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A Review on Building Information Modelling in Nigeria and Its Potentials

Mansur Hamma-Adama, Tahar Kouider

Digital Open Science Index, Civil and Environmental Engineering Vol:12, No:11, 2018 waset.org/Publication/10009816

***Abstract*—**Construction Industry has been evolving since the development of Building Information Modelling (BIM). This technological process is unstoppable; it is out to the market with remarkable case studies of solving the long industry's history of fragmentation. This industry has been changing over time; United States has recorded the most significant development in construction digitalization, Australia, United Kingdom and some other developed nations are also amongst promoters of BIM process and its development. Recently, a developing country like China and Malaysia are keying into the industry's digital shift, while very little move is seen in South Africa whose development is considered higher and perhaps leader in the digital transition amongst the African countries. To authors' best knowledge, Nigerian construction industry has never engaged in BIM discussions hence has no attention at national level. Consequently, Nigeria has no "Noteworthy BIM publications." Decision makers and key stakeholders need to be informed on the current trend of the industry's development (BIM in specific) and the opportunities of adopting this digitalization trend in relation to the identified challenges. BIM concept can be traced mostly in Architectural practices than engineering practices in Nigeria. A superficial BIM practice is found to be at organisational level only and operating a model based - "BIM stage 1." Research to adopting this innovation has received very little attention. This piece of work is literature review based, aimed at exploring BIM in Nigeria and its prospects. The exploration reveals limitations in the literature availability as to extensive research in the development of BIM in the country. Numerous challenges were noticed including building collapse, inefficiencies, cost overrun and late project delivery. BIM has potentials to overcome the above challenges and even beyond. Low level of BIM adoption with reasonable level of awareness is noticed. However, lack of policy and guideline as well as serious lack of experts in the field are amongst the major barriers to BIM adoption. The industry needs to embrace BIM to possibly compete with its global counterpart.

***Keywords*—**Adoption, BIM, CAD, construction industry, Nigeria, opportunities

I. Introduction

ARCHITECTURE Engineering and Construction (AEC) business is developing as a result of digital transition. This development became obvious since development of BIM concept. However, this is yet to be achieved globally due to conventional nature of the industry. BIM is the most recent development of the construction industry's process and a promising concept determine to shape the industry's fragmented culture [1]. BIM is described as a set of interacting policies and processes that are being enabled by technologies in generating a methodology to procure building works [2], purely from inception (or renovation) through the construction process to completion and to the entire lifecycle of a building. Fig. 1 presents a representation of BIM (schematic).

There are numerous applications of BIM, to mention but a few with: design coordination, energy performance simulation, scheduling and quantity take-off, clash detection and 3D visualization [4], [5]. Countries have been adopting BIM at different level and with different purpose, having different experiences (in benefits), depending on adoption level and possibly their challenges earlier to the adoption. For example, McGraw Hill Construction [6] study discloses some substantial benefits of adopting BIM by Australia and New Zealand; these include the reduction in rework, business reputation, effective management of construction time and cost as well as reduction in errors and omissions. The rationale behind BIM adoption varies from country to country; however, there are common goals amongst most of the countries. These include, improving the industry's productivity and unifying its standardizations by changing its way of working [7], [8].

BIM has now gone beyond a concept for building design and construction; it is fully into the infrastructural development process. Bentley has been developing highly sophisticated BIM tools for engineering of infrastructural design and construction processes and it is generating acceptance throughout the construction and facility management sector. The same can be noticed with Autodesk in the recent years. Fig. 2 presents an outlook of infrastructural engineering design in a BIM environment [9].

Developed countries' BIM awareness has gone near universal and its adoption and implementation is currently dynamic, though there is generated argument on its clarity in adoption level or stage [10]. However, there remains a long way to go in most of the developing countries especially Nigeria. Regardless of several years of discussions and researches in the area of BIM concept and its adoption, Nigerian construction industry has not been seen in the BIM discussion. Till 2013, when a first study surfaced, this study was mainly on assessment of readiness of the first line adopters of BIM in the industry (consultants - designers). The assessment was due to lack of clarity on whether the industry is ready (technologically) to adopting the concept; but not the other two fields (process and policy) – this is a sign of starting point or '*readiness ramp*' [10]. Furthermore, the starting point was an exclusive searching for a significant match towards the concept adoption.

