JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

ASSESSMENT ON ADOPTING BUILDING INFORMATION MODELING IN ETHIOPIA CONSTRUCTION PROJECTS CASE IN ADDIS ABABA CITY

A research Submitted To The School of Graduate Studies Jimma University Institute of Technology Faculty of Civil and Environmental Engineering In Partial Fulfillment of The Requirements For The Degree of Master of Science In Construction Engineering and Management

By:

Munir Mohammed Mussa

JANUARY 2020

JIMMA ETHIOPIA

JIMMA UNIVERSITY

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF GRADUATE STUDIES

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

ASSESSMENT ON ADOPTING BUILDING INFORMATION MODELING IN ETHIOPIA CONSTRUCTION PROJECTS IN ADDIS ABABA CITY

A research Submitted To The School of Graduate Studies Jimma University Institute of Technology Faculty of Civil and Environmental Engineering. In Partial Fulfillment of The Requirements For The Degree of Master of Science In Construction Engineering and Management.

Advisor: - Eng Alemu Mosisa (assistant professor)

Co- Advisor: Eng Mamaru.Desalgn (Msc)

JANUARY, 2020

JIMMA ETHIOPIA

JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

ASSESSMENT ON ADOPTING BUILDING INFORMATION MODELING IN ETHIOPIA CONSTRUCTION PROJECTS CASE IN ADDIS ABABA CITY

MUNIR MOHAMMED MUSSA

APPROVED BY BOARD OF EXAMINERS

1. Engr. Alemu Mosisa ________ 10/02/20
   Main advisor — Signature — Date
2. Engr. Mamaru Dessalegn ________ 10/02/20
   Co - advisor — Signature — Date
3. Dr. Bayou Chane Tegegne ________ 07/02/20
   External Examiner — Signature — Date
4. Engr. Abebe Eshetu ________ 10/02/20
   Internal Examiner — Signature — Date
5. Engr. Kemal Ture ________ 13/02/20
   Chairperson — Signature — Date

DECLARATION

I Declare That This Research Entitled "Assessment On Adopting Building Information Modeling In Ethiopia Construction Projects Case In Addis Ababa City" Is My Own Original Work, And Has Not Been Submitted As A Requirement For The Award of Any Degree In Jimma University or Elsewhere.

Munir Mohammed Mussa	_____________	10/02/20
Name	Signature	Date

As research Adviser, I hereby certify that I have read and evaluated this proposal paper prepared under my guidance, by Munir Mohammed Mussa entitled "ASSESSMENT ON ADOPTING BUILDING INFORMATION MODELING IN ETHIOPIA CONSTRUCTION PROJECTS CASE IN ADDIS ABABA CITY" and recommend and would be accepted as a fulfilling requirement for the Degree of Master Science in Construction Engineering and Management.

Advisor: Engr. Almu Mosisa (Assistant professor)	_____________	10/02/20
Name	Signature	Date
Co - Advisor: Engr. Mamaru Desalgn (MSc)	_____________	10/02/20
Name	Signature	Date

ABSTRACTS

Building Information Modeling (BIM) is an expanding collection of concepts and tools which have been attributed with transformative capabilities in the (AEC) industry.

Building Information Modeling (BIM) has recently attracted extensive attention in the Architectural, Engineering and Construction (AEC) industry with an increase in the use of information technology, all the while increasing productivity, efficiency, infrastructure value, quality, and sustainability, rendering a purer image of constructability issues that are dealt with at the beginning of the construction process. Here in our country we are constantly facing low productivity in the field of construction industry because of project time and cost overrun and inability to accept best practice.in order to change our construction industry our industry must apply ICT applications. BIM is one of ICT applications used in AEC industry. The purpose of this paper was to assess adopting of BIM and to analyze benefit of BIM, key drivers and barriers of BIM adoption, thus providing better understanding of BIM and its usefulness in various stages of the construction projects.

A qualitative and quantitative survey design was used in this research to hit expected outcome. Various related literature was reviewed and several web sites were searched. Purposive sampling method was applied for the selection of Construction Company. And the collected data was analyzed by calculating frequency, relative importance index (RII) and by using SPSS software. The findings are analyzed and presented by chart and table.

From findings identified the key drivers of BIM are government pressure (RII of 0.94), accurate construction sequencing (RII of 0.93) and clash detection and automation of schedule/register generation (RII of 0.93). Makes project communication easier (RII of 0.96) and shorten project duration (RII of 0.9) are the main benefits of BIM .The last finding that the researcher identified was related with barriers to adopt BIM, lack of expertize (RII of 0.88) and lack of training (RII of 0.87) are the main barriers to adopt BIM.

