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Evaluation of Information Management Systems applicable to Construction Operations in Nigeria

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ABSTRACT

The construction industry in Nigeria is still lagging behind in using information management systems to carry out construction operations; especially with advanced information management systems known as construction 4.0 technologies. This lack of technological adoption increases cost and scheduling overruns, quality concerns, safety incidents, and generally inadequate stakeholder coordination and communication in construction operations. Hence this study evaluates the application of information management systems in construction operations in Nigeria with focus in South Eastern Nigeria. The study explored perception on the performance of construction projects in the region and the level of utilization of IMS in construction operations. Also the study in the literature unveil relevant construction 4.0 IMS such as cyber physical system (CPS), digital twin (DT) and unmanned aerial vehicle (UAV) systems that can be applicable in construction operations.Using a quantitative survey methodology, the study collected data from 329 construction professionals from among 1,203 professionals in South Eastern Nigeria who are architects, civil engineers, quantity surveyors, mechanical and electrical engineers, construction managers, and project managers—by means of a questionnaire. The data was analyzed using the SPSS software program, which also produced pertinent measures of dispersion and inferential statistical tests was conducted. The study results reveals that the most popular application of IMS in construction industry in Nigeria areproject management software (cost management software (Master Bills, WinQS, Excell Spreadsheet), design tools (AutoCAD and Build Soft), and planning tools (MS Projects and Primavera); Document management systems (MS Word, and MS PowerPoint etc); communication systems (emails etc);Enterprise Resource Planning (ERP) systems**.** It further shows thatthe application of IMS in Nigeria construction operations though growing is still at the nascent stage. The study recommends that the construction regulatory body in Nigeria must establish standardization and coordination policy on the use of IMS technologies in construction operations. This will solve software and technology interoperatibility challenges that professionals faced when handling projects.

Keywords: Construction 4.0, Construction Operations, Information Management System, Project Management

1. INTRODUCTION

The construction industry has been significantly impacted by the widespread use of information technology in the quickly evolving information era. Numerous parties, intricate contractual and economic relationships, a large volume of data, and distinctive project characteristics are characteristics of the construction sector [1]. As a result, Nigeria's construction sector is big and intricate, with many different stakeholders and projects [2].Therefore, given their uniqueness and unique qualities, effective management is essential to the success of projects and construction enterprises [3]. Information technology adoption and use is one way to guarantee reliable performance and high-quality results in building projects [4]. The construction sector has seen a substantial transformation because to IT solutions including project management software, communication tools, and 3D modeling access [5]. These technologies let builders make changes to ideas and drawings, post updates, save building times, and cut down on paperwork. Building information modeling (BIM) and other data-driven technologies have also completely changed the construction sector.

All things considered, the construction sector has seen substantial advancements and changes as a result of the incorporation of information technology. It increases efficiency and dependence on data, improves construction quality and safety measures, simplifies processes, and fosters cooperation and project management [6]. Information is controlled and distributed with the use of IT tools and software, which makes it accessible and helpful to project teams [7]. The construction sector might so gain from more output, lower expenses, and better project results.

However beyond the technology is information management systems. Information management has therefore emerged as a significant trend in the growth of the construction industry to enhance the management effectiveness and caliber of construction projects [6]. The use of an information management system may raise the standard of project management by digitizing, integrating, and automating the whole project process. Information systems collect, store, and process data and information in a variety of ways to produce facts that are shared as knowledge or digital goods [7]. Organizations rely on these systems for operations management and quality assessment [6]. The field of project management has also evolved, incorporating sophisticated information technologies that support decision-making and necessitate real-time data for all parties [8].

However, there are still some challenges and problems with the use of information management in the construction sector, particularly in developing nations like Nigeria. First of all, the construction industry's diverse and complex projects cause management procedures to become disjointed and uncoordinated, which makes the use of information management systems challenging and complex [9]. Second, implementing an information management system necessitates a certain level of investment and training expenses, and construction companies may encounter technical issues and resource limitations throughout the promotion and implementation phase [6].

Furthermore, it is necessary to thoroughly practice and validate the impacts and contributions of information management systems. Additionally, there has not been any standardization or coordination in the integration of information systems technology into construction project management [9]. Information system integration in construction operations in Nigeria is still disjointed, nevertheless. As a result, the construction sector continues to face quality issues, cost overruns, and ongoing coordination problems [6]. The main problem is that no one information system has been able to fully meet the diverse needs of all project departments and stakeholders.

Although technologies like BIM, ERP, and project management software have shown promise in enhancing certain elements of construction projects, their diverse implementation has not produced a comprehensive solution [10]. However, construction companies would not be able to easily increase efficiency, safety, sustainability, and profit across a project's life cycle if there were no standard best practices for technology adoption.Therefore, the purpose of this study is to evaluate the applicability of information management system technologies in construction operations in Nigeria. The specific goals include: (1) assessing the performance of construction organisations in South-East;(2) evaluate the important information management systems applicable to construction operations; (3) assess the level of utilization of information management systems in construction organization's operations in south east Nigeria.

This study's primary contribution is its thorough examination and synopsis of how information management is applied to enhance project management in the construction industry. The research findings may be used to help Nigerian construction companies implement information management systems more effectively, enhance project management quality and efficiency, and accomplish sustainable development. Beyond IMS application alone, however, the literature reviewed for this study will demonstrate the hybrid synergy between integrated data management and IMS application. Because distinct stages of design, building, and maintenance produce BIM data in various formats, IMS technology, also known as BIM process implementation, has difficulties when it comes to integrated data management and exploitation [11]. Therefore, in order to achieve high productivity and effectiveness in construction project management, it is critical to identify the major areas of application of information systems in a construction project. Additionally, it suggests IMS solutions based on AI for construction procedures.

2. LITERATURE REVIEW

2.1 Concept of Information Management System

Information technology is the foundation of a management information system, which is primarily used to transform unprocessed data from both internal and external sources into information [12]. Reports that help different departments within an organization make better and more informed decisions are then created using this data. Information management systems collect and process data from internal and external sources to expedite business decision-making, to put it short. In other words, management information systems are made up of a database that holds organizational data in a manner that makes it easier to create reports that expedite decision-making [13].To understand the fulcrum, the phrases "management," "information," and "system" are essential. Accordingly, the term "management" describes the part that makes use of human resources, primarily for the purpose of making decisions [12]. However, while the system operates using a set of rules or procedures that dictate how something is done, information is mostly driven by technology.

2.1.1 Components of Information Management Systems

The outputs of a system are where its goals are realised. Providing the members of the organisation with the proper outputs is the primary goal of an information system[14]. Every organisation is a component of a larger system. Information systems are utilised to provide management with performance feedback about the company. Feedback is defined as a system's outputs that are changed back into inputs to regulate the system's behavior [15]. Information systems are used to compare performance data with previously set standards. Managers can create corrective measures based on the information on the disparities, and these can subsequently be incorporated back into the company's operations [15](see figure 1 below):

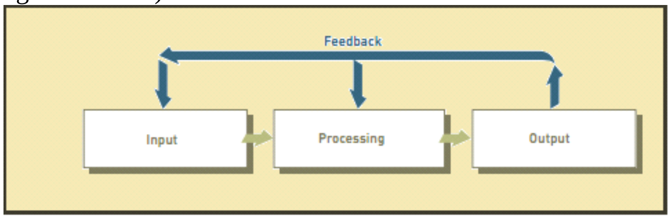

Figure 1: Components of Information management Systems[15]

Input: Input in information systems refers to the process of gathering and storing unprocessed data.

