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Post-COVID-19 BIM adoption, Challenges and Perspectives among AEC firms in Africa: Case of Morocco

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Abstract

The COVID-19 pandemic emphasized the remote potential of Building Information Modeling (BIM) to enable Architecture, Engineering, and Construction (AEC) operators to sustain work under the resulting challenging circumstances. Some studies pointed out the post-COVID-19 context of BIM use in several regions, but none in Africa. Therefore, based on a mixed-method design, this study aims to fill this research gap and provides a reference for BIM-related parameters in Africa including BIM adoption, challenges and perspectives by considering Morocco as a case study. This study disclosed that the COVID-19 occurrence fastened BIM adoption among Moroccan AEC operators by 19% and urged governmental initiatives toward BIM adoption regulation but confirmed that these are still insufficient compared to the significant identified BIM challenges. This paper confirmed that personal and government-related challenges are the most critical BIM challenges in Africa and highlighted that BIM faces 2 more considerable challenges in Morocco caused by a considerable loophole in local regulation. In this vein, the paper provides remedy actions to lessen the impacts of identified challenges and smoothen BIM adoption.

Keywords

Building Information Modeling, Architecture, Barriers, Developing countries, Africa, Regulation, Construction

1. Introduction

A recent study (Bouhmoud et al., 2022b) showed the enforced restrictive health measures to face the coronavirus disease 2019 (COVID-19) caused the African AEC industry 3 types of severe complications: Financial such as revenue losses and extra-costs due to transportation, materials and workforce shortage; Operational such as production halving and termination or postponing of new or ongoing projects; and managerial/strategic impacts namely shrinkage of construction projects and challenging adaptation of new processes and workflows. Experts believed that the construction sector could be the sector pulling economies out of the negative effects of COVID-19 (Hogan, 2020) but only if the used practices were upgraded digital and remote technologies, Information and Communications Technologies (ICTs) such as virtual reality, Building Information Modeling (BIM) and unmanned aerial vehicles (Meisels and Pendergast, 2021). In fact, Bouhmoud et al. (2022a) revealed that combining the BIM with fast-track construction approach helped revealed the big potential of BIM in keeping the construction sites on activity as well as building the needed health facilities in record durations but disclosed that African countries led behind other countries in this regard.

Moreover, Naroura (2014) highlighted that BIM helps to fasten decision-making processes and enhance projects understanding and quality by 65% and 54% respectively; optimize the workflow, including clash management and modifications, by 54%; and increase the cost control by 37%. The Hong Kong Housing Authority and Housing Department (2016) confirmed that, based on collaborative 3D models, BIM allows the AEC stakeholders to manage, store and share information in efficient and remote ways. Similarly, Ahmed and Bristow (2017) demonstrated that it allows a near real-time track of design and erection progresses with detailed daily progress reports. Elghaish and Abrishami (2020) showed that 4D BIM allows an automated multi-objective to optimize and leads to cost-saving of 22.86%. Zhang et al. (2018) proved that by using BIM model to enable 3D printer, fast-tack projects could be built in a tight time, with optimized costs

and under challenging circumstances such as large neighborhoods for destitute people in poor countries or healthcare facilities during pandemics spread. As a result, BIM technology is experiencing an upward worldwide adoption (Liu et al., 2019) with an exceptional rise during the COVID-19 crisis (Dodge Contractor Panel, 2021).

In Africa, Saka and Chan (2019) confirmed that BIM technology was lightly known and barely adopted among AEC operators. This fact was confirmed by Bouhmoud and Loudyi (2020) where, based on a comparative study, they revealed that, among the 34 identified BIM barriers worldwide, Africa straggles with further primary BIM challenges compared to the remaining continents such as inadequate infrastructure, lack of electrical power, and internet connectivity; and less advanced BIM challenges such as lack of insurance and collaboration management tools. However, in an earlier study, Bouhmoud et al. (2022b) showed that COVID-19 occurrence helped increasing BIM adoption among the AEC operators. In this vein, this study aims to investigate the post-COVID-19 BIM adoption context, including barriers and perspectives but none in Africa with Morocco as a case study and, thereby, this paper would enlighten both scholars and decision-makers about BIM adoption context in the discussed region, by responding to the following questions:

1. Has COVID-19 impacted BIM adoption? And how?
2. What are the most impactful challenges on the BIM adoption?
3. What are the future BIM perspectives?
4. What are the needed actions to overcome BIM adoption challenges?

