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Determinants of Unmanned Aerial Vehicle (UAV) Adoption for Real-Time Construction Monitoring in an Emerging Construction Market

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ABSTRACT

Digital technologies are becoming increasingly popular in the construction industry to enhance project performance, decision-making, and site operations. In this aspect, UAVs have proven to be useful technologies for providing real-time monitoring of construction sites, thus enabling efficient site surveillance, tracking of building progress, safety checks, and data gathering. Yet, while the benefits of UAVs have proven for the industry, many emerging construction markets are not widely using the technology. This study explores the determinants of UAV adoption for real-time construction monitoring, identifying the perceived benefits and challenges that could impact the adoption by construction professionals in Lagos State, Nigeria. The design of the study was quantitative, and primary data were gathered from construction professionals using a structured questionnaire. The data were analysed by descriptive statistics like Mean Item Score (MIS), Relative Importance Index (RII), and, as mentioned in the study, appropriate inferential statistical methods. The results show that construction professionals believe that there are substantial advantages to the use of UAVs, including the ability to improve project monitoring efficiency, enhance safety management, improve data accuracy, facilitate timely decision-making, and strengthen project documentation. Despite the various benefits offered by UAVs, some challenges limit their use, such as high acquisition and operational costs, inadequate technical expertise, regulatory uncertainties, battery limitations, and adverse weather conditions. Overall, the study finds that, although the operational benefits of UAVs are very attractive, technical, financial, and institutional challenges need to be overcome to ensure greater UAV utilisation in the construction industry. This study, which adds to the increasingly large body of evidence on the adoption of digital technology in construction, brings empirical evidence from an emerging construction market and provides useful learning for construction organisations, policy makers and professional organisations looking to accelerate the uptake of UAV technology into project monitoring practices.

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KEYWORDS: *Unmanned Aerial Vehicles (UAVs), Real-time construction monitoring; Technology adoption; Construction industry; Emerging construction market; Digital construction.*

1. INTRODUCTION

The construction industry is undergoing rapid digital transformation, with emerging technologies increasingly reshaping project planning, execution, and monitoring. One such technology, in particular, has garnered significant interest: Unmanned Aerial Vehicles (UAVs), also known as drones, which can deliver precise, timely, and cost-effective data for construction project management. The UAVs can enhance the visibility of the project and facilitate evidence-based decision-making by enabling real-time monitoring of the site, automated progress tracking, safety inspection, and high-resolution data collection, which is more difficult to achieve using conventional monitoring methods that mainly depend

on manual inspections and periodic site visits (Shakhatreh et al., 2019). As a result, UAV technology has emerged as a key part of the digitalisation strategy in the global construction industry. The drone market is booming as UAVs become more popular. The construction drone market is expected to reach USD 6.25 billion in 2025, which is a 12.73% CAGR from 2024, while the construction drone monitoring market is projected to grow from USD 412.12 million in 2024 to USD 845.71 million by 2030 (Grand View Research, 2024). This steady market expansion indicates a growing confidence in the use of UAVs for construction applications, underscoring their significance in improving project efficiency, safety, and monitoring.

UAVs are not just used for aerial photography in the construction industry; they can also be used for various other tasks, such as topographical surveys, volumetric measurements, safety checks, quality assessment, progress documentation, and real-time monitoring of construction activities. These capabilities extend to project monitoring, enabling stakeholders to have access to project information at all times, minimizing human risk in hazardous environments and allowing interventions when deviations from the project take place (Martinez et al., 2021). In addition, digital technologies enabling real-time monitoring and data-driven decision-making have been linked with improvements in organizational performance and competitiveness in the construction industry (Aliu et al., 2025). As a result, UAV technology has become an increasingly valuable tool to aid in the delivery of construction projects. Despite those acknowledged advantages, there are regional differences in the uptake of UAV technology. Since the early 2010s, the developed world has seen a gradual shift in the use of UAVs in construction practice, where top-tier contractors have started to use drones routinely as a part of their project operations as tools for surveying, monitoring progress, managing safety, and documenting projects (Irizarry et al., 2012; Zhou & Gheisari, 2018). According to Durdyev & Ismail (2019), in contrast, adoption rates in many developing countries have been rather slow despite its growing technological availability and its falling cost of acquisition.

