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Investigation of the Main Barriers to the Adoption of BIM in Togo

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Abstract The application of Building Information Modeling (BIM) in construction projects has been recognized as the solution to improve their performance. Therefore, worldwide, the adoption of BIM is increasing; some governments have even mandated the use of BIM in specific projects. However, the findings from BIM practical adoption revealed that developing countries are still reticent to adopt it because of numerous difficulties. Despite the important contribution of the construction industry to the country's development and the influence of BIM on the performance of construction projects, no studies have been conducted on the adoption of BIM in Togo. The main goal of this paper is to investigate the current state of use of BIM in the Togo architecture, engineering, and construction (AEC) industry and evaluate the main barriers to its adoption through a questionnaire survey. A Likert scale was used to evaluate the Togo AEC industry practitioners' perception of the barriers to the adoption of BIM adoption. The survey results show that “Incompatibility and interoperability problems,” “Complicated and time-consuming modeling process,” and “Lack of subcontractors who can use BIM technology” are the three main barriers to BIM adoption in the Togo AEC industry.

Keywords: *construction management, building information modeling, BIM benefits, BIM implementation barriers, Togo*

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1. Introduction

1.1. Concept of BIM and its Application in Construction Projects

BIM can be defined as a digital working method that consists of semantically enriching 3D models and using them during the project's whole lifecycle for different performance analyses, to exchange the project data between different stakeholders, or for project management activities. Van Nederveen, in this way, defines BIM as “a model of information about a building that comprises complete and sufficient information to support all lifecycle processes” [1].

The literature has revealed the benefits of the application of BIM at different stages of construction projects. During the design phase, the use of BIM allows the exchange of 3D models in a neutral format, such as Industry Foundation Classes, between different disciplines and software [2,3]; the use of BIM, therefore, allows direct feedback between the architect design tool and other specialist tools and allows one to perform the needed analysis and optimize some of the features of the building as the design evolves [4,5]. The use of BIM also facilitates the cost estimation process by allowing the extraction of the quantities of building components and materials at any stage of the design [6,7] and the creation of semi-automatic cost estimation, coined 5D cost estimation; 5D cost estimation helps to reduce the additional work in case of changes in the design [8,9]. During the preconstruction phase, the use of BIM also facilitates the identification of design clashes by enabling the creation of a federated model from different disciplines models (architecture, structure, HVAC, electrical, plumbing, etc.) before the clash detection analysis [10,11]. During the construction phase, the application of BIM is highly valuable for project scheduling by enabling 4D scheduling, which consists of linking 3D models with the schedule of the project [12,13]; 4D scheduling allows to visualize the construction steps over time and detect the potential contradictions in the logic of schedules or the time-space conflicts [12,14]. The literature has also revealed the benefits of using BIM during the project operation phase; the use of BIM during this phase allows to generate the needed geometric and semantic information for the building maintenance and repair, energy consumption calculations, and emergency evacuation planning [15,16,17].

1.2. BIM Implementation Levels

The implementation of BIM is defined in 4 levels by

Succar as BIM Level 0, BIM Level 1, BIM Level 2, and BIM Level 3 [18].

BIM Level 0, or the pre-BIM level, is characterized by using traditional 2D CAD tools for the design and 2D drawings to exchange project data [18].

BIM Level 1 is characterized by using some BIM software such as ArchiCAD and Revit but only to create 3D models for visualization or generate 2D drawings; at this level, 2D drawings are still used to exchange project data [18].

BIM Level 2 is characterized by a BIM model-based collaboration between different disciplines or the use of BIM for 4D scheduling or 5D cost estimation [18].

The BIM Level 3 is characterized by using a central database or federated database to share the building models [18].

1.3. Strategies for Effective BIM Implementation in BIM Leading Countries

The United States of America (US), the United Kingdom (UK), and Singapore are considered as the leading BIM adoption countries in the world because of their government's strategies to support the adoption of BIM. The adoption of BIM in those countries is encouraged by governmental and private organizations responsible for setting BIM Guides, Protocols, and Mandates [19,20].

The adoption of BIM in the U.S. is supported by some government organizations such as the U.S. Army Corps of Engineers (USACE), the United States General Services Administration (GSA), the United States Department of Veterans Affairs (VA) who not only settled mandates to use BIM in some specific projects since 2006 but has also released standards and protocols to facilitate its use [21,22,23,24]. Other private organizations, such as the American Institute of Architects (AIA), have also contributed to the successful implementation of BIM; the AIA, from 2008, has released a series of contractual documents concerning the use of BIM in construction projects [25].