The previous research concentrated mostly in trying to assess BIM (within a limited profession or location) or assess

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BIM's roles and benefits in general – there was no meeting point into identifying the present stage of the key BIM fields (technology, process and policy). Moreover, no any available Noteworthy BIM Publications (NBPs) within this study context. This paper presents literature findings ahead of data collection for the development of strategic framework for BIM adoption in the Nigerian AEC. We investigate its awareness and adoption level and discuss challenges and possibility of its adoption in Nigeria.

This work aimed to explore the industry's BIM stand, industry's challenges, and opportunities of adopting BIM through review of available and relevant literatures.

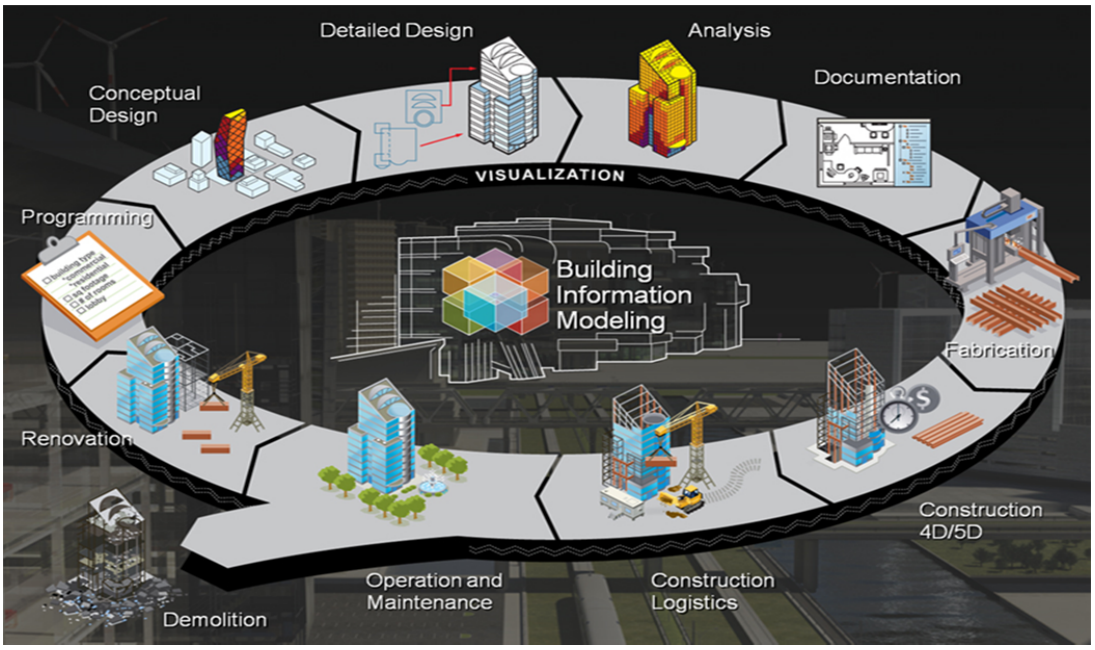

Fig. 1 Schematic representation of BIM interaction [3]

Fig. 2 BIM for infrastructure [9]

II. Literature Review

A. BIM Concept and Its Adoption around the World

Considering BIM as a complete 3-dimensional digital depiction of a building system or subsystem, and a sophisticated technology comprising both accurate building model and incorporated information (in database) of the building components. This requires recognition beyond 3D of it being sample representation of a building or its components [11]-[13]. Most importantly, BIM remains the most potential development in the world of construction industry [14].

