# Perceived Benefits and Barriers of Building Information Modeling (BIM) adoption in the AEC Sectors of Ethiopia

Muluken Tilahun Desbalo
Chair of construction management, Addis Ababa University
Ethiopian Institute of Architecture Building Construction and City development
Addis Ababa, Ethiopia

Prof. Dr. Ing Hans Joachim Bargstadt
Chair of Construction Engineering and Management
Bauhaus University of Weimar
Weimar, Germany

***Abstract* - Building Information Modeling (BIM) has been recognized as one of the most efficient technological novelty in response to the challenges within the construction industry. Most of the developed countries have adopted BIM to improve the performance of their construction industry.**

**The purpose of this study was to identify and cluster the benefits of BIM into the Planning, design, construction, and Operation and maintenance stages of the project lifecycle. It was also intended to identify the challenges of implementing BIM in the construction industry in Ethiopia. The challenges have been clustered into the process, technology, organization, human, and policy-related challenges.**

**An online questionnaire was distributed to 235 participants to collect data from practitioners involved in the design, construction, and research activities from academia and industry. Relative importance index (RII) was used to analyses and rate the identified variables. Based on RII values, the top-ranked perceived benefits of BIM in the AEC sector of Ethiopia were easy quantity and cost estimates, Timely integration and data sharing, digital project documentation, and ease of producing as-built documents during planning, design, construction, and operation and maintenance stages respectively. On the other hand; Lack of collaborative initiatives from the industry, fragmented nature of the industry, none widespread of BIM are identified as process-related barriers to BIM adoption. Whereas; Insufficient ICT infrastructures, High cost of BIM technology, the longer time required to adopt BIM has been identified as technology-related barriers to BIM adoption. Organization related barriers to BIM adoption were: Lack of BIM-based workflow, Lack of comprehensive framework and implementation plan, and lack of senior management support and attention. Human or stakeholder related barriers to BIM adoption include Lack of adequately trained BIM professionals, lack of client awareness and knowledge about BIM, and unfamiliarity with BIM use. Finally; Standard and policy-related barriers to BIM adoption were found to be a lack of BIM National Standards and guidelines, Lack of legal framework for BIM application, and the Absence of standard BIM-based contract documents and contractual relationships. Finally, recommendations were forwarded to those stakeholders who have a significant role in avoiding the barriers in adopting BIM and to properly use benefit from technological innovation.**

***Keywords - Benefits, Barriers, BIM, Construction Industry Ethiopia***

## 1 INTRODUCTION

Construction is a key industry in countries across the world, though it has struggled to evolve its approaches as other industries have done [1].

The productivity of the construction industry is far behind other industries compared with retail, manufacturing, and automotive industries since they have transformed their efficiencies, boosted productivity, and embraced the digital age, construction appears to be stuck in the time Wrap [1] and [2]

In contrast to the conventional design and construction approach in which individual professionals predominantly work in their specialized arena, the BIM approach to building design and construction emphasis knowledge sharing in the form of a single repository that develops throughout the life cycle of the building project [3].

BIM has been acknowledged as one of the most appropriate platforms for the Architecture, Engineering, and Construction industry, which is considered to be multi-organizational and multi-disciplinary as a solution to improve construction performance challenges during the planning, design, construction operation, and maintenance stage of entire project lifecycle [4]

The construction industry at a global level is suffering from poor productivity and inefficiencies [1] and [5]

Numerous research and development have been produced to minimize these performance challenges in the construction industry.

The challenges would be more remarkable when it comes to the case in developing countries, where the construction industry has different performance challenges of poor productivity, poor information management, delay, cost overrun, waste, and rework [6].

The existence of multifaceted challenges in the AEC sectors in Ethiopia such as delay in construction industry development (CID), policy implementation and corruption, weak capacity of contractors and consultants, lack of collaboration and professionalism, lack of benchmarking, and nature of the construction industry have been identified as main challenges in Ethiopia [6], [7] and [8].

The adoption and implementation of BIM in the AEC sectors became a subject of research and development in the past decades and its implementation has also ensured continuous and sustainable developments in the sector [9].

The challenges in implementing BIM have also shifted from overcoming technical difficulties to seamlessly integrating BIM into daily working processes and achieving continuous improvements [10], [4] [11], and [12]

To address these challenges, BIM users, namely, organizations at the industry level and stakeholders at the project level should first evaluate the current conditions in BIM implementation to identify appropriate improvement footpaths that best match the characteristics of users [12]

Although the developed countries are harvesting the fruits of benefits of adopting BIM for infrastructure development projects, the adoption of BIM for infrastructure development projects in Ethiopia is very much limited in Ethiopia [13]

Different studies revealed that the adoption of BIM has shown a significant improvement in project performances of many projects. As a result it was possible to achieve cost savings up to 40%, time saving and quality improvement are some of its benefits [14], [15] [16] , [17], [18],[18]], [19] and [20]

Hence; the objectives of this research are to:

- Identify and cluster the perceived benefits of BIM into planning, design, and construction and operation stages of the construction project life cycle in Ethiopia.
- Identify and cluster the Barriers to BIM adoption into Process, technology, Organization, human and Policy and guideline related challenges within the construction industry in Ethiopia

## 2 LITERATURE REVIEW

### *2.1. What is BIM*

Different people and organizations have given different definitions from diverse perspectives for BIM-based on their particular use and the various ways they work with BIM.

*Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during the life cycle; defined as existing from earliest conception to demolition* [21]. Which focuses on collaboration and integration of stakeholders at different phases of the life cycle is the peculiar feature of BIM.

Whereas; [22] defined BIM as a modeling technology and associated set of processes to produce communicate and analyze building models. [23]; on the other hand defined BIM with little deviation as a set of interacting policies, processes, and technologies to generate digital building data of the whole life cycle.

Emphasis was given to depth of information as defined in [24] as a comprehensive digital representation of a built facility with great information depth.

Autodesk, [25] on the other hand defines Building Information Modeling, or BIM, as an intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct and manage buildings and infrastructure.

According to [26], BIM is many things and most likely, the construction industry has not yet realized its full capabilities. BIM is entangled with technology, both hardware, and software. The emphasis here is given to the development of BIM to multiple dimensions.

Professionals or practitioners may view building information Modeling, BIM from a different perspective, Building SMART international defines BIM from a different perspective; A new approach to being able to describe and display the information required for the design, construction, and operation of constructed facilities [27] and [25].

Even though different scholars or organizations have divergent perspectives in defining BIM, there is a common consensus in the definitions, where the idea intersects one another.

For the context of this study; BIM is defined as a digital representation of the physical and functional characteristics of a facility or asset [28].

### *2.2. Why BIM*

In the last decades, digitalization has transformed a wide range of industrial sectors resulted in a tremendous increase in productivity, product quality, and product variety [24].

However; the continuous digitization of information for the entire process of the construction industry is far behind other industries [29],[24],[1]

Although digitization in construction has been adopted in the AEC industry, it is far behind compared to other industries [24]. Useful information has been lost since information is predominantly handed over by printed drawings.

BIM has many things to do in the AEC sector. For 3D visualization, space planning clash detection,4D scheduling, Constructability analysis, structural analysis, quantity take-offs, and creating shop drawings[14].

Moreover; BIM is needed by Construction Managers to understand the processes and tools that are used throughout a project's lifecycle, beyond the design phase[26].

Furthermore; BIM use has the potential to improve construction efficiency, enhance collaboration and knowledge sharing among the team members, and support construction-related tasks [14] and [30] that is why different countries are adopting BIM for their respective construction industry.

### *2.3. BIM Dimensions*

BIM dimensions refer to how kinds of data are linked to an information model. By including additional dimensions of data, Which helps highly to have a complete understanding of the construction project including how it will be delivered, what it will cost and how it should be maintained etc [31]

**i.)** 3D BIM models

A 3D BIM model is beyond a three-dimensional model geometry since a 3D model produced by a BIM tool can support multiple different views of the data contained within a drawing set, including 2D and 3D geometries [32]

3D BIM model not only reveals massive information for infrastructure and building design details including geometry, dimensions, and materials, but also provides opportunities for multi-disciplinary collaboration, coordination, and integration [20]. 3D BIM models can also be used in constructability reviews and identification of errors and omissions [33]

**ii.)** 4D BIM Models

The use of the term 4D is intended to refer to the fourth dimension: time, where 4D is 3D BIM model plus schedule (time) [32]

This fourth dimension of information extends to a project information model in the form of scheduling data. This data is added to components which will build in detail as the project progresses [31]and [34]

Whereas [35] described 4D is planning as a process to link the construction activities represented in time schedules with 3D models to develop a real-time graphical simulation of construction progress against time.