Currently the AEC industry throughout the world is attempting to adopt BIM as the future standard for building design, construction, and operation. Like other country Ethiopian construction project management institute (ECPMI) drafted road map to adopt BIM in all middle level public projects @ 2024. However the adoption rates of this technology have been lower than expected due to lack of expertize, lack of training impeding implementation. Therefore all stakeholder of construction industry are to take responsibility of adopting new innovation come to the industry to remain competitive both internationally and nationally.

Key words: Building Information Modeling, key driver of BIM, Benefit of BIM, barriers of BIM

ACKNOWLEDGMENT

Above all, I thank the Almighty God for giving me patience and courage to do this research paper.

I would like to express deepest gratitude to my Advisor Engr. Alemu mosisa (Assistant professor) and my co-advisor Engr. Mamaru desalgn (Msc) for all their limitless efforts in guiding me through my work.

I would like to express my appreciation to all organizations and individuals who contributed directly or indirectly to this research paper and provided the necessary materials and support for realization of this paper. Especial thanks are forwarded to contractors and consultants who sacrificed their time in filling the questionnaires and for those who give me their willingness for the interview questions.

I would like to thank all my friends those who help me to accomplish this research paper.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

AEC	Architecture, Engineering and Construction
BIM	Building Information Modeling
CIFE	Center for Integrated Facilities Engineering
CAD	Computer Aided Design
CPM	Critical Path Method
ECPMI	Ethiopian construction project management institute
ICT	Information and Communication Technology
MEP	Mechanical, Electrical and Plumbing
NBIMS	National Building Information Model Standard
PPP	public privet partnership
3D	Three dimensions: x, y, z
2D	Two dimensions: x, y
RFI	Request for information
RII	Relative importance index
SPSS	Statistical package for social science
WLV	Whole Life Value

CHAPTER ONE

INTRODUCTION

1.1. Background

The nature of construction industry involves many stakeholders but if the relation among the stakeholders not properly managed and handled the industry become more complex and difficult to achieve expected goal, the other complexity related with project management. Project Management is a specialized management technique necessary for the planning, organization and control of projects under one strong point of responsibility (Gwaya A. O, et al., 2014). (King T. D, 2015) also described Project Management as the application of knowledge, skills, tools, and techniques to project activities in order to meet project requirements. As a response to the increasing complexity of projects, information and communication technology [ICT] has been developing at a very fast pace (Taxén L & Lillieskӧld J, 2008). There is an increasing use of information technology in construction project management. Computer-aided designs (CAD) are widely used in the process of creation, modification, analysis, and optimization of construction designs (Saracar M, et al., 2008) like other industries, the construction companies' benefit from a range of information and communication technology (ICT) solutions when delivering their projects. It has been suggested that construction projects will be more effective and productive with ICT applications (Latifi A.A, et al., 2013). One of these ICT applications is Building Information Modeling (BIM), which could have many benefits in supporting construction. In terms of more effectiveness and productivity, BIM yields advantages for scheduling, design, implementation, and facility management. From a stakeholder perspective, BIM helps owners, designers, contractors, and management teams to collaborate, visualize and manage construction work better (Azhar.S, et al., 2012). BIM is currently the most common denomination for a new way of approaching the design, construction and maintenance of buildings. It has been defined as "a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle" (Succar B, 2009).

BIM has a potential use at all stages of the project life-cycle: it can be used by the owner to understand project needs, by the design team to analyze, design and develop the project, by the contractor to manage the construction of the project and by the facility manager during operation and decommissioning phases (Grilo A & Jardim-Goncalves R, 2010).

BIM assists in attaining construction industry goals such as; Improving productivity and efficiency, increasing infrastructure value and quality. At the same time it reduces; lead times, lifecycle costs and duplications. Even though BIM has been in use for more than 20 years, only recently the awareness regarding BIM benefits, such as more efficient and effective building construction, design and operation has developed among project owners (Coates P, et al., 2010).

However there are certain drawbacks to BIM implementation, as the traditional style of "projecting" is still dominant especially in the developing countries and the transitions to new instruments is always difficult. Here in our country implementation of BIM is hindered in people, product and process related cases.

1.2. Statement of the Problem

According to the World Bank there exist 135 middle- and low-income economies referred to as developing countries. These countries face large knowledge gaps and can be characterized by limited and occasional technological innovation (World Bank, 2015). The majority of employees in the industry are unskilled in developing countries, construction is a labor-intensive industry besides, and construction is also considered as the most material intensive. The low efficiency of construction in developing countries implies a promising area for development because construction could assist a more effective employment of human and material resources, the industry is often considered as a driver for growth and achieving development goals (Adams R.H, 2004).