Going further, BIM has gone beyond being just a drawing and documentation tool; and it is not solely about software but

represents a more collaborative method of working [13], it is also considered as a process of transforming the way cities are designed. The benefits of using BIM during the building design stage have been well-publicized and are fueling its adoption rate among architects worldwide - transforming their drawing-based processes to model-based processes. Although there is significant BIM adoption at design and construction stages in countries like United States (US), United Kingdom (UK), Germany and Scandinavian countries; but its effective usage is still dangling in many countries, this includes usage as a platform for facility management which along inclined to the entire facility life cycle. Fig. 3 presents how information is shared (in the central model) between the project stakeholders.

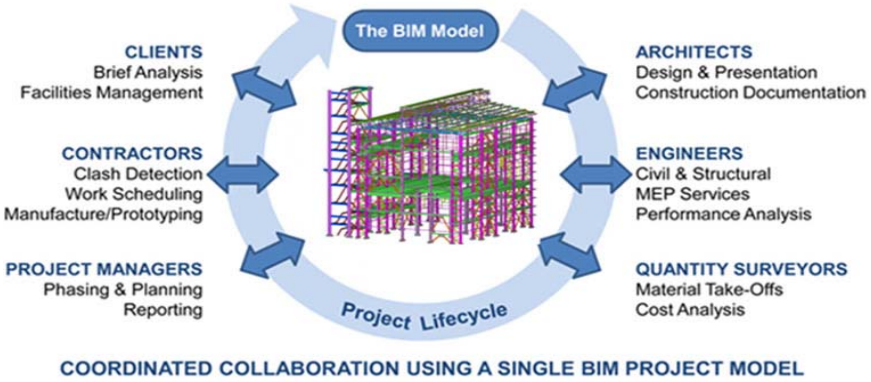

Fig. 3 Schematic representation of data exchange and collaboration [15]

BIM tools are the latest software technology being introduced throughout the built environment and perhaps the manufacturing industry. Manufacturing industry have since realized the benefits of using of BIM. A typical of automobile industry is a clear example. The automobile industry recorded significant success from adopting BIM process [16]. However, the construction industry is generally known to be resistive to changes; and most contractors are not ready for new innovations, rather persist with the traditional way of doing things [16], [17].

Researches seemed to be focused on software developments for the BIM process rather than strategic adoption or utilization [8]. It is therefore necessary to invest in the industry's social change, provide the right tools as well as trained personnel to effectively implement changes in the industry [18], this research is also interested in exploring the necessary changes in the present working practices. One could foresee successful BIM application as being an integral challenge that will demand systematic consideration of interdependencies and effective changes in management to realize its full potential.

In spite of progressive adoption of BIM in the US, UK, and some developed nations, the construction industry is known to be a very conventional and bound by tradition and rigidity group to bring on board [17]. A significant development is notice in Hong Kong (developed) construction industry even though it is part of China (developing country). The Chinese government of course supported the BIM adoption and implementation; however, there is still considerably slow adoption of BIM in the industry [14]. Thus, government support might not be an immediate action to facilitation speedy BIM adoption.

Moreover, Chan [14] study discovered that about 33% believed that lack of training is a significant reason for insufficient use of BIM; two-third (67%) felt that use of BIM is not necessary as 2D is sufficient to meet their need. This could be a clear lack of understanding (knowledge) of BIM process. Similarly, in addressing individual perceptions to this technological tool in the UK, some perceived BIM as an unrequited addition to the existing work process [19]. Therefore, design fee will most likely increase in order to reward the BIM usage. Chan [14] also believed that high initial cost and lack of standardization between BIM platforms are also amongst the main reasons why BIM is not adopted in Hong Kong. Similarly, in the UK, cost is also a barrier of BIM adoption along with a lack of clarity in the industry. Although those that adopted BIM clearly revealed some of the adoption benefits such as speedy project delivery, cost efficiency and information retrieval [13]. Walasek and Barszcz [17] argue that the level of design fee needs to be revisited to effectively facilitate the ROI on the use of BIM concept. On the other hand, Coa et al. [4] reported a survey carried out on BIM adopters/users from China where about half (50.94%) of the respondents disclosed that the costs of BIM in their projects have been passed onto the clients/owners. Some respondents also revealed that some clients allow the inclusion of the BIM cost in the bidding prices. Therefore, considering the above arrangement, cost might not necessarily of concern as a barrier, but something else. Moreover, Cao et al. [4] revealed that cost of BIM would not be an issue to BIM adopters because the BIM consultant who provides full IT support is being paid by client. On the other hand, a study carried out by Azhar [20] on four successful projects who recorded an average of 634% ROI on the cost of BIM is clearly portraying a huge potential benefit of adopting BIM. Since 2010, nearly 60% of western European countries are reported as frequent users of BIM, 74% of them perceived positive return on their overall investment [21]; thus, European nations may be