Nigeria presents an interesting context for examining this disparity. Africa's biggest economy is still undergoing rapid urbanisation, substantial investments in residential, commercial, and infrastructure development, and has a growing need for efficient project monitoring systems (Adebayo & Ogundimu, 2020). Meanwhile, in Nigeria, construction activities have been facing constant problems such as project delays, cost overrun, poor monitoring of projects, and poor safety performance (Akanni et al., 2015). The technological readiness of using UAVs within construction projects seems to be growing in the country, as evidenced by the indigenous manufacturing of these drones and the increasing awareness of their usage. (Onososen et al., 2023), but there is evidence that UAV deployment within construction projects is not yet rampant. (Zhong et al., 2025) The gap between the technological possibilities and their application indicates that a number of factors still affect the decision to adopt this in the Nigerian construction industry.

Current research has primarily focused on proving the technical capability and operational use of UAVs in the construction industry, such as surveying, mapping, safety checks, and documentation of the construction project (Irizarry et al., 2012; Siebert & Teizer, 2014). These studies represent important evidence on the efficacy of UAV technology, but only limited analysis has focused on the factors impacting its adoption in nascent construction markets with significantly different economic, technical, regulatory, and industry environments than those in the developed world. Therefore, empirical evidence that explains why adoption of UAV technology is still limited is still inadequate. This is a crucial need to fill as it is essential to understand what drives and what slows the adoption of UAVs, as it is the basis for promoting digital transformation for construction industries in resource-limited environments. This type of evidence can help construction organisations decide on the investment in technology and help policymakers and regulatory agencies create enabling environments to promote responsible use of UAVs in construction. Thus, the purpose of this study is to investigate the determinants of UAV adoption for real-time construction monitoring in an emerging construction market by exploring the perceived benefits and perceived challenges influencing the adoption of UAVs by construction professionals in Lagos State, Nigeria. The study will help add to the existing body of knowledge on digital technology adoption in emerging markets and provide practical implications for construction organisations, technology suppliers, and policymakers wanting to help enable wider use of UAV technology in the monitoring of construction projects in Africa.

2. Literature Review

2.1. Perceived Benefits of UAV Adoption for Real-Time Construction Monitoring

The use of Unmanned Aerial Vehicles (UAVs) has revolutionized the monitoring of construction projects by delivering up-to-date, accurate, and detailed

information about the site, which improves the performance of the construction project. Instead of traditional monitoring, UAVs can acquire data quickly, monitor in real-time, and provide enhanced visualization of construction activities, which allows for more efficient project monitoring, eliminating the need for manual inspections on site and saving time and money (Irizarry et al., 2012; Siebert & Teizer, 2014). Several studies have been conducted on the use of UAVs to enhance monitoring of construction work by capturing high-resolution aerial images, creating three-dimensional maps, and automating progress tracking. These are used to help with the planning, quality control, and decision-making for the project, and also help identify construction defects and schedule deviations early on (Martinez et al., 2021). Another advantage of using UAVs in the field of health and safety is that they decrease the occupational risk of humans in hazardous locations during inspection, thus minimizing the risk to workers (Gheisari & Esmaeili, 2019).

UAV technology not only improves the efficiency of the operation but also makes the project documentation and communication between the project stakeholders more efficient. Accurate and up-to-date visual documentation enhances reporting, aids in dispute resolution, and provides project managers with reliable on-site information for timely decisions. Although these are acknowledged benefits, there is evidence that these benefits vary according to context, and the level of impact on UAV adoption is dependent upon specific construction market conditions, which vary between developed and emerging markets, especially in relation to technology, finances, and institutions. This shows that the perceived benefits that affect the adoption of UAVs in the construction industry in Nigeria need to be analyzed.

