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ASSESSMENT OF THE IMPACT OF DRONES FOR EFFECTIVE BUILDING CONSTRUCTION SITE PERFORMANCE

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ABSTRACT

The aim of this research is to examine the impact of drones in building construction industry in view of achieving effective construction site performance. The population of the study was made up of 611 participants and a sample size of 242 was obtained using Taro Yamane formula. Table of random numbers was adopted as the sampling technique. Well structured close-ended questionnaires were used as data collection instrument; the data retrieved were presented in tables and chart. Mean, standard deviation, ranking, and ANOVA were used to analyze the data. It was revealed from the findings of the study that drones technology has significant impact in building construction industry, and larger building construction sites tends to benefit more from the advancement in drone technology. This study concluded that the integration of drones in the construction industry has brought about transformative advancements in effectiveness, efficiency, accuracy, safety, and increase in productivity across all sectors of the construction process. As technology continues to advance globally, it is expected of drones to increasingly play a crucial role in shaping the future of the building construction industry, empowering professionals to achieve higher productivity, minimize risks, and deliver projects of exceptional quality with scheduled time and budgeted cost. It was recommended that since drones can be used to monitor sites from faraway, professional bodies in the construction industry should lobby the Government to enforce law that will encourage the use of drones on large construction sites so as to ensure adequate monitoring of construction activities to avoid shoddy works and mistakes that may lead to disaster.

Keywords*: Drone; Drone cost, Impact of drone, Drone efficiency*

INTRODUCTION

The construction industry, traditionally labour-intensive and time-consuming, is undergoing a technological revolution with the integration of

Unmanned Aerial Vehicles (UAVs). UAVs, commonly known as drones, are transforming various aspects of construction projects, from surveying and mapping to monitoring and inspection. According to Sriastava (2024), the reason behind inefficient practices and inadequately in the construction sector can be traced back to the fact that the sector has been slow to adopt technologies that can show instant results, like drone technology in construction. While several companies have adopted drones in construction, contributing to the global construction drone market, which was valued at $4,800 million in 2019, and is projected to reach $11,968.6 million by 2027, however, the adoption on a mass scale is still limited. According to Urwin (2024), drone refers to an aerial vehicle that receives remote commands from a pilot or relies on software for automatic flight. Drones display features like cameras for collecting visual data and propellers for stabilizing their flight patterns. Urwin further maintained that, a drone also called an unmanned aerial vehicle (UAV) is a broad term that refers to an aircraft that operates autonomously or by remote control, with no pilot on board and can offer a range of services ranging from package delivery to aerial photograph. The construction industry is vast, with many different jobs that need to the done to construct a building. Many potential risks can occur at a construction site, so it is essential to have regular inspections to identify any problem before they become more significant. As robotics technology advances, drones make construction sites safer and more efficient, with drones having the capability to augment operational safety, construction accidents are been reduced drastically (Rodriguez, 2022). With a unique aerial advantage and real-time data recording functionality, drone technology in the construction industry can increase efficiency, lower costs, and streamline workflows. Above all, drone technology empowers the construction industry with the right information at the right time, thus ensuring that the project gets finished within the time and budget (Sriastava, 2024).

Drones in construction and infrastructure have revolutionized the entire project life cycle, which helps construction companies regularly track the construction progress, streamline communication and decision-making, build detailed maps and 3D models, and keep site workers out of hazardous areas. Drones are a faster and safer alternative to traditional land-based surveying methods in construction projects. They can complete survey work in 60% to 70% less time and eliminate risks to personnel in rugged terrain (Unmanned Aircraft System, 2024). Drone with their downward-facing sensors like the thermal, multispectral, LIDAR, and

RGB, can capture a massive amount of aerial data in a short time. The data points help companies manage many challenges like costly and time-taking surveys, identification of construction mistakes, deadlines, penalties, and miscommunication between contractors and stakeholders. Drone technology in the construction industry also introduces new applications that were earlier hard to access or even track, such as inspecting hard-to-reach areas or optimizing construction sites as shown in Plate 1. As the domain grows, the use and impact of drones in construction will continue to grow. Here are the different benefits of drone technology in construction (Virtusa Engineering First, 2024).