Ethiopia is one of the developing countries in the horn of Africa like in other developing countries, the construction industry in Ethiopia, faces many challenges in its practice. Some of these challenges are project cost overruns, time overrun, poor quality, a failure to cope with project requirements and the inability to adopt best practices (Aregaw Z. T & Zewdu G. T, 2015)

In order to change the construction industry effectiveness and efficiency, construction industry in Ethiopia must apply ICT applications in the construction industry. BIM is one of ICT application used in AEC industry.

The rapid adoption of BIM services and products is attributed to the benefits it offers to adopting companies. Some primary benefits, perceived by project stakeholders, include enhanced efficiency, opportunities to boost collaboration among project stakeholders, better visualization (capbell D.A, 2007).

The purpose of this study is to assess the potential of adopting building information modeling in Ethiopian construction in a case of Addis Ababa city in order to increase effectiveness and efficiency of the industry and to clarify ambiguities of stake holders about BIM.

1.3. Research Question

- What are the key drivers for BIM adoption on a construction industry?
- What are advantages of BIM adoption in the construction industry?
- What are barriers hindering the wide spread of adoption of BIM?
- Who should be responsible for the adoption of BIM?

1.4. Objective of the Study

1.4.1. General Objective

To assess the potential Adoption of Building Information Modeling for Ethiopian construction project.

1.4.2. Specific Objectives

- To identify the key drivers for BIM adoption on a construction project.
- To determine advantages of adopting BIM in construction project.
- To identify barriers hindering adoption of BIM.
- To verify the responsibility of stakeholder for the adoption of BIM.

1.5. Significance of the Study

- This study used to asses an alternative technique in design build and managing construction for stake holders. BIM will improve the quality and also improve construction industry by enhancing project management.
- The construction industry in Ethiopia faces many challenges some of the problems time and cost overrun. The study also tries to show how to minimize the common problems of our local contractor by assessing adoption of BIM.
- Academically this paper can be used as to professionals and other individuals whom in the future may establish too deeply conduct further researches related to the topic.

1.6. Scope of the Study

- The main scope of the study is to assess the potential of adoption of BIM in construction industry.
- This study is limited to Addis Ababa where contractor, consultants and smart government building are resided. It is also limited to contractor consultancy found in Addis Ababa with category I /One/; this is because of the financial capacity to implement BIM and their organizational structure is full of professional.

CHAPTER TWO

LITERATURE REVIEW

2.1. What Is Building Information Modeling?

The National Building Information Modeling Standards: defines BIM as a digital representation of the physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life -cycle; defined as exiting from earliest conception to demolition. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholders (NBIS, 2007).

Building information modeling (BIM) is one of ICT application in the AEC industry used as a vehicle to enhance communication among all the project stakeholders. This tool has already begun changing how designers work with their consultants and with builders, but it also has the ability to help guide the industry in a more sustainable direction by allowing easier access to the tools necessary to quantify a design approach (Tatjana D, et al., 2010).

Building information modeling (BIM) is an emerging approach to the design, analysis, and documentation of buildings. At its core, BIM is about the management of information throughout the entire life cycle of a design process, from early conceptual design through construction administration, and even into facilities management. By information we mean all the inputs that go into a building design: the number of windows, the cost of materials, the size of heating and cooling equipment, the total energy footprint of the building, and so on. This information is captured in a digital model that can then be presented as coordinated documents, be shared across disciplines, and serve as a centralized design management tool. With a tool like Revit, you will reap the benefits of fully coordinated documents, but this represents just the tip of the BIM iceberg (Tatjana D, et al., 2010).

Building information modeling (BIM) is a kind of CAD system, based on parametric technology that stores the information on the building and designs in an integrated database and enables more effective conceptualization and construction of infrastructure by using 3D design information representation (Weygant R. S, et al., 2011).