Similarly, [33] described 4D modeling use for activities sequencing with visualization Simulation for update time and resourced schedule.

**iii.)** 5D BIM Models: Cost

Material quantities are extracted automatically and changed when any changes are entered in the model. Hence; Micro and Macro Costing Models can be generated [35].

BIM 5D model with open interfaces integrating the series of software, Revit, Tekla, MagiCAD, such as the establishment of the model, while integrating Project, Excel, Word, and other office software, schedule, list of price, contract terms and other information's through the model [36] which can be represented by the formula:

$$\text{BIM5D} = \text{Model} + \text{Data} + \text{sharing} + \text{App} \qquad (1)$$

The 5D model allows the designer and owner to make more informed decisions, resulting in higher-quality construction that meets cost constraints, and hence BIM greatly facilitates the development of interim estimates [30],[37].

**iv.)** 6D BIM Models: Sustainability

The sixth dimension 6D BIM refers to project management (thermal analysis, environmental analysis, and automated building certification) [38]. Whereas [39],[35], and [40], on the other hand, classified 6D as Facility management. However;6D is referred as sustainability/energy management in most of the literatures [41],[42],[43], [37]. Hence; 6D BIM is accepted as energy analysis or sustainability analysis in this study.

**v.)** 7D BIM Models

The 7D BIM models link the entire asset information both the graphic and functional which is required during the post-construction stage for use in maintenance and operation [43] some other authors relate O and M with 6D like [14],[44]. 7D contains all necessary information to the owner for the use and maintenance of the building [42] and it is a database BIM record model and used to reinforce to utilize the planning and decision making relevant to facility management [37].

*2.4. BIM Maturity levels/BIM Maturity stages*

In the process of moving towards a fully collaborative and integrated working process in the construction industry, the UK set a milestone being defined within the process in the form of levels which is called BIM levels [31].

The UK government recognized that the process of moving the construction industry to 'full' collaborative working will be progressive, with distinct and recognizable milestones being defined within that process, in the form of 'levels'. These have been defined within a range from 0 to 3, and, whilst there is some debate about the exact meaning of each level, the broad concept is as follows[30].

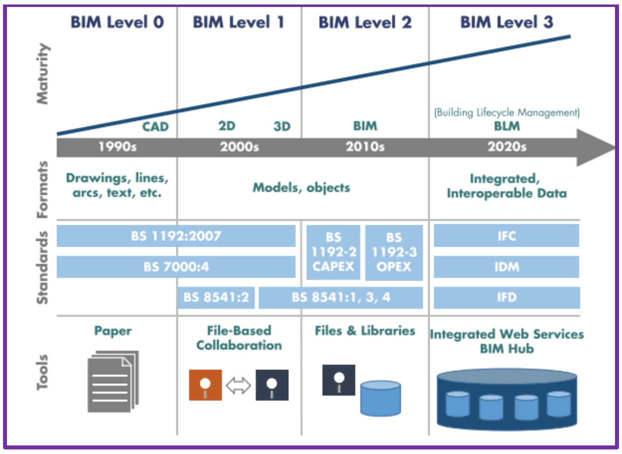


FIGURE 1: BIM maturity Levels, Source [30]

*2.5. Benefits of BIM use*

There are perceived benefits of BIM use as a result of increased efficiency, collaboration, and communication [14] to reduce project cost and time compared with the traditional approach. Among other stakeholders in the construction industry, clients and Facility managers are the most significant beneficiaries of BIM implementation [45]

The benefits of BIM adoption spans from Construction project planning to Facility maintenance and management. Some authors have identified the perceived benefits of adopting BIM during different stages of the construction process.

This study clusters the benefits of BIM implementation into planning, design, Construction and, Operation and maintenance stages of the construction process.

i). Benefits of BIM during Construction planning phase

There are many benefits of BIM during the planning phase of construction projects. Table 1, below summarizes the perceived benefits of BIM for the construction project planning phase identified by different kinds of literature.

TABLE 1: Benefits BIM during the planning phase

| Sn | Benefits of BIM use during the Planning Phase | Source Publications |
|---|---|---|
| 1 | Reduce contingencies | [33] and [18] |
| 2 | Provides easy and quick alternative analysis | [46] |
| 3 | Facilitates energy analysis modeling | [46] |
| 4 | Provides easy quantity and cost estimates | [46] |
| 5 | Facilitates specifications development | [46] |
| 6 | Enhance Site analysis | [47] and [48] |
| 10 | Helps in managing requirements | [49] and [50] |
| 11 | Facilitates decision making | [51] ,[50] |

ii). Benefits of BIM during Construction Design phase

Table 2, below summarizes the perceived benefits of BIM for construction projects during the design phase identified from different kinds of literature.

TABLE 2: Benefits of BIM during Design Phase

| Sn | Benefits of BIM use during Design Phase | Source Publications |
|---|---|---|
| 1 | Evaluates the impacts of design solutions/ design optimization | [51], [51] [52] ,[14] and [53] |
| 2 | Lowers risk and better predicts due to discovery of errors, omissions and conflicts before construction | [54],[17],[18],[55],[56] and [56] |
| 3 | Building systems clash detection (Identification of design error) | [47] , [18], [52][26],[20],[48] and [50] |
| 4 | Enable Automation of documentation (better accuracy and accounts for adjustments and changes automatically) | [57],[53], [46],[48] and [52] |
| 5 | Enables faster reviews for approvals | [18] and [14] |
| 6 | facilitates project visualization and simulation | [54],[33],[33],and [20] |

iii).Benefits BIM during the construction phase

Table 3 below summarizes the perceived benefits of BIM for construction projects during the construction phase reviewed from the literature.

TABLE 3: Identified Benefits of BIM during the construction phase

| Sn | Benefits of BIM use during Construction | Source Publications |
|---|---|---|
| 1 | Reduce request for information's (RFIs) | [19],[58],[57],[57],[57] and [57] |
| 2 | reduce change orders | [57],[58],[52],[57],[57],[45] and [59] |
| 3 | Reduce construction and production cost | [1],[60],[16],[17],[18],[61],[55],[20] and [20] |
| 4 | Reduce project delivery time/ improved time management | [60],[16],[17],[18],[61],[55],[20]and [56] |
| 5 | Reduce on-site waste and construction materials use | [62],[52],[20] ,[43] and [43] |
| 6 | Improves product/project quality | [63],[63],[64],[55],[52],[44],[56],[56]and[65] |
| 7 | Increase prefabrication | [55],[52],[14],[43]and [50] |
| 8 | Improves construction safety | [14], [61],[55],[52],[46],[66] and [50] |
| 9 | Allow auto quantification, better cost estimate and control | [50],[64],[52] and[44] |
| 10 | reduce Rework | [54],[62],[18],[60],[66] and [67] |
| 11 | Improves risk Management | [62], [67],[17], [68],[66], and [48] |

iv). Benefits BIM during Facility Operation and maintenance phase

Table 4 below summarizes the perceived benefits of BIM for construction projects during the Facility Operation and maintenance management phase reviewed from literature.

TABLE 4: Benefits of BIM during Operation and Maintenance stage

| Sn | Benefits of BIM use during Operation and Maintenance | Source Publications |
|---|---|---|
| 1 | Promotes Digital Facilities management using digital life cycle data | [48],[15] ,[69] ,[53],[43] and [62] |
| 2 | Help in producing as-built documents | [55],[52] |
| 3 | Improved Commissioning and Handover of Facility Information | [22] |
| 4 | Better management and operation of facilities | [22] and [46] |
| 5 | Integration with facility operation and management systems | [22] and [46]] |
| 6 | Operational simulation for maintainability | [52] |
| 7 | The same critical information is present in a single electronic file | [52] and [50] |
| 8 | Reduce the facility manager's effort to collect relevant FM information from fragmented sources | [26] |
| 9 | Provide the end product with an interactive facility management tool | [49],[62] |

## *2.6. Barriers to BIM adoption*

Even though the implementation of BIM has proven benefits in the AEC sectors as confirmed by different scholars [23], the adoption process may face some or a group of challenges or barriers based on the context where the approach is to be realized. Hence, it is very important to identify and categorize these barriers to pave the way towards the proper implementation of BIM especially in the least developing countries taking the best practices from all over the world.

After reviewing the barriers from different kinds of literature, the barriers were categorized into five main categories in a way to set measurement metrics in the future after implementation for its continuous improvement [12]. Whereas [70] categorizes the barriers to BIM adoption into three to study the readiness of the industry concerning the product, process, and people to position BIM adoption in terms of current status and expectation across disciplines in Australia.

