



RESEARCH ARTICLE

The Impact of Cloud-Based Construction Management Systems on Project Delivery in Nigeria

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Abstract

This study aims to evaluate the awareness and usage patterns of Cloud-based Construction Management Systems (CCMS) features, measure their impact on project delivery variables (time, cost, quality, communication, and safety), and identify primary barriers hindering holistic implementation. A quantitative research design was employed, utilizing a structured questionnaire distributed to construction professionals. Awareness of CCMS was analyzed using percentages and mean item scores, while the Relative Importance Index (RII) was used to rank the barriers to CCMS deployment. Following a Shapiro-Wilk test, which confirmed a non-normal distribution of the survey data ($p < 0.05$), the non-parametric Spearman Rank Correlation Coefficient was utilized to analyze the impact of CCMS feature usage on project delivery outcomes. Contrary to recent literature characterizing the sector as digitally resistant, the results reveal a robust awareness of core CCMS functionalities, including Real-Time Document Management (61%), Mobile Field Data Collection (69%), and Safety Inspections (55%). However, actual implementation remains fragmented and "spatial" rather than uniform. Correlation analysis confirms that CCMS usage significantly optimizes project delivery; specifically, Request for Information (RFI) tracking and mobile field data strongly enhance team communication at .68 and .72 coefficients respectively, while digital quality and safety inspections positively impact site health and safety with a coefficient of .85. The study identifies financial constraints (RII-.93), inadequate site infrastructure (RII-.89), and stakeholder misalignment (RII-.88) as the primary implementation barriers. Surprisingly, the "digital skills gap" ranked a distant fourth with RII of .85. Findings indicate a rapid upskilling of the modern construction workforce, proving that human capital and digital literacy are no longer the primary bottlenecks to technology adoption. To achieve comprehensive CCMS integration, industry stakeholders must pivot their focus from basic IT training toward resolving systemic, structural, and economic challenges.

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1. INTRODUCTION

The rise of cloud-based platforms is a key aspect of any industry's digital growth. Infusion of digital technologies and platforms into workflow processes has greatly enhanced business performance and their competitive edge by fostering sustainable practices and effective stakeholder engagement (Satyani & Febriyantoro, 2024). The Architecture, Engineering, and Construction (AEC) sector has equally experienced the emergence of digital platforms, such as Wikihouse, Sidewalk Labs, and Bosch IoT Suite, which aim to coordinate demand and supply-side actors (Chan *et al.*, 2020). In addition, the infusion of cloud-based systems into the Building Information Modelling (BIM) framework for managing construction

processes has been shown to enhance the construction workflow (Congiu *et al.*, 2023). Similarly, in today's world of dispersed projects, cloud-based systems in the management of construction have become highly valuable tools over the last two decades for achieving sustainable construction success, specifically by improving cost, quality, and time management targets (Kineber *et al.*, 2022; Menegon Lopes, & Silva Filho, 2024). As construction projects become more complex, fragmented, and fast-paced, these systems act as a centralized hub for real-time data, connecting field and office teams to reduce rework and delays. Therefore, Cloud-based Construction Management Systems (CCMS) have evolved from just gaining relevance to becoming essential in the digital transformation of the AEC sector over time (Forcada *et al.*, 2026).

Parsamehr *et al.* (2023) pointed out that the AEC industry has been trailing behind in the implementation of modern management concepts and novel technologies. The lag is due to negative issues that still affect management of construction projects such as the deployment of poor communication, coordination and management tools; interdisciplinary and fragmented teams; and use of non-interoperable Information Communication Technology (ICT) systems, which hinders cost, time, and productivity goals (Abd Aziz *et al.*, 2022; Prebanić & Vukomanović, 2021; Rasheed *et al.*, 2023). When tools lack interoperability and fail to transparently share information across different phases of a project, it stalls the implementation of innovative, integrated systems like BIM and forces project actors into disconnected silos (Norell & Stehn, 2024). Furthermore, a construction team's inability to transfer vital knowledge due to reliance on a single, inadequate medium for communication or utilizing outdated tools causes severe misunderstandings of design intent, poor cooperation, financial difficulties, delays, incidence of delivering critical information to the wrong stakeholders, and in many cases, project failure (Abd Aziz *et al.*, 2022; Taleb *et al.*, 2017; Rasheed *et al.*, 2023). Manual tracking and a lack of digital tools or skills worsen project visibility and collaboration, thereby causing teams to take inappropriate or delayed actions, directly leading to costly mistakes and extended timelines (Duarte-Vidal *et al.*, 2021; Chen *et al.*, 2024).