2. Methodology

The study used an embedded mixed-method design based on three methodological instruments: survey, Systematic Literature Review (SLR), and interviews.

2.1. Survey and validation

2.1.1. Questionnaire

The questionnaire included 4 categories of questions: (1) respondents' background questions, (2) questions about COVID-19 impact on BIM adaption, (3) questions about post-COVID-19 BIM perspectives., and (4) a Likert-scale question, from 1 (Not significant) to 5 (extremely blocking) with 'I don't know' scale, was included to rank the listed challenges and open-ended questions allowing the respondents to list any possible missing challenges and give further explanations.

To build the Likert-scale question a SLR about BIM challenges was undertaken (§2.2).

2.1.2. Respondents' list:

Through a purposive sampling, the authors listed 97-targeted respondents from the different AEC industry expertise areas including architects, AEC administrations, developers, engineering firms, and academic / R&D stakeholders (Fig. 1):

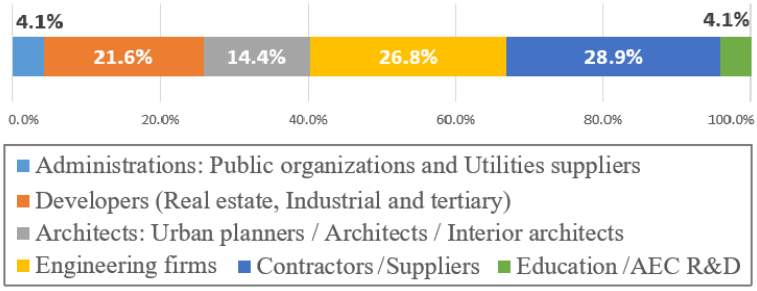

Fig. 1. Targeted respondents by areas of activity

2.1.3. Web-based and interview-based surveys

Based on the pre-designed questionnaire, a web-based survey was conducted in the first place through an emailing process. Then, an interview-based survey was conducted for the remaining targeted respondents who did not respond online. As a result, 89 feedbacks have been collected giving then a response rate of 92%.

2.1.4. Validation of the new findings:

The findings could bring out new challenges hindering BIM adoption specific to the Moroccan context. Therefore, to confirm their trustworthiness, the authors are running more substantiations by either analyzing the official data and statistics delivered by the concerned public institutions or interviewing the representative of an institution directly related to the newfound challenge.

2.2. Systematic Literature Review

A previous SLR (Bouhmoud and Loudyi, 2020) gathered all BIM challenges/barriers listed in the literature until 2020. In other to build a well-founded survey questionnaire, it was necessary to consider the data published afterward hence a

complementary SLR was achieved based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach (Fig. 2).

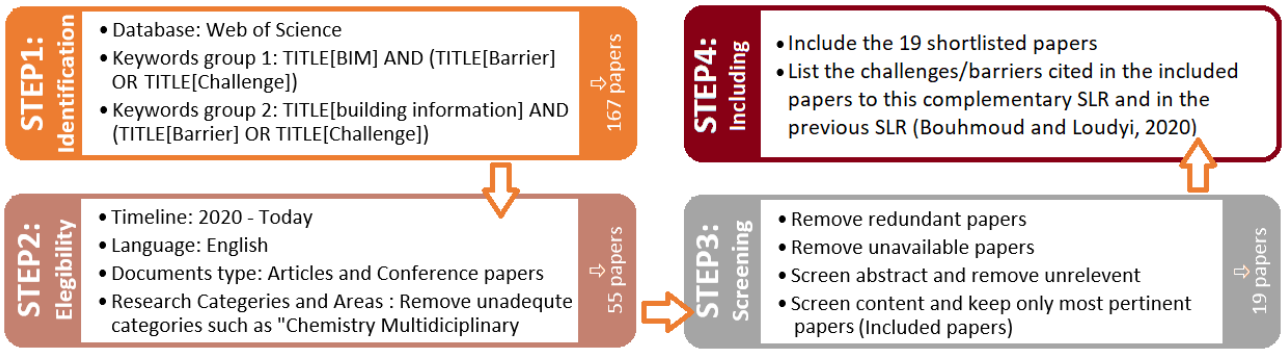

Fig. 2. workflow of the complementary conducted SLR

2.3. Interviews:

To confirm the survey's findings and collect the public perspectives toward BIM adoption, the authors interviewed five representatives of the Moroccan Ministry of National Territory Use, Town Planning, Housing and City Policy (MNTUTPHCP).