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considered positive on BIM adoption.

In the US, UK and Australia, much researches have been carried out on BIM, especially regarding potential benefits as well as streamlining the stages of its full adoption. McGraw-Hill survey reported US as a country with highest adoption rate [6]. Moreover, Construction [22] reported 71% BIM adoption in the US, whereas UK was 62% adoption [23], that is after the expiration of April 2016 BIM level 2 mandate.

The 2015 NBS National BIM Report lamented the limited expertise and resource that can research and educate the industry stakeholders in this innovative field. Upon all the challenges, more countries are building up to BIM adoption (i.e. Ireland, Germany, Finland, Denmark, Norway, France and Canada); the most recent amongst is Ireland. Ireland recently (last quarter of 2017) released a "Roadmap to Digital Transition" for its construction sector, three years after National BIM Council (NBC) was formed. The first national survey (for benchmarking) on BIM carried out in 2015 by Construction IT Alliance (CitA) reported vast demand of BIM [23]. The developed roadmap is targeting three key performance (20% increase construction exports, 20% reduction in both delivery time and capital cost) by 2021. On the other hand, a successful (on time and to budget) procurement of Heathrow Terminal Five (T5) is considered a typical case study. The principles of Constructing the Team by Latham [24], and Rethinking Construction by Egan [15] were adopted and the result was commended. Had BAA followed a traditional method for T5's procurement, T5 would have ended up 2 years late and cost 40% more with six fatalities [25]. It is therefore important to consider the procurement route as being significant to achieving a successful BIM implementation [26]. Similarly, BIM can effectively improve tendering and cost estimate [27] cited by [14].

The clients' acting to enforce the use of BIM could be most probably a quicker solution to achieving its adoption and implementation [28], [16]. Some findings associated the downhill situation of BIM adoption in most developing countries with lack of government involvement. Government involvement is amongst the significant driving factor to speed adoption of BIM [28]. On the same trend, Froise and Shakantu's [29] studies of South African construction industry revealed that lack of awareness and enforcement by the government as the contributory factors that slow the BIM adoption process.

B. BIM in Nigeria

South Africa is considered more developed than most African countries, including Nigeria. Their level of BIM adoption is higher than any other country in the African continent as a whole [29], [30]. However, procurement route is found to be a major barrier to its implementation [29], [31].

There is a limited research on BIM within the study context, on a general level beyond specific discipline and city in Nigeria. These can be noticed in a compiled 14 available published works (refer to Table I).

TABLE I
THE AVAILABLE BIM PUBLICATION WITHIN THE STUDY CONTEXT (COMPILED BY AUTHOR)