2.2. Challenges Influencing UAV Adoption for Real-Time Construction Monitoring

Although the advantages of UAVs (Unmanned Aerial Vehicles) are becoming well known, their use in the construction sector is limited due to various technical, financial, organisational and regulatory issues. These barriers have hindered the general adoption of UAV technology, especially in new construction applications where resources and institutional issues are greater. A common obstacle cited is the high cost of UAV acquisition, operation and maintenance. Other costs to the organisation include the cost of specialised software, equipment upgrades, personnel training and routine maintenance. Such investment costs can deter construction companies, particularly small and medium-sized, from adopting the use of UAVs for their future operations. Technical issues also have an impact on UAV adoption. The limited battery life, limited flight duration, weather sensitivity, and the need for skilled operators limit the versatility of UAVs in construction. Adverse weather, such as heavy rainfall and strong winds, may cause the flight of UAVs to be interrupted and can impact the quality of the data collected during the flight, which can reduce the reliability of UAVs for ongoing project monitoring. Moreover, there is a lack of trained personnel who can operate the UAV and interpret aerial data, which is a major challenge in the effective implementation of this.

There are also regulatory and institutional challenges that need to be addressed before UAVs are deployed on construction sites. Regulatory and institutional restrictions also add to the complexity of deployment of UAVs within construction projects. Aviation regulations exist to protect public safety, privacy, and airspace security; they apply to the operation of UAVs. But due to difficult approval processes, uncertainty with regulations, and limitations on flight activities, organisations may be reluctant to introduce UAVs into regular project monitoring. It is common to have limited institutional support and a lack of comprehensive implementation guidelines in emerging economies, exacerbating these challenges. There are also organisational factors that have an effect on the adoption of UAVs. Organisational resistance to technological change due to a lack of awareness of UAV capabilities and data security and privacy concerns can limit the willingness of organisations to adopt the technology. Also, project monitoring processes can be resistant to change in construction organisations when there are perceived risks in implementing the process that outweigh the perceived benefits.

While these are identified in other studies as problems in construction, in varying significance, the relative importance of these problems will depend on the economic, technological and regulatory environments in which organisations operate. This implies that the evidence drawn from the developed countries might not fully apply to understanding the factors limiting the use of UAVs in the emerging construction markets. Hence, understanding the challenges that affect the adoption of UAVs in the construction industry in Nigeria becomes crucial to determine the specific barriers and devise strategies for the industry to adopt the technology to facilitate the use of UAVs for real-time construction monitoring.

3. Methodology

A quantitative approach was used to elicit standardized feedback from construction professionals on the perceived benefits and challenges

to UAV adoption. The overall study included both semi-structured interviews and document analysis, but here the focus is only on the questionnaire data pertinent to the benefits and challenges that are perceived to affect the adoption of UAVs. The study was carried out in Eti-Osa Local Government Area of Lagos State, Nigeria. The target population included construction professionals who make decisions that relate to technology within construction organisations. This comprised project managers, architects, engineers, quantity surveyors, contractors, consultants and drone technicians in registered construction companies in Lagos State. The 36 registered construction companies in Eti-Osa Local Government Area were the sampling frame used. These companies had an estimated population of around 360 construction professionals, with an average of 10 professionals per organisation, across the identified professional categories. A sample size was obtained using Yamane's (1967) formula for a finite population at a 95% confidence level. The minimum sample size computed was 189 respondents, which was raised to 200 to enhance the power of the study and reduce the potential effects of non-response in accordance with the recommendation of Saunders et al. (2019). Professionals of various disciplines were included in the sample to provide good representation of important stakeholder groups in the construction project delivery process. A structured questionnaire was developed to meet the objectives of the study, and primary data were gathered through this questionnaire. The questionnaire used a 5-point Likert scale to get a sense of how important each benefit and challenge was to the respondents, allowing for a comparison of relative importance. The questionnaires were analysed using the Statistical Package for the Social Sciences (SPSS). The data were analyzed using descriptive statistical methods such as Frequency Distribution, Percentage, Mean Item Score (MIS), Standard Deviation (SD), and Relative Importance Index (RII). Mean Item Score and Relative Importance Index were used to identify and prioritize the perceived benefits and challenges affecting UAV use in real-time construction monitoring. Before the main data analysis, the internal consistency of the questionnaire was tested by Cronbach's Alpha, which resulted in the data measurement instrument being reliable when using the questionnaire.