In the UK, the adoption of BIM is mainly supported by the government; in 2011, the Government Construction Strategy mandated the application of BIM Level 2 on all public sector projects by 2016 and designed the BIM task group as the leader of this program; the UK government strategy to achieve BIM Level 3 has begun in 2015 under the responsibility of the Center of Digital Built Britain [26]. The BIM task group has released some BIM protocols from 2013 to support the government mandate [27,28]; some other organizations, such as the British Standards Institution B/555 and the AEC (UK), have also supported the implementation of BIM by delivering some BIM standards and BIM guidelines [29,30,31].

The adoption of BIM in Singapore is supported by the Construction and Real Estate Network (CORENET), which was launched in 1995 and led by the Ministry of National Development and driven by the Building and Construction Authority (BCA). In 2012, the BCA mandated the BIM e-submission of new projects with a Gross Floor Area of more than 20000 square meters from 2013 and later mandated the BIM e-submission of new projects with a Gross Floor Area of more than 5000 square meters from 2015 [32]. The BCA has released several guidelines since 2012 to support the adoption of BIM in Singapore; the BCA has also released a series of BIM essential guides from 2013 to provide detailed guidance on BIM practices for each discipline; the BCA has also released some Code of Practice to meet the requirements for BIM e-Submissions [33].

1.4. Common Barriers and Difficulties in the Adoption of BIM in Construction Projects

Despite the numerous benefits of BIM, the literature has also revealed some technology, economic, organization, and environment-related barriers that influence its adoption. 22 potential barriers were retrieved from previous qualitative studies or case studies on the adoption and implementation of BIM. Table 1 summarizes the retrieved barriers and their sources.

Table 1. Summary of the Retrieved Potential Barriers to the adoption of BIM

N	Barriers	References
1	Insufficient infrastructures	[34-38]
2	Complexity of software programs	[39]
3	Incompatibility and interoperability problems	[37, 40]
4	Data owning conflicts	[24, 37,38,39]
5	High cost of software	[35, 37, 38]
6	Higher cost of employees training and education	[37, 39]
7	Lack of projects likely to substantially amortize the investment	[34]
8	Difficulties in Initial set up of BIM	[24, 34]
9	Lack of expertise within the organizations	[24, 37, 39, 41]
10	Lack of collaboration among stakeholders and team members	[24, 35, 38]
11	Lack of interest because projects worked on were perceived as too small to adopt BIM	[34]
12	Lack of detailed processes or workflow to apply BIM technology	[24, 34, 36, 40, 41]
13	Lack of subcontractors who can use BIM technology	[35, 39]
14	Lack of contractual arrangements	[34, 37,38,39]
15	Complicated and time-consuming modeling process	[34, 40]
16	Lack of Funding	[34, 37, 39, 40, 42]
17	Lack of national standards	[34-36]
18	Lack of government support and pressure in the implementation of BIM	[34, 35, 38]
19	Lack of Skilled personnel	[34, 35, 37, 42]
20	Resistance of employees and collaborators to change traditional methods	[34, 36, 37, 40, 41]
21	Weak education and training in universities	[24, 35]
22	Lack of Client demand	[34,35,36, 37,38, 40]

The review of studies on the barriers to the adoption of BIM in some developing countries in recent 6 years has revealed that the high cost of software and hardware, the lack of BIM experts, the weak knowledge about BIM and its benefits, the resistance to change from the traditional method, the lack of support from the government and the unavailability of BIM standards and protocols are the main barriers to the adoption of BIM in developing countries. The findings are summarized in Table 2.

Table 2. Findings from Recent Studies about the Adoption and Implementation of BIM in Developing Countries

