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APPLICATION OF BUILDING INFORMATION MODELLING IN CONSTRUCTION PROJECTS DELIVERY IN NIGER DELTA, NIGERIA

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ABSTRACT

Purpose: Globally, there is tremendous increase in the use of Building Information Modeling (BIM) due to the fact that Governments around the world have recognized the inefficiencies affecting the construction industry in general, and have recommended and mandated the practice of Building Information Modelling (BIM) as a strategy to addressing a declining productivity. The study investigates on application of BIM in construction projects delivery in Niger-Delta region of Nigeria. The study focuses on the barriers associated with Building Information Modeling (BIM) in construction project delivery and classified them into three aspects.
Design/methodology/approach: Both the qualitative and quantitative approaches were employed in generating preliminary data for field testing. The survey involved one hundred and twenty participants in the six states of nine states of the Niger-delta with notable volume of construction projects and awareness of BIM tools. Data collected were analyzed using mean score and criticality index.
Findings: The study revealed that there are three main categories of the barriers in BIM based on the three main types of the stake holders in construction projects. The study unravelled the probability of occurrence and impact of the 14 barriers in construction project delivery. In addition, the study also reveals that seven barriers were fund to be most critical and that 4 of these 7 barriers were associated with the professional participating in construction projects and 3 were associated with the public sectors.
Originality/value: The study concluded that appropriate BIM development will enable construction industry to make expected contributions to the economic and development growth of Niger-Delta region of Nigeria. In order to pave way for BIM towards improving productivity and increased efficiency in Nigeria construction industry the research recommended that the Government should support the adoption and implementation of BIM in all capital projects at the three tiers of government and the professional bodies relevant in the construction industry should mandate training and retraining of their members on the application of BIM and forestall strong team work need in BIM concept for efficiency of construction industry in Nigeria.

Keywords: Building information modelling; construction; projects delivery; Niger Delta.

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1. INTRODUCTION

Recently, Building Information Modelling (BIM) has been recognized as a strategy to addressing the inefficiencies and declining in productivity of the construction industry. It has become very obvious that continuing to do things in the construction industry the way they had been done in the past may not lead to success due to technological advancements. The need for change and the rate of change across both large and small construction organizations is constantly increasing. A lot of organizations are realizing the need to improve their operations in order to remain relevant. Therefore, constantly improve both their managerial skill and technological know-how. The construction industry is not left out in the change taking place in the world, as a matter of fact, there has been a paradigm shift from the use of the conventional 2D-based documentation and staged delivery processes to a digital prototype and collaborative workflow. BIM is defined as the use of ICT to streamline the building lifecycle process in order to provide a safer and more productive environment for its occupants, to affect the least possible environmental impact from its existence and to be more operationally efficient for its owners throughout the building lifecycle (Arayici *et. al*., 2012).

The use of BIM which is a collaboration model is the most effective way of addressing the fragmentation in the construction industry, improve productivity and eliminate wastages. BIM architecture broadly enhance today's computer-aided design (CAD) capabilities with an improved ability to link design information with construction supply chain processes, such as estimating, offsite fabrication of elements, construction scheduling and cost control, materials procurement and tracking and general site operations. Furthermore, collaboration builds trust and common goals that serve the owner rather than competitive relationships where each team member often strives to maximize their individual goals (Eastman, Teicholz, Sacks, & Liston, 2011) BIM has modified the way construction projects are designed, constructed and operated. Using BIM in the construction, led to increase in the profitability, better time and cost management as well as improving in client-customer relationship. BIM is beneficial for all stages of construction as noted by many (Eastman, et. al., 2011 & Azhar, *et. al*., 2012). Alufohai (2012) attributed the low level of awareness and adoption of BIM to the low level of knowledge and use of BIM by professionals in the Nigerian construction industry.