[71] Categorized critical barriers to BIM adoption into lack of National standard, high cost of application, lack of skilled personnel, organizational issues, and legal issues.[72] On the other hand; categorized barriers to BIM adoption into legal and contractual, cultural, management, financial, and security.

[73] Also categorized the barriers to BIM adoption into technological, people, organizational culture, and recognition from the government.

[44] Categorized the barriers to BIM adoption as technical, economic, normative related, and education and training barriers.

According to [74], barriers to BIM adoption are categorized into Technical, process, Mindset related, legal challenges, and return on investment-related challenges.

Having the list of barriers to BIM adoption are identified, they are categorized into five main categories in this study as process-related, technology-related, organizational, human/stakeholders, and standard/policy based on the maturity measurement tools provided by different bodies like NBIM, CMM, IU BIM proficiency index quick scan, BIM assessment profile, DC scorecard, BIM cloud score, owner's CAT BIM characterization framework [12].

The categorization of barriers to BIM adoption would be important to measure the maturity stage of BIM after it is adopted in a certain industry concerning the standard measurement tools of BIM implementation in every category.

**i.)** Process related barriers to BIM adoption

A process in the context of this research is defined as a modeling process and information flow of BIM and the coordination among different disciplines and documentation process [12]

The Process related barriers include the processes of procuring, designing, constructing manufacturing use, manage and maintain structures and their interactions amongst one another [23]

Process related barriers are those which are against the establishment, management, and documentation process of BIM related activities [12]

Based on the reviewed pieces of literature, the most frequently stated, process-related BIM barriers are summarized in the table below

TABLE 5: Process related Barriers to BIM adoption

| Sn | Process related to BIM barriers | Source Publications |
|---|---|---|
| 1 | Lack of collaborative initiatives from the industry / lack of information sharing in BIM | [50],[75],[1],[63],[61],[52],[72],[72],[14],[76] and [76] |
| 2 | Initial setup of BIM is difficult / high initial cost | [76],[77],[63],[18] and [18] |
| 3 | Lack of Proven benefit / intangible business benefits | [18],[62],[78],[10],[15] ,[63] ,[61],[79]and [72] |
| 4 | Fragmented nature of the construction industry | [80],[77],[33],[55],[81] and [81] |
| 5 | Difficulty in allocating and sharing BIM-related risks and costs | [75],[10],[10] and [81] |
| 6 | Lack of detailed processes or workflow to apply BIM technology | [10],[18], [81] and [76] |
| 7 | Lack of subcontractors who can use BIM technology | [77] and [64] |

**ii.)** Technology related barriers to BIM adoption

Technology is "the application of scientific knowledge for practical purposes" Oxford dictionary cited by, [23]

The barriers to BIM adoption organized under this category clusters barriers related to proficiencies of BIM functions and qualities of relevant software, hardware, and deliverables [12].Whereas [23] includes equipment and networking systems necessary to increase efficiency, productivity, and profitability of AEC sectors under the technology field.

On the other hand;[73] includes the selection of hardware, software, and infrastructure that are important for the technology aspect as to adopt new technology in an organization.

From the literature reviewed, some of the recurrently identified technology-related BIM barriers are presented in table 6 below.

TABLE 6: Technology Related barriers to BIM adoption

| Sn | Technology related to BIM barriers | Source Publications |
|---|---|---|
| 1. | Insufficient ICT infrastructures | [80],[75],[63],[60],[79] and [82] |
| 2. | The software programs are complex and are not easy to use. | [75],[63],[79],[55],[69],[52] and [83] |
| 3. | Incompatibility and interoperability problems | [54],[10],[77],[15],[63],[60],[16] and [16] |
| 4. | High-cost of BIM software and technology / high cost of investment | [84],[75],[10],[15],[63],[18],[79] and [14] |
| 5. | Recurring need for additional and associated resources and high economic expenses | [62],[10] and [16] |
| 6. | The need to manage sophisticated data with the level of evolution of the model | [15] and [85] |
| 7. | Longer time required to adapt to new technologies (BIM) | [10],[63] and [43] |

**iii.)** Organization related barriers to BIM adoption

Organizational motivations are the fundamental factor that affects BIM adoption in the AEC industry [86]. Organization factor involves features such as enterprise-scale, IT ability, top management support, and organizational motivation

Organization related barriers are those which focuses on organizational BIM planning including objectives strategies and leadership supports [12]

According to [73] organization culture, awareness program, training and education strategies, government support are under organization related barriers.

Table 7 below shows some of the most frequently identified BIM barriers related to the organization.

TABLE 7: Organization related Barriers to BIM adoption

| Sn | Organization related to BIM barriers | Source Publications |
|---|---|---|
| 1. | Lack of Funding | [80],[77],[63],[83],[85] and [45] |
| 2. | Lack of government support and lack of interest | [80],[84],[75],[15],[63],[60],[16] |
| 3. | Lack of Senior Management Support and attention | [84],[54],[10],[79] and [71] |
| 4. | BIM requires radical changes in current workflow, practices, procedures and culture change | [77],[18],[79],[55],[71],[72] [73] |
| 5. | lack of BIM based work flow | [75],[62],[64],[76] and [66] |
| 6. | BIM requires new responsibilities among projects participants about the BIM model | [77],[55],[70],[72],[73] and [14] |

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 10, October-2020

**iv.)** Human/stakeholder related barriers

Human or stakeholders related barriers are those which are associated with the capabilities, mentalities, and training of BIM staff [12], whereas;[23] merged the human and stakeholder related activities with process-related barriers in his three interlocking BIM fields activity.

Human related BIM barriers are summarized in table 8 based on works of literature

TABLE 8: Human related barriers to BIM Adoption

| Sn | Human related BIM barriers | Source Publications |
|---|---|---|
| 1. | Lack of client awareness and Knowledge About BIM | [80],[84],[75],[54],[62],[78],[10],[77],[15] &[63] |
| 2. | Lack of Skilled personnel | [80],[84],[75],[54],[62],[78],[77],[15] [63], [16] |
| 3. | Resistance to change attitude | [80],[84],[54],[10],[77],[15] ,[63], [16],[18] |
| 4. | Higher cost of staff training | [84],[75], ,[10],[77],[79],[71],[52] [14] |
| 5. | Reluctant to introduce new technology | [80],[84],[75],[62],[52],[43],[45], [65] |
| 6. | Weak education and training in universities and government centers | [54],[78],[15],[63],[18],[79],[83],[43],[67] |
| 7 | Lack of Client demand | [75],[54],[62],[78], [77],[15],[63] [18] |

**v.)** Standards, policy, and guidelines related barriers

Standards are official rules used when producing something. The standard category measures the implementations of standards, guidelines, specifications, and contracts [12].

Policies are written principles or rules to guide decision-making [23] which are preparing Practitioners, delivering research, distributing benefits, allocating risks, and minimizing conflicts within the AEC industry.

TABLE 9: Standards, policy and guidelines related barriers to BIM adoption

| Sn | Standard/guideline related BIM barriers | Source Publications |
|---|---|---|
| 1. | Lack of BIM National Standards and guidelines/lack of industry standard | [80],[75],[54],[78],[10],[77],[15],[16],[ 18] , [61] |
| 2. | Legal and Security Issues/ Security of confidential data in BIM model/Ownership, Insurance, Licensing ,and Cyber crime | [75], [62], [77], [15],[79],[69],[71],[52], [83] |
| 3. | Lack of legal framework for BIM application | [45],[10],[15],[63],[69],[72],[14],[85] |
| 4. | The need to formulate BIM related contracts, contractual relationships and BIM related disputes | [75],[10],[77],[15],[16],[79],[55] [69] |
| 5. | Lack of law enforcement by local authorities on BIM | [16] |
| 6. | Lack of BIM National Standards and guidelines/lack of industry standard | [80],[75],[54],[78],[10],[77],[15],[16],[ 18] ,[61] |

## 3 RESEARCH METHODOLOGY

### *3.1 Introduction*

This study adopted a literature review to identify the perceived benefits and barriers to BIM adoption from literature all over the world. A structured online questionnaire was distributed amongst practitioners to investigate the perception of concerning benefits and challenges of adopting BIM.

A quantitative approach was utilized as a primary methodology to achieve the defined objectives of the study. That was because the quantitative method enables researchers to collect data on perceptions and attitudes of a wide range of respondents, and thus the findings become applicable to a population. Survey instruments are also acceptable since it has been used in different similar studies [87].