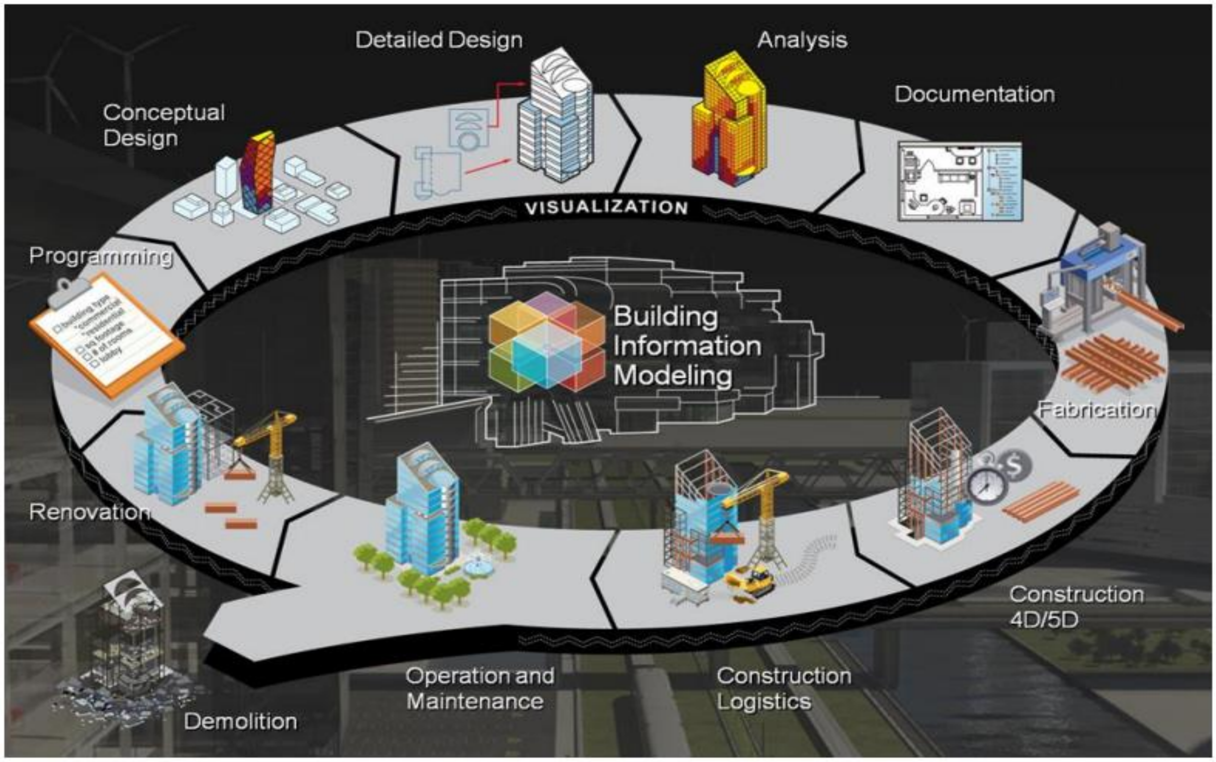

Figure 2. 1: Life Cycle of BIM (source BIM strategy 2011)

As the BIM concept spreads, a great number of tools are developed to achieve its perspectives. These tools vary depending on the end user, the use purpose, and the construction stage at which they are used. There are a number of BIM software applications available in the market. According to (Azhar S, et al., 2008) the top three software's are as follows:

- Autodesk® Revit™
- Graphisoft® Constructor™
- Bentley® Architecture™

After discussion with different AEC companies, the authors picked Autodesk® Revit™ as their first choice. The Revit™ software package includes three software applications: Revit™ Architecture, Revit™ MEP, and Revit™ Structure. Revit™ Architecture has the 2-D capabilities of AutoCAD, as well as the 3-D modeling design functions. AutoCAD files can be imported to produce models. For estimating functions, information can be exported to other estimating programs which have been designed to work with Revit™

Architecture. Revit™ MEP is used for the design and modeling of mechanical/electrical/plumbing systems. Revit™ Structure is a modeling and drafting program that can model all types of materials and structural systems. All of the Revit™ programs use a centralized database so all changes are updated universally.

2.2. Building Information Modeling Global Adoption.

Building Information Modeling (BIM) is not a new concept; early researches were conducted on BIM since 1970s.Chuk Eastman wrote on "The use of computers instead of drawings in building design" in 1970. He considered drawings as: "the principal medium for design problem-solving, coordination and for communication" (Eastman C.M, 1975) Since then, series of researches were conducted on the use of ICTs in design and construction management. BIM is one of ICT application in the AEC industry.

Although BIM is rapidly expanding around the globe, there is significant difference between construction companies' experience with the business benefits from BIM in various regions. Further researches in many developed countries such as Germany, France, Brazil, Austria, Finland, Denmark, Norway and Sweden revealed that BIM is gaining wide industry awareness and adoption. A little over one third of the industry in Western Europe (36%) has adopted BIM. BIM is becoming established with contractors in other regions such as Japan, South Korea and Austria/New Zealand represent the next tier of maturity, with a three to five experience tier. This shows how rapidly BIM is advancing. In East Asia, for example South Korea, contractors show a 65% BIM adoption rate in 2012. In south Asia, Singapore has been promoting BIM since 1997; and in 2011 the country issued its nationwide BIM implementation roadmap so that BIM started to be used for various aspects in construction such as building plan approvals and fire safety certifications. From 2015 onwards, the government mandated the use of BIM in public sector projects for new building projects over 5000 m2 In China; the government sat a five year plan (2011-2015) to formulate a BIM framework. In Hong Kong, BIM implementation is moving rapidly (Chan C, 2014).