Country	Number of studied items	Main barriers
Yemen [43]	27	Financial barriers Lack of BIM knowledge Improper introduction of BIM concepts Lack of awareness of BIM benefits Lack of pressure from the government
Indonesia [44]	14	Lack of BIM training Lack of BIM experience and capability Lack of client demand High cost of BIM software and hardware Inadequate information technology (IT) facilities
Cambodian [45]	13	Resistance to change from the traditional method High cost of BIM software Lack of BIM experts
Middle East and North Africa developing countries [46]	22	Lack of BIM knowledge Commercial issues and investment cost Lack of BIM experts Interoperability issues Lack of client demand
Nigeria [47]	33	Lack of familiarity with BIM capacity Resistance to change from the traditional method Poor awareness of BIM benefits
Uganda [48]		Acquisition and training costs
Iraqi [49]	12	Lack of BIM experts Lack of BIM knowledge Traditional methods of contracting
Iran [50]	26	Lack of pressure from the government Resistance to change from the traditional method The gap between industry and academia
Pakistan [51]	12	Lack of Government regulation about BIM Lack of conferences/seminars on new technologies such as BIM by organizations Lack of BIM experts Lack of support from the top management Non-readiness of organization
Jordan [52]	20	Cost of training Cost of BIM software Lack of BIM knowledge Lack of adequate BIM guidelines Huge BIM up frontal investment
Ethiopia [53]	20	Lack of BIM professionals, - Unavailability of BIM training, Lack of BIM-ready stakeholders Lack of guidelines or Standards for BIM implementation, Lack of supportive delivery methods

1.5. Research Methodology

An in-depth literature review was conducted to summarize the main application areas of BIM in construction projects, the implementation strategies of BIM in some leading BIM adoption countries, and the potential barriers to BIM adoption. Then, Google's online survey tool was used to design the questionnaire; the questionnaire was sent to Togo AEC industry practitioners to investigate the current state of use of BIM in Togo and evaluate their perception of the barriers to the adoption of BIM. The questionnaire includes the respondent personal background and the description of the enterprise where he is working, the current state of the use of BIM in the enterprise, and the barriers to the adoption of BIM. More than one hundred Togo AEC industry practitioners were invited to participate in the study; 52 valid questionnaires were received and were used for further analysis.

2. Survey Results

2.1. Respondent’s Background Information

The respondent's personal background information and the enterprise where they are working information are summarized in Table 3. It includes the respondent's highest study qualification, work experience and position, organization type, enterprise size, and main activities. The survey results show that the majority of respondents (69.3%) hold a master’s degree, and 69 % of them have work experience of more than 5 years. Although the majority of the respondents of this study have more than one responsibility in the enterprise, the survey results show that approximately a quarter of them have an influential position within the enterprise. The respondent's background information indicates that they have the minimum educational requirement and good work experience to provide relevant and insightful information for this study. The survey results show that the majority of enterprises where the respondents are working are public (69%), and 73% of them have a number of employees below 200 and are therefore considered as small and medium enterprises. The enterprises where the respondents were working are considered as multidisciplinary since they are involved concurrently in many activities.

Table 3. Respondent’s Background Information

Respondent and the enterprise information	Category	Percentage	Total (Percentage)
Respondent's highest study qualification	Modular training	3.8%	100
	Bachelor’s degree	26.9%	
	Master’s degree	69.3%	
Respondent's work experience	Lower than 2 years	11.5%	100
	2–5 years	19.2 %	
	5–10 years	38.5 %	
	More than 10 years	30.8 %	
Organization type	Public	69%	100
	Private	31%	
Number of employees within the enterprise	Less than 10	26.9%	100
	10-49	32.7%	
	50- 99	13.5%	
	100-199	11.5%	
	Over 200	15.4%	
Enterprise activities	Architecture design	24%	
	Structural design	32%	
	Building Construction	28 %	
	Road and bridge construction	16%	
	Project management	32%	

According to the survey results, 28.5% of the respondents have never used BIM, while 19.23% are beginners in the use of BIM,40.38% are intermediate users of BIM, and 11.54% are experts. Regardless of the important number of BIM non-users among the respondents, it can be concluded that more than 50% of the respondents have a good level of expertise in BIM. The BIM users were asked to select their awareness method of BIM, and the results revealed that 52.78% of the respondents were trained through self-learning, followed by 38.89% of them who got their training from universities, and only 8.33% of the respondents got their training from their enterprise. The results show that the training program of BIM in enterprises and universities needs to be strengthened.