### *3.2 Expert review on the benefits of BIM and barriers to its adoption in Ethiopia*

Initially; the perceived benefits and the challenges of adopting BIM were identified from the literature and sent to practitioners to review and categorize the already identified variables. Once the response from experts in the field was collected, further filtering of variables has been performed before the variables are sent to respondents to collect the intended primary data.

### *3.3 Research Instrument*

The questionnaire has been used as a research instrument to collect data to achieve the research objectives. The questionnaire encompassed demographic information of the respondents, the perceived benefits of BIM adoption identified from reviewed literature which have been categorized into (planning, design, construction and operation, and maintenance stage) benefits in one hand; the barriers to BIM adoption were organized in to process, Technology, Human, Organizational and standard related challenges based on published scientific works of literature.

A Likert scale consisting of five points, with 1 is being lowest and 5 is highest, is utilized to judge the respondent's perception of the questions. The principal consideration for using the Likert scale is to determine the extent to which respondents agree or disagree with a particular statement or view. The responses to each statement/question are then used to calculate RII ranging from 0 to 1.

### *3.4 Sampling Method*

The sample for this investigation is chosen from population practitioners within the AEC industry of Ethiopia. All the stakeholders of AEC including Architects, Consultants / Engineers, General Contractors, Project Management, and Academics / Research are made part of this survey. Out of 255 questionnaires sent out, 98 Responses were received after excluding some incomplete questionnaires before final analysis is carried out (38.4% response with a 95% confidence level).

### *3.5 Demographic profile of the respondents*

Respondents to this survey include 9 Ph.D. holders, 68 Master's degree holders, 20 Bachelors, and 1 unspecified professional level. Out of the 98 respondents; 13 architects, 38 Civil Engineers, 35 Construction Technology and Management professionals, 2 surveyors, 3 urban planners and the rest 7 were unspecified.

Respondents were also asked to specify the sectors where they have been worked or is working now. Accordingly; the following results have been obtained.

TABLE 10: Respondent's Category by Work sector

| Answer Choices | Responses |
|---|---|
| Building construction | 57.14% |
| Infrastructure | 13.27% |
| Water Works project | 4.08% |
| Both | 17.35% |
| Other (please specify) | 8.16% |

As shown in Table 10 above, most of the respondents (57%) were involved in the design and construction of building projects the rest were involved in infrastructure and waterworks projects or both which represents the construction industry in general.

The respondents' response by organizational category is shown in table 11 below.

TABLE 11: Respondent's category by Stakeholder

| Category | Responses |
|---|---|
| Employer/project manager | 15.31% |
| Consultant | 33.67% |
| Contractor | 23.47% |
| Researcher/academics | 44.90% |
| Other (please specify) | 4.08% |

From table 11 above, about 44.90% of the respondents represent researchers/academicians, and (33.67%) were from the consultant category which indicated that most of the respondents were represented by consultants and academicians.

### 3.6 *Method of Data analysis*

The data collected from respondents were analyzed using SPSS version 24 and Microsoft excel.

When processing the results of research conducted within the research, mostly descriptive and inductive statistics were used. When analyzing the results of the research areas, and the importance index was used based on which the ranking of the perceived benefits of BIM its challenge during implementation has been compiled.

The RII derived to summarize the importance of each indicator: perceived benefits of BIM and the challenges of its implementation in this case,

$$RII = \frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$$

Where, W = weighting as assigned on Likert's scale by each respondent in a range from 1 to 5, where 1 = strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = strongly Agree. N =Total number in the sample.

## 4 RESULT AND DISCUSSION

### 4.1 *INTRODUCTORY RESULTS*

This section discusses the analysis results of the instrument and its interpretation.

The researcher was intended to identify the type of BIM software which commonly used in the construction industry in Ethiopia. Accordingly; 88% of the respondents confirmed that they are familiar with Autodesk AutoCAD. Whereas 67 % of the respondents were familiar with MS Project and 37% use Primavera software.

The most commonly used 3D modeling BIM software for the architectural design was ArchiCAD (43%) followed by Revit Architecture (31%). This result indicated that the use of BIM software is limited only to 3D architectural modeling, construction scheduling, and structural analysis as a standalone application.

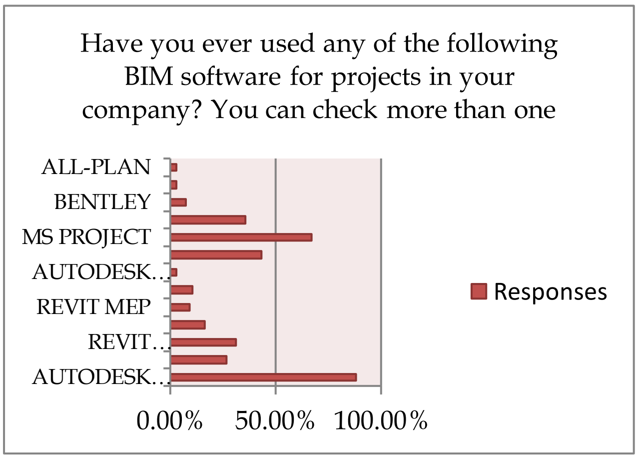


Figure 2: Usage of BIM software at a company level in Ethiopia

The degree of awareness about BIM from practitioners in the construction industry in Ethiopia was requested; accordingly 73.5% of the respondents were aware of BIM. Where 70% of the respondents got awareness through reading research and attending workshops which indicate that producing more researches would improve the degree of awareness about BIM in the Ethiopian construction industry shown in figure 3 below.

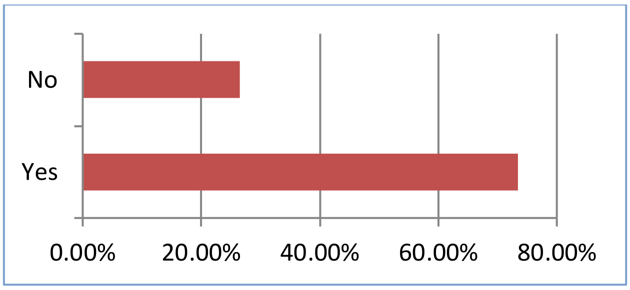


Figure 3: Awareness about BIM in Ethiopia

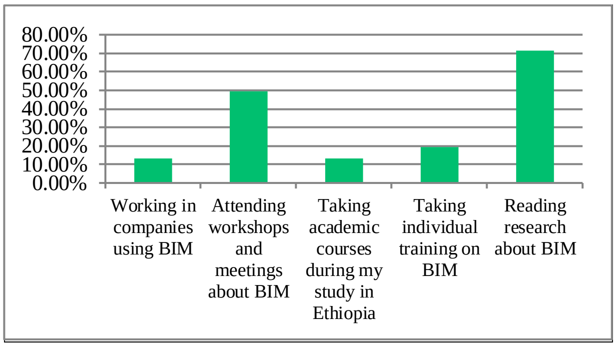


FIGURE 4: Modes of respondents' awareness about BIM by respondents in Ethiopia

Construction project document/data storing transfer practice in Ethiopia

One of the important features of BIM implementation lies in its capacity to produce all project information in one digital model. Respondents were enquired to indicate their level of agreement about the practice of data storing and transfer practice. Accordingly; the result in figure 5 below shows that construction project data strong and transfer has been made both in the form of hard copies/paper-based/ and Digital file/softcopies.

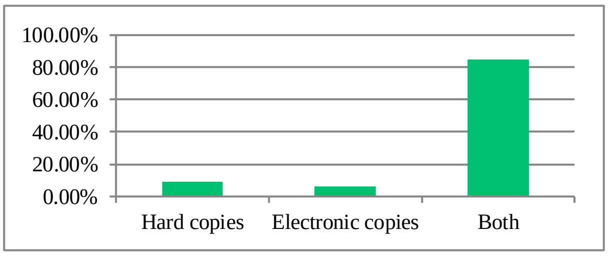


FIGURE 5: Construction Documents and Data storing and transfer modes in Ethiopia

However; the degree of BIM maturity level has been requested by providing a detailed explanation of each maturity stage to indicate the level of agreement about BIM maturity stages in Ethiopia. The result has shown that the BIM maturity level of the Ethiopian construction industry falls under BIM level 0 (51%) and BIM level 1 (43%) figure 6, where paper-based drawings and lines are practiced and 2D CAD drawings, object-based collaboration is expected to be practiced.

The author's argument here is since the BIM maturity stage of the Ethiopian construction industry level falls under BIM level 0 and BIM level 1, most of the data; files can only be stored and transferred in hard copies in the Ethiopian construction industry which contradicts the respondent's response.