Once BIM has been utilized on a project, its results speak for themselves and "firms that have switched to BIM don't switch back" to 2-D (Zeiger, 2008). Anecdotal results on one large firm's projects suggest that a 2 – 3 times payback is gained for the contractor for BIM expenditures (Post, 2008). The study investigates an application of BIM in construction projects delivery in Niger-Delta region of Nigeria. The study focuses on the barriers associated with Building Information Modelling (BIM) in construction project delivery and classified them into three aspects.

2. LITERATURE REVIEW

Globally, there is increase rate of using BIM either by governments for the public work or private sector and anticipated to continue to increase. BIM is mandated in some countries such as US and, UK and a number of other countries (Smart Market Report; 2010). The adoption of BIM has tremendously increased globally between 2010 and 2018. In USA it

was 54 % in 2012, in European countries it reached 36% in 2010. In the UK, BIM adoption between in 2012 was 39%, in the Middle East, only 10% in 2013 (Smart Market Report, 2014; Staff, 2014; NBS, 2014; NBS, 2013). Some countries in the Europe such as Finland, Denmark, Norway and Sweden are known as the BIM leaders in the word (Jensen & Johannesson, 2013; Khosrowshahi & Arayici, 2012). Accordingly, there are numerous publications, research results, and policies developed for BIM implementation in Europe. Even most private owners are also requiring the use of BIM in order to increase efficiency of the building, lower costs and to enable more creative designs.

In the days of master builders, the model of a building was in the mind of that master builder. Now, one person cannot possibly envision all the spatial relationships and requirements for all aspects of the building. Coordinating the many specialized fields involved in building has been difficult using 2-D because information is not centralized and communicating spatial relationships between the components is difficult. Returning to the concept of the master builder, BIM offers the single entity visualization and planning. The entity is a group of specialists who view and work a design concept made available by BIM software. Defining BIM is difficult because it refers to software tools, an independent created model, and to the process of designing and coordinating a project using BIM tools.

The term "BIM" often refers to the technology that helps organize the data concerning the relationships of the building components and represents them in 3-D. BIM tools are often more intuitive and easier to use than traditional 2-D software tools because images are represented more realistically. When an element is changed on one view, all related information, be it in charts, schedules, elevations, details, etc., is changed simultaneously and represented accordingly in other views. The power of BIM tools is not limited to its ability to help visualize the design, but includes the amounts of data that are related to the objects in the design and its ability to communicate this information about individual project components (Kymmell, 2008).

BIM can be used as a noun to mean a Building Information Model which is a compilation of building information. The data are interrelated objects with all pertinent information on each object attached to it. A door in a model is not just a few lines representing a door, but contains all information that pertains to manufacturing, locating, installing, finishing and maintaining it. Users needing access to information view only information pertinent to their interest without changing the overall relational data. Thus, the power of the model is that many parties can work with a common database and have current information.

When used as a verb, Building Information Modelling refers to the act of simulating real activity relating to a building or construction project (Eastman *et. al*., 2008). Similarly, the BIM Smart Market Report (2014) defines BIM as "the process of creating and using digital models for design, construction and/or operations of projects"). Whichever the case or tense, BIM refers to a relatively new technology that supports visualization and communication of building design and construction processes. Rather than a software, BIM is "a systems approach to the design, construction, ownership, management, operation, maintenance, use, and demolition or reuse of buildings" (Smith & Tardif, 2009). The most important part of BIM is not the software functionality, but collaboration in the design and planning process which speeds the process and clarifies design (Onuma, 2008). Depending on context "BIM" may be used to. Represent either of these definitions in this work.

In Nigeria public sector, the main challenges regarding efficiency and productivity here are poor budgeting and corruption. Also, Construction projects in Nigeria often involve wild inflation of costs. As such, the adoption of BIM will greatly enhance transparency, allowing different stakeholders (bidding contractors, parliament, civil society organizations etc) to have a better idea of true scope of projects (Alufohai, 2012). The current rebasing

of the Nigerian economy shows that construction contribution to GDP growth from 2010-2013 has risen to 7.2%. This cannot be compared to Manufacturing, with a contribution to GDP growth of 14.3% ((National Planning Commission, 2014). The low productivity in the Nigerian Construction Industry is attributed to the inefficiency in production processes that are prevalent in construction projects. As such, BIM serves as a practical and innovative approach whereby the planning, designing, building and management of infrastructure is done in a coordinated and integrated manner which improves efficiency and reduces waste, and thus, enables the increased productivity to support GDP growth in Nigeria.