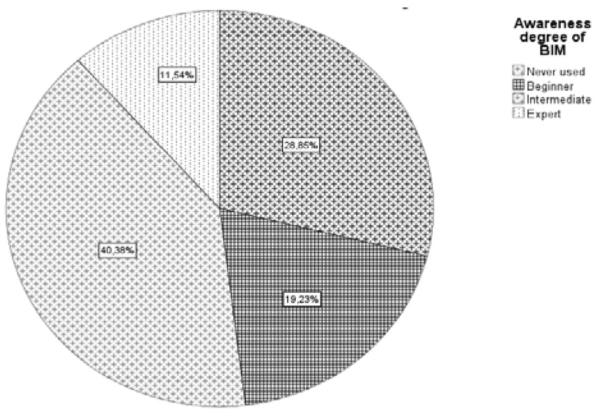

Figure 1. Awareness degree of BIM of the participants

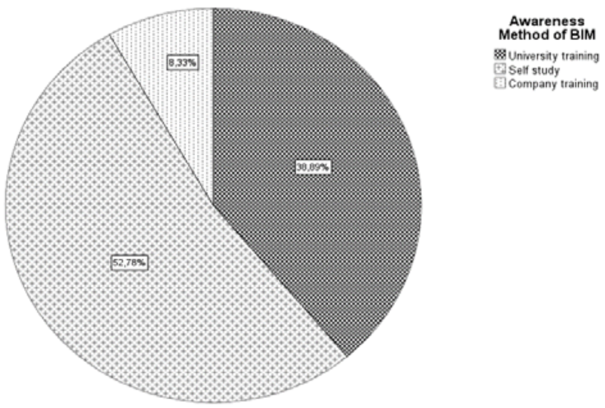

Figure 2. Awareness method of BIM of the participants

2.2. The Use of BIM within the Enterprise

The second part of the questionnaire consists of investigating the current state of the use of BIM within the enterprise where the respondents were working; only the BIM users were invited to participate in this part of the questionnaire. The survey results reveal that 27.03% of the enterprises are using BIM for 1-3 years, 27.03% of enterprises are using BIM for 5-10 years,21.62% of enterprises are using BIM for less than one year, 13.51% of enterprises are using BIM for 3-5 years and 10.81% of enterprises are using BIM for over 10 years.

The survey results show that the most used BIM software within the enterprises are Autodesk Robot and ArchiCAD, followed by Revit Architecture and Revit Structure, which are the most popular BIM tools for 3D architectural and structural modeling. The findings of Autodesk Robot, ArchiCAD, Revit Architecture, and Revit Structure as the most used BIM software can be explained by the fact that 32% of the respondents selected structural analysis as their application area of BIM tools, while 30% of them selected design and 3D modeling as their application area of BIM tools. It was found that BIM is less used for quantity take-off and cost estimation, 4D scheduling, information sharing, space planning, and environmental analysis.