Processing: Processing in information systems refers to the conversion of data into meaningful outputs.

Output: Producing valuable information, often in the form of documents and reports, is what information systems output entails.

Feedback: Feedback in information systems refers to data obtained from the system and utilised to adjust input or processing operations. Decision-makers and managers alike need feedback [15].

Computer-Based Information Systems: A single collection of hardware, software, databases, telecommunications, personnel, and protocols that are set up to gather, process, store, and transform data into information is known as a computer-based information system (CBIS) [16].

Components of Information Systems: The general components of information systems (figure 2) are as follows:

- Hardware
- Software
- Databases
- Human resources
- Procedure

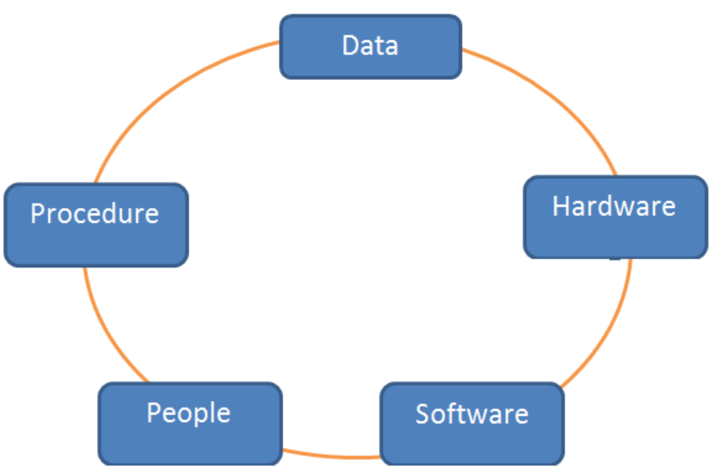

Figure 2: Components of Information Systems[16]

Databases: Programmes employ data, or facts, to provide insightful information. Normally, data are kept on disc or tape in a machine-readable format until the computer need them. Large data centres, various sizes of computers, the Internet, smart phones, and tiny computing devices may all store data [16].

Hardware: Hardware in an information system refers to the hardware, which includes the central processing unit (CPU) and all of its supporting components. Input and output devices, storage devices, and communications devices are examples of support equipment. Support equipment is made up of the actual parts of a computer that carry out the input, processing, output, and storage functions [16].

Software: Computer programmes and the manuals that accompany them are what it is. Instructions readable by a machine make up computer programmes. The computer programmes that control how the computer hardware functions are categorised as software. System software and applications software are the two main divisions of the software. The term "system software" describes the operating system, such as Windows, Mac OS, Ubuntu, and so on. Specialised software used to do commercial activities is referred to as applications software ([16].

People: In the majority of computer-based information systems, people are the most important component. These are the users who log daily business transactions into the information system. Professionals with the necessary qualifications, including accountants and human resource managers, are often the users. The support team that makes sure the system is operating correctly generally works in the ICT department [16].

Procedures: These are the rules that govern how a computer system operates. User manuals may provide recommendations that serve as procedures. The strategies, policies, practices, and guidelines for using the CBIS, including computer security, upkeep, and operation, are all included in the procedures [16].
Information systems are an essential component of modern organisations and organisations. They are made to assist with management tasks and help decision-makers make informed choices that will lead to success and a competitive edge [16]. Management theorists define it as an information system, which is any structured set of personnel, hardware, software, data resources, communications network, and other elements that gathers, processes, and distributes information inside an organisation.

2.2 The Role of Information Systems in Construction Project Management

Computer-based systems collect, filter, process, store, and distribute information, which is then used to support organizational decision-making and improvement practices [17]. These types of data from the systems administration of building projects are completely the same since businesses get a great deal from the procedure. The project stakeholders benefit from improved sharing, cooperation, and communication as a result [6]. There has been some sort of baseline towards improved performance with greater outputs but at cheaper prices and higher quality simply because information systems have emerged in building operations [6]. Given the central location it provides for project managers to observe a variety of drumbeats, identify potential risks, and make decisions based on real-time information, information systems have a significant amount of power in project management.

2.2.1 Information Management System Technologies Applicable in Construction Operations

A wide range of information systems, such as enterprise resource planning (ERP) systems, building information modeling (BIM), project management information systems (PMIS), collaboration and communication tools, and more, can be used in construction processes.

Project Management Information Systems (PMIS)

A digital tool called a project management information system is designed to give practitioners a comprehensive range of options for planning, scheduling, monitoring, and controlling [18]. According to [19], a project manager may use a PMIS to track project performance in connection to daily choices about their difficulties and foresee potential dangers while making such decisions based on timely data. Generally speaking, PMIS will help improve data display and interaction between stakeholders by providing a standard platform. Figure 3 below shows the features of a PMIS:

Figure 3: Features of a PMIS [20]

Building Information Modeling (BIM)

BIM is a digital representation and display of a project's functional and physical characteristics [21]. By providing project stakeholders with a common platform for exchanging and visualizing data, BIM makes collaboration easier. By reducing errors, making construction easier, and assisting with maintenance, BIM makes it possible to provide better project outcomes [22]. Figure 4 below shows the BIM maturity levels:

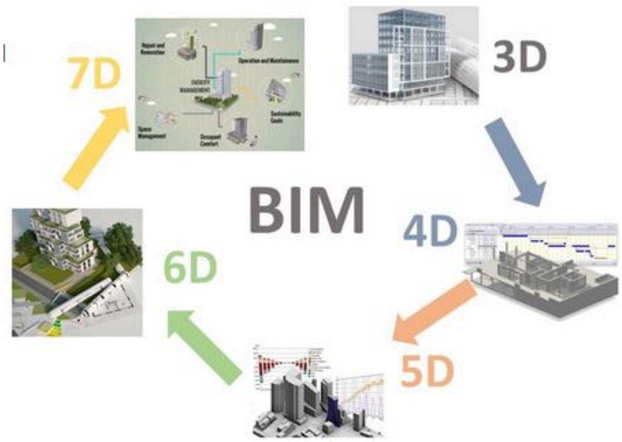

Figure 4: BIM Maturity Levels [23]

Enterprise Resource Planning (ERP) Systems

ERP systems are computer programs that integrate the departments of project management, financial management, procurement, and human resources with various corporate processes [24]. ERP systems (figure 5) facilitate stakeholder exchange of project data and may provide aggregated project data [24]. It has the ability to improve organizational performance, save operating costs, and streamline business processes in addition to enhancing project outcomes [24].

