Most Prevalent Barriers to the Implementation and Adoption of Cloud Computing by Construction Professionals in Nigeria

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Abstract:- The construction industry continues to prioritize completing projects quickly while maintaining quality within budget constraints. Despite existing literature addressing this issue and providing management tools, human decision flaws and slow response to project activities hinder effective implementation. The emergence of Industry 4.0 in the Architectural, Engineering, and Construction (AEC) sector offers potential support for human decisions during project implementation. Recognizing the interconnected nature of the industry, a decision support system leveraging cloud technologies becomes crucial for efficient project management, analysis, and data processing. This study focuses on assessing barriers to the adoption of cloud computing by construction professionals in Nigeria. The research, based on literature reviews, structured interviews, and questionnaires, involving 60 respondents (47 analyzed), reveals that limited awareness of Industry 4.0 technologies, particularly cloud computing, exists among construction professionals. Additionally, the study identifies key barriers such as inadequate internet facilities, high costs, economic conditions, lack of power infrastructure, and reluctance from organizations and clients to fund cloud services not included in project costs.

Keywords:- *Cloud Computing, Construction, Services, Barriers, Adoption, Implementation, Nigeria.*

I. INTRODUCTION

The field of construction is a decentralized, data-driven, and project-based industry with extensive data exchange and processing requirements throughout the product lifecycle, as noted by [24], requiring several professions and companies (primarily buildings). Traditional disciplines (architectural, structural, mechanical, and electrical engineering) as well as numerous and new subject matter occupations in areas of environmental science and waste management have been much valuable to plan, reconstruct, rebuild, and operate buildings. However, according to [8], these disciplines often face fragmentation, attributed to many individual participants, each pursuing their own objectives. This is a major challenge intensified in construction projects with diverse stages, creating conflicts in information management among stakeholders.

While many professions, as noted by [29] have strict data-sharing requirements, the construction industry necessitates adequate data storage and communication among all project stakeholders, and information control systems, such as the advent of cloud computing (CC), can be deployed to facilitate communication and collaboration among project stakeholders. According to [27], with the rapid advancement of technology, IT-enabled services globally enhance project convergence and successful knowledge exchange, utilizing internet servers and shared databases. According to [15], cloud-based data centers can provide high-performance processing capability by analyzing large volumes of IoT (Internet of things) data, offering useful insights for decision-making. Cloud computing is changing the way individuals, businesses, and governments store, process, and leverage computing power **[19]**. With the rapid advancement of technology, IT-enabled services such as the cloud are now widely available worldwide, and the use of this technology requiring internet or sharing of databases, can now be used to enhance the convergence of various project phases, as well as successful knowledge exchange [28]. Hence, to address information management challenges amongst construction projects stakeholders, building managers would have to cultivate the adoption and integration of new and advanced technologies in construction project management and delivery. This study aimed at (1) investigating the familiarity of Nigeria construction professionals with existing cloud computing services, (2) investigating barriers to the implementation of cloud computing technologies by construction professionals in Nigeria, (3) determine the most prevalent barriers to the implementation, and (4) adoption of cloud computing services by construction professionals in the Nigeria construction industry.

A. Used Cases of cloud computing Technology in Construction.

According to [25] the delivery of cloud computing services, which enables remote access to computing services via the internet using ICT approaches is feasible in construction, and can help achieve building resilience, as noted by [15]. While this is an evolving area with a lot of potentials, cloud services has both economy [30], scalability[16], security [34], storage [5], and collaboration [32] advantages when put in use by construction professionals. Companies in the construction industry are actively seeking innovative approaches to minimize both infrastructure and operating costs, resulting in a struggle to manage the extensive IT infrastructure, which necessitates specialized human resources and training [5] While this is true, the poor profit margins in the Nigeria construction industry currently makes cost of hosting a cloud service a potential obstacle to adoption of IT solutions into construction.[33]. Cloud computing technology now bridge this gap, serving great economic advantages, and allowing construction companies, particularly small and medium enterprises (SMEs), to now have access to high-end computing facilities and applications through the technology that would otherwise be too expensive to purchase [14] (Othman et al., 2021). This is likely to lead to a decreased overall project delivery cost, providing construction businesses with competitive and operational benefits, along with increased agility. [30] Through the elimination of ownership and operational expenses, allowing payments only to be made for the service used [8], The scalability and on-demand nature of cloud services also present unusual advantages to the construction industry.[3] in his research deployed the scalability feature of cloud service to propose a Building Information Modelling (BIM) -Governance model. According to [5], cloud computing enables construction companies to acquire IT resources as services tailored to the specific requirements of each construction project diminishing the economic feasibility of investing in higher-capacity infrastructure, as traditional capital investments in computing facilities become less essential. Hence, the construction industry can now take advantage of gaining access to high-performance servers with powerful central processing unit (CPUs), graphics processing units (GPUs), and exceptionally fast Solid-state Drive (SSD) drives. According to [16], with this potential, SMEs will be able to compete on an equal footing with larger corporations without having to make a large initial investment. According to [2], the Architecture, Engineering, and Construction (AEC) sector, which is a highly fragmented, data-intensive, project-based business that relies on a variety of extremely diverse professions and firms and has stringent data processing and sharing needs requiring high security measures. While this is important, almost 63% of construction firm in operation in Nigeria operates as SME's [2], and according to [34] making over 50% of the construction companies incapacitated to afford personal security infrastructure for construction data protection. Making it exceedingly expensive for construction companies to build system availability on in-house computing infrastructure that can match cloud service providers' 99.99% SLA (Service Level Agreement) and uptime [5]. common cloud security measures include encryption, the use of up-to-date security software, cyber insurance security coverage, security audits, and most especially Virtual machine, which according to [31], creates a logical abstraction layer that allows applications, operating systems, and system services to function in a conceptually separate system environment that is separate from the physical computer systems.