The benefits of BIM are tangible to all the project teams throughout the entire project phases, beginning from the project inception, briefing, design, construction, operation and maintenance till demolishing of the construction (Hardin 2009; Jung & Joo 2011; Eastman et a., 2011). The following are some of the most recognized benefits resulting from the implementation of BIM: Improved collaboration and integration for the construction industry; Client's early involvement and decision; Acquired competitive advantage; Reliable sustainability analyses; Control of the construction site; Error-free design; Increased client satisfaction; Reduced project time and cost and Improved safety management.

Adoption of BIM entails an entire shift in practice both in term of technology and culture. As such culture transformation poses more challenges than technology because culture is a product of many years and cannot change overnight. Since, construction sector in Nigeria was developed prior to the era of digital evolution; its adoption will change most construction practices. According to Aibinu and Venkatesh (2013), there is absence of industry widespread standard for coding and classifying construction work. In addition, there is lack of skilled personnel, which leads to lack of BIM expertise and suitable conceptions to use BIM features in the market. Below are some of the barriers to the adoption of BIM in the Niger delta region of Nigeria classified into three main categories of stake holders in construction projects.

Table 1: Identification and classification of barriers associated with BIM in construction projects

Main category	Barrie items
Public sector	lack of enabling environment; Lack of standard to guide implementation; Frequent power failure; Client are not requesting the use of BIM on project; Structure/culture of the industry and Lack of protocols
Professional	Unavailability of appropriate technology and infrastructure; Individual/personal disposition; Compatibility between software platforms; Cost of required software upgrade; Lack of knowledge and level of awareness ; and Lack of professionals to handle the tools
Contractor	Inadequate BIM experience to (know- how) change; Poor internet connectivity; Low access to credit facilities

3. METHODOLOGY

Data were collected through structured multiple choice questionnaire. The questionnaire was divided into two parts; part A contained personal data of the respondents, part B comprised the barriers to BIM in construction projects and the drivers for BIM adoption and measure to remove the barriers. The survey respondents were asked to rate the criticality of these identified risks based on their perception and experience. The survey

respondents were asked to rate their probability or likelihood of occurrence and the magnitude of the potential impact based on their perception and experience on the 5-point Likert scale; whereby 5 represented very likely and 1 not likely to rate their probability. In terms of the magnitude of the impact: 1 Implied negligible impact; 2 Marginal impacts; 3 Substantial; 4 Severe; and 5 Disastrous. The intent was to use the results from this analysis and from the assessment of their impact to compute the Criticality Index (CI) for each risk factor. Criticality is assumed to be the combined effect of probability of occurrence and the impact of occurrence of the risk. The index developed by Wang et al. (2000) was used for measuring risk. The numerical scores assigned by respondents were transformed to a criticality index (CI) using the following formula:

$$Criticality\ index = \frac{(5n_1 + 4n_2 + 3n_3 + 2n_4 + n_5)}{5(n_1 + n_2 + n_3 + n_4 + n_5)}$$

Where: n1, n2, n3, n4 and n5 represents number of respondents who answered most critical, very critical, critical, less critical and not critical respectively.

A total of 180 questionnaires were distributed to professionals practicing in the six states of nine states of the Niger-delta with notable volume of construction projects, at the rate of 30 questionnaires to each state. 120 of 180 questionnaires administered were returned and analyzed using descriptive analysis and the relative importance index methods. The return rate of 66, 67% indicated that the result can be relied upon.