Historically, project management success was defined almost exclusively by the "Iron Triangle" - the interconnected constraints of delivering the agreed-upon scope of work within the allocated cost (budget) and time (schedule), while meeting the specified quality standards (Project Management Institute - PMI, 2021). Modern construction recognizes that the traditional triangle (time, cost, quality) is insufficient. Safety and communication are now primary parameters due to the high-risk nature of construction, making safety a prerequisite (Ibrahim *et al.*, 2024), and the fragmented teams in construction requiring seamless communication to prevent reworks and to keep projects on track (Hughes *et al.*, 2017).

This study aims to evaluate the impact of CCMS on the delivery (time, cost, safety, communication, and quality) of construction projects in Nigeria. This is achieved by assessing the current level of awareness of CCMS among construction professionals in Nigeria; examining the extent of utilization of CCMS among construction professionals in Nigeria; evaluating the effect of CCMS on construction project delivery in Nigeria; and identifying the barriers hindering the effective deployment of CCMS on construction projects in Nigeria.

2. RELATED WORK

Cloud-based Construction Management Systems (CCMS) are applications that focus on the effective implementation of construction management processes. They are internet-based software platforms that allow teams to plan, track, and manage projects in real time from any device. It centralizes documentation, budgeting, and communication, replacing traditional, disconnected, or paper-based methods to enhance collaboration between field and office teams (Prebanić & Vukomanović, 2021; Woodward & Mrozowski, 2020).

2.1 Components and Features of CCMS

Key components of the CCMS include a centralized data repository that stores blueprints, RFIs, submittals, and contracts in one secure, accessible location, ensuring everyone uses the latest versions (Bhzad & Sanad, 2012). Also, the platform allows for real-time collaboration by facilitating communication between professionals and stakeholders, while reducing errors and speeding up decision-making (Prebanić & Vukomanović, 2021). Furthermore, its mobile accessibility features enable field workers to access plans,

submit reports, and update project status from tablets or smartphones (Woodward & Mrozowski, 2020). The project control dashboard features tools for scheduling, budgeting, resource allocation, and expense tracking to keep projects on time and under budget (Forcada *et al.*, 2026). Finally, CCMS has automation functions that streamline workflows for tasks like submittals, payments, and reporting (Prebanić & Vukomanović, 2021).

2.2 Level of Awareness of CCMS in the AEC Sector

The AEC industry is gradually embracing digital transformation, and CCMS is gaining traction. Awareness is growing, but adoption varies significantly by geographic region, with many professionals recognizing benefits like scalability, cost-efficiency, and remote access.

Developed countries, such as the UK, USA, Australia, and Singapore, have a high level of awareness and adoption of CCMS, driven by government initiatives, industry standards, and technological infrastructure (Aftab *et al.*, 2023; Rinchen *et al.*, 2024). In contrast, developing countries face challenges in adopting CCMS due to limited resources, inadequate infrastructure, and a lack of awareness (Jaiswal *et al.*, 2024). Many construction professionals in these countries are still unfamiliar with CCMS concepts and benefits, hindering widespread adoption (Aftab *et al.*, 2023; Bello *et al.*, 2024). In a study of cloud computing awareness amongst AEC professionals in Nigeria, 96.2% of construction professionals were aware of cloud computing, with most adopting the concept (Oke *et al.*, 2021).

More broadly, the AEC industries remain “in the beginning levels of development” regarding IT infrastructure uptake compared to other sectors. Therefore, awareness exists but is inconsistent globally, with knowledge and implementation lagging awareness levels.

2.3 Benefits of CCMS in the AEC Sector

CCMS allows for real-time collaboration because of its web-based platforms (Prebanić & Vukomanović, 2021). This ensures all stakeholders (contractors, owners, consultants) work from the same, up-to-date information, reducing errors and miscommunication, which account for nearly 48% of project rework (Forcada *et al.*, 2026; Woodward & Mrozowski, 2020). Field crews can update daily logs, access blueprints, and submit RFI (Requests for Information) directly from mobile devices, eliminating paper-based, slow, or offline workflows because of its mobile field access (Woodward & Mrozowski, 2020).

Cloud-based solutions provide real-time budget tracking, helping to manage materials and labour to avoid the 4–6% cost overruns often associated with rework (Hughes *et al.*, 2017). In addition, digital tools enable rapid sharing of safety checklists and instant incident reporting, which is critical for maintaining safety standards on site (Ibrahim *et al.*, 2024). Furthermore, the ability to manage projects from anywhere remains a key feature for modern, flexible teams since the advent of the COVID-19 pandemic (Duarte-Vidal *et al.*, 2021; Chen *et al.*, 2024).

CCMS is particularly beneficial to the industry because of its low initial investment, unlike older on-premises software. Cloud-based systems have low upfront costs and do not require in-house server maintenance (Chen *et al.*, 2024). As a result, CCMS are expected to be fully integrated with other technologies such as BIM and Digital Twins and IoT Integration (Chan *et al.*, 2020). With the new Environmental, Social, and Governance (ESG) rules, these systems are becoming crucial for tracking carbon metrics and material usage (Zhang, 2025).