Collaboration in a common data environment is strongly promoted by using cloud services. Apart from underscoring the significance of teamwork and collaboration among experts for the successful completion of the project [14]

[35], emphasized on the importance of a Common Data Environment (CDE), which typically provided as a cloud service, and serves as a virtual storage facility for collecting and managing documentation related to building projects, effectively minimizing the risk of misunderstandings and data loss, as underscored. A typical example of such platform is the use of BIM, which according to [13] is more than just a technical shift, but also a process transformation model. CDE represents a BIM Level 2 maturity instrument where 3D models are utilized to generate project design outputs and managed through various professional platforms. According to [6], during the planning, construction, and operation stages of a building, project participants share varied information from different domains using agreed procedures. This virtual space enables all project stakeholders, even if located at different times and places, to engage in negotiations, brainstorming, discussions, knowledge-sharing, and collaborative efforts to complete tasks, often aimed at producing an executable deliverable and its supporting artifacts.

B. Current stage in the Nigeria Construction industry.

According to [9], a wide variety of related processes are required during construction project execution, and a centralized platform that unites all project stakeholders, enables transparency, real-time data analysis, and prevents the loss of construction project data and storages is increasingly essential for handling the massive amounts of data created during the life cycle of a construction project. Construction stakeholders do not necessarily have to own the information technology (IT) resources [25]. As cloud computing integrates into the construction industry, opportunities for growth and the infusion of other intelligent technologies emerges for assisting construction stakeholders in making informed decisions, and enhancing the success of construction project delivery, particularly in Nigeria is now very possible [11]. This will enhance remote collaboration and real-time data storage [8] However, the deployment of cloud computing services on construction sites remains an emerging area in Nigeria's construction industry. Despite the global discourse on the importance, use cases, benefits, and challenges of cloud computing, only 4% of these literatures are from Nigeria [4], and mainly focused on the benefits and challenges of adopting cloud technologies on a global perspective, following existing literatures. This speaks to the infancy of the inclusion of these services in the Nigeria global economy, and while most of this research are based on the financial and IT sectors of the country, only a few generally addressed possible used cases of cloud computing in the construction industry [10]. To the extent of the literature reviewed, none of these studies in Nigeria went further to identifying new barriers by specifically tailored to the professionals involved in the Nigeria construction industry for the possibility of gathering new information. As [10] put this, and I quote, “Nevertheless, as the use of cloud computing grows in sub-Saharan Africa, and some of the risks and challenges become more apparent, users (providers inclusive) in the region will have many lessons to learn...”. Hence, the need for increased research activities specifically this study on cloud computing within the Nigeria construction industry [5].

C. Barriers to the Adoption of Cloud Computing

While there are numbers of challenges that may impede the implementation and adoption of cloud computing in Nigeria, only some of these challenges are common to all industry. As more of these challenges are evident to construction professionals by the day, some of these challenges are covered in existing literature reviewed. To integrate cloud computing technologies in construction, [17] noted that a constant flow of data will be essential for different and distributed site teams on construction projects. The authors underlined that such data must be always consistently reliable and accessible to project teams. According to [8], in the construction stages, mobile/cloud BIM technology can aid in tracking progress, construction schedule coordination, and the elimination of clashes caused by design errors if the primary challenges hindering the implementation and adoption are resolved [37].

The conclusion obtained was that, regardless of location, mobile/cloud technology can assist in the monitoring of real-time progress, coordination, clash detection, and data exchange across project teams [7]. Interoperability was identified to be the key to the success of mobile/cloud BIM technology implementation in an evaluation of mobile/cloud BIM computing technologies [18]. Contractual difficulties, a lack of ownership of shared data, and contractual inadequacies were mentioned by [23] as the key impediments to mobile/cloud BIM technology adoption and integration. Further research on data security, ownership, and stability issues is needed, according to [22]. The authors believe that using mobile/cloud-BIM technology will enhance secure collaboration.

However, the willingness to collaborate as well as cultural differences continue to be barriers to the adoption of mobile/cloud BIM technologies. Furthermore, it was determined that training time and costs are a key impediment to BIM adoption using mobile/cloud technologies. According to research, the construction industry lacks qualified professionals and experts in BIM implementation and adoption [24] Nevertheless, the authors suggest that "industry leaders" and professional organizations should promote ongoing professional development training and incorporate mobile/cloud BIM technology into both professional and higher education. Conversely, [38] Supported the adoption of open standard file formats to ease the sharing and exchange of data among diverse systems and vendors. In addition, the authors advocated for a central web-hosted server to promote transparency and long-term cloud development. Issues of ownership and intellectual property rights, on the other hand, demand more attention, and a construction contract should be tailored to meet these needs. Therefore, the absence of this contract can impede the adoption or acceptance of this technological innovations by construction stakeholders. Given the data exchange platform, other researchers advocated for a common data environment, which does indeed encourage project team collaboration.

This study aimed to narrow the gap in knowledge and enhance the understanding of cloud computing adoption among construction professionals in Nigeria. The research specifically targeted construction professionals directly engaged in construction activities. The objective was to contribute to existing knowledge regarding the barriers that impact the implementation and adoption of cloud computing in the Nigerian construction sector. Additionally, the study sought to identify the predominant challenges that currently hinder the full exploration of cloud technologies within the Nigerian construction industry.

II. RESEARCH METHOD

This study includes both quantitative and qualitative techniques. The study was completed in two steps. In order to obtain data from a targeted audience, a qualitative interview was conducted using a pilot question with selected construction professionals who are familiar with the cloud platform in order to identify new information not contained in the list of barriers identified from literatures. Questionnaire survey containing modified lists was then used in a quantitative manner to collect information from a larger audience of construction professionals.

The purpose of the questionnaire survey was to triangulate data from the population; to improve, expand, by investigating and elaborating through data analysis, some of the issues identified; and to explore the experiences of the sample population in relation to the topical issues that will be revealed after the questionnaire survey's data has been analyzed. Construction professionals in Lagos State were the study's target respondents and the data utilized in this study was gathered from. construction professionals in Lagos state. The model employed for the purpose of this research is as shown in Fig 1.0.