4. Results and Discussion

4.1. Background Characteristics of Respondents

A total of 200 questionnaires were administered, and all were returned completed, which is a 100% response rate. High response rates were achieved through both online and direct personal administration of the questionnaire were obtained providing a robust dataset for analysis. The respondents had various educational backgrounds and experience in the field. The majority of respondents had a Higher National Diploma (36.5%), 30.5% a Bachelor's degree, 24.5% a Master's degree, and 0.5% a doctoral qualification. The results of this educational profile show that most respondents had tertiary education and therefore were appropriately qualified to give informed opinions on the adoption of UAVs in the construction industry.

In terms of professional roles, Civil/Structural Engineers (29.0%) were the largest group, followed by Quantity Surveyors (24.0%), Project Managers/Construction Managers (20.5%), Architects (18.5%) and UAV Technicians/Drone Operators (8.0%). The multi-disciplinary nature of the composition of the sample ensured that the study could reflect the voices of the main profession groups involved in the planning, building and monitoring of construction projects. In terms of professional experience, in terms of number of years, the highest percentage of respondents (36.5%) reported having experience between 6 and 10 years, 18.0% reported having experience between 11 and 15 years, 17.0% reported having experience of over 20 years, 14.5% reported having experience of 1 to 5 years, and 14.0% reported having experience of 16 to 20 years. There is a high proportion of mid-career and experienced professionals, which increases the quality of the results as people are likely to have a considerable amount of knowledge about the current and new digital technologies used in construction project monitoring and about how they are applied.

Table 4.2: Background Characteristics of Respondents

Characteristic	Category	Frequency (n)	Percentage (%)
Highest academic qualification	HND	73	36.5
	B.Tech./B.Sc.	61	30.5
	PGD	16	8.0
	M.Tech./M.Sc.	49	24.5
	PhD	1	0.5

Current job role	Civil/Structural Engineer	58	29.0
	Quantity Surveyor	48	24.0
	Project Manager/Construction Manager	41	20.5
	Architect	37	18.5
	UAV Technician/Drone Operator	16	8.0
Years of professional experience	1–5 years	29	14.5
	6–10 years	73	36.5
	11–15 years	36	18.0
	16–20 years	28	14.0
	Over 20 years	34	17.0

4.2. Perceived Benefits Influencing UAV Adoption for Real-Time Construction Monitoring

Benefits are analysed across four categories: safety, monitoring and progress tracking, cost and efficiency, and data quality and documentation. The RII interpretation threshold used is: RII ≥ 0.80 = High agreement; 0.60–0.79 = Moderate; < 0.60 = Low.

4.2.1. Safety Benefits

Table below presents perceived safety benefits. All five items returned RII values above 0.75, indicating broad agreement. Eliminating the need to access hazardous elevated areas (MIS = 4.06, RII = 0.812) and reducing worker exposure to dangerous situations (MIS = 4.03, RII = 0.8050) were both ranked first and second, respectively. Overall site safety management improvement ranked third (MIS = 3.95, RII = 0.7900), followed by monitoring compliance with PPE and safety protocols (MIS = 3.86, RII = 0.7720) and monitoring compliance at fifth (MIS = 3.77, RII = 0.7540). These findings are consistent with Gheisari and Esmaeili (2019), who identified hazard identification and worker risk reduction as the most widely recognised UAV safety benefits in construction.

Perceived Safety Benefits of UAVs

S/N	Item	MIS	STD	RII	Rank
1	UAVs eliminate the need for workers to access hazardous elevated areas for inspections	**4.06**	0.98	0.812	**1st**
2	UAVs can reduce worker exposure to dangerous situations on construction sites	**4.03**	1.10	0.8050	**2nd**
3	UAVs can help identify safety hazards before accidents occur	**3.95**	1.10	0.7900	**3rd**
4	UAVs can improve overall construction site safety management	**3.86**	1.01	0.78	**4th**
5	UAVs can monitor compliance with safety protocols and PPE usage	**3.77**	1.05	0.757	**5th**

Source: Field Survey, Scale: 1 = Strongly Disagree to 5 = Strongly Agree.