3. MATERIALS AND METHODS

This study employed a descriptive survey design. This design is ideal because it allows the collection of standardized, quantifiable data from many professionals regarding their experiences and perceptions without manipulating any variables (Saunders *et al.*, 2019). Active construction professionals were sampled. Specifically, Architects, Civil/Structural Engineers, builders, Quantity surveyors, and Planners within active construction organisations. To ensure high-quality responses, professionals sampled are employed within organisations registered with the Federation of Construction Industry (FOCI). These

organisations carry on high-profile projects across the geopolitical zones of Nigeria. Also, they are the most likely organisations to deploy CCMS for project delivery.

Five (5) questionnaires were sent to each firm to cover the professionals in the sample frame. The number of firms registered with FOCI is a total of 94 firms; therefore, 470 questionnaires were sent. The questionnaire used was constructed to elicit responses to address each objective of this study. Seventeen (17) project activity factors of CCMS were used for the study. Their impact on five (5) project delivery indicators was tested. The instrument of data collection has five sections, the first examining the responder’s demography and the second evaluating the awareness of the professional on CCMS implementation. The third section examined the extent of use of CCMS within the organisation, and the fourth section evaluated the impact CCMS features have on project delivery indicators of time, cost, quality, communication, and safety. Finally, the fifth section elicited responses on the barriers to the implementation of CCMS in the organisations sampled.

Descriptive and inferential statistical methods were employed for analysis using the SPSS 23 tool. Simple percentages were used to evaluate awareness of CCMS in the AEC sector, while the extent of use of CCMS for project delivery was analysed using mean item scores. Spearman’s rank correlation was used to analyse the impact of CCMS use on project delivery indicators, and the Relative Importance Index (RII) was used to identify barriers of note in relation to the project. To test the distribution of the survey data, the Shapiro-Wilk test was employed, as it is widely recognized as the most powerful statistical test for assessing normality across various sample sizes (Razali & Wah, 2011). After administering the Shapiro-Wilk test, the result indicated that the variables violated the assumption of a normal distribution ($p < 0.05$), non-parametric statistical methods were required. Following the guidelines established by Field (2018), the Spearman Rank Correlation Coefficient was selected as the appropriate test to measure the strength and direction of the relationships between CCMS feature usage and project delivery outcomes.

4. RESULTS

4.1 Response Rate & Demography

This study distributed 470 questionnaires to give every profession a chance to respond. This is meant to enhance diversity and improve research findings. Of the 470 sent out, 293 were returned. The response rate analysis is shown in Table 1. Also, key demographics of the respondents are presented in Table 2.

Table 1. Response Rate.

Respondents Profession:	No. in Sample	No. Returned	Response Rate
Architect	94	66	70 %
Quantity Surveyor	94	69	73 %
Civil/Struct. Engineer	94	74	79 %
Builders	94	58	62 %
Planners	94	26	28 %
Total	470	293	62 %

Table 2. Respondents’ Demography

Respondents Characteristics	%
Respondents above 35 years	85%
Respondents with Additional Degrees	55%
Respondents with more than 10 years’ experience	75%
Registered Respondents with Professional Institutions	81%

Experience of professionals for the study was sacrosanct, and the distribution shows a good percentage of matured professionals with 85% of the respondents above 35 years of age and 75% having more than ten years’ experience in the industry. In addition, the distribution showed that 55% has additional degrees with 81% being corporate members or fellows of their respective professional institutes. Hence, this confirms that most of the respondents have requisite experience to provide information for the study. All the participants are involved in the project delivery process with 92% being senior decision makers in the project delivery process of their organizations. This implies the respondents are strategic decision makers in the project delivery process for their organizations.

Civil/structural engineers, quantity surveyors, and architects rank highest amongst the professionals selected with 74%, 69%, and 66% respectively; builders are 58%, while planners are 26%. All the organizations sampled have more than 10 years' experience in the AEC sector of Nigeria.

4.2 Level of Awareness of CCMS in Nigeria's AEC Sector

The respondent's level of awareness regarding the following features typically found in Cloud-based Construction Management Systems (CCMS) was measured on a five-point Likert scale, with respondents who are completely unaware having a point of 1 and respondents who have experienced the use of the feature having 5 points. The data employed shows a normal distribution for descriptive statistics analysis. Figure 1 shows the distribution graph of the data set.