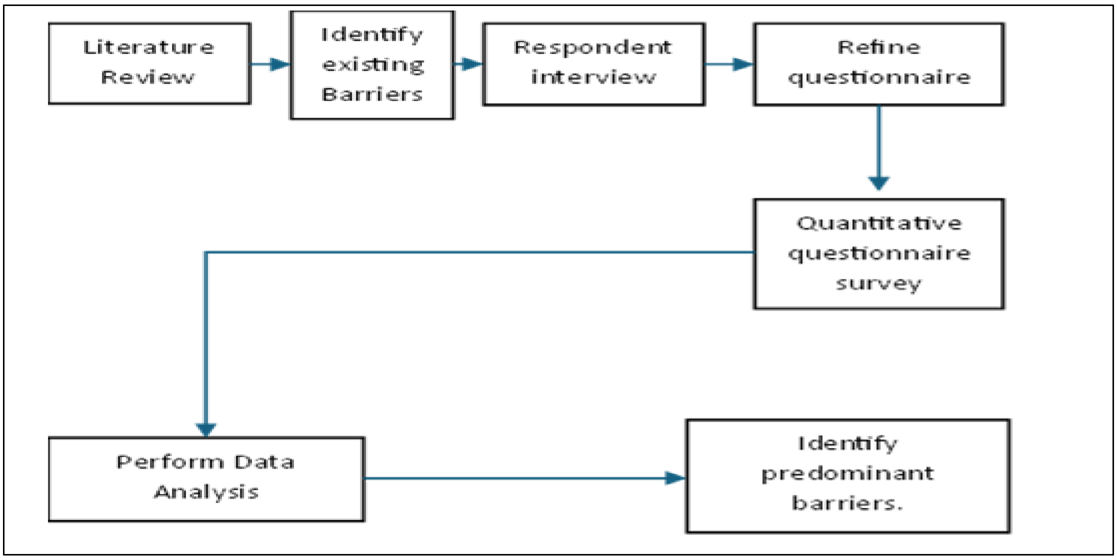

Fig. 1: Research model curated from [7]; [24]

Construction professionals in Lagos State were the studies. target respondents and the data used in this research was collected from construction professionals in Lagos state.

A. Data Requirement

For this study, both primary and secondary data were collected. Primary data on the barriers to the implementation and adoption of cloud computing in the Nigerian construction industry was gathered from construction professionals who currently works in the various construction firms under examination, and secondary data were gained from a review of other relevant literature.

B. Sample Size and Techniques

A sample is a specimen, or a portion of a population taken to show that the rest of the population is comparable [12] As part of this study, a random sample of Ten (10) construction professionals in Nigeria were asked closed ended questions as a pilot survey, which aimed at confirming the peculiarity of the globally existing barriers of the implementation and adoption of cloud computing which were deducted from literature reviewed and to identify new barriers tailored to the Nigeria construction industry, thereby adding to the exiting knowledge. Furthermore, a basic random sampling approach and process was used to select the sample from the population and to ensure all respondent have an equal chance respectively. Because of the nature and goals of the study, statistical sampling procedures was used to collect data. This type of sampling is less prone to bias because only these groups could be of benefit to the study's subject. The sample size will be calculated using Yaro Yamane's formula. The needed sample size is n.

N= is the population size
1=is a constant and
E= is the assumed

error margin or level of significance was taken as 5% or 0.05. Therefore, e^2 = 0.0025. The error margin of 5% or 0.05 implies that 95% confidence level is absorbed.

In calculating the sample size, the result is as follows:
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$$n = \frac{60}{1+60(e0.0025^2)} = \frac{60}{1.003} = 59.98 \cong 60.$$

(1)

Therefore, a sample size of 60 will be used.

C. Method of Data Collection

As previously stated, questionnaires were employed in this study of construction professionals in Lagos, Nigeria. The section A, B, C, and D will be used as the questionnaire. Before the issuance of questionnaire, a model involving a pilot survey adapted from [21] were used to generate new information from the one-on-one sections with selected construction professionals. These professionals were selected because they have the knowledge of cloud computing and are familiar with cloud services. New variables were deducted from the pilot survey and were used to refine the final questionnaire before issuing to the large respondent. Section A of this questionnaire contained the demographic information of the respondent. Section B, the second half of the report, addressed questions about the various types of barriers to the implementation of cloud computing by construction professionals in Nigeria. This section of the survey shows a primary factor identified in literatures as well as the variables for the measurement of this factors. Part C inquired from the respondent, their familiarities to cloud computing platforms and tools, while the section D which is the last section identified the various types of barriers to the adoption of cloud computing by construction professionals in Nigeria with rage on nominal scales. Questions asked in the pilot survey study were adapted from existing literatures, and the questionnaires issued to the other experts who the final audience were refined with new findings adapted from the respondent in the pilot survey.

D. Method of Data Analysis

The data generated through the administration of the study instruments were evaluated and handled using Statistical Packages for Social Sciences (SPSS 20.0). To create a manageable summary, Excel was utilized for editing, coding, and tabulation. On a nominal scale, descriptive and exploratory statistics [36[were used to evaluate the data, to determine the relative important index.

III. RESULTS AND DISCUSSION

A. Rate of Response

A total of sixty (60) questionnaires were distributed to construction professional in Lagosstate to boost the sample, out of these forty-eight (48) questionnaires were retrieved and were considered good enough for use after editing for completeness. These forty-eight questionnaires represent eighty percent (80%) and was recorded as an effective response rate. This information is summarized in table1 below:

Table 1: Responses to questionnaires

Respondents	No of questionnairessent out	Good Response received	Percentage response received
Construction Professionals in Lagosstate	60	48	80
Total	**60**	**48**	**80**

A response rate of eighty percent (80%) was considered well enough for the study.

B. Demography of the Respondents

The data collected revealed information such as involvement in the construction industry, highest academic qualification, profession, membership of professional body, professional body grade of membership, organization forms, number of employees. All this information is to provide the researcher with a clear understanding of the nature of the respondent. The result shows that architects, engineering quantity surveying, construction management and building are represented in the research. The profession with a high number of respondents in the study are Engineers, followed by Quantity surveyors, Construction manager, Builder and Architect respectively. The study shows that all the respondents are affiliated with their professional bodies.