4.2.2. Monitoring and Progress Tracking Benefits

As shown in Table below, monitoring benefits attracted the highest RII values across all benefit categories. UAVs providing more comprehensive site coverage than traditional methods topped the category (MIS = 4.33, RII = 0.865), followed by enabling more frequent monitoring (MIS = 4.03, RII = 0.805). Within Perceived Monitoring and Progress Tracking Benefits section, enabling more frequent monitoring (MIS = 4.03, RII = 0.8-5) ranked second, and identify deviations from project schedules at an earlier stage (MIS = 3.93, RII = 0.768) ranked third. BIM integration for automated progress tracking returned the lowest score in the category (MIS = 3.29, RII = 0.658), consistent with the earlier finding that awareness of BIM-UAV integration is limited.

Perceived Monitoring and Progress Tracking Benefits

S/N	Item	MIS	STD	RII	Rank
1	UAVs provide more comprehensive site coverage than traditional monitoring methods	**4.33**	0.89	0.865	**1st**
2	UAVs enable more frequent monitoring of construction progress	**4.03**	1.02	0.805	**2nd**
3	UAVs help identify deviations from project schedules at an earlier stage	**3.93**	1.14	0.785	**3rd**
4	UAVs provide more accurate and objective progress assessment	**3.84**	1.13	0.768	**4th**
5	UAVs facilitate better coordination among project stakeholders	**3.66**	0.98	0.731	**5th**
6	UAVs can be integrated with BIM for automated progress tracking	**3.29**	1.02	0.658	**6th**

Source: Field Survey, Scale: 1 = Strongly Disagree to 5 = Strongly Agree.

4.2.3. Cost and Efficiency Benefits

The table below presents cost and efficiency benefit ratings. UAVs reducing time for site inspections (MIS = 4.18, RII = 0.835) and improving overall project efficiency (MIS = 4.07, RII = 0.813) were the strongest performers. Preventing costly errors through early detection (MIS = 4.01, RII = 0.8030) and reducing labour costs (MIS = 3.98, RII = 0.795) also scored well. UAVs providing a good return on investment returned the lowest score in the category (MIS = 3.82, RII = 0.763), with a standard deviation of 1.02, suggesting divergence in opinion. This ambivalence is plausible given the high equipment costs in the Nigerian context and the limited direct UAV experience among respondents from which to evaluate financial returns.

Perceived Cost and Efficiency Benefits

S/N	Item	MIS	STD	RII	Rank
1	UAVs reduce the time required for site inspections	**4.18**	0.98	0.835	**1st**
2	UAVs improve overall project efficiency and delivery timelines	**4.07**	0.91	0.813	**2nd**
3	UAVs help prevent costly errors and rework through early detection	**3.98**	1.03	0.795	**3rd**
4	UAVs reduce labour costs associated with monitoring activities	**3.96**	1.00	0.792	**4th**
5	UAVs reduce transportation costs for site visits	**3.84**	1.10	0.762	**5th**
6	UAVs provide a good return on investment for construction projects	**3.82**	1.02	0.763	**6th**

Source: Field Survey, Scale: 1 = Strongly Disagree to 5 = Strongly Agree.

4.2.4. Data Quality and Documentation Benefits

Table below presents data quality findings. UAVs providing higher quality visual documentation than traditional methods scored highest (MIS = 4.127, RII = 0.854), followed closely by generating more accurate site measurements and spatial data (MIS = 4.15, RII = 0.830) and generating data is more reliable than manual inspection reports (MIS = 4.02, RII = 0.804). UAVs facilitating better communication with stakeholders was the lowest-rated item (MIS = 3.82, RII = 0.763) but still fell within the 'Moderate-to-High' agreement range. These findings indicate broad consensus that UAVs enhance documentation quality in construction contexts.

Perceived Data Quality and Documentation Benefits

S/N	Item	MIS	STD	RII	Rank
1	UAVs provide higher quality visual documentation than traditional methods	4.270	0.843	0.854	1st
2	UAVs generate more accurate site measurements and spatial data	4.150	0.873	0.830	2nd
3	UAV-generated data is more reliable than manual inspection reports	4.020	0.844	0.804	3rd
4	UAVs provide better documentation for dispute resolution	3.945	1.003	0.789	4th
5	UAV data enhances transparency and accountability in project delivery	3.835	1.133	0.767	5th
6	UAVs facilitate better communication with clients and stakeholders	3.815	1.023	0.763	6th

Source: Field Survey. Scale: 1 = Strongly Disagree to 5 = Strongly Agree.