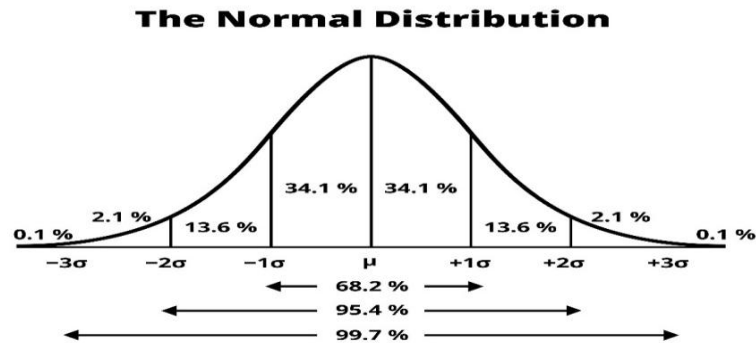


Figure 1. Standard Deviation of the Distribution

The percentage distribution of the respondents is presented in Table 3.

Table 3. Awareness of CCMS Features in the AEC Sector

Construction Management Features in CCMS	N	LA & UA Score 1-2	MA Score 3	HA & HU Score 4-5	Mean Score	(SD)
Real-Time Document Control (Blueprints, specs via device)	293	12%	27%	61%	4.2	0.85
Mobile Field Data Collection (Daily logs, site photos)	293	18%	13%	69%	4.1	0.90
Quality and Safety Inspections (Mobile checklists, punch lists)	293	15%	30%	55%	3.8	0.95
Schedule Integration (Live Gantt charts, timelines)	293	20%	35%	45%	3.6	1.05
RFI and Submittal Tracking (Automated workflows)	293	25%	30%	45%	3.4	1.12
Automated Budgeting and Cost Tracking (Financial health, change orders)	293	35%	35%	30%	2.9	1.30

LA = Low Awareness; UA = Unaware; MA = Moderate Awareness; High Awareness; Have Used; Standard Deviation; RFI = Request for Information

A significant number of respondents were aware of the features of CCMS, with real-time document control and mobile field data collection being most prominent. Quality and safety inspection is 5% above the average mark. These three features show strong consistency amongst respondents with low standard

deviations. Awareness wanes on the other three features with near-average awareness; the standard deviation, however, indicates a strong inconsistency in their responses.

4.3 Extent of Use of CCMS Within Construction Organisations in Nigeria

The respondent’s extent of use of the features in CCMS was measured on a five-point Likert scale of 1= Never Used and 5 = Always. Table 4 below shows the mean item score of the responses

Table 4. Extent of Use of CCMS Features in the AEC Sector

Construction Management Feature	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)	MIS	SD	Rank
Real-Time Document Control	2%	5%	12%	35%	46%	4.18	0.89	1
Schedule Integration (Gantt)	5%	8%	15%	40%	32%	3.86	0.92	2
Mobile Field Data Collection	10%	12%	20%	30%	28%	3.54	0.98	3
Automated Budgeting & Cost	15%	15%	25%	25%	20%	3.20	1.21	4
RFI and Submittal Tracking	18%	22%	25%	20%	15%	2.32	1.28	5
Quality and Safety Inspections	25%	25%	20%	18%	12%	2.27	1.35	6

LA = Low Awareness; UA = Unaware; MA = Moderate Awareness; High Awareness; Have Used; Standard Deviation; RFI = Request for Information

Real-time document control, Schedule Integration, and Mobile field data collection have the highest MIS, respectively, and showed high consistency in the responses received from professionals. Automated budgeting and cost tracking also have above-average MIS, but the consistency in the responses is low, judging from the standard deviation. RFI and submittal tracking, together with quality and safety inspections, have below average MIS

4.4 Impact of CCMS Features of Construction Project Delivery Key Indicators

The respondents were required to tick their perception of the impact the CCMS features exert on construction project delivery. Five (5) key indicators of cost, time, quality, communication, and safety were used for the study. The distribution of the construct was tested using the Shapiro-Wilk test. The outcomes from the test indicating the need for a non-parametric test are shown in Table 5. Subsequently, the Spearman Rank correlation, being a non-parametric test, was selected to test the impact of the CCMS features on the construction project delivery indicators, as shown in Table 6.

The assumptions of the Shapiro-Wilk Test of Normality will be predicated on the following hypothesis in relation to the data for the project delivery variables

(H₀): The data for this variable is normally distributed.

(H₁): The data for this variable is *not* normally distributed.

Table 5. Shapiro-Wilk Test of Normality

Project Delivery Variable	Statistic (W)	df	Significance (p-value)	Distribution Result
Cost Control Performance	0.882	293	0.003	Not Normal (Reject H0)
Time/Schedule Performance	0.845	293	0.002	Not Normal (Reject H0)
Quality Standards	0.910	293	0.012	Not Normal (Reject H0)
Team Communication	0.876	293	0.001	Not Normal (Reject H0)
Health & Safety	0.895	293	0.005	Not Normal (Reject H0)

The significance of all the variables is less than $p \leq 0.05$; all the null hypotheses were rejected, warranting a non-parametric test.