Plate 1: UAVs revolutionizing construction through aerial surveys and inspections
Source: Bhoda (2024)

Construction industry professionals have long envisioned technological disruption to address common challenges of time and cost overruns to construction productivity and material wastage. Gone are the days when each task at these expansive project sites was to be carried out manually, as the use of technology innovations like robots, machine control, telemetric, and unmanned air vehicles (UAVs)/drones have taken over, ensuring maximum efficiency while reducing material wastage. Additionally, the rising complexities at the project sites justify the use of drones, which are usually preferred for tasks that are dangerous, dull, or dirty (Verma, 2020). Drones/UAV provides construction stakeholders with expansive, accurate, and precise spatial data. The data obtained through a drone can be

analyzed with engineering software and furthermore, can be overlaid on construction drawings. The data captured via each flight is processed through a photogrammetry software which is then used to create digital elevation models (DEMs), orthophotos, and 3D point clouds. A variety of secondary data products such as shape files, contour lines, and raster products are created when imported into a geographic information system (GIS). Furthermore, the overlaying of spatial data on CAD/construction drawings allows professionals to compare 'as designed" to "as built", thus enabling the identification of spatial mistakes well before they are executed on site (Verma, 2020).

Aim and Objectives of the Study

The aim of this research is to examine the impact of drones in building construction industry in view of achieving effective construction site performance.

Based on the aim of the study, the objectives are as follows:

i. To determine the cost components of drones/UAVS in building construction.
ii. To investigate impact of drones in building construction.
iii. To examine cost efficiency of drone in building construction

1.2 Research Hypothesis

H_0 : Significant difference does not exist between different building construction sites in the study area on the impact of drones for construction.

Cost Components of UAVS in Building Construction

According to Bhoda (2024), costs associated with acquisition of drones for building construction include:

i. Initial Investment: The initial cost of UAVs includes the purchase price of the drone, which can range from a few hundred to several thousand dollars, depending on the model and capabilities. High-end UAVs equipped with advanced sensors, cameras, and GPS systems can cost upwards of $10,000. Additionally, construction companies must invest in software for data processing and analysis, which can add another significant expense.
ii. Training and Certification: Operating UAVs in construction requires skilled personnel. Companies must invest in training programs to ensure that their staff are proficient in drone

operation and understand the regulatory requirements. The cost of training varies but typically includes the expense of obtaining certification from relevant aviation authorities, such as the Directorate General of Civil Aviation (DGCA) in India or the Federal Aviation Administration (FAA) in the United States.

iii. Maintenance and Repairs: UAVs require regular maintenance to ensure optimal performance and longevity. Maintenance costs include routine checks, software updates, and replacements of parts such as propellers and batteries. Accidents or crashes can also lead to repair expenses, which can be substantial depending on the extent of the damage.

iv. Insurance: Given the potential risks associated with UAV operations, insurance is a critical cost component. Insurance policies for UAVs cover liabilities arising from accidents, property damage, and personal injuries. The cost of insurance depends on various factors, including the type of drone, its usage, and the coverage limits.

v. Operational Costs: Operational costs encompass expenses related to the actual deployment of UAVs on construction sites. These include costs for data storage, battery replacements, and potential downtime during unfavorable weather conditions. Additionally, companies may need to allocate budget for data analysis and interpretation, which often involves hiring or contracting specialized personnel.