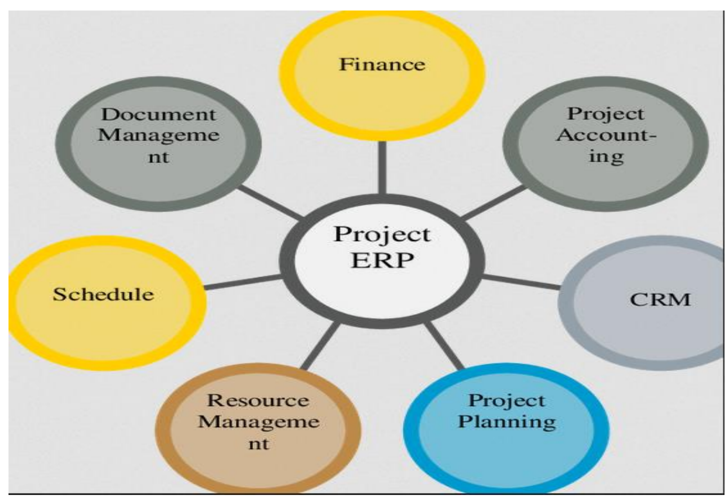

Figure 5: ERP in Project Management [24]

Collaboration and Communication Tools

To help with communication, the project's many stakeholders employ methods including video conferencing, instant messaging, and email [25]. This assignment can help the team make the best choice in addition to bridging communication barriers [25]. Tools like communication and teamwork are also seen to be the key to a successful project [25]. Thus, they promote connections, lessen miscommunication, and ease the exchange of knowledge.

Integrated video conferencing

The construction sector has historically struggled with communication, which was made worse by a worldwide lockdown that made project teams work from a distance[26]. As information moves from owners to project managers to contractors, it is much too frequently distorted, which eventually causes delays in the timeline and even financial losses. Zoom, Google Docs, and shared files are just a few of the numerous communication technologies that may be used to aid, but spreading information over so many platforms will only make the issue worse [27]. The benefits of project management solutions with fully integrated video conferencing are unmatched for construction teams.
Instead of utilizing other systems and tools to refer to pictures, problems, or financial information, construction teams may use project management platforms with integrated video conferencing to keep track of all conversations and activities together with project data records [28]. By issuing meeting minutes, allocating tasks, and monitoring all follow-up on a single platform, integrated video conferencing(figure 6) solutions allow users to end meetings with a clear plan of action [28].

Figure 6: An Example of an Integrated Teleconferencing in a Project [28].

Other Specialized Information Systems

Safety management systems, quality management systems, and cost management systems are additional systems that may be tailored for information systems within construction projects. These could provide various features to meet specific project requirements. For example, quality management systems guarantee adherence to standard standards, whereas safety management systems are able to detect and remove safety hazards [25]. Cost management systems may be used to determine project costs, identify areas for cost reduction, and allocate resources as efficiently as possible [25].

2.3 Construction 4.0 Information Management System

Construction 4.0 is only starting to take hold, even though the Building Information Modeling (BIM) methodology has played a significant role in facilitating the digital revolution of the construction industry [29]. Even while experts agree that it will be a significant shift for the sector, clear definitions are still hard to come by. Remembering that this revolution's roots are in the First Industrial Revolution (mechanization), the Second Industrial Revolution (electrification), and the Third Industrial Revolution (automation) appears helpful in placing it in its global perspective. Based on pervasive connectivity, the Fourth Industrial Revolution (Industry 4.0) promises to drastically enhance company operations[29].
International agreement on the true meaning of the term "Construction 4.0" is still lacking. Others see it as a way to find a logical complementarities between the primary emerging technological approaches in the construction industry, while others define it as a straightforward and pure instantiation of the concept of Industry 4.0 in construction (that is, the use of ubiquitous connectivity technologiesfor real-time decision-making) [30]. Others, however, view it as a more comprehensive strategy that goes beyond the basic technological foundation to better address the issues facing the sector today [29]. Regardless of how it is defined, the main shift brought about by Construction 4.0 appears to center on a decentralized connection made possible by pervasive connectivity between the real and virtual worlds. Through technical methods like BIM, the link between these two worlds is already there in the construction sector [29]. The Internet of Things, Digital Twin, additive manufacturing, UAV, cloud computing, Cyber-Physical Systems (CPS), and, of course, BIM are the primary technologies that comprise Construction 4.0, although it is not restricted to just those.

2.3.1 Some of Construction 4.0 Information Technologies

Cyber-Physical Systems (CPS) Information Management

Cyber-Physical Systems (CPS) are designed systems that combine physical and computational components. CPS uses real-time data analysis and complex algorithms to monitor and manage physical processes [31]. CPS gives machines the ability to make decisions on their own, adjust to changing circumstances, and perform better in a variety of ways by integrating intelligence into physical things and situations. Because of the enormous amount of data in cyber physical systems (CPS), big data approaches are constantly used to handle and store the data [31]. Massive heterogeneous data streams that are gathered from independent sources and processed in distributed data storage systems are the focus of big data in CPS. The size, complexity, and rate of data availability necessitate the development of new methods for examining and interpreting valuable information from massive information streams [32] (figure 7). This presents difficulties for the design and administration of CPS in a number of areas, including performance, energy efficiency, security, privacy, reliability, sustainability, fault tolerance, scalability, and flexibility[31].

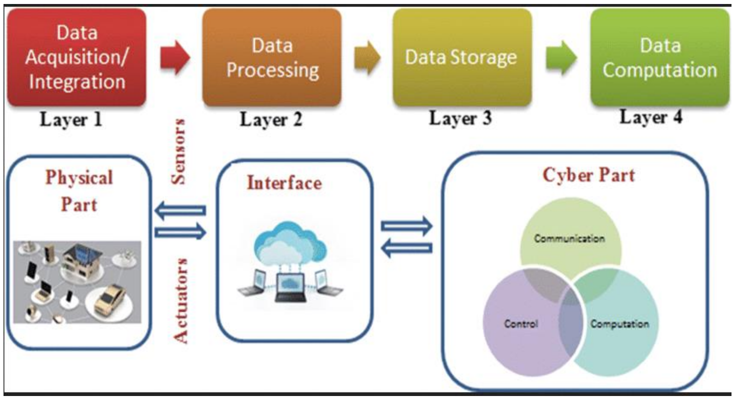

Figure 7: Data Process in CPS[32].

Digital Twin Information Management System

Over the past ten years, the manufacturing, production, and operations sectors have seen the emergence of the "digital twin" (figure 8) idea for data-centric management of a physical system [33]. Generally speaking, digital twins are current digital representations of a system's functional and physical characteristics. A system could be a composite system (like a building project, which combines elements of social and physical systems), a biological system (like a patient), a social construct (like the stock market), or a physical instrument (like an airplane engine).

The nature of digital twins in the built environment is reflected in the UK's definition of a "National Digital Twin" (NDT), which is defined as an interconnected ecosystem of digital twins that each model a component, a system, or a system of systems of buildings and infrastructure, connected via securely shared data [33]. To direct the creation of the UK's NDT, a set of nine guiding principles known as the Gemini Principles has been developed [34]. Some of the principles are unique to digital twins in the public domain (public good in perpetuity, openness, and evolution), while others are relevant to the development of the fundamental concepts for DTC (requirements for value creation, provision of insight, security, quality, federation, and curation). They do not offer the level of function detail required to outline DTC needs. In construction, digital twins are a new phenomenon and is based on the foundation of BIM.