Table 6. Impact of CCMS On Construction Project Delivery in the AEC Sector

Variables	Cost Control	Time/Schedule Performance	Quality Standards	Team Communication	Health & Safety
Real-Time Document Control	0.35*	0.62**	0.45**	0.81**	0.22
RFI and Submittal Tracking	0.41**	0.75**	0.52**	0.68**	0.15
Mobile Field Data Collection	0.28*	0.58**	0.64**	0.72**	0.40**
Automated Budgeting & Cost	0.88**	0.32*	- 0.12	0.45**	0.05
Schedule Integration (Gantt)	0.55**	0.82**	0.25*	0.60**	0.18
Quality and Safety Inspections	- 0.20	0.15	0.78**	0.38*	0.85**

* Significance @ $P < 0.05$; ** Significance @ $P < 0.01$

Strong direct correlations can be observed across the variables. Real-time document control correlated with time/schedule performance and team communication. So also did RFI and submittal tracking correlating averagely with cost control but significantly with time/schedule performance, quality standards, and team communication. Mobile field data collection and quality and safety inspection both correlate weakly with cost control, but they correlate strongly with team communication and health and safety, respectively. The correlation analysis shows that the features impact on the appropriate project delivery indicator. The two negative coefficients (-0.12 and -0.20) are not statistically significant based on the study's $P < 0.05$ threshold. However, even as weak or statistically insignificant trends, they perfectly illustrate the classic, real-world trade-offs inherent in construction project management.

4.5 Barriers to Effective Deployment of CCMS on Construction Projects in Nigeria

Literature identified key barriers to the implementation of CCMS on construction projects. Respondents were requested to identify barriers with high importance affecting CCMS deployment in Nigeria. The Index was ranked, and the importance levels identify the importance of each factor (Trochim 2020). The Relative Importance Index values are presented in Table 7.

Table 7. Importance Level of Barriers to Use of CCMS on Construction Projects in Nigeria.

Constructs (Unobserved)	Variables (Observed)	Observed Variables			Unobserved Construct		
		RII	Rank	IL	RII	Rank	IL
Infrastructure	Internet Connectivity	0.9328	1	H			
	Internet Bandwidth in New Sites	0.8899	2	H	0.8964	2	H
	Power – Erratic Supply	0.8664	3	H			
Financial Constraint	Software Subscription Cost	0.8688	4	H			
	Foreign Exchange Rate	0.9636	2	H	0.9365	1	H
	Cost of Internet for Data	0.9656	1	H			
	Cost of Hardware	0.9478	3	H			
Digital Literacy	Inadequate Capacity Building	0.8575	2	H			
	Existing Staff Lack Digital Skills	0.8903	1	H	0.8576	4	H
	Project Team Skill Mismatch	0.8251	3	H			
Cultural Resistance	Older Professionals' Resistance	0.8344	2	H			
	Entrenched Traditional Methods	0.7870	3	HM	0.8263	6	H
	Management Support for Transition	0.8575	1	H			
Client Demand	Clients Digital Knowledge	0.9377	1	H			
	Incompatible Digital Tools	0.7781	3	HM	0.8507	5	H
	Mandate from Clients/Government	0.8364	2	H			
Project & Stakeholders	Consultants Digital Level	0.8291	4	H			
	Stakeholders Demand	0.9530	1	H	0.8887	3	H
	Funding Agencies Demand	0.9368	2	H			
	Type of Project & Complexity	0.8356	3	H			

H = High; HM = High Medium; IL = Importance Level

All the barriers have high importance levels. However, financial constraints and infrastructure provision for CCMS use rank highest amongst the barriers. Surprisingly, cultural resistance has waned to the least important barrier to the implementation of CCMS. Digital literacy is also given a high importance level, but it is coming as the fourth most important factor for the implementation of the CCMS in Nigeria.

4. DISCUSSION OF FINDINGS

The findings of this study represent a departure from the recent position established by Bello *et al.* (2024), indicating that industry awareness of CCMS has not expanded considerably. Whereas previous literature frequently characterizes the construction sector as digitally resistant, this research reveals a robust familiarity with operational features of CCMS, specifically Real-Time Document Management, Mobile Field Data Collection, and Quality and Safety Inspections. While core feature awareness is high, the data also

highlights fluctuating levels of familiarity across other system capabilities. This aligns with modern adoption theories (Aftab *et al.*, 2023; Oke *et al.*, 2021), which suggest that technological awareness in construction does not occur uniformly but rather develops in distinct tiers based on project roles and immediate operational needs.

The response rates and demographic profile employed for the study are highly appropriate and establish a strong foundation of validity for a study within the Architecture, Engineering, and Construction (AEC) sector in Nigeria. This is predicated on a robust core representation of key professionals, high data reliability through relevant experience of firms, adequate construction phase insights, and a clear acknowledged limitation in the number of planners. The disproportionately low response rate from Planners (28%) compared to Engineers (79%), Architects (70%), or Quantity Surveyors (73%), introduces potential skew in the "Schedule Integration" awareness data, reinforcing the premise that CCMS implementation remains highly siloed and fragmented across specialized project roles.

