-34-

EFFECT OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) ON SUSTAINABLE CONSTRUCTION DEVELOPMENT IN NIGERIA

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Abstra*ct*
Sustainability in construction development can be perceived in the areas of ICT barriers and benefits management. Management of sustainable building materials and waste management in the implementation of construction projects affects the overall success of construction projects as the global ICT Development Index ranking by the International Telecommunication Union (ITU) shows that Nigeria moved up two places from 135 spots in 2012 to 133 in 2013. The objective of this study was to assess the effect of Information and Communication Technology on Sustainable Construction Development in Nigeria; determine the effects with respect to need, barriers, and benefits of ICT implementation on sustainable construction development; and make recommendations on possible improvement. A total of 240 questionnaires were administered to respondents in construction companies to provide empirical data for the analysis. Findings indicated that Nigerian Construction Industry needs ICT throughout the construction stages right from pre-design, through and up to operation and maintenance. For sustainable construction development to be achieved, the cost of installation of ICT infrastructure, lack of regulations by the government in the adoption of ICT, lack of knowledge about ICT and other software in the construction industry, unwillingness to change by senior construction professionals, and poor management of the supply chain are the major barriers that are to be addressed in Nigerian construction industries. The study recommended that **Government should come up with a policy regulating the adoption of ICT for construction works and proper ICT training.**
Keywords: Sustainable construction developmentz Information and Communication Technology (ICT); Barrier and benefit management.

I. INTRODUCTION

Sustainable development leads to the fulfillment of societal ideals considered relevant to the needs and aspirations of society. Factors, which influence such developments, are based on the human ability to explore, invent, and utilize. Satisfaction of spiritual, physical, and material needs and the mastery of the environment are parameters of development when applied to human society (Nwabueze and Ozioko, 2011). Information and Communication Technology (ICT), also known as information technology (IT) has radically transformed the way we live, learn, work, and play. Many companies in the construction industry do not generally appear to have appreciated the positive changes and surveys in developing and emerging economies such as South Africa in 1999 (Arif and Karam, 2001), and Nigeria in 2005 (Oladapo, 2007). However, one of the major challenges today in developing countries of which Nigeria is one is sustainable development (Nwankwo *et al.,* 2019). On this note, the study seeks to assess the effect of Information and Communication Technology on Sustainable Construction Development in Nigeria.

II. OBJECTIVES OF THE STUDY

The objective of this study was to assess the effect of ICT on sustainable construction development in Nigeria to facilitate construction industry growth and this is achieved through the following objectives;

i. to evaluate the need for ICT implementation in the construction industry in Nigeria
ii. to examine the barriers against ICT implementation in the construction industry in the study

area

iii. to ascertain the effects of ICT on sustainable construction development in the study area

III. LITERATURE REVIEW

Information and Communication Technologies (ICT)

ICT is a technology that can be used to facilitate contact between all stakeholders involved in project work, including designers, architects, managers, and owners (Singh *et al.,* 2021). IT-based technology has many resources and technologies that have an immense potential to ease work related to the flow of information or data storage. It is an important and effective tool for both current and future users (Gomes-Meneses *et al.,* 2014; Holmstrom *et al.,* 2014; Sunbul *et al.,* 2016]. Insufficient communication efficiency and the resulting weaknesses and design defects have often been overlooked as a source of delays in the industry. The magnitude of the communication barriers could not be seen as a significant factor affecting the execution of the project, especially in terms of time and price or overall project cost. However, some organizations have pointed out that this aspect is a key factor that impacts projects on an enormous scale (Aliagha et al., 2015; Hampson et al., 2003; Alsafouri and Ayer, 2017).

ICT in the Nigerian Construction Industry

The construction industry in Nigerian consists of diverse professionals such as engineers, builders, architects, quantity surveyors, land surveyors, contractors, suppliers, and geo-informatic experts among others, which require an exchange of project data and information in discharging their services of achieving project objectives of time, cost, and quality to the project owners (Olubunmi, Olaniyi, & Fisayo, 2014). A large number of professional teams and the data-intensive nature of the industry requires specialized coordination of project tasks using ICT to achieve the project objectives (Bilal *et al*., 2016).