3. Findings of the SLR

The findings of the complementary SLR confirmed some of the BIM challenges disclosed by the previous SLR (Bouhmoud and Loudyi, 2020), the disparity between Africa and other continents, and the lack of studies related to BIM adoption among the Moroccan AEC firms. The main found existing BIM barriers / challenges are:

- Resistance to change, fragmentation and business culture,
- Inadequate professionals' education,
- High initial investment cost for BIM implementation,
- Lack of BIM standards and guidelines,
- Lack of governmental strategy for BIM adoption,
- Lack of awareness of either BIM or its added value,
- Lack of governmental incentives,
- Shortage of skilled BIM workforce and expertise,
- Lack or absence of clear contractual terms adapted to BIM use
- Lack of adequate training,
- Lack of interoperability,
- Risks related to data Security & Reliability,
- Lack of Compatibility with existing tools,
- Lack of client demand,
- Confusion of ownership and copyrights,
- Disturbance of the Workflow,
- Lack of executive Buy-in,
- Needed time for BIM implementation.

To shorten the responding time, the aforementioned challenges were combined into nine key challenges: Ch1: Lack of qualified workforce and experts in BIM, Ch2: Requirement of considerable additional budget, Ch3: Requirement of more time to both workflow adaptation and implementation, Ch4: Lack of decent trainings and academic BIM education, Ch5: Lack of regulations, standards, and guidelines, Ch6: Lack of governmental incentives and adoption strategies, Ch7: Lack of client demand and buy-in, Ch8: Resistance to change and business culture, and Ch9: Lack of BIM awareness.

4. Finding of the Surveys and Interview

4.1. Respondents' background

The respondents had diverse academic backgrounds, with civil engineers on the top with 63%, followed by architects and topographers with 14% and 10% respectively. 46% of the respondents had between 8 and 15-year experience and 44% had more than 16-year experience. Likewise, they had high job positions including CEO's position (27%) and chiefs of department / senior project directors (64%) whereas the remaining were either professors, scholars, consultants, or projects managers (Fig. 3). As shown in Fig. 4, the respondents represented engineering firms, contractors/suppliers, and developers at the percentages of 29%, 25% and 24% respectively. Architectural firms represented 17% of represented institutions and the remaining 5% gathered administrations and academic institutions (Education / AEC R&D). For the institutions' size, 71% of them had more than 500 employees and 25% had 51-100 employees.