While the overall adoption of CCMS is gaining traction globally, the practical implementation of its features remains fragmented, especially in developing countries. Consistent with the findings of Alaloul *et al.* (2020) and Sepasgozar *et al.* (2023), who noted the construction industry's tendency toward uneven digital transformation, this study shows a highly heterogeneous implementation of core features. Specifically, tools such as Real-Time Document Management, Mobile Field Data Collection, Quality and Safety Inspections, and Automated Budgeting experience isolated or 'spatial' implementation, rather than uniform deployment across all project phases and roles.

The positive correlations identified in this study between CCMS feature usage and project delivery metrics are strongly supported by recent literature. For instance, Mambo *et al.* (2025) demonstrated that cloud adoption significantly optimizes time, cost, and quality metrics on-site. This aligns seamlessly with findings from Al-Mekhlafi *et al.* (2022), who confirmed that cloud computing drivers directly improve the sustainable success targets of construction projects, effectively mitigating schedule delays and budget overruns. This study includes the direct impact of CCMS features such as RFI and submittal tracking and Mobile field data on Team communication. In addition, Quality and safety inspection and mobile field data exerts positively on Health and Safety on construction projects.

The negative correlations observed in the data highlight the persistent, real-world trade-offs between cost, quality, and safety inherent in construction management. The slight negative correlation (-0.12) between automated budgeting tools and quality standards illustrates the risk of value engineering; when teams aggressively enforce budget limits, the pressure to cut costs often results in the use of cheaper materials or rushed execution, which can inadvertently compromise the overall quality of the build (Tran & Tarigan, 2022). Conversely, the negative correlation (-0.20) between rigorous quality and safety inspections and cost control underscores the practical reality that comprehensive assurance measures demand significant financial investment. Conducting thorough inspections requires dedicated personnel, extends timelines, and often necessitates costly rework or work stoppages, demonstrating that prioritizing high safety and quality standards directly conflicts with short-term efforts to minimize project budgets (Al Hawarneh *et al.*, 2021).

Despite the established positive impact of CCMS on project delivery, both localized and global data reveal a shifting hierarchy of adoption barriers. Comprehensive implementation remains heavily impeded by financial constraints, inadequate site infrastructure, and stakeholder misalignment. Interestingly, this study found that a lack of digital skills ranked as a distant fourth among implementation barriers. This finding presents a compelling contrast to earlier literature (Oesterreich & Teuteberg, 2016; Munir *et al.*, 2020), which historically positioned the 'digital skills gap' and lack of IT training as primary hurdles to technological adoption. Consequently, this lower ranking suggests a rapid upskill and a strong upward trajectory in the foundational digital literacy of modern construction professionals. This aligns with global trends showing a universally diminishing skills barrier due to rapid workforce upskilling (Aftab *et al.*, 2023), confirming that the construction industry's digital evolution has transitioned from foundational user education toward overcoming complex systemic and infrastructural challenges.

To maximize the benefits of Cloud-Based Construction Management Systems (CCMS), construction firms should shift their resources from basic digital training toward upgrading on-site infrastructure and

overcoming financial constraints. Because implementation currently remains fragmented, project managers must focus on integrating these tools uniformly across all project phases and roles while addressing stakeholder misalignment through collaborative, standardized workflows. Additionally, firms can secure immediate improvements in safety, communication, and overall time and cost efficiency by prioritizing the deployment of high-impact features such as mobile field data collection, quality inspections, and RFI tracking.

5. Conclusions

In conclusion, this study provides a highly nuanced perspective on the current state of Cloud-based Construction Management Systems (CCMS), challenging the traditional narrative that the construction sector remains inherently digitally resistant. The findings demonstrate that modern construction professionals possess a robust awareness of core CCMS functionalities, particularly Real-Time Document Management, Mobile Field Data Collection, and Safety Inspections. However, the data reveals that the transition from awareness to holistic implementation remains heavily fragmented. Rather than experiencing uniform, site-wide integration, CCMS deployment is currently characterized by a "spatial" or tiered approach, driven largely by immediate operational needs and isolated project roles, particularly within developing contexts.

Despite this heterogeneous adoption, the research unequivocally validates the immense value of CCMS when utilized. The study confirms strong positive correlations between the active use of specific cloud features and critical project delivery metrics. Beyond optimizing traditional parameters of time, cost, and quality, this research uniquely highlights that tools like RFI tracking and mobile data collection act as massive multipliers for team communication and site health and safety.