Impact of Drones in Building Construction

With a unique aerial advantage and real-time data recording functionality, drone technology in the construction industry can increase efficiency, lower costs, and streamline workflows. Above all, drone technology empowers the construction industry with the right information at the right time, thus ensuring that the project gets finished within the time and budget (Srivastava, 2024).

i. Topographic mapping: Following topographic maps is critical when it comes to planning large-scale construction projects. The maps help divulge design mistakes due to a lack of focus on terrains. Even though maps are crucial in a construction project, they are extremely expensive to build, leading to construction firms not prioritizing them. At the back of the expertise in terms of mapping wide areas, drones for construction sites come in handy when visualizing the site's topography, thus helping

projects be on schedule and budget. Moreover, the images produced by the different types of drones used in construction can be used for building 3D models enabling the construction workers to highlight issues in the pre-construction stage itself (Srivastava, 2024). Surveying and mapping construction sites using drones offers significant advantages over traditional methods, revolutionizing the field of land surveying and providing valuable data for design and construction processes. Surveying with drones involves capturing high-resolution aerial imagery that provides a comprehensive aerial perspective of the construction site (Choi, Kim, Na, 2023).

ii. **Tracking equipment:** The issue almost every construction manager faces is losing equipment on a job site. Using drone technology in construction can help workers do a flyover and assess if the material is where it is supposed to be. Another way it helps is recognizing if any equipment which should be terminated is still on-site, thus preventing expensive accidental damage. Drone use in construction can also be seen in identifying equipment malfunctioning. The recording feature that the different types of drones used in construction are equipped with can help identify challenges remotely and offer visuals that would help technicians with quicker diagnostics and repairs (Srivastava, 2024).

iii. **Quality control and remote monitoring:** Construction monitoring using drones is one of the top benefits of using the technology. It can generate aerial views that give clients a complete view of how the project is progressing, ensuring that their spending will not be wasted. Additionally, it helps better internal communication by sending real-time information to the teams involved in different project phases. Through drone construction monitoring, it becomes easy for different departments – engineering, construction managers, workers, and owners to access the data simultaneously and catch any prominent issue in the process. Drones provide an efficient and accurate method for monitoring construction progress throughout the project's lifecycle. By regularly capturing aerial imagery or conducting photogrammetry surveys, drones enable project managers to assess the status of different construction activities (Irizarry and Costa, 2016). The captured data can be compared against the project timeline, enabling progress tracking

and the identification of any delays or bottlenecks. Real-time progress monitoring allows for proactive decision-making and resource allocation adjustments to keep the project on schedule.

iv. **Surveillance:** According to a report by the National Equipment Register, more than $300 million worth of construction equipment gets stolen from job sites every year, making equipment security a key part of the job. When using drones in construction, the drone operator can quickly fly over to ensure that equipment is in a safe area, identify unauthorized individuals on-site, and take note of damage or theft in real time. With these practices, construction companies can save thousands of dollars that get spent on stolen equipment.

v. **Worker's safety:** Previously, construction workers had to climb roofs or use scaffolding for inspections, which was dangerous and limiting. With construction drones, you can ensure safety, inspect the entire site, and monitor in real-time (Rodriguez, 2020). According to the data reported by the National Safety Council, fatal construction injuries are estimated to cost $5 billion every year in the US alone. Now, while there are policies like the Occupational Safety and Health Administration in place that have penalties to the tune of $13,653 to $136,532 in case of violations, the incidents of workplace accidents are not seeing a downfall. Workers often climb on unsteady platforms, work in hazardous conditions, and use unsafe equipment. Using drones in the construction industry, construction managers can use videos to monitor the work site for safety concerns, ensuring that the site is suitable for working and does not pose any hazards (Srivastava, 2024).

vi. **Structural inspection:** Another use of drones in construction can be seen through the fact that they can be flown between structures to check their stability. Moreover, drones built with thermal sensors can identify heat leaks, electrical issues, and cold spots for construction quality analysis. Another use case of drones in terms of inspection can be seen in the planned maintenance of large-scale architectures like towers, bridges, scaffolding, and roofs – a task that can be handled in a few hours through drone technology in construction management.

vii. **Reduction in expenses:** Drones are more affordable than mobilizing a technical inspection team. For instance, when inspecting a tall building with cracks, drones can capture shots

inside and outside without the need for a crane or dedicated team (Rodriguez, 2020). The biggest impact of using drone technology in the construction industry in terms of expenses can be seen in surveys. A surveyor usually charges $100 per hour, while a drone surveyor works on a $120 per hour mode. However, a drone surveyor will only need to work 40 hours per calendar year, leading to $4800 annual surveying fees. On the other hand, a traditional surveyor will be required to work at least 1300 hours for a complete survey, costing a total of $130,000. Optimizing surveying costs will be substantial for large construction firms with complex, big-scale projects. Srivastava (2024) highlighted the different activities drones will be able to save on as: Construction site analysis, project planning and design, asset inventory, project collaboration.