Historically, the Nigerian construction industry after the millennium breakthrough was still faced with the use of a traditional paper-based approach to information and communication management (Amusan *et al*., 2018). The report published by the International Telecommunication Union (ITU) showed that Nigeria ranked 153rd among 178 countries in global ICT ranking and 27th among 51 African countries. This result was not surprising as the industry was characterized by three major constraints: inadequate and erratic electricity supply, high cost of computer software and hardware, and insufficient jobs among the contractors operating in the industry (Gambo, 2017).

Fifteen years later, the ICT Development Index (IDI) of Nigeria was 2.60 in 2017 compared to 2.44 in 2016 while still maintaining the 143rd position among 176 countries globally and 15th position among 38 African countries (ITU, 2016; ITU, 2017). Even though the IDI went up from 2.35 in 2013 and now 2.60 in 2017, the percentage growth in IDI over the 4 years is still low when compared with the IDI growth of other African countries. The percentage of households with computers and internet access stands at 10.56 and 15.23, respectively (ITU, 2016). The research suggested that ICT penetration at the household level can be used to explain ICT penetration at the organizational level (Hilty and Aebischer, 2015). As such, the statistics of ICT usage at the household level in Nigeria help draw a background for understanding ICT penetrations in the Nigerian construction industry.

Need of ICT in the Construction Industry

ICT is needed for construction works such as predesign activities, design activities construction activities, operational activities, and maintenance activities (Paudyal and Prakriti, 2016).

Pre-design: To define the requirements of the clients concerning space management, cost, quality, and time of completion of the project. It includes preliminary design, layouts, site soil tests, topography, etc. to check the feasibility of the project. For pre-design the following **computer programs may be**

found applicable: Google Earth, GPS, and GIS.
Design: The designing phase includes virtual construction before starting the real construction to check the efficiency of the project. It's considered a major step to be taken in the construction that highly improves the performance of the project in all respects. The design software includes the following: CAD, SAP, ETAB, STAAD BIM, etc

Operation: Computerized system is used in the operation of structures like the adjustment of the gate of the dam. It is also highly useful in structures like hospitals, and shopping complexes for the operation of elevator, lift, escalator etc.

Construction planning: It involves cost estimation and schedule management or any one of them. It may also include the choice of technology, time taken to complete each task, required resources, etc. In bigger projects, both the dimensions i.e. schedule and budget information must be considered. Microsoft Project is a software commonly used for construction management.

Maintenance: Regular maintenance of the constructed structures can be done using ICT. For example, Scanner can be used to detect the width of internal cracks and determine whether the structure is safe or not.

Construction: Construction includes the following: a) Batching: Concrete mix aggregates are introduced in the mixture in correct proportion within accuracy by the direct input of data in the computer. b) Compaction: By fixing the number and frequency of vibrations digitally compaction in roads, foundations, etc. can be done easily, and c) Curing: The amount of water required for curing can be instructed from the computerized system.

Barriers to ICT Implementation
Various barriers affect the use of information, communication, and technology in the building and development industry. Several researchers have identified the initial cost of ICT equipment, the cost of maintaining ICT resources and technologies, and their training and growth as a major barriers to ICT adoption (Mitropoulous and Tactum, 1999; Root and Thorpe, 2001). Inter-industry management in construction projects is limited, but ICT communication technologies will boost collaboration (Shankar *et al.,* 2010) The lack of strategic decisions of the organization leads to a lack of investment in ICT technology (Root and Thorpe, 2001).

Infrastructural Deficiency: Infrastructural deficiency is real in Nigeria and is a vital technology adoption issue among Nigerian construction firms (Egoeze, Misra, Akman, & Colomo-Palacios, 2014; Mudi, Bioku, & Kolawole, 2015). Most construction firms in Nigeria lack adequate infrastructure to effectively tap into the opportunities provided by cyberspace due to low access speed from internet providers and poor and erratic power supply from the national grid (Onyeji-Nwogu, Bazilian, & Moss, 2017; Vincent & Yusuf, 2014). The logistic performance index (LPI) is a function of the infrastructural performance of countries around the world. A review of the LPI global ranking showed that Nigeria which ranked 100th position among 160 countries in 2010 with an LPI score of 2.59 now ranked 110th position with an LPI score of 2.53 (The World Bank, 2018).