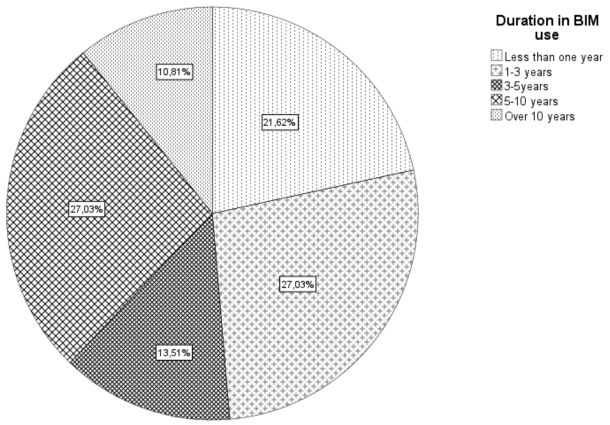

Figure 3. Pie chart diagram of the duration of BIM use within the enterprise

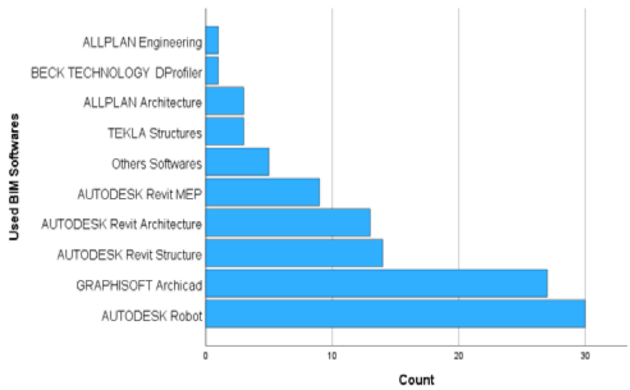

Figure 4. Bar chart diagram of the used BIM softwares

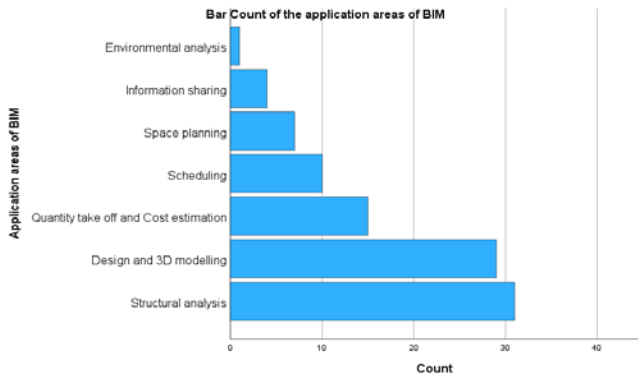

Figure 5. Bar chart diagram of the application areas of BIM

2.3. Benefits of the Application of BIM

The top five benefits reported by the BIM users are improved visualization, time-saving, various design options production, fast and accurate drawing extraction, enhanced collaboration and communication. 36% of respondents agreed on the possibility to fastly and accurately extract 2D drawings from BIM models; 35% of respondents believed that the use of BIM improves visualization and therefore allows to avoid misconceptions during the design phase; 35% of the respondents agreed that the use of BIM results in time-saving;33% of respondents agreed that the use of BIM allows to explore various design options; 33% of respondents believed that the use of BIM enhances collaboration and communication between the project different stakeholders.

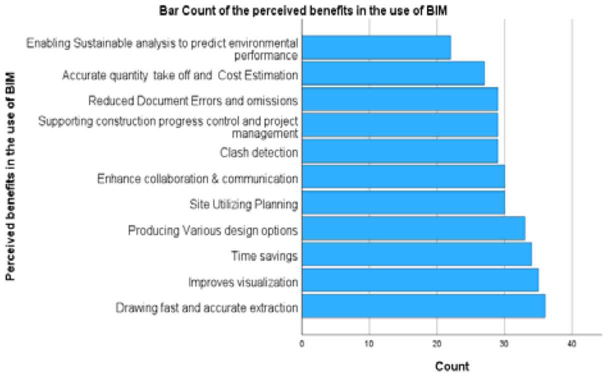

Figure 6. Bar chart diagram of the perceived benefits of BIM

2.4. Main Barriers to the Adoption of BIM

A Likert scale was adopted to evaluate the respondent's perceptions of the barriers to the adoption of BIM. Likert scales can be used to measure the attitude or perceptions of a group of participants about a set of items; this method is valuable when the study variables cannot be directly observed or quantified by conventional measurement techniques [54]. In this study, the respondents were asked to select their level of agreement about the potential barriers to the adoption of BIM, where "1" represented "strongly agree" and "5" represented "strongly disagree".

The Cronbach's Alpha coefficient was calculated to evaluate the internal consistency of the barrier items; the Cronbach's Alpha coefficient explains the internal consistency or the degree of intercorrelation between the scale's items [55,56]. The general formula of the Cronbach's alpha coefficient is:

$$\alpha = \frac{k}{k-1}\left(1-\frac{\sum S_i^2}{S_T^2}\right) \qquad (1)$$

Where:

k is the number of items, S_i^2 is the variance of the i^{th} item, and S_T^2 is the variance of the total score formed by summing all items [56].

The Cronbach's alpha value ranges between 0 and 1, where values close to 1 indicate a high intercorrelation between the scale items; values between 0.70 and 0.95 are generally regarded as satisfactory [55,56]. The overall Cronbach's alpha value of the barrier items was 0.943, indicating a high degree of internal consistency among the items. The Table 4 shows the values of Cronbach alpha if any item is deleted; the results indicated that all the items are highly intercorrelated.

The findings show that the 3 most important barriers to the adoption of BIM in the Togo AEC industry are "Incompatibility and interoperability problems" with a mean value of 2.769, "Complicated and time-consuming modeling process" with a mean value of 2.673, "Lack of subcontractors who can use BIM technology" with a mean value of 2.596.

Table 4. Values of Cronbach alpha if any item deleted

	Item	Cronbach's Alpha if item deleted
1	Insufficient infrastructures	0.942
2	Complexity of software programs	0.940
3	Incompatibility and interoperability problems	0.941
4	Data owning conflicts	0.940
5	High cost of software	0.940
6	Higher cost of employees training and education	0.939
7	Lack of projects likely to substantially amortize the investment	0.940
8	Difficulties in the Initial set up of BIM	0.941
9	Lack of expertise within the organizations	0.943
10	Lack of collaboration among stakeholders and team members	0.940
11	Lack of interest because projects worked on were perceived as too small to adopt BIM	0.940
12	Lack of detailed processes or workflow to apply BIM technology	0.941
13	Lack of subcontractors who can use BIM technology	0.942
14	Lack of contractual arrangements	0.939
15	Complicated and time-consuming modeling process	0.942
16	Lack of Funding	0.940
17	Lack of national standards	0.940
18	Lack of government support and pressure in the implementation of BIM	0.940
19	Lack of Skilled personnel	0.940
20	Resistance of employees and collaborators to change traditional methods	0.941
21	Weak education and training in universities	0.940
22	Lack of Client demand	0.940