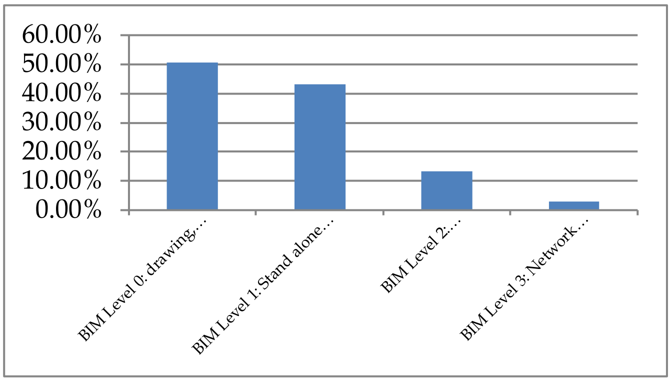


FIGURE 6: BIM Maturity Level/stage at Industry Level

Figure 6 above shows the maturity level of BIM implementation at the Industry level based on the response collected from participants involved in this survey. Hence Most of the respondents (51%) agree with BIM level 0 and (43%) agree with BIM level 1 respectively. 100 percent of the respondents agree that there is a requirement for a BIM implementation plan is require improving the maturity level of BIM in Ethiopia.

Accordingly, the BIM implementation plan made possible within 5 years (39%) and 5 to ten years (47%), as shown in figure 7. This indicated that concerned regulatory bodies and all stakeholders involved in the construction industry in Ethiopia to prepare a BIM plan which would help to achieve BIM stage 2 within five to ten years.

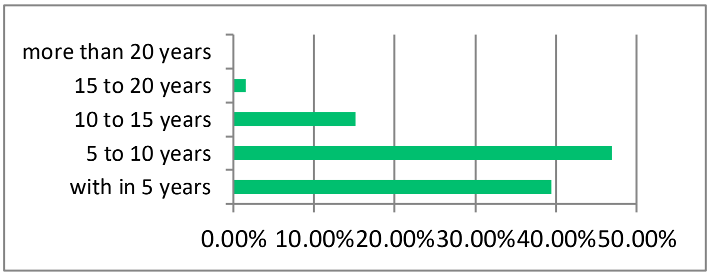


FIGURE 7: respondent's level of agreement about BIM time frame required to achieve BIM level 2 in Ethiopia

### 4.2 *Perceived Benefits of BIM in AEC in Ethiopia*

**i)** Benefits of BIM during the planning phase of the construction project

Respondents were asked to show their level of agreement about the benefit of BIM during the planning stage of construction project management. Accordingly; the top five perceived benefits of BIM during the planning phase is shown in table 12 below

TABLE 12: Respondent's View about BIM benefits for Construction project Planning stage

| BIM Benefits During planning phases | RII | Rank |
|---|---|---|
| Provides easy quantity and cost estimates | 4.53 | 1st |
| Provides easy and quick alternative analysis | 4.46 | 2nd |
| Improve project understanding and control | 4.46 | 3rd |
| Facilitates decision making | 4.46 | 4th |
| Helps in managing requirements | 4.41 | 5th |

**ii)** Benefits of BIM during Design phase of Construction project

Based on the list of BIM benefits during the design stage of the construction project identified from different kinds of literature, respondents were questioned to show their level of agreement. Accordingly; the most important benefits of BIM during the design stage were simultaneous and faster data access and its ability to improve integration and collaboration among the design team and the rest of the stakeholders involved in the design process.

TABLE 13: Respondent's view on Design phase benefits of BIM

| BIM Benefits During Design phases | RII | Rank |
|---|---|---|
| Allows Simultaneous and faster Access/Timely integration and data sharing | 4.58 | 1st |
| Improves integration, coordination, and collaborative working environment | 4.58 | 2nd |
| Building systems clash detection (identification of design error) | 4.56 | 3rd |
| Robust information and sharing | 4.51 | 4th |
| Ensures communication quality | 4.51 | 5th |

**iii)** Benefits of BIM during the construction phase of the Construction project

The top five benefits of BIM during the construction phase based on the respondent's view is shown in table 15 below.

TABLE 14: Respondents' view about the Construction stage benefits of BIM in Ethiopia

| BIM Benefits During Construction phases | RII | Rank |
|---|---|---|
| Enhance digital project documentation | 4.63 | 1st |
| convenient data exchange | 4.61 | 2nd |
| Allow auto quantification, better cost estimate, and control | 4.44 | 3rd |
| Reduce request for information (RFIs) | 4.32 | 4th |
| Reduce project delivery time / improve time management | 4.32 | 5th |

**iv)** Benefits of BIM during Facility operation and maintenance phase

In the operation and maintenance phase, Building Information Modelling creates available all-in-one information on the performance of the project during its development stage (planning, design, and Construction). The respondent's view about the benefits of BIM during the facility management phase of the construction project is shown in table 15 below

Table 15: Respondent's view on Facility management phase benefits of BIM

| BIM Benefits During Facility Operation and maintenance management phases | RII | Rank |
|---|---|---|
| Help in producing as-built documents | 4.46 | 1st |
| Promotes Digital Facilities management using digital life cycle data | 4.42 | 2nd |
| Improved Commissioning and Handover of Facility Information | 4.39 | 3rd |
| Integration with facility operation and management systems | 4.39 | 4th |
| Better management and operation of facilities | 4.37 | 5th |

### 4.3 *Barriers to BIM implementation in Ethiopia*

The barriers to BIM implementation in Ethiopia are categorized into five main classes. The respondents' view on the challenges of BIM implementation in the construction industry in Ethiopia is shown in the following charts and tables.

#### 4.1 Process related to BIM barriers

Modeling process and information flow of BIM and the coordination among different disciplines and documentation processes [12]. According to the respondent's view on the process related to BIM, implementation barriers are shown in table 17 below.

TABLE 16: Process related Barriers to BIM implementation

| Process Related Barriers to BIM Implementation in Ethiopia | RII | Rank |
|---|---|---|
| Lack of collaborative initiatives from the industry/lack of information sharing in BIM | 4.45 | 1st |
| Fragmented nature of the construction industry | 4.36 | 2nd |
| None widespread use of BIM | 4.25 | 3rd |
| Lack of subcontractors who can use BIM technology | 4.16 | 4th |
| Lack of detailed processes or workflow to apply BIM technology | 4.13 | 5th |

### 4.2 Technology related to BIM barriers

The BIM barriers organized under this category clusters barriers related to proficiencies of BIM functions and qualities of relevant software, hardware, and deliverables. Accordingly; technology-related Barriers to BIM implementation based on survey participants' response is shown in table 17 below.

Table 17: Respondents view on Technology related Barriers to BIM implementation

| Technology Related Barriers to BIM Implementation in Ethiopia | RII | Rank |
|---|---|---|
| Insufficient ICT infrastructures | 4.21 | 1st |
| High-cost of BIM software and technology | 3.91 | 2nd |
| Longer time required to adapt to new technologies (BIM) | 3.88 | 3rd |
| Recurring need for additional and associated resources and high economic expenses | 3.75 | 4th |
| The need to manage sophisticated data with the level of evolution of the mode | 3.75 | 5th |

### 4.3 Organization Related Barriers to BIM Implementation in Ethiopia

Organization-related barriers are those which focus on organizational BIM planning including objectives strategies and leadership supports [12]. The top ten organization related barriers to BIM implementation accepted by most of the respondents are shown below in table 18.

TABLE 18: Respondents view on Organization related Barriers to BIM implementation

| Organization related Barriers to BIM Implementation in Ethiopia | RII | Rank |
|---|---|---|
| lack of BIM-based workflow (BIM requires new practices, procedures, and culture change) | 4.3 | 1st |
| Lack of a comprehensive framework and implementation plan | 4.3 | 2nd |
| Lack of Senior Management Support and attention | 4.29 | 3rd |
| Lack of government support and lack of interest | 4.18 | 4th |
| BIM requires new responsibilities among projects participants about the BIM model | 4.18 | 5th |

### 4.4 Human/ Stakeholders Related Barriers to BIM Implementation in Ethiopia

These are barriers related to the capabilities, mentalities, and training of BIM staff [12], whereas;[23] merged the human and stakeholder related activities with the process in his three interlocking BIM fields activity.