4. ANALYSIS AND RESULTS

4.1 Probability of occurrence of barriers of BIM in construction projects delivery in Niger-Delta Region of Nigeria

Table 2 shows that all the 14 barriers to BIM were rated to have some element of probability of occurrence; it is evident that none of the barriers has mean score less than 2.00 as a rating of 1.00 has represented not likely to occur in construction projects delivery. The analysis of survey respondent revealed that the first 5 most occurrence barriers were fund in the category of the professionals in the built environment this indicates that the professionals in the built environment are the main influencers of the application of BIM in construction projects delivery in Niger-Delta region of Nigeria. Successful of the application of BIM in the Niger-Delta region of Nigeria depend on the readiness of the professionals in the built environment to tackle: compatibility between software platforms; knowledge; technology; cost of software and team work. The result also showed that the barriers in the public sector category were ranked high. This implied that government need to mandate the use of BIM in public work for successful implementation of BIM.

4.2. Impact of barriers of BIM on construction projects delivery in Niger-Delta of Nigeria

In Table 3, all the 14 risk factors were rated as having a significant impact on application of BIM on construction projects delivery as they all had an overall MS ranging between 2.35 and 4.00 From the scale employed a score of 2 represented a marginal impact, 3

represented substantial impact; whilst 4 represented a severe impact.

Table 2: Probability of occurrence of barriers to BIM in construction projects delivery in Niger-Delta Region of Nigeria

Category	Barriers to BIM in Construction Projects in Niger-Delta region	MEAN	RANK
Public Sector	Lack of enabling environment	3.44	8th
	Lack of standard to guide implementation	3.56	6th
	Frequent power failure	3.40	10th
	Lack of protocols	3.31	12th
	Structure/culture of the industry	3.44	8h
	Client are not requesting the use of BIM on project	3.62	5th
Professionals in Built Environment	Lack of professionals to handle the tools	3.47	7th
	Non-availability of appropriate technology and infrastructure	3.65	4th
	Compatibility between software platforms	3.87	1st
	Cost of required software upgrading	3.76	3rd
	Lack of knowledge and level of awareness	3.82	2nd
	Individual/personal disposition	2.58	13th
	Poor internet connectivitv	2.55	14th
Contractors	Low access to credit facilities	3.33	11th

Table 3: Impact of barriers of BIM on construction projects delivery in Niger-Delta of Nigeria

Category	Barriers to BIM in Construction Projects in Niger-Delta region	MEAN	RANK
Public Sector	Lack of enabling environment	3.69	6th
	Lack of standard to guide implementation	3.58	7th
	Frequent power failure	3.40	8th
	Lack of protocols	3.00	9th
	Structure/culture of the industry	3.83	5th
	Client are not requesting the use of BIM on project	3.86	3rd
Professionals in Built Environment	Lack of professionals to handle the tools	4.00	1st
	Non-availability of appropriate technology and infrastructure	3.86	3rd
	Compatibility between software platforms	4.00	1st
	Cost of required software upgrading	3.00	9th
	Lack of knowledge and level of awareness	2.98	11th
	Individual/personal disposition	2.87	14th
	Poor internet connectivity	2.94	13th
Contractors	Low access to credit facilities	2.98	11th

4.3. Criticality of BIM on construction projects delivery

Table 4 shows that 7 of the 14 barriers were critical to the application of BIM on construction projects delivery while the remaining 7 were somehow critical. The decisional rule was that any barriers with CI greater than 0.5 are said to be critical; meaning that they are likely to occur and have a severe impact if they occur. In addition, any barriers with CI of less than 0.5, but not less than 0.3, are somehow critical on the project. None of the barriers were rated below a CI of 0.3 which implied that all of the barriers were likely to occur; and when they occurred they would have an impact ranging from a marginal impact

to a severe impact on the project.