4.2.5. Summary of Perceived Benefits

The results showed that construction professionals perceived that UAV technology will provide a significant amount of benefits for real-time construction monitoring. In all four benefit dimensions (safety, monitoring & progress tracking, cost & efficiency, and data quality and documentation), the levels of agreement for each category were high, with Relative Importance Index RII values exceeding 0.75. The results indicate that respondents were aware of the benefits of using UAVs in the construction industry for better monitoring and management of construction projects. Monitoring and progress tracking was identified as the most influential dimension amongst the identified benefits. The most important benefit of using UAVs as compared with conventional monitoring methods was the ability to provide comprehensive site coverage (MIS = 4.33; RII = 0.865). Likewise, the ability of UAVs to facilitate more frequent monitoring and early identification of project schedule deviations was rated very highly, showing construction professionals see UAV technology as a valuable tool to enhance project control and aid timely decision-making. Safety-related benefits were also highly recognised. The elimination of the need for workers to access hazardous elevated areas during inspections was one of the most important perceived benefits (MIS = 4.06, RII = 0.812), closely followed by a reduction of workers' exposure to dangerous situations (MIS = 4.03, RII = 0.805). The results presented here reinforce the increasing recognition of the role of the UAV in safety management and how it can help to minimize the hazards associated with work in the construction industry. Regarding operational efficiency, respondents agreed that UAVs significantly reduce the time required for site inspections (MIS = 4.18; RII = 0.835) and improve the

overall project efficiency (MIS = 4.07; RII = 0.813). Consequently, respondents affirmed that UAVs produce higher-quality visual documentation than traditional monitoring methods (MIS = 4.13; RII = 0.854), while also generating more accurate site measurements and reliable project records that support project documentation and decision-making.

Summary of Perceived Benefits

Benefit Category	Highest-Ranked Benefit	MIS	RII	Rank
Safety	Eliminates the need to access hazardous elevated areas	4.06	0.812	3
Monitoring and Progress Tracking	Provides more comprehensive site coverage than traditional methods	4.33	0.865	4
Cost and Efficiency	Reduces time required for site inspections	4.18	0.835	2
Data Quality and Documentation	Provides higher-quality visual documentation than traditional methods	4.13	0.854	1

4.2.6. Discussion of Result

The results show that the main value of UAV technology for construction professionals is the ability to improve project monitoring, enhance safety, increase operational efficiency, and generate high-quality project information. The high comprehensive site coverage rating indicates how vital the ability to monitor timely and accurately is in construction project delivery. The results align with the results of Gheisari and Esmaeili (2019), where UAV technology plays a major role in ensuring construction safety, including improved hazard identification and reduced worker exposure to high-risk work areas. Likewise, the high scores for monitoring efficiency and documentation support the research of Irizarry et al. (2012) and Martinez et al. (2021), who found that UAVs improve project tracking, project documentation, and provide accurate and timely site information and decision-making. The comparatively low rating for return on investment indicates that while construction professionals are aware of the operational benefits of UAVs, there is still a degree of uncertainty in the Nigerian construction industry about the economic returns.

4.3. Challenges and Barriers to UAV Adoption on Nigerian Construction Projects

The study also identified some challenges constraining the adoption of UAVs in the construction industry in Nigeria. Generally, respondents viewed technical, organisational, financial and skill-related obstacles as significant barriers to large-scale adoption. Technical and operational challenges had the highest overall responses. Limited flight time and battery life of UAVs (MIS = 4.30; RII = 0.860) and adverse weather conditions (MIS = 4.25; RII = 0.850) were the top two challenges identified. In addition, a lack of qualified and licensed UAV pilots (MIS = 4.24; RII = 0.848) and a lack of organisational readiness for technology adoption (MIS = 4.17; RII = 0.833) were identified as significant constraints. Economic and financial challenges were also significant, with the high initial cost of UAV equipment as the highest ranked in the economic barrier category (MIS = 4.04; RII = 0.808).