This study redefines the modern barriers to digital transformation in the built environment. The surprising revelation that the "digital skills gap" has fallen to a distant fourth among implementation barriers indicates a rapid, successful upskilling of the construction workforce. It proves that human capital and digital literacy are no longer the primary bottlenecks to CCMS adoption. Instead, the true hurdles are now structural and economic. To move beyond fragmented, siloed usage and harness the full potential of cloud-based systems, industry stakeholders must pivot their focus away from basic IT training and directly address the pressing systemic issues of financial constraints, deficient site infrastructure, and stakeholder misalignment.

References

- Abd Aziz, N., Mohd Rahim, F. A., & Aziz, N. M. (2022). Systematic Literature Review on Communication in Construction Project Management: Issues among Project Participants. *Journal of Surveying, Construction & Property*, 13(1), 52–70. <https://doi.org/10.22452/jscp.sp2022no1.5>
- Aftab, U., Jaleel, F., Mansoor, R., Haroon, M., & Aslam, M. (2023). Obstructions in BIM Implementation for Developing Countries: A Mini-Review. *Engineering Proceedings*, 45 (1), 26. <https://www.mdpi.com/2673-4591/45/1/26>
- Alaloul, W. S., Liew, M. S., Zawawi, N. A. W. A., & Kennedy, I. B. (2020). Industrial Revolution 4.0 in the Construction Industry: Challenges and Opportunities for Stakeholders. *Ain Shams Engineering Journal*, 11(1), 225-230. <https://doi.org/10.1016/j.asej.2019.08.010>
- Al Hawarneh, A., Bendak, S., & Ghanim, F. (2021). Construction Site Layout Planning Problem: Past, Present and Future. *Expert Systems with Applications*, 168, 114247.
- Al-Mekhlafi, A. B., Isha, A. S. N., Chileshe, N., Abdulrab, M., Saeed, A. A. H., & Makki, A. A. (2022). Exploring the Cloud Computing Implementation Drivers for Sustainable Construction Projects—A Structural Equation Modeling Approach. *Sustainability*, 14(22), 14789.
- Bello, A. O., Eje, D. O., Idris, A., Semiu, M. A., & Khan, A. A. (2024). Drivers for the Implementation of Modular Construction Systems in the AEC Industry of Developing Countries. *Journal of Engineering, Design and Technology*, 22(6), 2043-2062.
- Bhzad S. (2012) Potential Use of Communications and Project Management Systems in Remote Construction Projects: The Case of Saudi Electric Company, *Journal of Engineering, Project, and Production Management*, 2(1), 14-22