S/No.	Publications	Remark
1	Abubakar et al. [32]	This study has some limitations, such as: Only building designers were considered for the study; The targeted location was only Kaduna & Abuja.
2	Abubakar et al. [33]	The study focused only on building construction firms; and the primary data were obtained from Abuja and Lagos and also centred on contractors only, therefore it cannot be generalised.
3	Dim et al. [34]	Reviewed literatures and some case studies from the UK
4	Kori & Kiviniem [35]	This research is limited to Architectural firms and is referring to some Architectural consultancy firms in Lagos, Abuja, Kaduna and Kano.
5	Ugochukwu et al. [36]	The study targets Anambra and Enugu states only; going by the procurement route mostly adopted by the public sector; consultants (designers) should have been amongst the respondents. No evaluation on the respondents' experience. For more clarity, response by the clients should have been evaluated separately from that of the contractors.
6	Wang et al. [37]	The findings revealed relatively high level of awareness at the same time lack of awareness as a barrier to BIM adoption. Sort of inconsistencies were discovered.
7	Ezeokoli et al. [38]	These findings are limited to a location (Anambra State only); only structural engineers were involved out of engineering disciplines in the survey; and only building construction was considered.
8	Timothy et al. [39]	The findings were derived from Architectural Firms only and targeted Akure only.
9	Ebiloma et al. [40]	In summary education and training is the main issue to be handled before serious BIM adoption in the study area. The study covered only one state (Akwa Ibom).
10	Hamma-adama et al. [30]	Although the survey targets the entire AEC; however, the enquiry is limited to North-west, North-central and Lagos
11	Onungwa & Uduma-Olugu [41]	The study was conducted within Lagos and its environs.
12	Onungwa et al. [42]	The study focused predominantly the South West of Nigeria specifically Lagos (75%) with just 6.3% from South - South region of the country.
13	Hamma-adama et al. [43]	Although the survey targets the entire AEC, but it was through individual professionals NOT as corporate entity or bodies.
14	Hamma-adama et al. [44]	As an interview based, it seems quite detailed with clear representations. Though quality is more important than quantity, but the sample size is relatively small.

From the compiled literature above, more than three-quarter of them revealed that lack of trained personnel in the technology as the significant barrier to adopting the concept, and more than half associated the lack of adoption with poor awareness and knowledge of its potentials (refer to Table III).

A recent study by Hamma-adama et al. [30] revealed only 22.8% adopts BIM and about 60% are just aware of the concept. Surprisingly, the 22.8% are mostly working on model base (BIM stage 1). Fig. 4 presents the adoption level.

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C. Challenges in the Nigerian Construction Industry

Building failure and collapse is one of the lingering issues in the Nigerian construction industry. This issue has been persisting for over a decade; however, not much has been achieved in tackling this threat [41]. Ayedun et al. [42] compiled findings on ten years collapsed buildings in Lagos state (2000 and 2010), out of the 54 collapsed buildings 37 collapsed due to structural related issues. To have an idea of the main causes of building collapse, 12 available publications on building collapse in Nigeria are drafted and analysed in Table II.

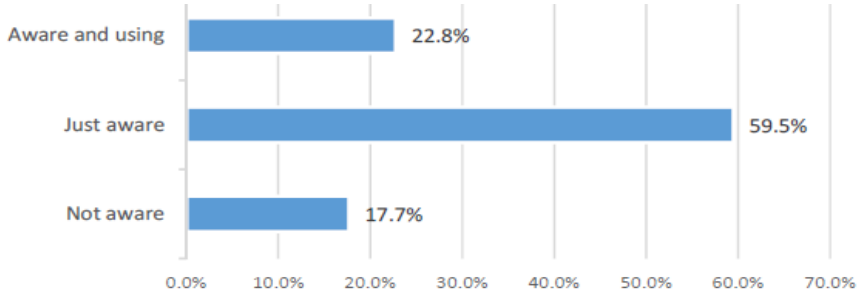

Fig. 4 BIM adoption in Nigeria [30]

TABLE II
CAUSES OF BUILDING FAILURE AND COLLAPSE IN NIGERIA (COMPILED BY AUTHOR)

S/No.	Publications	Sub-standard building materials	Design issues	Construction issues	Poor workmanship	Quackery
1	Ayininuola, & Olalusi [47]	✓	✓	✓	✓	
2	Windapo [48]	✓	✓			
3	Dimuna [49]	✓	✓	✓		✓
4	Usman et al. [50]	✓	✓	✓		
5	Ayodeji [51]	✓	✓		✓	
6	Ayedun et al. [46]	✓	✓	✓	✓	
7	Amadi et al. [52]	✓	✓	✓		✓
8	Olagunju et al. [45]	✓	✓	✓		
9	Ede [53]	✓		✓	✓	
10	Tanko et al. [54]	✓		✓	✓	✓
11	Argwa [55]	✓	✓	✓	✓	
12	Hamma-adama & Kouider [56]	✓		✓		
	Frequencies	12	9	10	6	3