Table 4.4 Challenges and Barriers to UAV Adoption on Nigerian Construction Projects

Barrier Category	Highest-Ranked Barrier	MIS	RII	Rank
Economic and Financial	High initial cost of UAV equipment	4.04	0.808	1
Technical and Operational	Limited flight time and battery life	4.30	0.860	1
Skills and Knowledge	Shortage of qualified and licensed UAV pilots	4.24	0.848	1
Organisational and Cultural	Lack of organisational readiness for technology adoption	4.17	0.833	1

The results show that the issues that restrain the adoption of UAVs go beyond the economic ones, but also technical, organisational and human aspects. The emphasis on battery life and weather conditions highlights the practical challenges of using UAVs for regular monitoring in tropical construction scenarios, where the duration of air time and climatic factors play a crucial role in the efficiency of the monitoring process. Similarly, having skilled UAV operators is also a challenge, which requires more investment in professional training and capacity development. The results of this study align with Irizarry and Johnson (2014), who found acquisition cost to be a recurring challenge for UAV adoption, and with Jeelani and Gheisari (2021), who indicated that technical constraints, regulations, and workforce capabilities are still major obstacles to UAV integration in construction practice. The organizational challenges found in this study also indicate that organizational readiness and management commitment, in addition to technology availability, are essential for successful implementation of UAVs, especially in the emerging construction market.

4.4. Qualitative Findings from Semi-Structured Interviews

Besides doing the survey, the study conducted five semi-structured interviews with construction professionals and a UAV service provider in Southwestern Nigeria, who were purposively. The study has included their profiles in the table below. Each interview took about 30- 45 minutes and was audio-recorded, transcribed, and thematically analysed. The results are presented according to the research objectives. Thematic analysis of the five semi-structured interviews corroborated the quantitative findings.

Profiles of the Interviewers

Code	Role	Organization Type	Years of Experience	Prior UAV Exposure
R1	Senior Project Manager	Large construction firm (Lagos)	18	Yes – procured drone services occasionally
R2	Quantity Surveyor	Private QS consultancy (Akure)	12	No – observed only
R3	Principal Architect	Architectural design firm (Abuja)	15	No – limited awareness
R4	Site Engineer	Mid-sized contractor (Ibadan)	8	Yes – personally flown a drone (hobby/construction)
R5	UAV Pilot / Service Provider	Specialist drone surveying firm (Lagos)	6	Extensive – core business

4.3.1. Qualitative Findings: Perceived Benefits

All five interviewees mentioned safety as the first benefit. R1 stated:
"You can go and take a look at a scaffold without anyone getting in or out on the ground – without a doubt that is a lot in a country like ours with our safety record."

R4 provided a practical example in which a trench was prone to collapse following heavy rainfall, due to which a drone was flown to locate the edge of the trench without putting anyone in danger. The second big benefit was progress reporting. R3 valued the fact that *"with a drone, you get a complete picture of the site in 15 minutes; a manual walk-around might take 2 hours and still miss some areas"*,

Opinions were more conservative regarding cost savings. R1 and R5 said that UAVs are beginning to be a cost-effective investment for companies in Nigeria, but R2 and R4 pointed out that the upfront investment is still a turnoff for some companies in the country. R5 continued

"The return will not be realised to a small contractor if they are paying ₦500,000 per flight unless they are involved in a very large earthworks project where volume accuracy makes millions of differences."

The respondents were very unanimous in their view that UAV data is better for documentation. R5 said:
"A measuring tape is not as accurate as orthomosaic maps when measuring over rough terrain, with the maps offering measurements within 2-3cm of accuracy.

R1 trusted UAV data enough to use it in claims negotiations when it is processed by a certified operator. R4 said that they don't feel *"you're still going to need a registered surveyor to certify the measurements"* from the drone, but agreed that it saves a lot of dispute. R2 and R3 saw value in having a weekly visual archive.