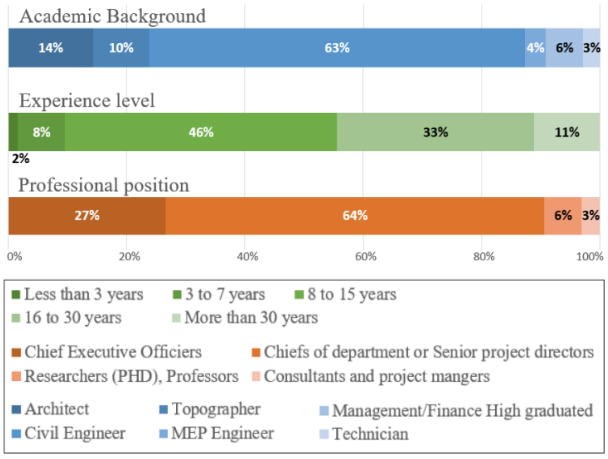

Fig. 1: Respondents' background

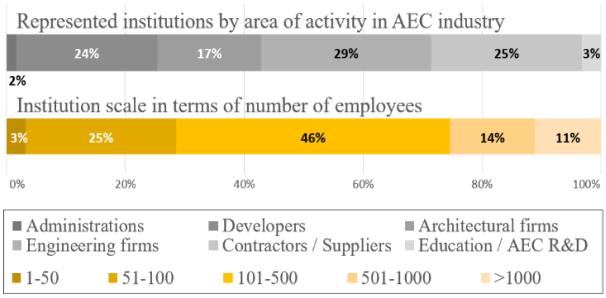

Fig. 2: Represented institutions' background

4.2. Impact weight of COVID-19 on BIM adoption in Morocco

To measure this metric, the respondents were asked to disclose their vision of BIM adoption before and after COVID-19 occurrence. The comparison (Fig. 5) showed that the respondents that were not planning to adopt BIM decreased by 19% due to the pandemic. Similarly, the rate of respondents who were planning to adopt it and those who were having BIM adoption in progress increased by 13% and 6% respectively.

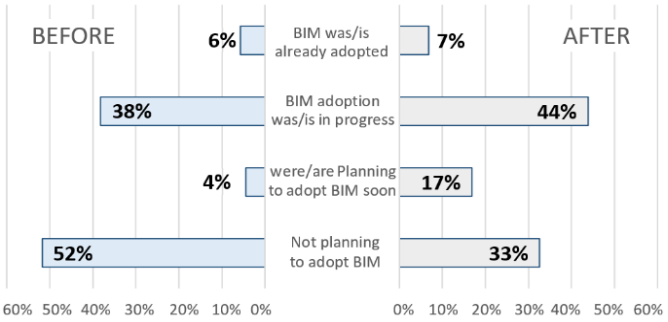

Fig. 3: BIM adoption before and after COVID-19 occurrence

4.3. Weight of BIM Challenges in Morocco

Fig. 6 syntheses the collected responses to Likert-scaled question that scaled the challenges' impact on BIM adoption in Morocco from 1(insignificant) to 5(very blocking).

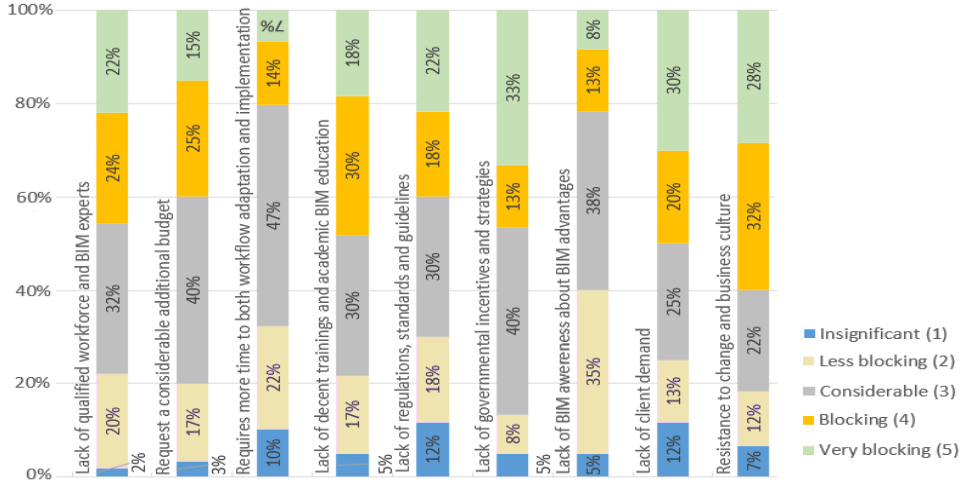

Fig. 4. Weight of BIM challenges in Morocco per scale

The following formula was used to calculate the Average Weight (AW) of each challenge Cht:

$$AW(Ch_t) = \sum_{i=1}^{5} p_i * s_i\,(CH_t) \quad with \begin{cases} t \in \{1,2,3,4,5,6,7,8\} \\ s_i = scale\ from\ 1(insignificant)\ to\ 5(very\ blocking) \\ p_i = percentage\ of\ respondents\ giving\ s_i\ to\ the\ CH_t \end{cases} \quad (1)$$

Table I disclosed that challenges due to personal-related and governmental/financial-related factors represent the highest blocking challenges hindering BIM adoption in Morocco, where the AW of "resistance to change and business culture" and "Lack of governmental incentives and strategies" exceeded 3.6. In the same vein, the three more personal-related challenges: "Lack of qualified workforce and BIM experts", "Lack of client demand and buy-in" and "Lack of decent trainings and academic BIM education" are considerable BIM challenges with an AW of 3.4. Meanwhile, the financial challenge "requirement of considerable additional budget" and the governmental challenge "Lack of regulations, standards, and guidelines" seem less impactful but remain considerable. "Requirement of more time to both workflow adaptation and implementation" and "Lack of BIM awareness" are the least impactful challenges in Morocco.