Technical Skills Deficiency: The lack of qualified and globally recognized IT personnel in Nigeria is an issue that is affecting IT adoption and development in Nigerian construction firms (Ejiaku, 2014; Faloye, 2014). In a period of constantly changing business environment, Nigerian construction firms are still faced with a lack of adequate human resources that possess the skill to design, program, install, configure, and maintain information technology and infrastructure (Ejiaku, 2014; Turaki et al., 2015). The training and education necessary to support skill transfer and acquisition are not encouraging, and neither is the industry taking advantage of the importation of

technical equipment and technical skill from industrialized nations into Nigeria as a way of achieving the acquisition of technological skills domestically (Ebong, Udoh, & Obafemi, 2014; Faloye, 2014).

Security and Protection: The adoption of technology concerning security concerns involves hackers, cyber fraud, virus attacks, and spyware infections (Waziri et al., 2017). A recent study concluded that the fear of insecurity is the main reason some users of IT in Nigeria declined the use of online facilities (Masa'Deh et al., 2015). The fear of hackers limits the interest of Foreign Service providers to invest in internet technology in Nigeria (Turaki et al., 2015).

Cost and Funding Constraints: Though cost is often said not to be the most important factor influencing the technology adoption decision (Sepasgozar & Davis, 2018), the cost of funding IT adoption seems to be an important issue in Nigeria and among Nigerian constructions firms (Awosan, 2014; Shaikh and Karjaluoto, 2015; Usman and Said, 2014). The lending rate from banking institutions in Nigeria has never been static and generally high, ranging from 16% to 26%, and varies from bank to bank. Apart from the high lending rate, there is a consensus that construction firms face delays from their clients to make payments as and when due for certified work (Kehinde et al., 2015). The fluctuating high lending rate, when combined with delayed payments, creates cash flow forecast constraints, thereby affecting true knowledge of the economic cost of IT adoption (Usman & Said, 2014).

Unethical Behavior: The ethics of technology adoption are the moral and professional principles guiding the adoption, implementation, distribution, and use of technological products and outputs. The existence of codes of ethical conduct in most organizations does not seem to impact positively ethical behaviors in construction organizations (Oladinrin & Ho, 2016). There appeared to be a high incidence of unethical behavior in the industry, the most common being the dishonesty of employees (Ogunyemi & Laguda, 2016). Loyalty, trust, and confidentiality of information are ethical factors that users of technology need to comply with. Generally, the big issue of IT adoption for ethics is that technology advances exponentially compared to the rate at which ethical codes are updated in organizations, resulting in a wide regulatory gap between technology and ethics (Wadhwa, 2014).

Faulty Regulatory Policies: The absence of enabling government policies and functioning regulatory agencies remains one of the major issues affecting IT adoption among construction firms in Nigeria (Abubakar, Ibrahim, Kado, & Bala, 2014; Ogunde, Olaolu, Afolabi, Owolabi, & Ojelabi, 2017). There is inconsistency in the area of policy formulation and implementation, which affects construction entrepreneurs working hard to survive in the difficult business terrain (Ogunde, Olaolu, Afolabi, Owolabi, & Ojelabi, 2017). The existing government policies lack attraction for IT adoption among construction firms to take full advantage of cutting-edge and disruptive technology (Abubakar, Ibrahim, Kado, & Bala, 2014). As of today, there are many regulatory agencies such as National Office for Technological Acquisition (NOTA), National
Information Technology Development (NITD), and Nigerian Computer Society (NCS), and most often there are controversies as to which regulatory agency has the purview to register IT contractors (Agbata, 2018). The unique nature of the construction industry concerning IT adoption requires industry-specific policy and regulation.