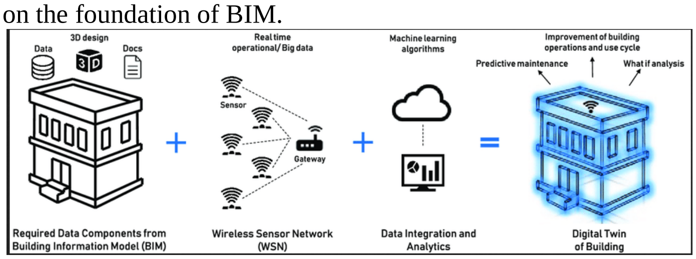

Figure 8: Digital Twin Process in Building[33]

Unmanned Aerial Vehicle (UAV) integration with BIM

A drone, sometimes referred to as an unmanned aerial vehicle (UAV), is an aircraft that is not piloted by a human. Unmanned Aerial Systems (UAS) is another name for drone technology. Because of their adaptability and ease of access to locations that are inaccessible to people, they are growing in popularity [35].

According to [36], an unmanned aerial vehicle (UAV) is any vehicle that is in the air without a human on board who is able to manage the aircraft from the ground. One of the major drawbacks of traditional construction project monitoring is that it requires a strict execution procedure that minimizes or eliminates the possibility of last-minute changes [22]. The accuracy of real-time data is frequently jeopardized due to the significant possibility of human mistake. On the other hand, a dependable monitoring and surveying system may be set up to get precise, fast, and trustworthy data by utilizing UAVs or drones with BIM [37]. Unmanned aerial vehicles (UAVs) are frequently equipped with high-resolution cameras, a variety of high-end parts and software, and high-quality sensors for a variety of uses. Following data gathering, sophisticated software is used to evaluate and analyze the data in order to improve operations, planning, and enhancements. The following figure 9 illustrates several crucial uses of drones and UAVs in construction monitoring:

3D Mapping

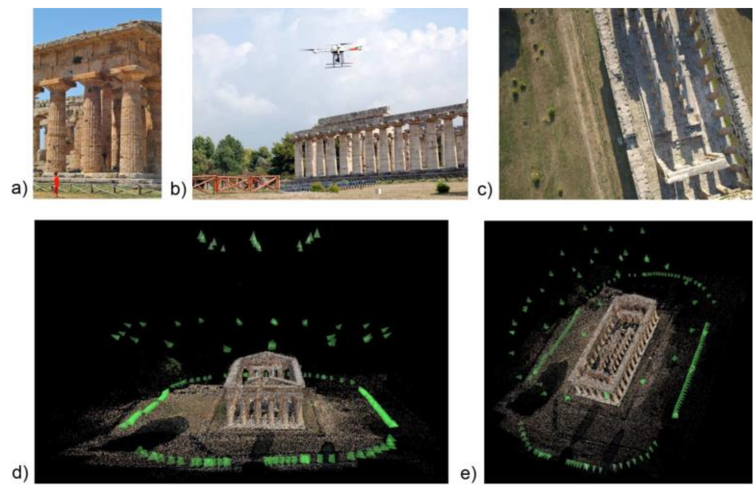

Figure 9: Integration of terrestrial images (a) with oblique (b) and vertical (c) UAV acquisitions for the surveying and modeling of the complex Neptune temple in Paestum, Italy. The integrated adjustment for the derivation of the camera poses of all the images (d, e) in a unique reference system

Aerial Photography & 3D Modelling

Figure 10: Aerial Photography[38]

Volumetric Measurement

Figure11: Orthomosaic Image

Job-site Documentation

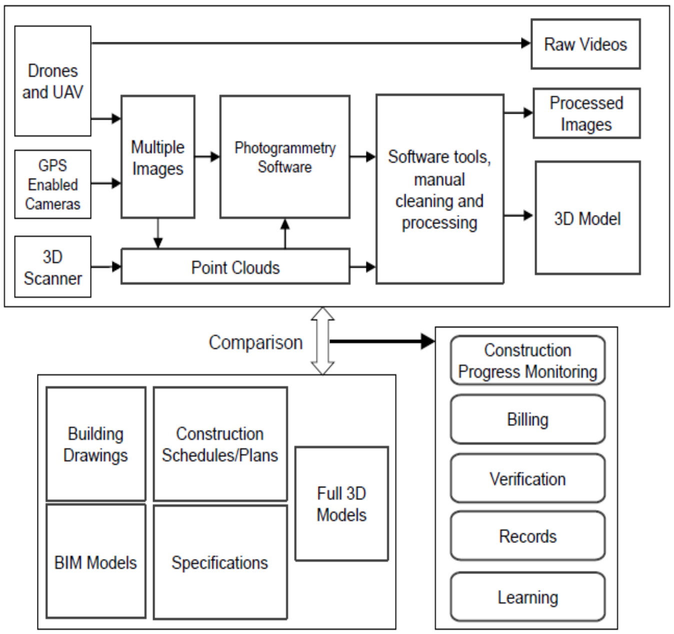

Figure 12: The overall concept of construction monitoring/reporting using drones and unmanned aerial vehicles (UAV) [39].

2.4 Theoretical Framework

2.4.1 Technology Acceptance Model

The technology acceptance model (TAM) is the most popular paradigm in information technology system research because it is both theoretically justifiable and economical [40]. In order to explain the adoption of information systems (IS), the Technology Acceptance Model (TAM) has been used in many of these innovation acceptance studies [41]. Furthermore, rather of focusing on the transmission of a technology to individual users, other academics have argued that TAM is better suited for examining the acceptance and diffusion of a particular technology inside an organization. Since its introduction by [42], the Technology Acceptance Model (TAM) has been used extensively to describe the variables that users would take into account in order to embrace a new technology.

Yet, it has been demonstrated that two key constructs: perceived utility and perceived ease of use determine users' intentions and attitudes toward utilizing technology, which in turn influence actual utilization. According to Davis, perceived usefulness is the degree to which a potential user believes that using a particular application system will improve their performance within an organizational concept, whereas perceived ease of use is the degree to which a potential user believes the targeted system will be simple to use [42].

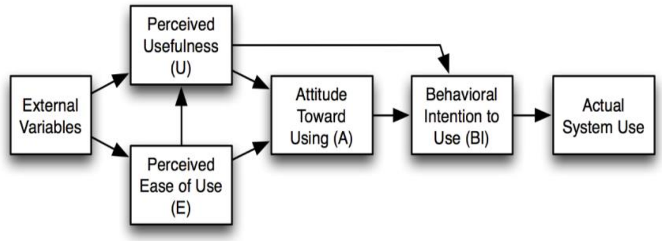

Figure 13: Technology Acceptance Model TAM [39]

The fundamental tenet of TAM is deployed in this study to ascertain construction professionals adoption, implementation or applicability of IMS and its technologies in construction operations in Nigeria.