Table 1. Average Weight of listed BIM Challenges

Code	Type	Challenge	AW
Ch8	P	Resistance to change and business culture	3.6333
Ch6	F/G	Lack of governmental incentives and adoption strategies	3.6167
Ch1	P	Lack of qualified workforce and BIM experts	3.4407
Ch7	P/M	Lack of client demand and buy-in	3.4333
Ch4	P/G	Lack of decent trainings and academic BIM education	3.4000
Ch2	F	Requirement of considerable additional budget	3.3167
Ch5	G	Lack of regulations, standards, and guidelines	3.2000
Ch9	P	Lack of awareness about BIM advantages	2.8500
Ch3	M	Requirement of more time to both workflow adaptation and implementation	2.8475

4.4. Additional BIM Challenges in Morocco and validation

The respondents were asked to cite, optionally, other challenges and scale them accordingly (1(insignificant) to 5(very blocking)). As a result, 14 respondents added 21 valid responses converging to two main challenges:

- **Ch10** "Huge use of cracked software licenses": Ch10 was considered as 'very blocking' 7 times and as blocking 3 times. According to the respondents, Ch10 firstly limited project's stockholders to freely exchange their models since the models developed with cracked licenses could carry viruses or malfunction that would harm models done in proper ways. Secondly, afraid of being recognized by the software suppliers and being pursued, the stockholders using cracked licenses refuse to connect their software to the cloud which makes BIM inapplicable.
- **Ch11** "Fierce competition by non-qualified engineering firms / Huge number of unqualified AEC companies proposing tight prices": Ch11 was cited 7 times where 5 scaled it as blocking, 1 as very blocking and 1 as considerable. The respondents explained that, in Morocco, opening an engineering firm is governed by general laws and does not require any level of academic or professional competences to create such companies. Therefore, many people without the required academic or professional skills see in the construction field a profitable business without worrying about the quality of their deliverables. These kinds of engineering firms usually do not call for qualified engineers; instead, they could assign the design tasks to technicians or practitioners in the field! The absence of law in this sense has given rise to many incompetent offices imposing reduced prices and lowering both prices and quality of deliverables in the design market. Considering this situation, BIM adoption would be difficult.

4.5. Validation of newfound BIM Challenges in Morocco:

To confirm the reliability of these two challenges, the authors went through more validation studies.

4.5.1. Ch10: the validation of this challenge was difficult since no related statistics have been found. However, an AEC software and hardware supplier participating in the survey confirmed that since 2013, his company has detected 25 cracked licenses per year on average, especially for Autodesk and Trimble BIM software.

4.5.2. Ch11: For this challenge, two elements were verified: a) the weight of unqualified engineering firms on the Moroccan construction market and b) if the creation of an engineering firm legally needs certain requirements, especially in terms of competencies' level.

- Officially Qualified engineering firms in Morocco:

The Moroccan authorities represented by the Moroccan Ministry of Equipment, Transport, Logistics and Water (METLW) has set in place a FREE certification (The Moroccan METLW, 2021) proving that the accredited firms in a specific discipline have the needed qualifications and adequate materials to accomplish the related missions. Any reliable engineering firm can acquire this certification for free. This certification is mandatory to work in public AEC projects.

Therefore, to verify the weight of unqualified engineering firms in the Moroccan construction market, the authors assessed and compared the number of existing engineering firms and the number of the accredited ones by the METLW (2021).