Table 19: Respondents view on Human/Stakeholder's related Barriers to BIM implementation

| Human/Stakeholder's related Barriers to BIM Implementation | RII | Rank |
|---|---|---|
| Lack of adequately trained BIM professionals | 4.54 | 1st |
| Lack of client awareness and Knowledge About BIM | 4.52 | 2nd |
| Unfamiliarity with BIM use | 4.39 | 3rd |
| Weak education and training in universities and government centers | 4.25 | 4th |
| Resistance to change the attitude | 4.21 | 5th |

### 4.5 Standard and policy Related Barriers to BIM Implementation in Ethiopia

Standard/policy related category measures the implementations of standards, guidelines, specifications, and contracts. [12]

Policies are "written principles or rules to guide decision-making"[23] which are preparing Practitioners, delivering research, distributing benefits, allocating risks, and minimizing conflicts within the AEC industry. The respondent's view in this category is shown in table 20 below

TABLE 20: Respondent's view on Standard and policy Related Barriers to BIM Implementation in Ethiopia

| Standard and Policy related Barriers to BIM adoption in the AEC in Ethiopia | RII | Rank |
|---|---|---|
| Lack of BIM National Standards and guidelines | 4.43 | 1st |
| Lack of legal framework for BIM application | 4.32 | 2nd |
| Absence of standard BIM-based contract documents and contractual relationships | 4.29 | 3rd |
| Lack of Domestic oriented BIM tools (building codes) | 4.18 | 4th |
| Lack of law enforcement by local authorities on BIM | 4.16 | 5th |

## 5 CONCLUSION AND RECOMMENDATION

### 5.1. *CONCLUSION*

The objective of this study was to investigate the perceived benefits of BIM technology and barriers to its implementation in Ethiopia. Accordingly; the findings of the study revealed that the perception of BIM technology in the construction industry in Ethiopia is found to be good. However; the level of BIM implementation in the industry is at its infant stage. Hence; it needs a holistic intervention from all stakeholders including practitioners, designers, researchers, regulatory bodies, and policymakers to enhance the digitization of construction project management practice in Ethiopia.

The top-ranked perceived benefits of BIM in the Ethiopian construction industry were the easy quantity and cost estimates, Timely integration and data sharing, its ability to enhance digital project documentation and it helps in producing as-built documents during planning, design, construction, and operation, and maintenance stages respectively.

Nevertheless of the above-listed benefits of BIM, there are multifaceted challenges that are identified as barriers to BIM implementation in Ethiopia. The top three barriers to BIM implementation in the construction industry in Ethiopia under each category include;

Process related barriers to BIM

- Lack of collaborative initiatives from the industry /lack of information sharing in BIM
- Fragmented nature of the construction industry
- None widespread use of BIM

Technology related Barriers to BIM

- Insufficient ICT infrastructures
- High-cost of BIM software and technology / high cost of investment
- Longer time required to adapt to new technologies (BIM)

Organization related Barriers to BIM

- Lack of BIM-based workflow (BIM requires new practices, procedures, and culture change)
- Lack of a comprehensive framework and implementation plan
- Lack of Senior Management Support and attention

Human/Stakeholder's related barriers to BIM

- Lack of adequately trained BIM professionals
- Lack of client awareness and Knowledge about BIM
- Unfamiliarity with BIM use

Standard and policy-related Barriers to BIM

- Lack of BIM National Standards and guidelines
- Lack of legal framework for BIM application
- Absence of standard BIM-based contract documents and contractual relationships

### *5.2. RECOMMENDATIONS*

Based on the conclusion of this study the author would like to forward the following recommendation:

Future researchers

Further researches shall be conducted in similar areas taking case studies and other instruments which would enhance the existing knowledge in the area of BIM and information technology application in the construction industry in Ethiopia.

Regulatory bodies

Regulatory bodies are recommended to develop BIM-related implementation plans, standards, policy and guidelines to achieve a certain BIM maturity level within the coming five years which is believed to improve the overall performance of the construction industry in Ethiopia.

Academic institutions

The educational institute which is delivering bachelor, Masters, and Ph.D. level training in the area of Civil engineering, Architecture, construction technology and management, and urban planning shall support their courses and training with BIM and recent technologies of ICT.

Professional associations

One of the key responsibilities of professional associations in the area of infrastructure planning and development is to advise the local government about the recent developments in their areas. Hence professional associations should provide advice and organize seminars and workshops in the area to enhance the perception of BIM benefits to their members and the general industry.

## REFERENCES

[1] J. Woetzel *et al.*, "Reinventing construction: a route to higher productivity," *McKinsey Glob. Inst.*, no. February, 2017.
[2] A. Grilo and R. Jardim-goncalves, "Automation in Construction Value proposition on interoperability of BIM and collaborative working environments," *Autom. Constr.*, vol. 19, no. 5, pp. 522–530, 2010, doi: 10.1016/j.autcon.2009.11.003.
[3] F. K. T. Cheung, J. Rihan, J. Tah, D. Duce, and E. Kurul, "Automation in Construction Early stage multi-level cost estimation for schematic BIM models," *Autom. Constr.*, vol. 27, pp. 67–77, 2012, doi: 10.1016/j.autcon.2012.05.008.
[4] X. Li, P. Wu, X. Wang, and Y. Teng, "Mapping the knowledge domains of Building Information Modeling ( BIM ): A bibliometric approach Automation in Construction Mapping the knowledge domains of Building Information Modeling ( BIM ): A bibliometric approach," *Autom. Constr.*, vol. 84, no. November, pp. 195–206, 2017, doi: 10.1016/j.autcon.2017.09.011.
[5] B. Vogl and M. Abdel-Wahab, "Measuring the construction industry's productivity performance: Critique of international productivity comparisons at industry level," *J. Constr. Eng. Manag.*, vol. 141, no. 4, pp. 1–10, 2015, doi: 10.1061/(ASCE)CO.1943-7862.0000944.
[6] T. Ayalew, Z. Dakhli, and Z. Lafhaj, "Assessment on Performance and Challenges of Ethiopian Construction Industry," *J. Archit. Civ. Eng.*, vol. 2, no. 11, pp. 1–11, 2016.
[7] D. G. Mengistu and G. Mahesh, "Challenges in developing the Ethiopian construction industry," *African J. Sci. Technol. Innov. Dev.*, vol. 0, no. 0, pp. 1–12, 2019, doi: 10.1080/20421338.2019.1654252.
[8] Ofori, "Developing the construction indudtries in developing countries to in enhace performances:the Case of Ethiopia," Addis Ababa, seventh, 2018.
[9] B. Succar, W. Sher, and A. Williams, "Architectural Engineering and Design Measuring BIM performance : Five metrics Measuring BIM performance : Five metrics," *BIM-benefit*, vol. 8, no. 2, pp. 120–142, 2012, doi: 10.1080/17452007.2012.659506.
[10] L. Zhang, Z. Chu, Q. He, and P. Zhai, "Investigating the constraints to buidling information modeling (BIM) applications for sustainable building projects: A case of China," *Sustain.*, vol. 11, no. 7, 2019, doi: 10.3390/su11071896.
[11] T. G. Kekana, C. O. Aigbavboa, and W. D. Thwala, "Building Information Modelling ( BIM ): Barriers in Adoption and Implementation Strategies in the South Africa Construction Industry," *Int. Conf. Emerg. Trends Comput. Image Process.*, pp. 109–111, 2014.
[12] C. Wu *et al.*, "OVERVIEW OF BIM MATURITY MEASUREMENT TOOLS," vol. 22, no. January, pp. 34–62, 2017.
[13] D. Addissie Nuramo and T. C. Haupt, "BIM for Infrastructure Sustainability in Developing Countries: the case of Ethiopia," in *2016*, pp. 1–12.
[14] C. Moreno, S. Olbina, and R. R. Issa, "BIM Use by Architecture, Engineering, and Construction (AEC) Industry in Educational Facility Projects," *Adv. Civ. Eng.*, vol. 2019, 2019, doi: 10.1155/2019/1392684.
[15] W. A. Hatem, A. M. Abd, and N. N. Abbas, "Barriers of adoption building information modeling (BIM) in construction projects of Iraq," *Eng. J.*, vol. 22, no. 2, pp. 59–81, 2018, doi: 10.4186/ej.2018.22.2.59.
[16] K. A. Ahmad Jamal, M. F. Mohammad, N. Hashim, M. R. Mohamed, and M. A. Ramli, "Challenges of Building Information Modelling (BIM) from the Malaysian Architect's Perspective," *MATEC Web Conf.*, vol. 266, p. 05003, 2019, doi: 10.1051/matecconf/201926605003.
[17] S. Azhar, "Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry," *Leadersh. Manag. Eng.*, vol. 11, no. 3, pp. 241–252, 2011, doi: 10.1061/(ASCE)LM.1943-5630.0000127.
[18] R. Matarneh and S. Hamed, "Barriers to the Adoption of Building Information Modeling in the Jordanian Building Industry," *Open J. Civ. Eng.*, vol. 07, no. 03, pp. 325–335, 2017, doi: 10.4236/ojce.2017.73022.
[19] K. Barlish and K. Sullivan, "Automation in Construction How to measure the bene fi ts of BIM — A case study approach," vol. 24, pp. 149–159, 2012, doi: 10.1016/j.autcon.2012.02.008.
[20] C. Chen and L. Tang, "Development of BIM-Based Innovative Workflow for Architecture , Engineering and Construction Projects in China," vol. 11, no. 2, 2019, doi: 10.7763/IJET.2019.V11.1133.
[21] R. Kister *et al.*, "NIBS Guideline 3-2012 Building Enclosure Commissioning Process BECx," 2012.
[22] C. Eastman, P. Teicholz, R. Sacks, and K. Liston, *A guide to Building*

*infrormation modeling*, Second edi. New Jersey: John Wiley & sons, 2011.