The academic finding reveal that all respondents are grounded academically, 56.25% of the responded barged first degree and 35.42% of the respondents obtained second degree, while the remaining respondents were Higher National Diploma. And they are between Graduate/probationer memberships to fellow memberships. Table 2 indicates the involvement of the respondent in construction industry, and the result shows that 68.75% of the respondents have between 1 years to 10years. 29.17% of the respondent had work in the industry for 11years to 20 years, while none of the respondents have spent 30 years above in the industry. It could be said that the respondents are knowledgeable about trends and evolvement in the construction industry.

The study further interrogated the form of organizations, the result shows that 43.75% of respondent are working in contracting organization, 29.17% of the respondent are working with private client's organization, 20.83% of the respondents work at consulting organization, while the remaining respondent are working with public client organization.

Table 2: Demographic of the Respondent

Variable	Level	Frequency	Percentage
Involvement in the construction industry	1 -10 years	33	68.75
	11 -20years	14	29.17
	21 to 30	1	2.08
	30 years above	0	0.00
Highest academic qualification	M.Sc.	17	35.42
	HND	4	8.33
	B.Sc.	27	56.25
Profession of the respondents	Engineering	23	47.92
	Quantity Surveying	12	25.00
	Architecture	3	6.25
	Construction Management	5	10.42
	Building	5	10.42
Membership of Professional Body	NSE	12	25.00
	COREN	15	31.25
	NIQS	13	27.08
	ARCON	3	6.25
	NIOB	5	10.42
Professional Body Grade of Membership	Graduate /Probational Member	13	27.08
	Corporate member	30	62.50
	Fellow member	4	8.33
	In view	1	2.08

Organization Forms	Private client organization	14	29.17
	Consulting organization	10	20.83
	Contracting organization	21	43.75
	Public client organization	3	6.25
Number of Employees	1 - 5 employees	7	14.58
	5-99 employees	17	35.42
	100-499 employees	18	37.50
	500 + employees	6	12.50

C. Challenges of the Implementation and Adoption of Cloud Computing in Nigeria

Literature reviewed aided in understanding that only a few of the obstacles that could prevent Nigeria from implementing cloud computing are universal to all industries, even though there are many others. This section interrogated respondent on the perceived barrier to the adoption and implementation of cloud computing in Nigeria However, there are many barriers identified from literatures and a few barriers that are tailored to the Nigeria construction professionals were observed and identified during the interview process as well as from the questionnaire responses. To determine the uniqueness of this barriers and how they can be grouped, the Exploratory Factor Analysis was used to do this. Table 3 shows this information. This table gives clarity to the selection of the number of Factors that the variables were grouped. Eigenvalue of greater than one signifies the most appropriate grouping of the barriers and number of factors to be considered as a barrier to the implementation of cloud computing in Nigeria.

The Scree plot in Figure 2 also considered to clarify this number of factors. The point of convergency of the screed plot helps to identify the number of appropriate factors that can be considered as a barrier that is currently impeding the implementation of cloud computing by construction professionals in the Nigeria Construction industry. Hence the very other factors were not given further attention but the two factors.

D. Most Prevalent Challenges of the Implementation of Cloud Computing in Nigeria

Table 3: Mean and SD of the identified variables

Code	Variables	Observations	Obs. without missing data	Mean	Std. deviation
IBAR 1	Access to internet facilities	47	47	3.681	1.181
IBAR 2	Poor network connection	47	47	4.085	0.929
IBAR 3	Access to sufficient internet bandwidth	47	47	3.936	0.791
IBAR 4	Availability of wired service	47	47	3.553	0.928
IBAR 5	Compatibility of cloud tools and machines	47	47	3.830	1.028
IBAR 6	Cost of purchase of cloud services for construction project management	47	47	4.319	0.810
IBAR 7	Cost of renting cloud resource for construction operations	47	47	4.170	0.732
IBAR 8	Cost of data/document/file and information sharing	47	47	3.979	0.737
IBAR 9	Financial strength of small and medium enterprise construction companies in Nigeria	47	47	4.298	0.749
IBAR 10	Operational cost of integrating cloud technologies for construction use	47	47	4.426	0.617
IBAR 11	Willingness of construction organizations to bear the additional cost of organizing workshop training for construction workers on Cloud computing technologies	47	47	4.021	1.073

The Table 4 shows the list of barriers that were considered as to be affecting the implementation of cloud computing by construction professionals in Nigeria. The IBAR 1, 5, and 11 shows a huge variance from the mean. This implies that some respondent rated this IBAR as really important variables that currently impedes the implementation of cloud services in Nigeria, while the others IBAR 2, 3, 4, 6, 7, 8, 9, 10 shows fair deviation from the mean. Table 4 shows this variance between the variables observed. The Values in bold are different from 0 with a significance level alpha=0.05. Showing a high correlation between the barriers to the implementation of CC.

The table 4 shows the correlation matrix between the identified factors. This provides a useful way to explore the relationships between the variables in your data. The value in the cell at row IBAR 3 and column IBAR 6 is 0.134, which indicates a positive correlation of 0.134 between IBAR 3 and IBAR 6. Similarly, the value in the cell at row IBAR 7 and column IBAR 5 is -0.047, which indicates a negative correlation of -0.047 between IBAR 7 and IBAR 5. Strong correlation was identified between some of the variables. IBAR 5 and IBAR 3 have a relatively strong positive correlation of 0.654, while IBAR 6 and IBAR 2 have a relatively strong positive correlation of 0.425. Generally, the bold values show strong correlations between each other.