Table 2. Domain of expertise defined by the METLW

Code	Domain of expertise	AF	Code	Domain of expertise	AF
D3	Urban hydraulics	97	D14	Structural studies	172
D4	Roads, Highways, Transport	142	D15	Lighting and communication networks for general purpose buildings	136
D5	Special structure	101	D16	Fluid networks for general purpose buildings	140
D6	Dams	16	D17	Roads, sanitation networks and drinking water	202
D7	Maritime and river work	38	D18	Low and medium voltage electricity networks, telephone networks and public lighting	68
D8	Defense Engineering works of a specific nature	4			
D9	Agricultural studies	83	D19	Environmental Impact Studies	79
D10	Industry and energy	30	D20	Geology, geophysics, hydrology, hydrogeological	38
D13	General studies	232	D21	Fire safety in buildings	9

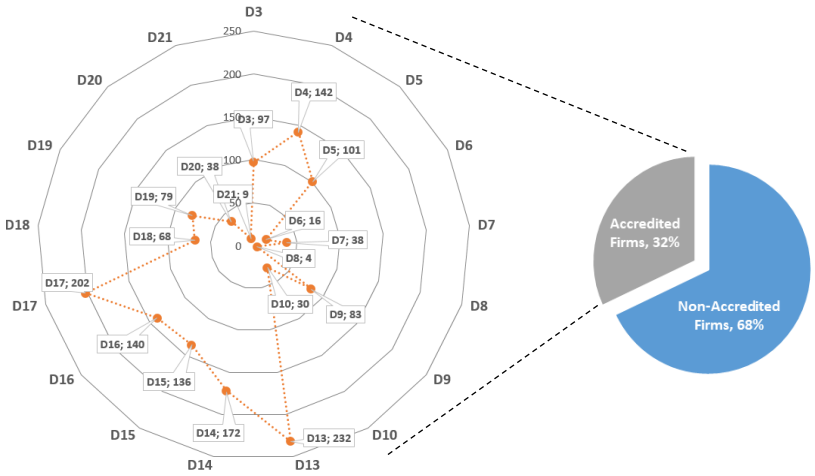

Fig. 5. Repartition of Moroccan engineering firms according to official accreditation by the METLW and Distribution of the accredited ones by domain of expertise.

The census of the accredited firms (AF) by the responsible authority (2021) showed that AF number vary from 4 to 232 according to the domain of expertise (Table 2 and Fig. 7). However, Considering that some engineering firms were simultaneously accredited in 2 or more domains of expertise, a triangulation of the AF in all domains of expertise was processed resulting to a total of 451 AF by METLW. Among them 232 (51%) were accredited in domain 13 "General studies", 202 (45%) were accredited in domain 17 "Roads, sanitation networks and drinking water" and 172 (38%) were accredited in domain 14 "Structural studies". Moreover, very few engineering firms were able to present the necessary competences' proofs in domain 8 "Defense Engineering works of a specific nature", domain 21 "Fire safety in buildings" and domain 6 "Dams" by presenting.

On the other hand, based on the reputed companies' database published in Morocco "Charika" (2021), 1412 existing engineering firms active in the 17 domains of expertise were counted. Consequently, less than third (451) of all existing engineering firms in Morocco (1412) were accredited whereas 68% were still not, which confirms the first element of the CH11 (Fig. 7).

- Regulations related to engineering firms' creation:

To verify this element the authors met the representative of Regional Center of Investment (RCI), Legal authority responsible for procedures of companies' creation in Morocco, in Casablanca. The representative confirmed that the Moroccan legislation does not require any academic or professional experience for engineering firms' creation and allows anyone to create and run that kind of companies.

4.6. BIM Perspectives in Morocco

According to the interviewees, BIM was part of the master agreement for the AEC industry development that was signed in 2018 by the 2 professional federations of AEC operators and 8 ministries including the MNTUTPHCP. However, they confirmed that BIM adoption strategy is still in fetus stage. However, considering COVID-19 impacts on the national AEC

industry, the government became more interested in developing and implementing a progressive strategy toward BIM adoption. In this vein, the MNTUTPHCP initiated the training of their staff in BIM and created a team, including scholars working in this area, to prepare, by 2022, a first guideline for the ministry to build, plan and implement strategy for gradual mandatory BIM adoption in Morocco.
Likewise, the Moroccan Institute for Standardization developed two projected standards related to BIM and adapted to Moroccan context, they are in validation process:

- PNM ISO 19650-1, IC 10.8.796, 2020: Organization and digitization of information relating to buildings and civil engineering works, including Building Information Modeling (BIM) / Information management by modeling construction information / Part 1: Concepts and Principles,
- PNM ISO 19650-2, IC 10.8.796, 2020: Organization and digitization of information relating to buildings and civil engineering works, including Building Information Modeling (BIM) / Information management by modeling construction information / Part 2: Realization phase of assets.