viii. **Improved communication:** Drones facilitate effective communication among the construction team, enabling stakeholders to visualize and understand the progress of the project (Yang, Park, Vela, and Golparvar-Fard, 2015). This visual documentation of the construction site's evolution aids in coordination, reducing the likelihood of misunderstandings, and fosters a shared understanding of the project's status among all stakeholders. Drones enhance construction site communication by up to 65%. Real-time video data enables accurate and efficient information exchange among team members, eliminating communication problems caused by radios and cell phones.

Cost Efficiency of Drone in Building Construction

Alvarado (2024) highlighted that, drones reduce the need for expensive manual labour, lower the risk of costly project delays, minimize rework due to errors, and the high-quality data provided by drones leads to better resources management and reduced materials wastage. Bhoda (2024) concluded that, Construction Company that implemented UAVs for site surveys and inspections reported a 30% reduction in project timelines and a 25% decrease in overall project costs. Another company found that using UAVs for volumetric measurements of stockpiles improved accuracy and reduced material wastage, resulting in significant cost savings. Bhoda further highlighted cost savings and efficiency gains for use of drones in construction as:

i. Reduced Surveying and Mapping Costs: Surveying and mapping in construction projects require extensive manpower and time.

UAVs can perform these tasks more efficiently and accurately, significantly reducing labor costs and time. Aerial surveys conducted by drones as seen in Plate 1 can cover large areas in a fraction of the time required by ground-based surveys, leading to substantial cost savings.

ii. Enhanced Project Monitoring and Management: UAVs provide real-time data and high-resolution imagery, enabling better project monitoring and management. This capability allows for early detection of potential issues, reducing the likelihood of costly rework and project delays. Improved site visibility also facilitates better communication and coordination among project stakeholders, enhancing overall project efficiency.

iii. Improved Safety and Risk Mitigation: Safety is a paramount concern in construction. UAVs can perform hazardous tasks such as inspections of high-rise structures or confined spaces, minimizing the risk to human workers. By reducing the need for manual inspections in dangerous areas, UAVs contribute to lower insurance premiums and fewer workplace accidents, translating to cost savings.

METHODOLOGY

Research Design

The research design adopted was a survey study in an attempt to examine the impact of drones in view of achieving effective building construction site performance.

Area of the Study

This study was conducted in South East geopolitical zone of Nigeria. This is due to the fact that most individuals in the zone always embark on construction of buildings resulting to spending of huge amount of money especially in this season of economic meltdown.

Population of the Study and Sample Size

The study population comprised of registered building professional contractors (CORBON, QSRBN, ARCON, and STRUCT. ENG.) in South-East Nigeria making a total 611 participants and a sample size of 242 was obtained using Taro Yamane formula.

Data Collection Method and Analysis

In order to achieve the aim of the study, well structured close-ended questionnaires were designed to gather information from the professionals on the impact of drones in building construction industry. The data collected were presented in tables and analyzed using ANOVA.

MODELING AND ANALYSIS

Data Presentation

Table 1: Responses of the respondents on the impact of drones in building construction industry.