Table 4: Correlation Matric of identified barriers

Variables	IBAR 1	IBAR 2	IBAR 3	IBAR 4	IBAR 5	IBAR 6	IBAR 7	IBAR 8	IBAR 9	IBAR 10	IBAR 11
IBAR 1	**1.0**										
IBAR 2	0.0	**1.0**									
IBAR 3	**0.3**	0.2	**1.0**								
IBAR 4	**0.3**	0.0	**0.5**	**1.0**							
IBAR 5	**0.3**	0.0	**0.7**	**0.6**	**1.0**						
IBAR 6	-0.1	**0.4**	0.1	0.1	0.1	**1.0**					
IBAR 7	-0.1	**0.3**	0.1	0.1	0.0	**0.7**	**1.0**				
IBAR 8	0.2	0.3	0.0	0.0	0.1	**0.4**	**0.4**	**1.0**			
IBAR 9	**0.4**	0.2	0.0	0.0	0.2	**0.3**	**0.3**	**0.5**	**1.0**		
IBAR 10	0.1	0.2	0.1	0.0	0.2	**0.3**	**0.3**	**0.4**	**0.5**	**1.0**	
IBAR 11	0.1	0.2	**0.4**	0.2	**0.4**	0.2	0.2	0.2	**0.3**	**0.5**	**1.0**

Table 5: Variance in Barriers

	F1	F2	F3	F4	F5	F6	F7	F8
Eigenvalue	**3.0**	**1.9**	0.9	0.6	0.2	0.1	0.0	0.0
Variability (%)	27.1	17.0	8.5	5.3	2.0	0.9	0.2	0.0
Cumulative %	27.1	44.1	52.6	57.9	59.9	60.9	61.1	61.1

The table 5 shows the result of the Principal Component Analysis (PCA) on the set of variables (F1-F8). The PCA is used to identified patterns and dimensionality of data. The table shows the eigenvalues, variability, and cumulative variability for each principal component extracted from analysis. The table shows an Eigenvalues measuring the amount of variance explained by each principal component. In this table, the first principal component (F1) has the highest eigenvalue of 2.976, which explains 27.058% of the total variability in the data.

The second principal component (F2) has an eigenvalue of 1.875, explaining 17.047% of the variability, The Cumulative shows the cumulative percentage of variability explained by each principal component. For example, the first two principal components (F1 and F2) explain a total of 44.105% of the variability in the data, the first three (F1-F3) explain 52.614%. This table gives clarity to the selection of the number of Factors that the variables were grouped. Eigenvalue of greater than one, signifies the most appropriate grouping of the barriers to the implementation of cloud computing in Nigeria. The Scree plot was also considered to clarify this number of factors. The point of convergency of the scree plot helps to identify the number of appropriate factors that can be considered as a barrier that is currently impeding the implementation of cloud computing by construction professionals in the Nigeria Construction industry. Hence the very other factors were not given further attention but the two factors.

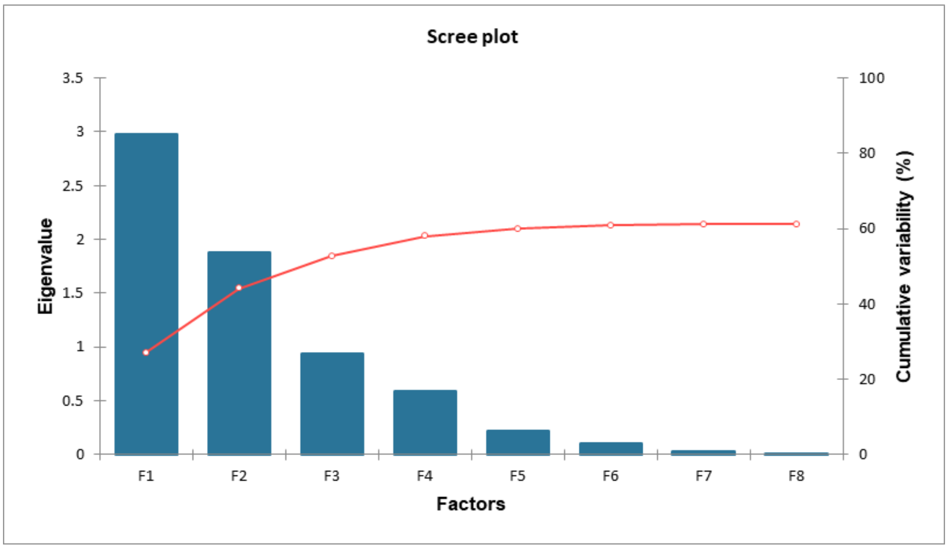

Fig. 2: Scree Plot of the loading of the barriers to the implementation of CC.

Table 6: Correlation between variables and factors

	Variables	F1	F2	F3	F4
IBAR 1	Access to internet facilities	0.372	-0.413	0.367	0.468
IBAR 2	Poor network connection	0.387	0.254	-0.195	-0.044
IBAR 3	Access to sufficient internet bandwidth	0.520	-0.640	-0.295	-0.064
IBAR 4	Availability of wired service	0.366	-0.601	-0.264	0.262
IBAR 5	Compatibility of cloud tools and machines	0.527	-0.714	-0.054	-0.061
IBAR 6	Cost of purchase of cloud services for construction project management	0.659	0.499	-0.483	0.231
IBAR 7	Cost of renting cloud resource for construction operations	0.588	0.498	-0.385	0.077
IBAR 8	Cost of data/document/file and information sharing	0.540	0.314	0.236	0.223
IBAR 9	Financial strength of small and medium enterprise construction companies in Nigeria	0.707	0.225	0.595	0.187
IBAR 10	Operational cost of integrating cloud technologies for construction use	0.626	0.192	0.265	-0.400
IBAR 11	Willingness of construction organizations to bear the additional cost of organizing workshop training for construction workers on Cloud computing technologies	0.611	-0.141	0.078	-0.633

The table 6, shows the results of a factor analysis - a statistical method used to identify underlying factors or dimensions that explain the correlations or patterns between several variables. In this case, the table shows the factor loadings (representing the correlation between each variable and each factor, with values ranging from -1 to 1) for each variable on four identified factors, labeled F1, F2, F3, and F4. On the first row, the variable "Access to internet facilities" has a high positive loading (0.372) on the first factor (F1), and lower loadings on the other factors, except F4.