Table 5. Ranking of barriers to BIM adoption

N	Item	Mean	Rank
1	Insufficient infrastructures	2.308	12
2	Complexity of software programs	2.404	10
3	Incompatibility and interoperability problems	2.769	1
4	Data owning conflicts	2.577	5
5	High cost of software	1.750	22
6	High cost of employees training and education	1.904	19
7	Lack of projects likely to substantially amortize the investment	1.865	20
8	Difficulties in Initial set up of BIM	2.423	9
9	Lack of expertise within the organization	2.096	14

N	Item	Mean	Rank
10	Lack of collaboration among stakeholders and team members	2.596	4
11	Lack of interest because projects worked on perceived as too much small to adopt BIM	2.558	6
12	Lack of detailed processes or workflow to apply BIM technology	2.481	7
13	Lack of subcontractors who can use BIM technology	2.596	3
14	Lack of contractual arrangements	2.462	8
15	Complicated and time-consuming modeling process	2.673	2
16	Lack of Funding	1.962	16
17	Lack of national standards	1.962	17
18	Lack of government support and pressure in the implementation of BIM	2.000	15
19	Lack of Skilled personnel	2.289	13
20	Resistance of employees and collaborators to change traditional methods	2.385	11
21	Weak education and training in universities	1.904	18
22	Lack of Client demand	1.808	21

Other barriers such as the lack of collaboration among stakeholders and team members, project data owning conflicts, the lack of interest because projects worked on were perceived as too small to adopt BIM, the lack of detailed processes or work-flow to apply BIM technology, the lack of contractual arrangements, the difficulties in the initial set up of BIM, the complexity of software programs, the resistance of employees and collaborators to change traditional methods, insufficient infrastructures, and the lack of skilled personnel were also identified as significant.

3. Findings and Discussion

The finding of this study revealed that although a relatively important awareness of BIM in the Togo AEC industry, its implementation is still at the initial stage since the main application areas were 3D architectural and structural modeling; it can be concluded that BIM is essentially considered as a 3D modeling tool by Togo AEC industry practitioners [18]. The complexity of BIM tools and the technical difficulties related to their use, such as interoperability problems with other software and the time-consuming modeling process, were found as important barriers to the adoption of BIM by the Togo AEC industry; the use of BIM tools also require the use of specific infrastructures and therefore their unavailability was found as a barrier to the adoption of BIM in Togo AEC industry. The lack of contractual arrangements and the lack of detailed processes or workflow for the use of BIM were also identified as important barriers to the adoption of BIM by the Togo AEC industry; the use of BIM in a project may raise some contractual issues, such as the sharing of additional cost, the difficulties in determining the ownership of the models, the difficulties to define the requirement about the models or the responsibilities of each participant; therefore the lack of standards and contractual arrangement may hinder the adoption of BIM. The lack of interest to adopt BIM because projects worked on are perceived as too much small, the resistance of the employees to change from their common working method, and the lack of collaboration among the project stakeholders were the main organization and people-related barriers that hinder the adoption of BIM in Togo AEC industry; this is essentially caused by the weak knowledge about BIM and its benefits. The findings from studies in other developing countries also show that the weak knowledge about BIM and its benefits is an important barrier to its adoption.

4. Conclusion

This paper has explored the main benefits of the application of BIM in construction projects and the common barriers that influence its adoption. This study is considered as a preliminary study on the adoption of BIM in the Togo AEC industry and fills the gap in the body of knowledge; the study mainly investigates the current state of the use of BIM in the Togo AEC industry and identifies the most important barrier to its adoption. The results indicated that the implementation of BIM in the Togo AEC industry is still at the initial stage; it was found that the complexity of BIM tools, the weak knowledge about BIM technology and its benefits, and the lack of standards highly influence the adoption of BIM. The findings of this study will serve as the basis to provide a framework for the successful implementation of BIM in the Togo AEC industry.

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Statement of Competing Interests

No competing interests.

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