S/N	ITEMS	CONSTRUCTION SITES														
	Below are the impact of drones in building construction industry:	Residential					Commercial					Industry				
		5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
1	Topographic mapping	207	15	9	9	4	196	23	13	6	6	224	15	3	1	1
2	Tracking equipments	207	12	12	9	4	219	0	18	3	4	207	33	2	1	1
3	Quality control	189	29	9	13	4	233	6	1	2	2	225	16	1	1	1
4	Remote monitoring Surveillance	219	4	9	9	3	234	4	2	2	2	236	2	2	2	1
5	Worker's safety	162	35	32	10	5	213	23	4	2	2	224	10	6	1	1
6	Structural inspection	207	14	10	9	4	228	13	1	1	1	236	2	3	2	1
7	Reduction in expenses	196	31	4	9	4	225	14	1	3	1	230	11	1	1	1
8	Improved communication	230	4	4	4	2	236	3	2	2	1	230	10	2	1	1
9	Track construction progress	234	6	2	1	1	234	6	2	1	1	239	2	1	1	1
10	Increase efficiency	231	10	1	1	1	237	4	1	1	1	238	3	1	1	1
11	lower costs	173	58	11	1	1	192	40	2	5	5	230	10	1	1	2
12	Streamline workflows	161	69	6	6	2	207	34	1	1	1	230	11	1	1	1
13	Improved accuracy and Reduced	228	13	1	1	1	230	11	1	1	1	231	10	1	1	1
14	material wastage	222	17	2	2	1	230	9	2	2	1	238	3	1	1	1

Source: Authors Field Survey 2024

Table 2: Mean, standard deviation, and ranking of respondents responses on the impact of drones in building construction industry

S/N	ITEMS	CONSTRUCTION SITES								
	Below are the impact of drones in building construction industry:	RESIDENTIAL			COMMERCIAL			INDUSTRIAL		
		$\bar{x}$	SD	Rank	$\bar{x}$	SD	Rank	$\bar{x}$	SD	Rank
1	Topographic mapping	4.69	0.83	7th	4.63	0.88	11th	4.87	0.45	6th
2	Tracking equipments	4.67	0.84	8th	4.75	0.77	9th	4.82	0.49	7th
3	Quality control	4.58	0.91	11th	4.91	0.54	4th	4.90	0.43	5th

4	Remote monitoring Surveillance	4.74	0.82	6th	4.90	0.53	5th	4.93	0.45	2nd
5	Worker's safety	4.39	0.99	13th	4.81	0.59	8th	4.87	0.49	6th
6	Structural inspection	4.69	0.84	7th	4.91	0.43	4th	4.93	0.45	2nd
7	Reduction in expenses	4.66	0.84	9th	4.87	0.47	6th	4.92	0.42	3rd
8	Improved communication	4.86	0.64	5th	4.92	0.45	3rd	4.91	0.43	4th
9	Track construction progress	4.93	0.42	1st	4.93	0.42	2nd	4.95	0.37	1st
10	Increase efficiency	4.92	0.41	2nd	4.94	0.39	1st	4.95	0.38	1st
11	lower costs	4.64	0.64	10th	4.68	0.76	10th	4.90	0.49	5th
12	Streamline workflows	4.56	0.74	12th	4.82	0.49	7th	4.92	0.42	3rd
13	Improved accuracy and	4.91	0.43	3rd	4.92	0.42	3rd	4.92	0.41	3rd
14	Reduced material wastage	4.87	0.49	4th	4.91	0.47	4th	4.95	0.38	1st

Source: Authors Field Survey 2024

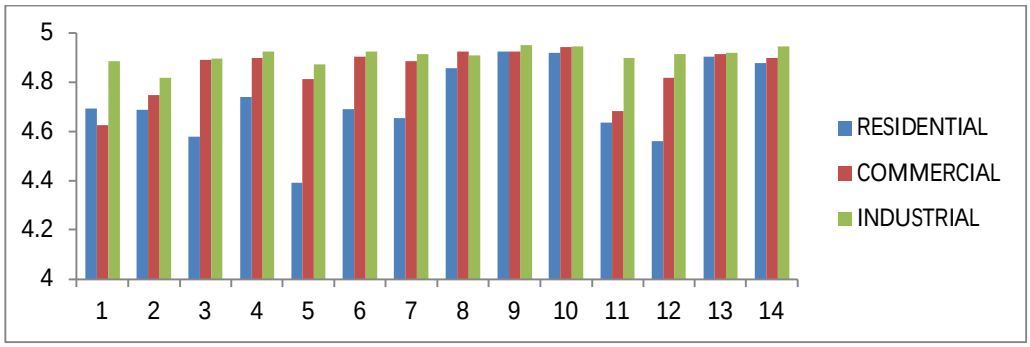

Figure 1: Bar chart of the mean responses of the respondents on the causes of accidents on building construction sites
Source: Authors Field Survey 2024

Inferential Data Analysis

Statement of Hypothesis

H_0 : Significant difference does not exist between different building construction sites in the study area on the impact of drones for construction.