3. METHODOLOGY

Using a questionnaire as the research tool, this study used the survey approach. Therefore, the study's goal was to obtain answers from professionals in the whole South Eastern Nigerian construction industry. To collect quantitative data, a questionnaire technique was employed. A questionnaire can also ensure that research is not biased and can be measured [43]. Respondents were asked to rate their agreement with each of the 23 topics on a five-point Likert scale, where five means "strongly agree," four "agree," three "neutral," two "disagree," and one "strongly disagree." Because they use construction information systems, architects, civil engineers, mechanical and electrical engineers, quantity surveyors, construction managers, and construction project managers were given the questionnaire.The population of the research, which was used to determine the sample size, consists of operational construction consulting and contracting companies in southeast Nigeria. Table 1 below shows the dispersion of these firms:

Table 1: Population of the Study

S/N	Construction firms	Population
1	Architectural Firms	200
2	Building Firms	204
3	Quantity Surveying Firms	189
4	Engineering firms	310
5	Construction Contracting Firms	300
	TOTAL	1203

Sources: Field survey 2024.

1,203 construction professionals from all states in the research region make up the sample frame, according to the study population. Table 1 above lists the many construction consulting and contracting companies in the southeast. In each instance, copies of the questionnaire were given to one state's construction companies. In order to reflect other professionals in the firm, the responders are mostly at least one construction professional from a firm in the research region.Throughout the states in the research region, questionnaires were distributed by electronic mail and then self-administered.
The Taro Yamane formula was used to calculate the sample size. This is provided as:

$$n = \frac{N}{1+N(e)^2}$$

Where:

n = sample size

N= Study population

e= 5% level of significance

1= constant

$$n = \frac{1203}{1 + 1203(0.05)2}$$

$$n = 300$$

A 10% attrition rate results in a sample size of 345. Consequently, 345 is the study's sample size.

The data was initially examined for normality using the Shapiro-Wilk test, and the reliability of the measuring instrument was evaluated by computing Cronbach's alpha. The more reliable the gathered data, the higher the Cronbach's alpha value, which goes from 0 to 1 [44]. The mean item score (MIS) was used in the subsequent analytic step to rank the items that the participants had recognized based on their significant degree. This was supplemented by the inferred standard deviation (S.D.) for each item.Exploratory factor analysis was ultimately performed in order to reduce the large number of variables to a smaller set of summary variables and investigate the underlying theoretical structure of the phenomena. Factor loadings with negative values in the study indicated that the associated variables needed to be interpreted differently. Additionally, the chi-square test of association was used.

4. RESULTS

Performance of Construction Organisations in South-East Nigeria

Table 2: Performance of construction organizations

S/n	Key Performance indicators and attributes.	Very Low n (%)	Very high n (%)	Mean±SD
1	Feedback capabilities between project participants	0 (0.0)	72 (21.9)	3.98±0.75
2	Technology advancement level and technical skill of the project team	0 (0.0)	54 (16.4)	3.89±0.76
3	Consultants' cooperation to Project progress monitoring	0 (0.0)	78 (23.7)	4.05±0.67
4	Consultants' Predictability and commitment to meet cost, time and quality	0 (0.0)	102 (31.0)	4.04±0.83
5	Consultants' commitment to ensure construction work is done according to specifications	0 (0.0)	161 (48.9)	4.31±0.81
6	Consultants' involvement to monitor the project progress	0 (0.0)	131 (39.8)	4.23±0.76
7	Consultants' cooperation to solve problems	0 (0.0)	83 (25.2)	4.09±0.69
8	Control mechanism of the project activities	6 (1.8)	60 (18.2)	3.71±0.95
9	Developing an appropriate organizing structure	6 (1.8)	36 (10.9)	3.60±0.89
10	Motivating skills of the management team and employee	0 (0.0)	72 (21.9)	3.78±0.95
11	Implementing an effective safety, quality assurance program	0 (0.0)	95 (28.9)	3.74±1.05
12	Project team leader's adaptability to changes and working relationship	6 (1.8)	90 (27.4)	3.96±0.89
13	Upgrade in communication system and use of IT	18 (5.5)	72 (21.9)	3.71±1.06
14	Good track record of timely completion of the project	6 (1.8)	90 (27.4)	3.74±1.07
15	Reduced Cost of processing information and construction work	12 (3.6)	66 (20.1)	3.69±1.03

16	Quality of resources (Equipment and Materials) and workmanship	0 (0.0)	90 (27.4)	3.96±0.86
17	Overall management actions, attitude and flexibility to information and innovation	0 (0.0)	60 (18.2)	3.85±0.78
18	Effective Communication system and coordinating among project participants	0 (0.0)	78 (23.7)	3.87±0.86
19	Good Relationship / Cooperation with employees and clients	0 (0.0)	102 (31.0)	3.98±0.91
20	Adopting learning and growth culture in the organization	6 (1.8)	66 (20.1)	3.76±0.92
21	Qualifications of human resources in the company	0 (0.0)	78 (23.7)	3.95±0.78
22	Project management Schedule and Planning performance / efficiency	0 (0.0)	90 (27.4)	3.96±0.86
23	Technological and technical capabilities of the company.	6 (1.8)	66 (20.1)	3.84±0.85
24	An availability of quality control system	0 (0.0)	84 (25.5)	3.85±0.89
25	Capacity and financial stability of the company and market share.	6 (1.8)	54 (16.4)	3.54±0.99
26	Adopting Training and learning to develop capacities and expertise in the organization	6 (1.8)	66 (20.1)	3.62±0.97
27	Higher Profitability ratio /yield to the company.	0 (0.0)	54 (16.4)	3.54±0.95

Source: Field survey (2024)

This objective presents the results of the descriptive analysis related to the performance of construction organisations in the study. The goal seeks to determine their current level of performance of a correlate of inherent deployment of information management system. Table 2 above shows that the participants rated as very high the following performance of firms, they include: consultants' cooperation to project progress monitoring (4.05±0.67) 1st , consultants' predictability and commitment to meet cost, time and quality (4.04±0.83) 2nd , consultants' commitment to ensure construction work is done according to specifications (4.31±0.81) 3rd , consultants' involvement to monitor the project progress (4.23±0.76) 4th and consultants' cooperation to solve problems (4.09±0.69) 5th.

Another group of the rating from the respondents as high are the following performance attributes of firms, they include: feedback capabilities between project participants (3.98±0.75) 6th , good relationship / cooperation with employees and clients (3.98±0.91) 7th , project team leader's adaptability to changes and working relationship (3.96±0.89) 8th , quality of resources (equipment and materials) and workmanship (3.96±0.86) 9th , project management schedule and planning performance / efficiency (3.96±0.86) 10th , qualifications of human resources in the company (3.95±0.78) 11th.

All the responses show high degree skewness. A high value response and they are arranged in different categories or order of mean value, which are indicated by mean response values greater than the criterion mean of 3 and very low standard deviations indicating low variability of responses. The effective performance indicators fall into the various sub groups of cost group, quality group, environment group, project management group, health and safety group, relationship group, innovation group, qualification group, financial group for measuring performance.