This suggests that this variable is strongly associated with F1 and F4 and may be a good indicator of this factor. This forms the basis of grouping the factors and variables. Variables that are strongly significant to Factor 1, were grouped as Broadband Connectivity while the variables collecting with Factor 3 were assigned Cost and Financials. From the table 7 below, it was also confirmed that there is a correlation between the factors as the primary variables highly significant to this research factors were intercepting around variables that geared towards the Cost of the implementation of this technology.

Table 7: The Relative Importance Index (RII) of the Barriers affecting the implementation of CC

Code	Variables	Weighted Value	Weighted Avg	RII	Rank
IBAR 1	Access to internet facilities	170	240	0.71	1
IBAR 6	Cost of purchase of cloud services for construction project management	127	240	0.53	2
IBAR 10	Operational cost of integrating cloud technologies for construction use	124	240	0.52	3
IBAR 9	Financial strength of small and medium enterprise construction companies in Nigeria	120	240	0.50	4
IBAR 5	Compatibility of cloud tools and machines	108	240	0.45	5
IBAR 11	Willingness of construction organizations to bear the additional Cost of organizing workshop training for construction workers on Cloud computing technologies	107	240	0.45	6
IBAR 2	Poor network connection	101	240	0.42	7
IBAR 7	Cost of renting cloud resource for construction operations	84	240	0.35	8
IBAR 3	Access to sufficient internet bandwidth	78	240	0.33	9
IBAR 8	Cost of data/document/file and information sharing	68	240	0.28	10
IBAR 4	Availability of wired service	55	240	0.23	11

Table 7 shows the relative importance index of the barriers affecting the implementation of cloud services by construction professionals in Nigeria. From the table, we can see that "Access to internet facilities" is the most important factor influencing cloud technology adoption in the construction industry, with an RII score of 0.71 and a rank of 1. "Cost of purchase of cloud services for construction project management" and "Operational cost of integrating cloud technologies for construction use" are the second and third most important factors, with RII scores of 0.53 and 0.52, respectively. The least important factor is "Availability of wired service", with an RII score of 0.23 and a rank of 11. Considering the above data, it can be concluded that the most predominant barriers to the implementation of cloud computing services by construction professionals in Nigeria is cost.

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E. Most Prevalent Challenges the Adoption of Cloud Computing in Nigeria

The Table 8 shows the list of barriers that were considered as to be affecting the adoption of cloud computing by construction professionals in Nigeria. While BAR22 shows that 68% of the respondent are indifferent about this barrier, BAR 1,7,8,17,25,30 and 36 shows a huge variance from the mean. This implies that some respondent rated this BAR as saturated and may or may not be considered significant variable currently impeding the adoption of cloud services in Nigeria. While variable 2, 3, 4, 6, 7, 8, 9, 10 shows fair deviation from the mean. Table 9 shows the variance existing between variables observed. The values in bold are different from 0 with a significance level alpha=0.05. BAR 4, 5 and 18 shows far deviation from the (p=0.05) level already sent. Although can be said to have a very high level of significance with a positive correlation, these variables cannot be completely determined and hence, the significance level can be said to be neutral.

These variables were loaded, and the eigenvalue of these variables were determined. The number of factors were not predetermined but was automatically generated through analysis as seen in the table 9. It was observed that the barriers impeding the adoption of cloud computing in Nigeria can be grouped under seven (7) factors. These factors are generated from the relationship between the variables and their correlated values as shown in Table 9. These factors are also shown on the Scree plot in Fig 3 and the point of convergence of the graph represents the factor areas. Since there is no standard naming to this factor [5]. Table 10 also shows the correlation between these variables and the Seven factor factors as well and the seven-factor component of the barriers affecting the adoption of cloud computing are represented in the Table 12.

The scree lot as well as the table 9 also shows that the more than 70% of the total variants of the barriers affecting the adoption of cloud computing as identified by construction professions in Nigeria were accommodated by these seven factors. As such, we can conclude that the rest of the factors are insignificant to affecting the adoption of cloud computing in Nigeria.

Table 8: Mean and SD of the barriers hindering the adoption of cloud computing

Variable	Mean	Std. deviation
BAR1	3.1	1.2
BAR2	3.7	0.9
BAR3	3.9	0.9
BAR4	3.7	0.9
BAR5	3.9	1
BAR6	3.8	0.9
BAR7	3.8	1
BAR8	3.5	1
BAR9	3.8	0.9
BAR10	3.8	1
BAR11	3.9	1
.	4.2	0.8
.	4	1
.	4.1	1
.	3.9	0.9
BAR39	3.7	1

Table 9: Percentage Variance between Eigenvalue Factors generated.

Factors	Eigenvalue	Variability (%)	Cumulative (%)
F1	18.477	47.376	47.376
F2	2.004	5.138	52.514
F3	1.876	4.81	57.324
F4	1.75	4.488	61.812
F5	1.307	3.351	65.163
F6	1.167	2.993	68.156
F7	1.027	2.633	70.79
F8	0.978	2.509	73.298

F9	0.811	2.079	75.377
F10	0.557	1.428	76.805
F11	0.442	1.134	77.939
F12	0.386	0.99	78.929
F13	0.356	0.912	79.842
F14	0.245	0.628	80.47
F15	0.218	0.559	81.029
F16	0.197	0.504	81.533
F17	0.149	0.383	81.917
F18	0.126	0.322	82.238
F19	0.075	0.192	82.431

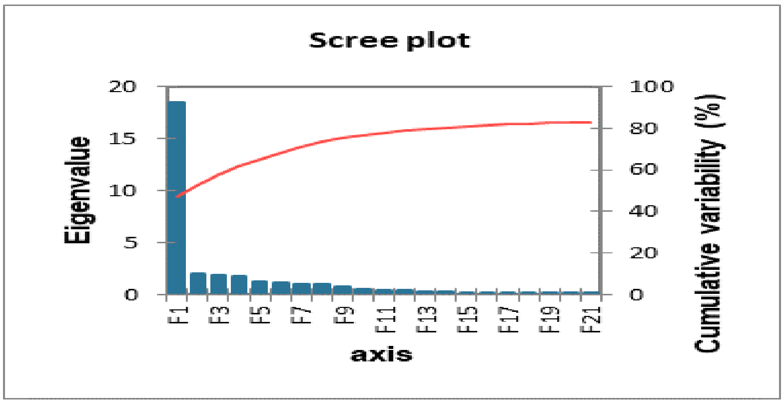

Fig. 3: Scree Plot showing Factors grouping of the barriers to the adoption of CC in Nigeria