Benefits of ICT on Sustainable Construction Development

According to Shankar *et al.,* (2009), ICT is a strong technology that enhances the exchange of information and definitely enhances successful decision-making. The management of various resources, including human resources, is made more available by the use of information and communication technology (Duan *et al.,*2016). Web-based resources are very reliable in terms of efficient and future communication, as can be seen in the increased pace of communication or the

virtually effortless storage of a significant amount of data (Georges *et al.* 2019). New technologies such as BIM (Building Information Modeling) have fully changed the perception of architecture in the global market. BIM-related software, such as Revit, offers features that prevent collision design and allow multiple designers to solve tasks quickly and efficiently (Singh *et al.,* 2021). Thanks to the successful use of these technologies (Singh *et al.,* 2021), the team participant cooperates with other group participants. The Internet is being used globally and thus has many advantages, such as additional consulting with world-famous experts. The major benefit of web technology and ICT methods in the construction sector is the very effective management and availability of the supply chain. The major effect on improved efficiency, as well as the reduction of time and cost constraints of a particular project, is addressed. ICT also has several incentives that may help to prosper construction-related companies and extend the reach of the projects. However, a specified approach is required at all levels to ensure the efficient adoption of information and communication technologies (Singh *et al.,* 2021).

IV. RESEARCH METHODOLOGY

A survey method in the form of a questionnaire was adopted to generate data. The work reviewed and analyzed the effect of ICT on sustainable construction development. The themes and issues covered in the research include ICT needs, barriers, and benefits of ICT implementation. The data analyzed were both descriptive and quantitative. The result was used to establish rankings of the benchmark indices among various issues. Efforts were made for the study to cover construction companies domiciled in each of the six geopolitical zones in the country in a bid to make the work as representative as possible. A comprehensive questionnaire was designed, validated by the relevant stakeholders, and administered to the respondents for data collection and analysis. The questionnaire used a five-point Likert-type scale to measure a range of issues from "Undecided" to "Strongly agreed" as the case may be. For authenticity and data integrity, the questionnaire was administered directly to Architects, Builders, quantity surveyors and engineers, and ICT managers of the different construction companies across Nigeria.

Table 1, Population distribution

S/N	Construction professionals	Sample Frame	Sample Size
i.	Architects	69	50
ii	Builders	30	25
iii	Engineers	121	81
iv	Quantity Surveyors	80	72
v	ICT Manager	20	12
	Total	**320**	**240**

I. RESULTS AND DISCUSSION

Questionnaire distribution and percentage response information are shown in Table 2. Accordingly, a total of 320 questionnaires were administered and only 240 questionnaires were completed, returned, and found useful. This corresponds to a response rate of 76%.

Table 2: Distribution of questionnaire and percentage response

Questionnaires	Frequency	Percentage (%)
Number of questionnaires returned	240	75
Number of questionnaires not returned	80	25
TOTAL	320	100

Source: Field Survey 2023

Table 3: The Needs for ICT for Construction Development

Need for ICT	Mean	RII	Ranking
Predesign Stage (Google Earth, GPS, and GIS).	4.51	0.90	1st
Design stage CAD, SAP, ETAB, STAAD BIM	4.30	0.86	2nd
Construction Planning Stage Microsoft project is software	4.25	0.85	3rd
Construction Stage	4.20	0.84	4th
Operational Stage	3.99	0.80	5th
Maintenance	3.88	0.78	6th
5 – 1 (Strongly agreed to undecided)			

Source: Literature Review and Field Work (2023)

Table 3 reveals that ICT is needed throughout the construction stages as they all have a mean score above average of 0.50. Predesign stage with a mean score of 0.90, Predesign stage with a mean score of 0.86, the Construction planning stage with a mean score of 0.85, the Construction stage with a mean score of 0.84 and the Operational stage and Maintenance stage with a mean score 0.80 and 0.78 respectively.