All respondent agreed that large-scale infrastructure/industrial projects are the most beneficial. *"Where a bungalow is involved, the drone is excessive, but when it comes to a road-building job that covers kilometres of ground, it's virtually required,"* R3 said. UAV deliverables to clients and consultants are usually valued higher than contractors are, as clients and consultants may not want to "show their hand." R5 reinforced*: "Some contractors say that the drone does not cover anything – delays, defects, everything is visible."*

4.3.2 Qualitative Findings: Barriers to UAV Adoption

Financial cost was almost always reported and listed in varying orders.
"The lack of a service market – there are simply too few reliable drone operators was the primary concern in R1, while cost was a secondary concern. R2 said that one of the main challenges for small companies is cost. *"But cost is high, yes, and if the value is obvious,* clients pay, R5 said. *"The larger issue is the regulatory headache."*

R3, R4 and R5 determined that there was a critical need for skills. R4: *"Even with a drone, I was the only one who knew how to fly it and when I was away, the drone remained in the box."* Even data processing skills are

scarce, R5 said*: "Flying is easy, turning 500 images into a 3D model takes specialized software and training, which is scarce in Nigeria."*

Both R1 and R2 emphasized management's risk aversion. R1 said, "*If the managing director never uses a drone, he will see it as an unnecessary expense and liability."* R4 said that the fear of the drone taking their jobs was raised by some of the labourers and even site supervisors: *"I had to tell them that it was there for a tool"*. In some instances, workers intentionally blocked drone flight by standing in the path of the drone or by creating dust until management explained to them the reason for the drone flight, R5 said. However, traditional monitoring approaches are very established, and architects may not find it possible to work without being physically present on site, said R3.

For Technical challenges (Q9), Weather was a significant issue for R4 and R5. R4: *"You may only have a couple of clear hours per week in the rainy season for flight time.* R1 said, "My project management system doesn't talk to the drone outputs well, so you need to do a lot of work manually to correlate the photos with the project schedule." R5 has confirmed that the majority of clients do not have the digital infrastructure needed to effectively put the UAV data to use beyond just viewing images.

5. Conclusion

The study explored the determinants of Unmanned Aerial Vehicle (UAV) adoption for real-time construction monitoring in an emerging construction market through a perception of benefits and challenges of the adoption amongst construction professionals in Lagos State, Nigeria. The results indicate that construction professionals are generally aware of the potential benefits of UAV technology in improving construction monitoring. Across the board, respondents recognized the improved site coverage, reduced inspection time, enhanced safety, and strengthened project documentation that UAVs provide, with strong confidence in the technology's ability to improve project performance and ultimately support informed decision-making. Yet the financial return on investment and low levels of awareness for BIM integration indicate that economic factors and digital maturity are still playing a role in decisions around adoption.

However, the study found that the perception of these technical, financial, organizational and skills barriers is limiting the use of UAV technology. The most prominent challenges related to adoption were limitations in battery life, adverse weather conditions, the high acquisition costs, shortage of qualified UAV operators, and the lack of organisational readiness. Moreover, the uniformity of the perceptions of these different groups of practitioners suggests that these barriers are not profession-specific, but rather industry-wide. This means that coordinated interventions are needed to support the adoption of UAVs as they involve multiple factors such as technological capability, workforce competence, organisational preparedness and investment capacity.

In conclusion, the study establishes that the limited adoption of UAV technology in the construction industry in Nigeria is not necessarily attributed to the absence of understanding of its benefits, but the current system could be a major impediment to its adoption. Smoothing out such impediments will be critical to ensure greater uptake of UAV technology to monitor construction projects and support the digital revolution in the construction sector in Nigeria.

6. Recommendations

The results of this study indicate that construction organisations need to focus on continuous capacity development by establishing specialized UAV training resources for construction professionals and creating strategies for incorporating UAV technology into regular project monitoring work. In addition, companies need to consider phased adoption strategies that allow them to progressively achieve operational advantages from the use of UAVs, while avoiding the financial costs of technology acquisition.

Professional organisations such as architects, engineers, builders and quantity surveyors need to include UAV-related skills within CPD programmes. Likewise, in higher education, the focus should be placed on improving curricula in the construction field to include UAV applications and other digital construction technologies so graduates will be better prepared to apply technology in a project delivery environment.

The study additionally calls upon the relevant government authorities and policymakers to create a more conducive regulatory framework by streamlining the process of approving UAV operations for construction activities and providing more detailed guidelines for implementing the sector. Furthermore, financial incentives should be provided for the development of digital technologies for construction to decrease financial obstacles and speed up the industry's adoption. The recommendations mentioned above will not only improve the use of UAVs in real-time construction monitoring but will also help to boost overall project performance, safety, and efficiency in the Nigerian construction sector.

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