Important Information Management Systems Applicable to Construction Operations

Table 3: Important information management system applicable to construction

S/N	Components of IMS	Mean	Rank	Remarks
1	Video conferencing / Tele conferencing	4.40	1st	Highly important
2	Mobile internet	4.20	2nd	Highly important
3	E-mail and Short Message Services (SMS)	4.20	3rd	Highly important
4	Presentations (e.g MS Power Point)	4.00	4th	Highly important
5	Spreadsheets (e.g., MS Excel)	4.00	5th	Highly important
6	AutoCAD / ArchiCAD	4.00	6th	Highly important
7	Word Processors (e.g., MS Word)	4.00	7th	Highly important
8	Electronic purchasing (E-purchasing)	3.80	8th	Moderately important
9	Microsoft Project / MS Project	3.80	9th	Moderately important
10	Electronic document management systems (EDMS) / Firms private servers	3.80	10th	Moderately important
11	Modeling and visualization (eg. 3D-CAD, 4D-CAD etc)	3.80	11th	Moderately important
12	Site surveillance Technologies (e.g. CCTV etc)	3.80	12th	Moderately important
13	Databases (e.gMsAccess)	3.60	13th	Moderately important

14	Power Project / PM Systems,	3.40	14th	Moderately important
15	Electronic tendering (E-tendering)	3.40	15th	Moderately important
16	Project specific websites (Extranets)	3.40	16th	Moderately important
17	Master bill / WinQS Estimate	3.40	17th	Moderately important
18	Microsoft Project Online	3.20	18th	Moderately important
19	Integrated software (e.g. Enterprise Resource Planning; ERP) / Web base tools (WPMS)	3.20	19th	Moderately important
20	Build soft	3.20	20th	Moderately important
21	Primavera	3.10	21st	Moderately important

The results in Table 3 shows three bands of Mean Item Scores (MIS, < 4.0 > 4.0; > 3.0 > 3.0) respectively. Seven (7) that is 33.33% of the total information management systems evaluated in the study are in the in top tier (MIS, < 4.0 > 4.0) to emerge as the most important information systems applicable to the construction operations. The MIS for this category of IMS components ranges between 4.00 – 4.40 and video conferencing/Tele conferencing, mobile internet, emailing and Short Media Messages, Ms PowerPoint and Spreadsheet, AutoCAD and Cad-related applications and word processors are in this category. The second comprised obtained the MIS greater than 3.0 and 66.37% out of the 21 of IMS components evaluated for applicability in the study belongs to this category. The most important and overall 8th – 12th important IMS in the study is e-purchasing, MS projects, electronic document management systems, modelling and visualization tools (3D-nD), site surveillance technologies and database management systems (MIS, 3.60 – 3.80).

Even though 21 IMS components obtained MIS greater than 3.00 to strong alignment with construction practice, the least important components are primavera, build soft, integrated software such as enterprise planning, master bills, and e-tendering systems (MIS, 3.10 – 3.40 > 3.00). The results for this category indicate reflect integrated/specialist application software and the low rating can be attributed to the possible low degree of awareness arising from low application.

Test of Hypothesis Two (Ho_1): Hypothesis one (Ho_1) determined the significance of the important IMS systems validated applicable to the construction industry.

Table 4: Chi Square test of association of IMS components with construction operations in South-East, Nigeria

S/N	IMS components	Chi-Square	df	Asymp. Sig.	Decision
1	Microsoft Project / MS Project	200.757[a]	1	0.000	Reject Ho_2
2	Primavera	12.842[a]	1	0.000	Reject Ho_2
3	Power Project / PM Systems,	24.076[a]	1	0.000	Reject Ho_2
4	Build soft	47.492[a]	1	0.000	Reject Ho_2
5	Master bill / WinQS Estimate	2.556[a]	1	0.110	Accept Ho_2
6	Spreadsheets (e.g.,MS Excel)	260.939[a]	1	0.000	Reject Ho_2
7	Presentations (e.g., MS Power Point)	260.939[a]	1	0.000	Reject Ho_2
8	Word Processors (e.g., MS Word)	219.942[a]	1	0.000	Reject Ho_2
9	Microsoft Project Online	18.021[a]	1	0.000	Reject Ho_2
10	Databases (e.gMsAccess)	.149[a]	1	0.700	Accept Ho_2
11	AutoCAD / ArchiCAD	219.942[a]	1	0.000	Reject Ho_2
12	E-mail and Short Message Services (SMS)	305.438[a]	1	0.000	Reject Ho_2
13	Mobile internet	260.939[a]	1	0.000	Reject Ho_2
14	Video conferencing / Tele conferencing	264.514[a]	1	0.000	Reject Ho_2
15	Electronic purchasing (E-purchasing)	78.787[a]	1	0.000	Reject Ho_2
16	Project specific websites (Extranets)	.149[a]	1	0.700	Accept Ho_2
17	Site surveillance Technologies (e.g. CCTV etc)	31.006[a]	1	0.000	Reject Ho_2
18	Electronic tendering (E-tendering)	31.006[a]	1	0.000	Reject Ho_2
19	Modeling and visualization (eg. 3D-CAD, 4D-CAD etc)	78.787[a]	1	0.000	Reject Ho_2
20	Electronic document management systems (EDMS) / Firms private servers	.878[a]	1	0.349	Accept Ho_2
21	Integrated software (e.g. Enterprise Resource Planning; ERP) / Web base tools (WPMS)	12.842[a]	1	0.000	Reject Ho_2

The statistical significance of the results on the applicability of the evaluated IMS components in Table 4 is determined using Chi Square test. The indicative hypothesis (Ho_2) for this examination states that there are no significant information management systems applicable to construction organisations' operations in South-East, Nigeria.

A Chi Square test of association (Table 4) of the applicability of the validated IMS systems to construction organisation's operations indicates that seventeen (17) out of 21 IMS components are significantly applied to construction operations (χ = 12.842 -305.438, p = 0.000 < 0.05). The null hypothesis for these group of IMS components are rejected and the alternate validated. The inference shows that 19 IMS systems are significantly applied to construction industry operations in South-East. IMS components in this category include MS projects, Primavera, power projects, QS software (master bills/WinQS estimate), excel spread sheet and MS power point.

On other hand, the results of the Chi Square test of association were accepted for four (4) out of 21 IMS systems to show that the knowledge of their applicability to construction organisation's operations in South-East is not popular (χ = 0.149 -0.878, p = 0.110-0.700 > 0.05). The null hypothesis for these group of IMS components are is validated. The inference shows that knowledge of the applicability of project specific websites, electronic document systems (or firm private servers), databases and Masterbills and WinQS to the construction industry in South-East, Nigeria is limited. Since the knowledge of the application of 81% (17) IMS components to construction operation in South-East is popular, the overall level of significance of the applicability of the evaluated IMS components to construction is significant (81% > 19%).

Factorisation of IMS Components: The study further explored the principal IMS components applicable to construction operation with a view to determining the most important IMS that enhance firm efficiency, effectiveness and overall performance using factor analysis.