Table 4: Barriers to the Implementation of ICT

Effects of Design Variation	Mean	RII	Ranking
Cost of installation of ICT infrastructure	4.58	0.92	1st
Lack of regulations by the government in the adoption of ICT	4.50	0.91	2nd
Lack of knowledge about ICT and other software in the construction industry	4.50	0.90	3rd
Unwillingness to change by senior construction professionals	4.39	0.88	4th
Poor management of the supply chain	4.35	0.87	5th
Lack of awareness of ICT	4.32	0.86	6th
Fear of data security on ICT platforms	4.30	0.86	7th
Every construction project is unique	4.00	0.80	8th
Cost of maintenance and development of ICT software and hardware	3.95	0.79	9th
More prominent construction organizations are not adopting ICT, and smaller organizations are following in their footsteps	3.83	0.77	10th
Fear of data security on ICT platforms	3.83	0.77	10th
Unavailability of trained staff and cost of training the staff	3.68	0.74	11th
5 – 1 (Most significant to Not Significant)			

Source: Literature Review and Field Work (2022)

Table 4 revealed that the Cost of installation of ICT infrastructure with a mean score of 0.92, Lack of regulations by the government in the adoption of ICT with a mean score 0.91, Lack of knowledge about ICT and other software in the construction industry with mean score 0.90, Unwillingness to change by senior construction professionals with mean score 0.88 and Poor management of the supply chain with mean score 0.87 are the major barriers against the implementation of ICT for construction works in Nigeria. Meanwhile, all the itemized barriers are also significantly affecting the implementation of ICT for construction works in Nigeria as they all have a mean score of above average of 3.5. From Table 4.3 above, it is evident that professionals believe that the postulated barriers are critical.

Table 5: Effect of ICT on Sustainable Construction Development in Nigeria

Effects	Mean	Rank
Project information is stored precisely in a better way	4.40	1
Effective Management control is superior using ICT	4.33	2
Easy to procure and manage supply chain	4.22	3
Rework errors are less	4.21	4
Data availability through ICT is reliable	4.00	5
The project will be completed in the given time and cost	3.99	6
Management control is better by using ICT	3.86	7
ICT provides excellent communication among team members	3.75	8
ICT will enhance decision making	3.70	9
Management of contracts is enhanced	3.68	10
There are more unity and partnership among members of the team	3.64	11
ICT re? nes the productivity of the organization	3.62	12

Source: Fieldwork (2022)

Table 5 shows the effects of ICT on Sustainable Construction Development in Nigeria with all the identified effects ranking above the average Mean Item Score of 3.00. Project information is stored precisely in a better way and ranks highest with an MIS of 4.42 followed by Effective Management control is superior using ICT and Easy to procure and management of the supply chain with MIS of 4.33 and 4.22 respectively. The lowest ranked effect is ICT refines the productivity of the organization with an MIS of 3.62. Even though it was ranked lowest among the identified effect of ICT, a Mean Item Score of 3.62 is still a strong statistical value to show that it thus has a significant effect in sustaining construction development in Nigeria.

VI. CONCLUSION

ICT is needed throughout the construction stages which involve pre-design, design, construction planning, construction, Operation, and maintenance. Adequate use of ICT in infrastructural facilities, as well as other construction-related activities, can provide the sustainable benefits of a better storage way of project information, easy procurement of effective and superior management control, effective management of supply chain and give a refined productivity of the organization. This in turn gives birth to sustainable construction development in Nigeria. However, for this sustainable construction development to be achieved, the cost of installation of ICT infrastructure, lack of regulations by the government in the adoption of ICT, lack of knowledge about ICT and other software in the construction industry, unwillingness to change by senior construction professionals and poor management of the supply chain are the major barriers that are to be addressed in Nigeria construction industries.

VII. RECOMMENDATIONS

Based on the findings of this research, the following recommendation is made to have benefited sustainable construction development in Nigeria by adopting ICT:

- Government should come up with a policy regulating the adoption of ICT for construction works
- Proper ICT Training for construction workers should be put in place and made affordable.
- Senior construction professionals should be educated and enlightened about the benefits of adopting ICT for sustainable construction development in Nigeria.

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