TABLE III
BARRIERS TO ADOPTION OF BIM IN THE NIGERIAN AEC (COMPILED BY AUTHOR)

S/No.	Publications	Culture of the industry	Lack of awareness	Policies & legal issues	Lacks trained staff	Affordability & availability of software packages
1	Abubakar et al. [31]		✓		✓	
2	Abubakar et al. [32]		✓		✓	
3	Dim et al. [34]	✓	✓			
4	Kori & Kiviniem [34]		✓	✓		
5	Ugochukwu et al. [36]		✓		✓	
6	Wang et al.[37]		✓		✓	✓
7	Ezeokoli et al. [38]	✓			✓	
8	Timothy et al. [38]	✓			✓	
9	Ebiloma et al. [39]				✓	✓
10	Hamma-adama et al. [30]				✓	
11	Onungwa & Uduma-Olugu [41]		✓		✓	
12	Onungwa et al. [42]		✓	✓	✓	
13	Hamma-adama et al. [42]	✓		✓		
13	Hamma-adama et al. [43]			✓	✓	
	Frequencies	4	8	4	11	2

The literature findings revealed predominant causes of building failure and collapse, sub-standard building materials, lack of or poor construction supervision and structural design issues (in descending order).

Delivering project effectively on-time and within cost is becoming unrealistic in construction industry. Majority of

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construction projects in Nigerian are delivered late (behind schedule) with re-work and beyond cost appropriated for. Generally, construction and demolition activities generate about 30% waste and it is one of the industries that generate huge waste [57]. Working with full materials on-site (i.e. full fabrication or construction on-site) is a main cause for generating the waste; offcuts, over supply and poor recycling are mainly the source. Succinctly, building collapse, project delays and cost overrun are amongst the crucial lingering challenges of Nigerian construction industry.

III. Research Method

Existing BIM adoptions are identified from numerous previous literatures. Then, Nigerian construction industry's challenges and the BIM adoption benefits are analysed through content analysis as to inform the end potential benefits of adoption.

IV. Findings and Discussion

Purely, there is low adoption of BIM mainly due to lack of trained personnel or expert and lack of awareness within the professional stakeholders (refer to Table III). Education is traditionally a key in training the professionals, the AEC courses are technically not ready to offer BIM tools training due to lack of training software and skilled BIM tutors [58]. Moreover, over three-quarter of students are graduating on 'file based collaboration' – 2D and 3D CAD knowledge with proficiency level between limited and practical application. Although, policy and regulations received attention by only four publications however, policy is part of BIM fields, hence must be acknowledged. There is no policy for adoption of BIM concept in the Nigerian AEC, hence one of the BIM fields is missing in this study context.

BIM process encourages offsite fabrication hence, this minimizes waste [56] and improves efficient delivery and quality assurance. Moreover, material quality and construction precision are easily managed. Collaborative working as well as free flow of information encourages transparency and team working. Simulation capabilities are enormous to establish structural stability and optimization, construction scheduling, and material take-off. Finally, all data generated are transferable and accessible throughout the facility lifecycle for facility management and renovation or demolition where applicable.

V. Conclusion and Recommendation

The purpose of this paper was to explore the Nigerian construction industry's BIM stands, industry's challenges, and opportunities of adopting BIM. The review established the following:

- There are numerous challenges facing the Nigerian AEC industry, these include: building collapse, inefficiencies, cost overrun and late project delivery
- BIM has potentials to overcome the above identified challenges and even beyond
- Low level of BIM adoption with reasonable level of awareness but serious lack of experts in the field
- Lack of policy and guideline for adoption.

To facilitate the BIM adoption, the following recommendations are made:

- ✓ Regulatory bodies and professional societies are the critical stakeholders to facilitate this digital shift
- ✓ Education and training are the first focal point of attention for the industry to overcome its experts deficit thereby creating more adoption.

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