5. Discussion

The study disclosed that the enforced restrictive measures against the COVID-19 spread helped increase the BIM adoption among Moroccan AEC operators by 19% where 35% of the operators who were not considering BIM adoption rescinded their decision considering its proved abilities to enable remote practices and overcome the challenging work conditions imposed by the COVID-19 in construction projects (Bouhmoud et al., 2022b; Bouhmoud and Loudyi, 2021). Nevertheless, the study confirmed that BIM adoption is still struggling with several challenges headed by personal-related category, which line up with previous studies conducted in other regions (Bouhmoud and Loudyi, 2020; Charef et al., 2019).
"Resistance to change and business culture" is on the top of personal-related challenges' category, tailed by "Lack of qualified workforce & BIM experts", "Lack of client demand & buy-in" then "Lack of decent trainings & academic BIM education" that was attributed to the lack of BIM tools, lack of experienced lecturers and the high cost of training for BIM (Shibani et al., 2020). Governmental and financial challenges are the second critical categories of BIM barriers where "Lack of governmental incentives and adoption strategies" is the most impactful. The study revealed that the Moroccan government is still in the ideation phase to prepare a BIM adoption strategy which will keep this challenge on the list of top BIM barriers for some years to come in Morocco. In addition of the worldwide challenges, BIM adoption in Morocco is facing two additional challenges: "Huge use of cracked software licenses", and "Fierce competition by non-qualified engineering firms / Huge number of unqualified AEC companies proposing tight prices".
Using cracked software licenses deters the collaboration parameter needed for BIM models as well as their security and reliability. Aleassa et al. (2011) and Bui et al. (2016) reported that this challenge was also detected in several countries headed by 25 developing countries. Moreover, having a large number of unqualified AEC companies, especially related to design stage, is pulling down both prices and quality in the AEC market and thereby disturbing the qualified ones to propose prices allowing using new technologies. This challenge is principally due to a loophole in the Moroccan legislation where neither academic background nor expertise are required for companies' creation in different AEC expertise areas. For instance, 68% of existing engineering firms in Morocco are not accredited in none of the 17 listed AEC domains of expertise.

6. Conclusion

The AEC industry leads behind the other industries in terms of ICTs use in common practices, mainly in developing countries where this industry is struggling with more financial and technological issues (Kajewski et al., 2001). However, the COVID-19 spread highlighted the urgent need to switch the current used practices in the AEC industry toward more automated and remote ones namely enabled by BIM technology. In the African country Morocco, the pandemic stimulated BIM adoption as it helped the increase of the rate of AEC bodies considering adopting BIM by 19% and the initiation of preparing BIM adoption regulation. However, the undertaken actions by both public and private bodies are still considerably timid considering the significant identified BIM challenges.
BIM adoption in Morocco is still struggling with several challenges where personal-related ones are the weightiest with 'Resistance to change and business culture" on the top". Governmental and financial challenges remained also significantly impactful where "Lack of governmental incentives and adoption strategies" headed the list. Moreover, the study highlighted the existence of a considerable loophole in Moroccan legislation that worsen the challenging unfair competition beside the common use of cracked licenses, which may further hamper BIM adoption. Therefore, to lessen these challenges' impacts and upgrade the national AEC industry toward more efficient and remote practices, the Moroccan policymakers should consider the following measures soon:

- ➔ Create and name a specialized authority responsible for BIM in the local AEC industry,
- ➔ Build founded strategies and timeline for BIM implementation,

- Design adapted BIM standards and guidelines adapted to the local context,
- Create an efficient legal framework including aspects related to contractual environment, ownership parameters, responsibilities…
- Set up considerable incentives both direct and indirect,
- Encourage Research and development,
- Incorporate BIM in academic syllabus, for either engineers, architects, or technicians' programs.

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