Table 4: Criticality of BIM on construction projects delivery

Category	Barriers to BIM in Construction Projects in Niger-Delta region	PB Mean	IB Mean	CI	Rank	Remark
Public Sector	Lack of enabling environment	3.44	3.69	0.51	6th	critical
	Lack of standard to guide implementation	3.56	3.58	0.51	6th	critical
	Frequent power failure	3.40	3.40	0.46	8th	somehow critical
	Lack of protocols	3.31	3.00	0.40	11th	somehow critical
	Structure/culture of the industry	3.44	3.83	0.53	5h	critical
	Client are not requesting the use of BIM on project	3.62	3.86	0.56	2nd	critical
Professionals in Built Environment	Lack of professionals to handle the tools	3.47	4.00	0.56	2nd	critical
	Non-availability of appropriate technology and infrastructure	3.65	3.86	0.56	2nd	critical
	Compatibility between software platforms	3.87	4.00	0.62	1st	critical
	Cost of required software upgrading	3.76	3.00	0.45	10th	somehow critical
	Lack of knowledge and level of awareness	3.82	2.98	0.46	8th	somehow critical
	Individual/personal disposition	2.58	2.87	0.30	12th	somehow critical
	Poor internet connectivity	2.55	2.94	0.30	12th	somehow critical
Contractors	Low access to credit facilities	3.33	2.98	0.30	12th	somehow critical

4.4. Discussion of findings

This study was carried out with the aim of investigating the application of Building Information Modelling in construction projects delivery in Niger-Delta region of Nigeria. The study examines the probability of occurrence of the identified barriers that influencing the application of BIM in construction projects delivery and also determined the impact of these barriers. The rate of probability of occurrence and the impact of these barriers were used in determine the criticality of the barriers and seven of the fourteen barriers were the most critical barriers that influencing the application of Building Information Modelling in construction projects delivery in Niger-Delta region of Nigeria: Compatibility between software platforms; Non-availability of appropriate technology and infrastructure; Lack of professionals to handle the tools; Client are not requesting the use of BIM on project; Structure/culture of the industry; lack of enabling environment and Lack of standard to guide implementation in descending other. This implied that all of these barriers were likely to occur; and when they occurred they would have a severe impact on the project. Moreover, all the fourteen barriers have impact on the application of BIM in construction projects delivery. This indicates that all of the barriers were likely to occur; and when they occurred they would have an impact ranging from a marginal impact to a severe impact on the project.

Furthermore, four of these seven barriers were associated with the professional in the built environment. This implied that if the professional can acquire adequate skill through training and re-training and having good team work spirit together with the adequate role of the government in establishing standard to guide implementation of BIM, creating

enabling environment and re structure construction industry. Nigeria will be among the leading countries in the world with the adoption of BIM and improve the performance of construction industry which will has great impact in the GDP. Globally, it has been recognized that low productivity in the construction industry is attributed to the inefficiency in production processes that are prevalent in construction projects and the adoption of BIM is expected to enhance performance and profitability for the construction industry. This has making the developed countries mandated the adoption of BIM for public project.

Finally, it is imperative that the Government at the three arms supports the implementation of BIM in all capital projects. This can be achieved through the integration of BIM into the National Integrated Infrastructure Master Plan (NIIMP) which aims to develop infrastructure throughout the country between 2014 and 2043.

5. CONCLUSION AND RECOMMENDATIONS

The study has established that if BIM is deployed appropriately, can provide significant savings; enhance the quality of the built environment that gets delivered and allow the industry to make expected contributions to the economic and development growth of the country. Hence, this study also found that computer status and technological level of construction professionals needs to be improved through mandatory seminars, workshops and conferences by the various professional bodies and academic curriculum of the courses in the built environment. The government need to streamline duplications of duties among the professionals in other to have the required team spirit needed for the application of BIM in construction projects delivery.

In order to pave way for BIM towards improving productivity and increased efficiency in Nigeria construction industry the research seeks to recommend the following: The Government should support the adoption and implementation of BIM in all capital projects at the state three tiers of government; Professional bodies relevant in the construction industry should take steps for the training and retraining of its members on the use and application of BIM. And strong cooperation between the professional bodies; and the full integration of BIM into the academic curriculum of professional courses in the built environment in order ensure that the graduates have the background knowledge of the concept and implementation of BIM before graduate.

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