[23] B. Succar, "Building information modelling framework: A research and delivery foundation for industry stakeholders," *Autom. Constr.*, vol. 18, no. 3, pp. 357–375, 2009, doi: 10.1016/j.autcon.2008.10.003.

[24] J. Beetz, *Building Informatgion Modeling*. Cham: Springer International Publishing, 2018.

[25] Y. Arayici, J. Counsell, L. Mahdjoubi, G. Nagy, S. Hawas, and K. Dewidar, *Heritage building information modelling*. 2017.

[26] I. B. Kjartansdóttir, S. Mordue, P. Nowak, D. Philp, and J. T. Snæbjörnsson, *Building Information This Book Is Element of: Modelling*. 2015.

[27] NIMBS Committe, "National Building Information Modeling Standard," *Nbim*, p. 180, 2007.

[28] P. Jackson, "Infrastructure Asset Managers BIM Requirements," *Bim-Fm*, p. 106, 2018.

[29] J. K. W. Wong, J. Ge, and S. X. He, "Digitisation in facilities management: A literature review and future research directions," *Autom. Constr.*, vol. 92, no. October 2017, pp. 312–326, 2018, doi: 10.1016/j.autcon.2018.04.006.

[30] R. Sacks, C. Eastman, G. Lee, and P. Teicholz, *BIM Handbook Rafael Sacks*, vol. 25, no. 2. 2018.

[31] R. McPartland, "What is BIM," 2017. [Online]. Available: https://www.thenbs.com/knowledge/bim-dimensions-3d-4d-5d-6d-bim-explained.

[32] C. Eastman, *A Guide to buildimng information Modeling for Owners, Managers, Designers,Engineersi and Contractors*, vol. 53, no. 9. Cambridge: Cambridge University Press, 2011.

[33] R. Masood, M. K. N. Kharal, and A. R. Nasir, "Is BIM adoption advantageous for construction industry of Pakistan?," *Procedia Eng.*, vol. 77, pp. 229–238, 2014, doi: 10.1016/j.proeng.2014.07.021.

[34] R. McPartland, "Building Information Modelling (BIM)." [Online]. Available: https://www.thenbs.com/knowledge/bim-dimensions-3d-4d-5d-6d-bim-explained.

[35] P. Smith, "BIM & the 5D Project Cost Manager," *Procedia - Soc. Behav. Sci.*, vol. 119, pp. 475–484, 2014, doi: 10.1016/j.sbspro.2014.03.053.

[36] J. Xu, "Research on Application of BIM 5D Technology in Central Grand Project," *Procedia Eng.*, vol. 174, pp. 600–610, 2017, doi: 10.1016/j.proeng.2017.01.194.

[37] R. R. Politi, E. Aktaş, and M. E. İlal, "Project Planning and Management Using Building Information Modeling Project Planning and Management Using Building Information Modeling ( BIM )," *13th Int. Congr. Adv. Civ. Eng. 12-14 Sept. 2018, Izmir/TURKEY*, no. September 2018, 2018.

[38] H. Gao, C. Koch, and Y. Wu, "Building information modelling based building energy modelling: A review," *Appl. Energy*, vol. 238, no. January, pp. 320–343, Mar. 2019, doi: 10.1016/j.apenergy.2019.01.032.

[39] I. Kamardeen, "8D BIM modelling tool for accident prevention through design," *Assoc. Res. Constr. Manag. ARCOM 2010 - Proc. 26th Annu. Conf.*, no. September, pp. 281–289, 2010.

[40] M. O. Fadeyi, "The role of building information modeling (BIM) in delivering the sustainable building value," *Int. J. Sustain. Built Environ.*, vol. 6, no. 2, pp. 711–722, 2017, doi: 10.1016/j.ijsbe.2017.08.003.

[41] P. Yung and X. Wang, "A 6D CAD Model for the Automatic Assessment of Building Sustainability," *Int. J. Adv. Robot. Syst.*, vol. 11, no. 8, p. 131, Aug. 2014, doi: 10.5772/58446.

[42] A. Mohanta and S. Das, "BIM as Facilities Management Tool: A brief review," *Proc. Sess. Sustain. Build. Infrastructures*, no. December, pp. 143–149, 2016.

[43] V. Kushwaha, "Contribution Of Building Information Modeling ( BIM ) To Solve Problems In Architecture , Engineering and Construction ( AEC ) Industry and Addressing Barriers to Implementation of BIM," *Int. Res. J. Eng. Technol.*, vol. 3, no. 1, pp. 100–105, 2016.

[44] C. Chen and L. Tang, "Development of BIM-Based Innovative Workflow for Architecture, Engineering and Construction Projects in China," *Int. J. Eng. Technol.*, vol. 11, no. 2, pp. 119–126, 2019, doi: 10.7763/ijet.2019.v11.1133.

[45] R. Eadie, M. Browne, H. Odeyinka, C. Mckeown, and S. Mcniff, "Automation in Construction BIM implementation throughout the UK construction project lifecycle : An analysis," *Autom. Constr.*, vol. 36, pp. 145–151, 2013, doi: 10.1016/j.autcon.2013.09.001.

[46] P. Meadati, J. Irizarry, and A. K. Akhnoukh, "BIM and RFID integration : A pilot study BIM and RFID Integration : A Pilot Study," no. May 2014, 2002.

[47] S. Azhar, W. A. Carlton, D. Olsen, and I. Ahmad, "Automation in Construction Building information modeling for sustainable design and LEED ® rating analysis," *Autom. Constr.*, vol. 20, no. 2, pp. 217–224, 2011, doi: 10.1016/j.autcon.2010.09.019.

[48] N. L. and T. Korman, "Implementation of Building Information Modeling (BIM) in Modular Construction: Benefits and Challenges," *Constr. Res. Congr. 2010*, pp. 1136–1145, 2010.

[49] N. Ham, K. Min, J. Kim, Y. Lee, and J. Kim, "A Study on Application of BIM ( Building Information Modeling ) to Pre-design in Construction Project," pp. 42–49, 2008, doi: 10.1109/ICCIT.2008.190.

[50] M. O. Fadeyi, "Gulf Organisation for Research and Development The role of building information modeling ( BIM ) in delivering the sustainable building value," *Int. J. Sustain. Built Environ.*, vol. 6, no. 2, pp. 711–722, 2017, doi: 10.1016/j.ijsbe.2017.08.003.

[51] A. S. Telaga, "Exploitation and Benefits of BIM in Construction Project Management Exploitation and Benefits of BIM in Construction Project Management," 2017, doi: 10.1088/1757-899X/245/6/062056.

[52] S. Azhar, M. Khalfan, and T. Maqsood, "Building information modeling (BIM): Now and beyond," *Australas. J. Constr. Econ. Build.*, vol. 12, no. 4, pp. 15–28, 2012, doi: 10.5130/ajceb.v12i4.3032.

[53] S. Azhar and A. Nadeem, "Building Information Modeling ( BIM ): A New Paradigm for Visual Interactive Modeling and Simulation for Construction Projects Building Information Modeling ( BIM ): A New Paradigm for Visual Interactive Modeling and Simulation for Construction Projects," no. August, 2008.

[54] M. R. Hosseini *et al.*, "BIM adoption within Australian small and medium-sized enterprises (SMEs): An innovation diffusion model," *Constr. Econ. Build.*, vol. 16, no. 3, pp. 71–86, 2016, doi: 10.5130/AJCEB.v16i3.5159.

[55] K. Barlish and K. Sullivan, "How to measure the benefits of BIM - A case study approach," *Autom. Constr.*, vol. 24, pp. 149–159, 2012, doi: 10.1016/j.autcon.2012.02.008.