Table 10: Correlation between identified barriers and the factor

	F1	F2	F3	F4	F5	F6	F7
BAR1	0.247	-0.038	0.114	-0.044	0.400	0.215	0.291
BAR2	0.755	0.283	0.309	0.042	0.155	-0.069	-0.099
BAR3	0.755	0.233	0.228	-0.033	0.029	0.170	-0.127
BAR4	0.757	0.016	0.391	-0.214	0.103	-0.004	-0.055
BAR5	0.763	0.349	0.222	-0.056	-0.009	-0.092	-0.039
BAR6	0.707	0.010	-0.148	0.267	-0.079	0.292	0.129
BAR7	0.795	-0.162	-0.188	0.307	-0.065	0.228	-0.111
BAR8	0.778	0.017	-0.048	0.346	0.023	0.250	-0.094
BAR9	0.854	0.086	0.164	0.162	0.077	0.013	0.027
BAR10	0.711	0.152	0.497	0.035	0.096	-0.004	-0.030
BAR11	0.772	0.071	0.046	0.374	-0.121	0.083	0.143

Table 11: The Relative Importance Index (RII)

Code	Variables	Weighted Value	Weighted Avg	RII	Rank
BAR12	Unstable economic situation of the nation	197	240	0.820833	1
BAR34	Unwillingness of organizations to fund Cloud Services when not included in project cost	196	240	0.816667	2
BAR20	Absence of power infrastructure project - electric power supply	195	240	0.8125	3
BAR14	Lack of awareness of Cloud Computing Technologies and Services by practitioners in the Nigeria construction industry	194	240	0.808333	4
BAR33	Unwillingness of clients to fund Cloud Computing Services used on their projects	194	240	0.808333	4

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BAR23	Lack of technical knowledge of Cloud Computing Technologies	191	240	0.795833	5
BAR29	Unwilling of stakeholders to give their private and commercial information such as project cost to a third-party	191	240	0.795833	5
BAR13	Unavailability of government strategies for the adoption of cloud technologies	190	240	0.791667	6
BAR24	Willingness of construction project stakeholders to learn new technologies	190	240	0.791667	6
BAR28	Reluctancy of construction workers and practitioners to accepting new technological innovations	190	240	0.791667	6
BAR35	Unwillingness of organizations to sponsor Cloud training for construction workers	189	240	0.7875	7
BAR22	Lack of time to conduct Cloud Computing studies by construction professionals	188	240	0.783333	8
BAR27	Inadequate facilitation skills and training on Cloud Computing Technologies	186	240	0.775	9
BAR5	The lack of data transaction policy from the government	184	240	0.766667	10
BAR11	Fear of high level of taxation on cloud users in the construction industry	184	240	0.766667	10
BAR15	Failure to admit ignorance in certain specialized aspects on project development that may need the intervention of cloud computing services and technologies to resolve	182	240	0.758333	11
BAR17	Insufficient studies on Cloud Computing Technologies	182	240	0.758333	11
BAR31	Absence of standards guiding the use of cloud platforms	181	240	0.754167	12
BAR6	Discrepancies of ownership of construction data (documents, etc.) in a cloud platform	180	240	0.75	13
BAR7	Freedom to share construction data with another member of the team	180	240	0.75	13
BAR26	Unconducive work environment	179	240	0.745833	14
BAR3	The Fear of data breach from service providers	178	240	0.741667	15
BAR21	Absence of trainings on Cloud Computing Technologies	178	240	0.741667	15
BAR32	Difficulties in establishing mutual project objectives between stakeholders in the construction industry	178	240	0.741667	15
BAR39	Possibility of team member to deny the ownership of construction data shared on Cloud platform	178	240	0.741667	15
BAR9	Lack of contractual provisions to support cloud construction data transaction	177	240	0.7375	16
BAR10	Regulatory ambiguities from government body	177	240	0.7375	16
BAR25	Unsupportive industrial norms	177	240	0.7375	16
BAR37	Absence of procurement and contract strategies for the implementation of Cloud Technologies	177	240	0.7375	16
BAR4	The unavailability of data security and privacy laws	176	240	0.733333	17
BAR38	Poor collaboration and working relationships among construction project stakeholders	176	240	0.733333	17
BAR2	The unavailability of data protection strategies to block data leakage	175	240	0.729167	18

BAR36	Fear of losing time implementing Cloud technologies during project execution due to very tight project schedules	175	240	0.729167	18
BAR16	Absence of the demand for Cloud Computing Technologies and Services	174	240	0.725	19
BAR19	Limited cloud service providers in Nigeria	174	240	0.725	19
BAR30	Reliability of cloud computing platforms	172	240	0.716667	20
BAR8	The lack of access levels for the different categories of stakeholders involved in the production and management of building data using cloud computing services	165	240	0.6875	21
BAR18	The unavailability of cloud service providers	158	240	0.658333	22
BAR1	The storage of construction design and financial information in shared resources would pose serious treats to the construction industry	145	240	0.604167	23

Table 11 shows the relative importance index of the factors that were identified from literatures as well as those included by the respondent of the interview as tailored to the Nigeria construction Industry.