- Chan, P. W., Scott, L., & Neilson, C. (2020). Construction in the Platform Society: New Directions for Construction Management Research. *Management*, 396, 405.
- Chen, X., Chang-Richards, A., Ling, F. Y. Y., Yiu, T. W., Pelosi, A., & Yang, N. (2024). Digital Technologies in the AEC Sector: A Comparative Study of Digital Competence Among Industry Practitioners. *International Journal of Construction Management*, 25, 63–76. <https://doi.org/10.1080/15623599.2024.2304453>
- Congiu, E., Desogus, G., Frau, C., Gatto, G., & Pili, S. (2023). Web-based Management of Public Buildings: A workflow Based on Integration of BIM and IoT Sensors with a Web–GIS Portal. *Buildings*, 13(5), 1327.
- Duarte-Vidal, L., Herrera, R. F., Atencio, E., & Muñoz-La Rivera, F. (2021). Interoperability of Digital Tools for the Monitoring and Control of Construction Projects. *Applied Sciences*, 11(21), 10370. <https://doi.org/10.3390/app112110370>
- Field, A. (2018). *Discovering Statistics Using IBM SPSS Statistics* (5th ed.). SAGE Publications.
- Forcada, N., Peñaranda, F., & Roca, X. (2026). Guidelines for Implementing Web-Based Models for Construction Management: The Lack. In *eWork and eBusiness in Architecture, Engineering and Construction* (pp. 165-166). CRC Press.
- Hughes, D. L., Dwivedi, Y. K., Rana, N. P., & Simintiras, A. C. (2017). Information Systems Project Failure—Analysis of Causal Links Using Interpretive Structural Modelling. *Production Planning & Control*, 28(16), 1313-1333.
- Ibrahim, A., Zayed, T., & Lafhaj, Z. (2024). Enhancing Construction Performance: A Critical Review of Performance Measurement Practices at the Project Level. *Buildings*, 14(7), 1988. <https://doi.org/10.3390/buildings14071988>
- Jaiswal, S. V., Hunt, D. V., & Davies, R. J. (2024). Construction 4.0: a Systematic Review of its Application in Developing Countries. *Applied Sciences*, 14(14), 6197.
- Kineber, A., Oke, A., Alyanbaawi, A., Abubakar, A., & Hamed, M. (2022). Exploring the Cloud Computing Implementation Drivers for Sustainable Construction Projects—A Structural Equation Modeling Approach. *Sustainability*, 14(22), 14789. <https://doi.org/10.3390/su142214789>
- Mambo, A., Mogbo, O., Bamgbade, A., Haruna, A., & Haruna, L. (2025). The Impact of Cloud Computing on Construction Project Delivery. *Nile Journal of Engineering and Applied Science*, 2(2)
- Menegon Lopes, J., & Silva Filho, L. C. P. da. (2024). Adoption of Fourth Industrial Revolution Technologies in the Construction Sector: Evidence from a Questionnaire Survey. *Buildings*, 14(7), 2132. <https://doi.org/10.3390/buildings14072132>
- Munir, M., Kiviniemi, A., Jones, S. W., & Finnegan, S. (2020). BIM Business Value for Asset Management: Structural Equation Modelling Approach. *Engineering, Construction and Architectural Management*, 27(7), 1503-1525.
- Norell, M., & Stehn, L. (2024). Architects Coping with Continuous Fragmentation. *Architectural Engineering and Design Management*, 1–16. <https://doi.org/10.1080/17452007.2024.2400156>
- Oesterreich, T. D., & Teuteberg, F. (2016). Understanding the Implications of Digitisation and Automation in the Context of Industry 4.0: A Triangulation Approach and Elements of a Research Agenda for the Construction Industry. *Computers in Industry*, 83, 121-139
- Oke, A. E., Kineber, A. F., Albukhari, I., Othman, I., & Kingsley, C. (2021). Assessment of Cloud Computing Success Factors for Sustainable Construction Industry: The Case of Nigeria. *Buildings*, 11(2), 36.
- Parsamehr, M., Perera, U. S., Dodanwala, T. C., Perera, P., & Ruparathna, R. (2023). A Review of Construction Management Challenges and BIM-based Solutions: Perspectives from the Schedule, Cost, Quality, and Safety Management. *Asian Journal of Civil Engineering*, 24(1), 353-389.
- Prebanić, K. R., & Vukomanović, M. (2021). Realizing the Need for Digital Transformation of Stakeholder Management: A Systematic Review in the Construction Industry. *Sustainability*, 13(22), 12690. <https://doi.org/10.3390/su132212690>
- Project Management Institute (PMI). (2021). *A Guide to the Project Management Body of Knowledge (PMBOK Guide)* (7th ed.). Project Management Institute.
- Rasheed, A. S., Adebisi, R. T., Amuda-Yusuf, G., & Suleiman, S. (2023). Drivers and Barriers of Using Web-Based Asynchronous Communication Tools for Monitoring Construction Projects. *Journal of Engineering, Project & Production Management*, 13(2).
- Razali, N. M., & Wah, Y. B. (2011). Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling Tests. *Journal of Statistical Modeling and Analytics*, 2(1), 21-33.

- Rinchen, S., Banihashemi, S., & Alkilani, S. (2024). Driving Digital Transformation in Construction: Strategic Insights into Building Information Modelling Adoption in Developing Countries. *Project Leadership and Society*, 5, 100138.
- Saunders, M. N. K., Lewis, P., & Thornhill, A. (2019). *Research Methods for Business Students* (8th ed.). Harlow: Pearson Education.
- Satyani, F., & Febriyantor, M. T. (2024). Digital Technology's Role in Sustainable Business Models and Performance Enhancement. *Journal The Winners*, 25(2), 137-149.
- Sepasgozar, S. M. E., Khan, A. A., Smith, K., Romero, J. G., Shen, X., Shirowzhan, S., Li, H., & Tahmasebinia, F. (2023). BIM and Digital Twin for Developing Convergence Technologies as the Future of Digital Construction. *Buildings*, 13(2), 441. <https://doi.org/10.3390/buildings13020441>
- Taleb, H., Ismail, S., Wahab, M. H., & Rani, W. N. M. W. M. (2017). Communication Management Between Architects and Clients. *AIP Conference Proceedings*, 1891, 020136. <https://doi.org/10.1063/1.5005469>
- Tran, D., & Tarigan, P. B. (2022). Time Cost Quality Trade-Off in Repetitive Construction Project for Sustainable Construction Project, *Sustainability Management Strategies and Impact in Developing Countries*, Vol. 6. Eds., Mohd Fadhil Md Din, Nor Eliza Alias, Norelyza Hussein, Nur Syamimi Zaidi. <https://doi.org/10.1108/S2040-726220220000026007>
- Trochim, W. M. (2020). *Research Methods: The Concise Knowledge Base*. Atomic Dog Publishing
- Woodward, T., & Mrozowski, T. (2020). Digital Transformation in Construction: The Shift from Paper to Cloud. *Journal of Information Technology in Construction (ITcon)*, 25, 1-15.
- Zhang, X. (2025). Influence Mechanism of Digital Technology on Environmental, Social, and Governance (ESG) Responsibility Fulfilment of Construction Enterprises from the Perspective of Sustainability. *Journal of Asian Architecture and Building Engineering*, 1-23.