[56] C. M. Herr and T. Fischer, "BIM adoption across the Chinese AEC industries: An extended BIM adoption model," *J. Comput. Des. Eng.*, vol. 6, no. 2, pp. 173–178, 2019, doi: 10.1016/j.jcde.2018.06.001.

[57] R. Liu, R. R. A. Issa, and S. Olbina, "Factors influencing the adoption of building information modeling in the AEC Industry," *EG-ICE 2010 - 17th Int. Work. Intell. Comput. Eng.*, no. January 2015, 2019.

[58] D. Bryde, M. Broquetas, and J. M. Volm, "The project benefits of building information modelling (BIM)," *Int. J. Proj. Manag.*, vol. 31, no. 7, pp. 971–980, 2013, doi: 10.1016/j.ijproman.2012.12.001.

[59] S. Rice and G. Student, "THE PERCEIVED VALUE OF BUILDING INFORMATION MODELING IN THE U . S . BUILDING INDUSTRY," vol. 15, no. February, pp. 185–201, 2010.

[60] S. Nur and A. Mohd, "( Bim ): Factors Contribution and Benefits," pp. 47–63, 2018.

[61] D. W. M. Chan, T. O. Olawumi, and A. M. L. Ho, "Perceived benefits of and barriers to Building Information Modelling (BIM) implementation in construction: The case of Hong Kong," *J. Build. Eng.*, vol. 25, no. April, 2019, doi: 10.1016/j.jobe.2019.100764.

[62] F. Khosrowshahi and Y. Arayici, "Roadmap for implementation of BIM in the UK construction industry," *Eng. Constr. Archit. Manag.*, vol. 19, no. 6, pp. 610–635, 2012, doi: 10.1108/09699981211277531.

[63] T. D. Oesterreich and F. Teuteberg, "Behind the scenes: Understanding the socio-technical barriers to BIM adoption through the theoretical lens of information systems research," *Technol. Forecast. Soc. Change*, vol. 146, no. October 2018, pp. 413–431, 2019, doi: 10.1016/j.techfore.2019.01.003.

[64] D. W. M. Chan, T. O. Olawumi, and A. M. L. Ho, "Perceived benefits of and barriers to Building Information Modelling (BIM) implementation in construction: The case of Hong Kong," *J. Build. Eng.*, vol. 25, no. February, 2019, doi: 10.1016/j.jobe.2019.100764.

[65] Y. Han and P. & Damian, "Benefits and Barriers of Building Information Modelling. United Kingdom," *Proc. 12th Int. Conf. Comput. Civ. Build. Eng. (ICCCBE XII) 2008 Int. Conf. Inf. Technol. Constr. (INCITE 2008)*, pp. 16–18, 2008.

[66] A. Gha *et al.*, "Building Information Modelling ( BIM ) uptake : Clear bene fi ts , understanding its implementation , risks and challenges," no. September, 2016, doi: 10.1016/j.rser.2016.11.083.

[67] M. Yaakob, J. James, M. Nasrun, M. Nawi, and K. Radzuan, "A Study on Benefits and Barriers of Implementing Building Information Modelling ( BIM ) in Malaysian Construction Industry," pp. 2842–2848, 2018.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 10, October-2020

[68] A. C. O. Miranda, "Potential use of BIM in the oversight of public works," no. August 2015, pp. 21–31, 2016.

[69] H. W. Ashcraft and H. W. Ashcraft, "BUILDING INFORMATION MODELING : A FRAMEWORK FOR COLLABORATION BUILDING INFORMATION MODELING :," no. October 2008, 2009.

[70] N. Gu and K. London, "Understanding and facilitating BIM adoption in the AEC industry," *Autom. Constr.*, vol. 19, no. 8, pp. 988–999, Dec. 2010, doi: 10.1016/j.autcon.2010.09.002.

[71] S. Liu, B. Xie, L. Tivendal, and C. Liu, "Critical Barriers to BIM Implementation in the AEC Industry," *Int. J. Mark. Stud.*, vol. 7, no. 6, p. 162, 2015, doi: 10.5539/ijms.v7n6p162.

[72] J. Majrouhi Sardroud, M. Mehdizadehtavasani, A. Khorramabadi, and A. Ranjbardar, "Barriers Analysis to Effective Implementation of BIM in the Construction Industry," in *ISARC 2018 - 35th International Symposium on Automation and Robotics in Construction and International AEC/FM Hackathon: The Future of Building Things*, 2018, no. July, doi: 10.22260/ISARC2018/0009.

[73] Z. Zahrizan, N. M. Ali, A. T. Haron, A. Marshall-ponting, and Z. Abd, "EXPLORING THE ADOPTION OF BUILDING INFORMATION MODELLING ( BIM ) IN THE MALAYSIAN CONSTRUCTION INDUSTRY : A QUALITATIVE APPROACH," pp. 384–395, 2013.

[74] A. Costin, A. Adibfar, H. Hu, and S. S. Chen, "Automation in Construction Building Information Modeling ( BIM ) for transportation infrastructure – Literature review , applications , challenges , and recommendations," *Autom. Constr.*, vol. 94, no. July, pp. 257–281, 2018, doi: 10.1016/j.autcon.2018.07.001.

[75] F. Siddiqui, "Barriers in Adoption of Building Information Modeling in Pakistan�s Construction Industry," *Indian J. Sci. Technol.*, vol. 12, no. 25, pp. 1–7, Jul. 2019, doi: 10.17485/ijst/2019/v12i25/142325.

[76] T. Tan, K. Chen, F. Xue, and W. Lu, "Barriers to Building Information Modeling ( BIM ) implementation in China ' s prefabricated construction : An interpretive structural modeling ( ISM ) approach," *J. Clean. Prod.*, vol. 219, pp. 949–959, 2019, doi: 10.1016/j.jclepro.2019.02.141.

[77] P. Li, S. Zheng, H. Si, and K. Xu, "Critical Challenges for BIM Adoption in Small and Medium-Sized Enterprises: Evidence from China," *Adv. Civ. Eng.*, vol. 2019, 2019, doi: 10.1155/2019/9482350.

[78] W. N. S. W. Mohammad, M. R. Abdullah, S. Ismail, and R. Takim, "Building information modeling (BIM) adoption challenges for contractor's organisations in Malaysia," *AIP Conf. Proc.*, vol. 2016, no. September, pp. 2–9, 2018, doi: 10.1063/1.5055550.

[79] R. Charef, S. Emmitt, H. Alaka, and F. Fouchal, "Building Information Modelling adoption in the European Union: An overview," *J. Build. Eng.*, vol. 25, no. February, 2019, doi: 10.1016/j.jobe.2019.100777.

[80] G. Amuda-Yusuf, R. T. Adebiyi, T. O. O. Olowa, and I. B. Oladapo, "Barriers to Building Information Modelling Adoption in Nigeria," *al Amuda-Yusuf USEP J. Res. Inf. Civ. Eng.*, vol. 14, no. 2, 2017.

[81] R. Miettinen and S. Paavola, "Automation in Construction Beyond the BIM utopia : Approaches to the development and implementation of building information modeling," vol. 43, pp. 84–91, 2014.

[82] E. A. Pärn, D. J. Edwards, and M. C. P. Sing, "The building information modelling trajectory in facilities management: A review," *Autom. Constr.*, vol. 75, pp. 45–55, 2017, doi: 10.1016/j.autcon.2016.12.003.

[83] S. Ahmed, "Barriers to Implementation of Building Information Modeling ( BIM ) to the Construction Industry : A Review Barriers to Implementation of Building Information Modeling ( BIM ) to the Construction Industry : A Review," no. May, 2018, doi: 10.32732/jcec.2018.7.2.107.

[84] Eadie et.al, "Building Information Modelling Adoption: An Analysis of the Barriers to Implementation," *Clim. Chang. 2013 - Phys. Sci. Basis*, vol. 53, no. 9, pp. 1–30, 2013, doi: 10.1017/CBO9781107415324.004.

[85] E. Alreshidi, "Factors for e ff ective BIM governance," vol. 10, no. March, pp. 89–101, 2017, doi: 10.1016/j.jobe.2017.02.006.

[86] G. Wang, Z. Liu, and H. Wang, "Key factors affecting BIM adoption is China based on TOEaRC," no. Icmmse, pp. 103–108, 2016, doi: 10.2991/icmmse-16.2016.40.

[87] J. W. Creswell, *Research Design: Quantitative, Qualitative and Mixed approach*, Fourth Edi. Nebraska Lincoln: Sage Publisher, 2014.