The table 11 shows that the unstable economic situation of the country as well as the unwillingness of organizations to fund cloud services when not included in project cost, absence of power infrastructure project - electric power supply, lack of awareness of cloud computing technologies and services by practitioners in the Nigeria construction industry, unwillingness of clients to fund cloud computing services used on their project, Lack of technical knowledge of Cloud Computing Technologies, Unwilling of stakeholders to give their private and commercial information such as project cost to a third-party, Unavailability of government strategies for the adoption of cloud technologies and Willingness of construction project stakeholders to learn new technologies are the Ten (10) most significant barriers to the adoption of Cloud computing technologies by the construction professionals in Nigeria. Out of this ten barriers, two (2) of highest ranked barriers, that is, the unwillingness of organizations to fund cloud services when not included in project cost and the unwillingness of clients to fund cloud computing services used on their project ranking 2nd and 4th respectively BAR 34 and 33 were variables that were not found in the literatures, but were new information recorded from interviewing various construction professionals who were able to contribute to the existing knowledge by tailoring this barrier to the Nigeria construction industry. These two barriers also have a high level of significance to the adoption of CC, as compared to others. The other factor that is more predominant is the Knowledge base. This is very important for a successful adoption of CC in the Nigeria construction industry.

From the factor and variable table, BAR 34 and BAR 33 also has a high level of significance to the factors group of seven (7) factors as identified from the Exploratory Factor Analysis.

Data Privacy, Data Security, Data Governance, Level of Awareness, Service providers and Infrastructures, Training and Education and Organization culture, Environment and Trust.

While these were initially assumed Ho and grouped into these categories, the Exploratory factor Analysis helped to prove this hypothesis, confirming from correlation between variables, that there are seven most significant factor group for the variables with great level of significance, with variance greater than 70 % at the 7th factor analysis.

F. Most Predominant Cloud Services Currently in Use by Construction Professionals

Table 12: Cloud Computing Services used by construction professionals

Variables		**Cloud Technologies**	**Weighted Value**	**Weighted Avg**	**RII**	**Rank**
		Zohobox	94	240	0.070833333	1
Cloud Computing Platforms		iCloud	129	240	0.05	2
		Intel	116	240	0.05	2
		Adobe Creative Cloud	109	240	0.045833333	3
		Amazon web Service	110	240	0.041666667	4
		[Microsoft Azure	116	240	0.041666667	4

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Communication tools		Microsoft Office	188	240	0.029166667	1
		Google Mail	190	240	0.025	2
		Google Drive	185	240	0.025	2
		Dropbox	161	240	0.020833333	3
		Yahoo	184	240	0.016666667	4
Cloud Software		Salesforce.com	82	240	0.091666667	1
		IBM	110	240	0.054166667	2
		BIM Neutral60	126	240	0.054166667	2

From the information on the table 12, it is evident that the construction professionals in Nigeria are still mostly used to Microsoft office as a communication platform. This is very dominant in amongst most construction organizations as well as construction stakeholders. Mailing is a very important part of communication in the Nigeria construction industry. As through this, documentation of construction issues, and documents are shared across project sites. Another unique part of the Nigeria construction industry is that its professionals are currently moving to using the iCloud platform services as well as Zohobox.

This shows that the apple platforms are now dominating the construction industry and have very good technical requirements required for mobile cloud computing platforms. With this information, it can be inferred that construction professionals will not have issues starting with cloud computing mobile application services. This is good news, knowing that mobile cloud can quickly take on the industry soon as a good broadband internet is made available. This shows a good potential for the implementation of cloud services by construction professionals.

Lastly, construction professionals are predominantly used to Salesforce. While IBM and BIM software were ranked equally, this shows that there is a great potential for the Nigeria construction professionals to learn operate and implement cloud services in a very short time from now.

IV. CONCLUSION

The study aimed to recognizing and prioritizing challenges within the domain of Cloud Computing (CC) in the context of the Nigeria construction industry. A comprehensive analysis of existing studies was conducted to pinpoint barriers elucidated in the literature. Leveraging the identified barriers, the research delved into understanding their impact on the implementation and adoption of CC by construction professionals in Nigeria. Additionally, the study explored the potential existence of new barriers specifically tailored to the construction ecosystem in Nigeria. Beyond those outlined in the literature, the research identified and investigated three new barriers. Utilizing Descriptive Statistics, Exploratory Factor Analysis (EFA), and Relative Importance Index (RII) methodologies, the study scrutinized the implications of these barriers on the implementation and adoption of CC services and applications by construction professionals in Nigeria.

The study primarily centered on experienced and registered construction professionals in Nigeria. Using the Exploratory Factor Analysis (EFA) component, the study identified technical factors that could impede the implementation of cloud computing. This analysis pinpointed the two most influential factors: the unavailability of broadband internet and the financial aspects associated with operating and subscribing to cloud services. Moreover, the EFA analysis played a crucial role in categorizing the identified variables, acting as barriers to the adoption of cloud technologies by construction professionals. These barriers were grouped into seven distinct categories: Socio-economic factors, Data Privacy, Security, Governance, Level of Awareness and Knowledge, Services and Infrastructures, Training and Education, and Organizational Culture, Environment, and Trust among project stakeholders in construction.

Subsequent to the EFA analysis, the study employed Relative Importance Index (RII) analysis to evaluate and rank the identified obstacles. The RII results highlighted that Access to internet facilities, Cost of purchase of cloud services for construction project management, and Operational cost of integrating cloud technologies for construction use were the foremost barriers hindering the implementation of cloud technologies by construction professionals in Nigeria. Simultaneously, the Unstable economic situation of the nation, Unwillingness of organizations to fund Cloud Services when not included in project cost, and Absence of power infrastructure project - electric power supply emerged as the three most significant barriers impeding the adoption of cloud computing services in the Nigerian construction industry.

Beyond addressing challenges to the implementation and adoption of Cloud Computing services, this study provided fresh insights into the exposure of construction professionals in Nigeria to mobile technologies. Analysis of the data suggests that these professionals have not fully embraced most existing cloud technologies currently in use in the industry. Instead, they appear more accustomed to general platforms for information management and storage, with Microsoft packages being the prevalent communication platform. Additionally, construction professionals predominantly use Apple and ZohoBox platforms, indicating substantial potential for the implementation of cloud computing technologies once the primary barriers related to broadband internet are addressed.

The outcomes of this study offer valuable insights for project managers, construction stakeholders, and cloud service providers, enhancing their understanding of the barriers and potentialities within the cloud business and market in Nigeria.

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