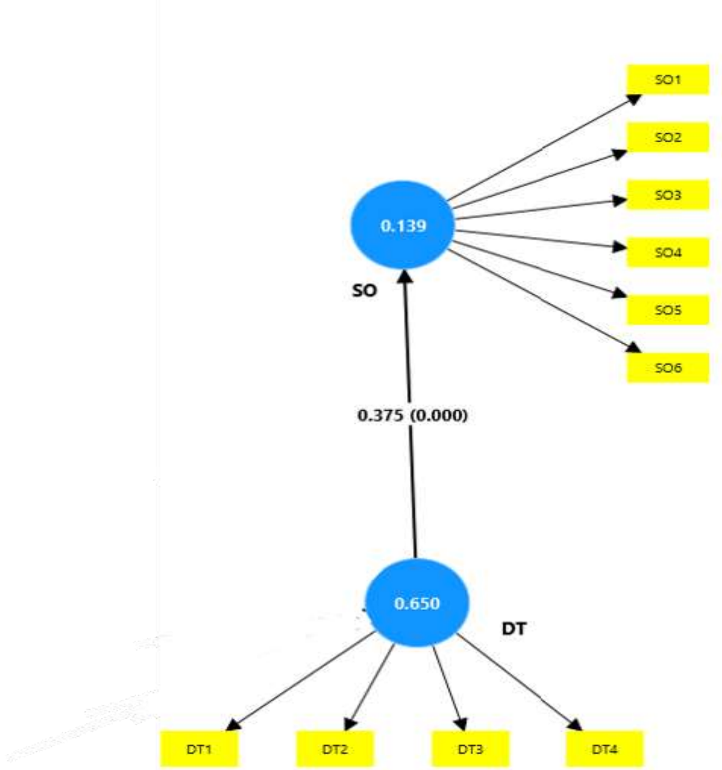

Fig. 2. Path Model Significance Results

This section presents the result of hypotheses testing for direct effect. The direct effect test aims to examine the relationships between the independent variables and the dependent variable. The direct hypotheses (H1) were evaluated through the bootstrapped path coefficients.

Table 4. Direct Hypotheses

Hypotheses	Beta	Sample Mean (M)	SD	T statistics	P values	Decision
DT -> SO	0.375	0.379	0.041	9.108	0.000	Accepted

DT: Digital Transformation; SO: Sustainability Outcomes

Regarding H1, the study confirmed that Digital Transformation significantly influences Sustainability Outcomes, though the relationship was negative ($\beta = 0.375$, $p < 0.000$). This result suggests that during the initial stages of digital adoption, sustainability performance may temporarily decline due to high implementation costs, resistance to change, and operational disruptions. However, previous literature indicates that the long-term effects of digital transformation eventually enhance sustainability by improving efficiency, reducing waste, and enabling data-driven decision-making (Ghobakhloo & Ching, 2019; Alassafi et al., 2024). Therefore, H1 is accepted, albeit with the understanding that the relationship is contextually dynamic and time-dependent.

DISCUSSION AND CONCLUSION

The UAE presents a unique context characterized by rapid urban development, strong government support for innovation, and ambitious sustainability goals. National initiatives and regulatory frameworks have accelerated the adoption of green building practices and digital technologies. However, the findings also suggest that the effectiveness of digital transformation is influenced by organizational readiness and industry maturity. While leading firms demonstrate high levels of digital integration, smaller organizations may face challenges due to limited resources and expertise. Studies indicate that 55% of contractors in the UAE still rely on manual processes for project management, leading to inefficiencies, cost overruns, and delays (Oke et al., 2023). This outdated approach is unsustainable in a competitive and increasingly digitalized global market. Digital transformation offers a pathway to address these inefficiencies by improving communication, reducing errors, and enabling real-time decision-making through data-driven insights (Ahmad, 2024). The results confirm that digital transformation adoption has a strong positive impact on sustainability outcomes across all dimensions.

The results demonstrate that sustainability performance in the UAE construction industry depends not on exposure to pressure or availability of technology alone, but on the organization’s ability to orchestrate these elements through transformation capability. These findings reinforce a capability-based view of digital transformation and advance understanding of how sustainability outcomes emerge in complex, regulated, and project-based industries.