Level of Significant: $\alpha = 0.05$
Test Statistic: Analysis of variance [ANOVA] was used to rate the frequency of the difference in agreement of the respondent on an opinion.

Rejection Rule: Reject H_0 if $P - value(Sig.value) < \alpha = 0.05$, otherwise accept.

Statistical Software Output (SPSS)

Descriptives

data

	N	Mean	Std. Deviation	Std. Error
1.00	14	4.7221	.15958	.04265
2.00	14	4.8500	.09915	.02650
3.00	14	4.9100	.03658	.00978
Total	42	4.8274	.13380	.02065

ANOVA

data

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.258	2	.129	10.555	.000
Within Groups	.476	39	.012		
Total	.734	41			

Post Hoc Tests

Multiple Comparisons

Dependent Variable: data

LSD

(I) code	(J) code	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-.12786*	.04177	.004	-.2123	-.0434
	3.00	-.18786*	.04177	.000	-.2723	-.1034
2.00	1.00	.12786*	.04177	.004	.0434	.2123
	3.00	-.06000	.04177	.159	-.1445	.0245
3.00	1.00	.18786*	.04177	.000	.1034	.2723
	2.00	.06000	.04177	.159	-.0245	.1445

*. The mean difference is significant at the 0.05 level.

RESULTS AND DISCUSSION

From the SPSS output above the estimated average value and standard deviation for the responses of the respondent stood as Residential ($mean$ = 4.722, Std = 0.159) and commercial($mean$ = 4.850, Std = 0.992)andindustrial(($mean$ = 4.910, Std =

0.037) respectively. This may imply difference in means. The least significance difference (LSD) of the multiple comparisons of the three variables under estimation in the post hoc test indicates that the mean difference is significant at the 0.05 level. Based on the data, there is sufficient evidence to reject the null hypothesis since $P - value$ = 0.00 < α = 0.05. Therefore, it was concluded that significant difference exists between different building construction sites in the study area on the impact of drones for construction. Drones are deployed on sites depending on the size of the construction, for large sites, drones perform exceptionally more than the cost involved in deploying it. The larger the site the more dangerous it becomes. This finding is in agreement with the conclusion of Verma (2020), the rising complexities at the project sites justify the use of drones, which are usually preferred for tasks that are dangerous, dull, or dirty.

CONCLUSION

Many potential risks can occur at a construction site, so it is essential to have regular inspections to identify any problem before they become more significant. As robotics technology advances, drones make construction sites safer and more efficient, with drones having the capability to augment operational safety, construction accidents are been reduced drastically. Drones are used in the construction industry to ensure safety of workers, topographic mapping and tracking, quality control and monitoring, inspection, save cost, and improve communication on sites. The roles drones play in the construction industry differs from site to site depending on the sizes of the construction site. A larger construction site tends to benefit more from drone technology compared to other sites. Therefore, the integration of drones in the construction industry has brought about transformative advancements in effectiveness, efficiency, accuracy, safety, and increase in productivity across all sectors of the construction process. As technology continues to advance globally, it is expected of drones to increasingly play a crucial role in shaping the future of the building construction industry, empowering professionals to achieve higher productivity, minimize risks, and deliver projects of exceptional quality with scheduled time and budgeted cost.

RECOMMENDATIONS

i. As creativity and innovations continue to advance in technology, construction industry stakeholders should always train their

workers in the sector to meet up with the latest trends technologically.

ii. Since drones can be used to monitor sites from faraway, professional bodies in the construction industry should lobby the Government to enforce law that will encourage the use of drones on large construction sites so as to ensure adequate monitoring of construction activities to avoid shoddy works and mistakes that may lead to disaster.

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