Table 5: Principal IMS systems and applications for construction organisations

Principal IMS components	Component 1	2	3	4	5	6	7
Primavera	.099	.083	.034	.041	.120	.114	**.831**
Power Project / PM Systems,	.019	.263	.110	.347	**.689**	.100	.309
Master bill / WinQS Estimate	.128	.198	.141	**.795**	.042	.051	.243
Spreadsheets (e.g., MS Excel)	**.729**	.046	-.139	.186	.088	-.224	.173
E-mail and Short Message Services (SMS)	.027	.460	**.751**	.043	.021	.017	.061
Video conferencing / Tele conferencing	-.075	-.011	-.067	.068	.143	**.835**	.140
Modeling and visualization (e.g., 3D-CAD, 4D-CAD etc)	.281	**.738**	-.043	.014	.153	.282	-.060

The test of significance of the factor analysis using the Kaiser-Mayer-Olkin (KMO) test (0.6876 > 0.50; p (0.000) shows that the matrix is compact and reliable with zero multicollinearity. The determinant matrix is also a non-identical matrix with and not positive definite (0.00000< 0.0000). IMS in construction in the study area can be best determined seven principal components with an explained variance of 70.231%, namely (Table 5): primavera, power project/PM systems, Masterbill/WinQS, Spreadsheet, email and SMS, video conferencing/Tele conferencing and modelling and visualization tools 93D-nD). The understanding of IMS system in construction organisations in South-East is represented by primavera, power project/PM systems, Masterbill/WinQS, Spreadsheet, email and SMS, video conferencing/Tele conferencing and modelling and visualization tools (3D-nD).

The Utilisation of IMS in Construction Organisations in South-East

The study in the section determines the level of utilization of IMS components among construction organisations in South-East, Nigeria. The study also compares the level of utilization across the three layers of organisations operating in South-East, Nigeria, namely: micro, small and medium organisations towards unravelling the segment that has shown significant level of engagement with information management systems.

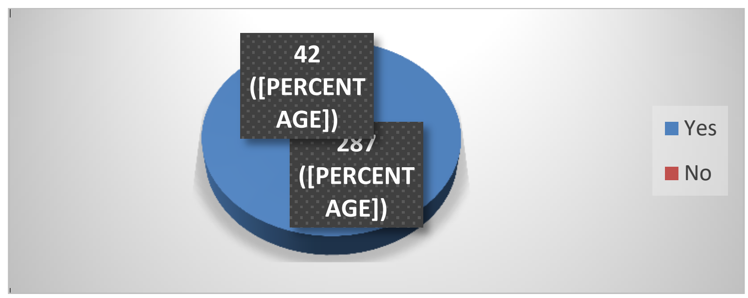

Figure 14: Utilization of information management systems in construction organization**.**Field survey, (2024)

Figure 14 above shows that out of 329 respondents, 42 construction firms says that they do not use any component of Information Management System (IMS) and 287 construction firms indicated that they use different levels of IMS. This is an indication that most firms use IMS in their operation. The percentage value for firms that do not use IMS is 13%, while 87% of the construction firms use information managementsystem. This section is mainly to establish the percentage or number of firms that uses any component of IMS in their firm.

Table 6: Level of utilization of IMS components in south-East

S/N	Components	MIS	Rank	Remarks
1	Video conferencing / Tele conferencing	2.80	10th	Low utilization
2	Mobile internet	3.65	5th	Moderately utilization
3	E-mail and Short Message Services (SMS)	4.00	1st	Highly used
4	Presentations (e.g., MS Power Point)	3.45	6th	Moderately utilization
5	Spreadsheets (e.g., MS Excel)	3.90	3rd	Moderately utilization
6	AutoCAD / ArchiCAD	3.85	4th	Moderately utilization
7	Word Processors (e.g., MS Word)	3.98	2nd	Moderately utilization
8	Electronic purchasing (E-purchasing)	2.53	11th	Low utilisation
9	Microsoft Project / MS Project	3.01	9th	Moderately utilisation
10	Electronic document management systems (EDMS) / Firms private servers	2.26	12th	Low utilisation
11	Modeling and visualization (eg. 3D-CAD, 4D-CAD etc)	3.16	7th	Moderately utilisation
12	Site surveillance Technologies (e.g. CCTV etc)	3.02	8th	Moderately utilisation
13	Databases (e.gMsAccess)	1.71	13th	Very low utilisation
14	Power Project / PM Systems,	1.71	14th	Very low utilisation
15	Electronic tendering (E-tendering)	1.56	15th	Very low utilisation
16	Project specific websites (Extranets)	1.53	16th	Very low utilisation
17	Master bill / WinQS Estimate	1.47	17th	Very low utilisation
18	Microsoft Project Online	1.47	17th	Very low utilisation
19	Integrated software (e.g. Enterprise Resource Planning; ERP) / Web base tools (WPMS)	1.27	18th	Very low utilisation
20	Build soft	1.01	19th	Very low utilisation
21	Primavera	0.74	20th	Very low utilisation

MIS = Mean Item Score (Field Survey, 2024)

The results in Table 6 shows four bands of Mean Item Scores (MIS, < 4.0, > 3.0 > 2.0 and > 1.0) respectively. One (1) out of the total information management systems evaluated in the study are in the in top tier (MIS, < 4.0) to emerge as the most important information systems applicable to the construction operations. The MIS for this category of IMS components that is, email and short media messages obtained a mean item score of 4.00 to emerge as the most prevalently or highly used IMS component in the study. The second tier comprised of components with mean item score ranging between 3.01 – 3.98 and eight components that is, 385 are in this category. The second to the 9th most prevalently used IMS components in the study, namely: word processor, spread sheets, AutoCAD, mobile internet, MS PowerPoint, modelling and visualization tools, site surveillance tools and MS projects. The IMS components (2nd – 9th) are moderately used in South-East, Nigeria.

The third band comprises of IMS components with the mean item scores greater than 2.0 (2.25; 2.53; 2.80) and only three or 13% of the components that is electronic document management system, electronic purchasing and video-conferencing are located within this tier and their overall level of utilization is low. The last tier comprises of components with the mean item score greater than 1.00. Ten components are situated in this zone (MIS, 1.01 – 1.71 > 1.00) and the overall level of use of these components is very low. The component with the least level of use is Primavera, build soft software, integrated software such as Enterprise resource Planning and Microsoft project online. In sum the overall level of utilization based on the descriptive statistics show an overall low level of application with an average mean of 2.48 to agree with the results of the previous that very proportion of the sample (13%) engages IMS components in their construction practice.

Test of hypothesis Ho_2: The study conducted a test of difference between the utiliisation of micro, small and medium construction organisations in the study to determine whether the low level of utilization of IMS components varies across the firm sizes using the Wilcoxon signed ranked test.