In summary, the discussion highlights that digital transformation adoption significantly enhances sustainability outcomes in UAE construction projects. However, its success depends on strategic implementation, organizational readiness, and supportive external conditions. Addressing existing challenges and leveraging emerging opportunities will be key to achieving sustainable and digitally enabled construction practices in the UAE.

Theoretical And Practical Implications

This study contributes to the literature by empirically validating the relationship between digital transformation adoption and sustainability outcomes within the construction context. Collectively, these theoretical implications extend existing scholarship by integrating context sensitivity, capability mediation, and cultural contingency into a coherent explanatory framework. The study thereby responds to calls for more mechanism-oriented and context-aware theorization of digital transformation and sustainability, particularly in policy-driven and project-based industries.

For practitioners, the findings emphasize the importance of integrating digital transformation strategies with sustainability objectives. Construction firms should prioritize investments in technologies such as BIM, IoT, and data analytics to enhance project performance.

Policymakers in the UAE can play a crucial role by providing incentives, training programs, and regulatory support to encourage digital adoption across the industry. Developing a skilled workforce and promoting knowledge sharing will be essential for sustaining long-term transformation.

Project managers should also focus on change management strategies to overcome resistance and ensure successful implementation of digital initiatives.

Overall, the practical implication is clear: digital transformation should be treated as a strategic organizational program governed by leadership, enabled through structured change management, and evaluated over extended time horizons rather than as a short-term technology deployment. Over the long term, firms should align promotion criteria and incentive systems with demonstrated engagement in digital and sustainability initiatives to reinforce behavioral alignment.

The study also carries significant implications for policymakers and regulators, particularly given the dominant role of environmental factors in driving digital transformation. Taken together, the policy implications suggest that effective digital transformation governance in construction requires a balanced regulatory ecosystem that combines enforcement, incentives, and capacity-building to ensure inclusive, sustainable, and capability-driven transformation.

Limitations and Future Research

The study is limited by the absence of objective and longitudinal performance indicators, especially with respect to sustainability outcomes. Sustainability performance was assessed through respondents' perceptions rather than through verifiable metrics such as energy consumption records, carbon emissions data, waste reduction statistics, or lifecycle cost indicators. This constraint is important in light of the study's finding that digital transformation may exert short-term negative effects on sustainability, suggesting that performance impacts are likely to vary across different stages of transformation maturity. Without longitudinal or objective data, the study cannot empirically confirm whether negative effects persist, diminish, or reverse over time.

Taken together, these limitations do not detract from the study's contributions but instead clarify the interpretive boundaries of the findings. They underscore the need for caution in drawing causal or long-term conclusions and highlight the importance of complementary research designs to deepen understanding of sustainable digital transformation processes

Subsequent studies should incorporate objective, performance-based sustainability metrics alongside perceptual measures. Integrating quantitative indicators such as energy efficiency data, material waste reduction rates, carbon emissions, or lifecycle cost performance would strengthen empirical rigor and reduce reliance on subjective evaluation. Objective measures would be especially valuable in assessing the economic and environmental trade-offs associated with early-stage digital transformation and in validating whether sustainability improvements materialize as digital maturity increases.

While this study provides valuable insights, further research is needed to explore longitudinal effects of digital transformation on sustainability outcomes. Future studies could examine how digital adoption evolves over time and its long-term impact on project performance.

Comparative studies across different regions or industries would also help generalize the findings. Additionally, incorporating qualitative approaches could provide deeper insights into organizational dynamics and decision-making processes.

CONCLUSION

This study set out to evaluate the impact of digital transformation adoption on sustainability outcomes in construction projects in the UAE. Digital transformation plays a critical role in enhancing sustainability outcomes in construction projects in the UAE. By leveraging advanced technologies, organizations can achieve environmental, economic, and social benefits. However, successful implementation requires strategic investment, cultural readiness, and supportive policies. This study highlights the importance of integrating digital innovation with sustainability goals to ensure long-term industry growth and resilience.

This study makes a substantive contribution to the understanding of digital transformation and sustainability within the construction industry by empirically demonstrating that digital transformation is fundamentally a strategic and organizational journey rather than a purely technical undertaking.

This research underscores that the true value of digital transformation in construction lies not in the tools themselves, but in the strategic intent, organizational capacity, and cultural alignment that enable those tools to generate sustainable outcomes. By bridging theory and practice within a rapidly evolving and policy-driven context, the study offers a rigorous and contextually grounded contribution to the growing body of knowledge on sustainable digital transformation in project-based industries.

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