Table 7: Wilcoxon signed-ranked tests of the difference between the level of utilization of IMS in micro and small and small and medium construction firms

Firm size		N	Mean Rank	Sum of Ranks	Z	Asymp. Sig. (2-tailed)	Decision
COM-Micro - COM Small	Negative Rank	15[a]	10.43	156.50	-2.479[b]	0.013	Reject Ho_3
	Positive Rank	4[b]	8.38	33.50			
	Ties	2[c]					
	Total	21					
COM-small – COM-Medium	Negative Rank	16[d]	10.97	175.50	-3.247[b]	0.001	Reject Ho_3
	Positive Rank	3[e]	4.83	14.50			
	Ties	2[f]					
	Total	21					

The indicative hypothesis (Ho_2) for this examination states the level of utilisation of information management systems among construction organisations in South-East is not significantly different between micro, small and medium firms. Due to the expected variations in the structure of construction organisation based on the effect of size and assets, the norm expects varying level of utilization with the medium firms expected to have greater level of utilization. However, the descriptive results of the standard deviation show the layers achieved consensus about the level of utilization of the IMS. This position is examined further to determine the veracity of the perceived agreement in the sample.

A Wilcoxon signed-rank test of the difference (Table 7) in the level of utilization of IMS by small and medium firms shows no statistically significant variation ($Z = -2.479^b$, $p = 0.013 < 0.05$). Also, a Wilcoxon signed-rank test of the difference (Table 7) in the level of utilization of IMS by micro and small firms shows no statistically significant variation ($Z = -3.247^b$, $p = 0.001 < 0.05$) respectively. Therefore, the low level of utilization of IMS across the three strata of the firms is similar and do not differ significantly, the null hypothesis (Ho_2) is rejected and alternative hypothesis validated.

The result in Table 7 further shows that 16 components obtained low and very low level of utilization of IMS in micro/small firms' category, while 4 components obtained a moderate rating and two components were tied in this category. Also, 15 components likewise obtained low and very low level of utilization of IMS in small/medium firms' category. Four (4) components also obtained a moderate rating, while two ties were recorded between the two categories of firms, that is medium and low.

5. DISCUSSION

The study revealed seven principal performance indicators for the construction Organisations in South-East, Nigeria, namely: level of cooperation among consultants during project progress monitoring, consultants' commitment to enforcing design specifications, joint problem solving among consultants, upgrade in the level of ICT uses, lower cost of information processing, technology and technical competencies of firms and institution of control systems. Construction examined in the study performed significantly very well in these assessment criteria and their overall performance level did not differ across Organisational strata (micro, small and medium firms). The study finds that resources of construction organisations are adequate and efficient to influence Organisational performance hence, the high rating of resource-related criteria. Supporting this viewpoint, [45] agreed that labour productivity, equipment utilisation, and material wastage are important resource-related indicators that can impact the performance of construction projects.

Furthermore, joint problem-solving emerged as one of the top performance areas for construction organisations in the study. It refers to the ability of project stakeholders to work together to solve problems that arise during the construction process [46]. This is an important indicator because construction projects are complex and problems are inevitable are reflected during (1) conflict resolution, that is, the ability of project stakeholders to resolve conflicts that arise during the construction process, and (2) through innovation, the ability of project stakeholders to come up with innovative solutions to problems that arise during the construction process. [46] reported that joint problem-solving is an important performance indicator that can impact the success of construction projects. Other relevant performance as indicated by the study are:communication-related performance, technological and technical expertise-related performance and quality control system-related performance.

In the core objective of the study which is on information systems in application in construction operation and their level of utilization, the study found that Enterprise Resource Planning (ERP) systems, Project management software (cost management software (Master Bills, WinQS, Excell Spreadsheet), design tools (AutoCAD and Build Soft), and planning tools (MS Projects and Primavera); Document management systems (MS Word, and MS PowerPoint etc)**;** communication systems (emails etc)are widely used in the construction industry in South Eastern Nigeria to manage project budgets, schedules and resources.These information management systems are used in different ways and to varying degrees in the construction industry, depending on the specific needs of the organisation and the project. In terms of specific applications commonly used in the research environment, MS Word, Excel, and Project Management software such as MS Project and Primavera are prevalent. The test of significance of these components revealed that 81% are useful applications to the construction industry, while 19% including project-specific websites, electronic document systems (or firm private servers), databases and masterbills/WinQS are not commonplace to the construction Organisations in South-East, Nigeria. The level of utilisation of these by micro and medium firms shows no statistically significant variation ($Z = -2.479^b$, $p = 0.013 < 0.05$). Even though this result is a surprise, it can be explained by the overall low level of utilisation of IMS systems in the research environment.

Furthermore, the overall level of utilisation is low and this result is consistent and expected given the antecedents of developing countries towards the application of information technology. The level of Information Communication Technology (ICT) adoption in construction Organisations in developing countries is often lower than in developed countries. [47]found that the adoption of ICT in construction Organisations in developing countries is often limited to basic applications such as email and word processing. Their study concluded that the adoption of more advanced technologies such as BIM and PMIS is often limited due to a lack of awareness of the benefits of these technologies and the high cost of implementation. This study therefore infers that the scope of IMS in the construction industry is vast and covers various aspects of project management, including design, planning, scheduling, cost control, procurement, and quality control. The components, systems and applications used in this study therefore exclude advanced and contemporary information management systems such as construction 4.0 technologies (except BIM). The context of advanced frontiers in information management systems are therefore with a low level of utilisation in this study and this can be explored further.

6. CONCLUSION

In conclusion, IMS adoption in Nigeria's construction sector has been sluggish, despite growing recognition of its importance as a tool for project administration and management. Construction operations have undergone a revolution because to the use of IMS, which has streamlined processes, enhanced safety and quality standards, and increased efficiency and data dependence. A deeper comprehension of several facets of the construction information management system has been made possible by research. The study concludes thatthe most popular application of IMS in construction industry in Nigeria areproject management software (cost management software (Master Bills, WinQS, Excell Spreadsheet), design tools (AutoCAD and Build Soft), and planning tools (MS Projects and Primavera); Document management systems (MS Word, and MS PowerPoint etc); communication systems (emails etc);Enterprise Resource Planning (ERP) systems

The findings from this research have pivotal implications as it reveals that the application of IMS in Nigeria construction operations though growing is still at the nascent stage as the common practice remains the wide use of at most Project Management software. Though there is good implementation of BIM, but the BIM maturity level in the country is still low. In other words, the results inform practitioners in the construction sector about the extent of IMS adoption in the nation and the areas that require development. They also highlight the modern construction 4.0 IMS that has to be implemented.

Recommendations

The study recommends that:

1. The construction industry in Nigeria must improve to adopt a hybrid framework in the application of IMS. This must involves multiplex use of technologies such as BIM, AI, deep learning etc for efficient project delivery. This is necessary because majority of the construction now are complex data that requires big data analytics and capabilities.
2. The construction regulatory body must establish standardization and coordination policy on the use of IMS technologies in construction operations. This will solve software and technology interoperatibility challenges that professionals faced when handling projects. A standard construction ethics manual must be updated and published to indicate relevant software and technologies that must be in use for each category of project.
3. Construction 4.0 technologies should be embedded in the training requirements for construction professionals in Nigeria. Nigeria Society of Engineers (NSE), Nigeria Institute of Quantity Surveyors (NIQS), Nigeria Institute of Architects (NIA) etc should update their training and certification process to include construction 4.0 proficency.
4. To find the optimal strategy for implementing a multi-information system, as well as some monitoring tools that track the project's development in real time, more study should be done.

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