BIM usage is accelerating powerfully, for instance, in USA looking at the statistics from (2007 to 2015), it can be seen that major private and government owners were driven to institutionalize its benefit faster, more certain delivery, and more reliable quality and cost. It can be seen that many countries have realized the potentials of such technological and procedural evolution within the construction industry (McGraw-Hill, 2014). According to (Lee S, et al., 2014). BIM technologies were mandated by US, UK government entities to empower design and construction and to meet and exceed enlightened owners targets. In US, since 2006, the general services administration (GSA) has included spatial program BIMs as part of the minimum requirements for submissions to the Office of Chief Architect for final concept approvals. Thus, the country has become a mature BIM market and led BIM best practice. Resulting BIM adoption in North America rise steeply from 28% to 71% between 2007 and 2012, and the UK and other regions are poised for similar dramatic expansions. Adoption by contractors (74%) recently exceeded architects (70%) in North America. UK aims to become the BIM leader in Europe (McGraw-Hill, 2014). From 2016 onwards, the government of UK mandated the use of BIM in public sector projects; as the country aims to become the BIM leader in Europe. Although BIM is rapidly expanding around the globe, there is significant difference between construction companies' experience with the business benefits from BIM in various regions (Matarneh & Hamad.J, 2017).

2.3. Adoption of Building Information Modeling in Africa

South Africa first embraced the BIM technology in the AEC sector during construction activities for FIFA 2010 World Cup and since then it has received its fame in the industry (Ede A.N, 2014).

BIM usage has received a great welcome and excitement among the structural and civil engineering sector. BIM implementation is limited to 3D modeling and interface management, the spectrum of BIM has yet to be fully utilized in the industry.

In South Africa, the architects use BIM for certain benefits it offers which include 3D images, documentation and visualization while other project members' work independently. To effectively utilize the BIM potentials, this requires the collaboration of project stakeholders through construction partnership (Amaka C.O & Dubem I.I, 2017).

The recent case study reported by (Kiprotich C.J, 2014) on BIM usage in Nigeria, highlighted two major benefits which are proper clash management and effective communication. The study demonstrated that BIM is still in its infancy within the industry and the spectrum of BIM usage has not fully utilized. According to (Opoko A. P, et al., 2019) the result of study shows that AEC professionals in Lagos mostly don't use BIM as a planning tool. They limit it to just the design stage of the project.

The study by (Mutonyi N & Chris C, 2018) established that the current status of BIM application among professionals in the Kenyan construction industry is still lagging. Based on the results obtained, the vast majority (90.5%) of the respondents agree that construction industry stakeholders are not yet clear about

The construction industry in Egypt is not clear enough on application of BIM, which urge the need to provide more knowledge and information to the construction contractor, trade contractors, suppliers and owners regarding the benefits of BIM technology. The research concluded that the government doesn't promote the utilization of BIM in public work. Adopting BIM in government projects will push the contractors and suppliers forward to use BIM. But stakeholders believe BIM is expanding in the Egyptian construction industry and practitioners think it is the future of construction industry while moving to sustainable buildings (Ahmed H. Elyamany, 2016).

According to (Michael G, et al., 2017) identified countries such as Algeria, Libya, Sudan, and Tunisia where the adoption of BIM could not be fully accounted.

In order to make BIM adoption more effective the whole process should be divided into stages, (Kaner I, et al., 2008) with the targets of each stage depending on the project type (Gu N & London K, 2010). According to (Sacks R, et al., 2016), The four levels of BIM adoption are:

1. CAD: Basic CAD features using only drawings, lines, arcs and text. Unmanaged CAD probably 2D, with paper (or electronic paper) as the most likely data exchange mechanism;
2. Lonely BIM: Includes some basic 3D elements, beginning of BIM;
3. Collaborative BIM': Includes the required information, supply chain management, and requires teams to be working together with 3D BIM, however with no obligation for the 4D program, 5D cost and operation elements to be included within the model, and

4. Intelligent BIM': Full integration of the BIM model into the life cycle management of the project.

These high-level implementation areas are strategies and policies, methods and approaches for adopting BIM that correspond to the overall company objectives for competitive positioning, operational excellence, and efficient delivery. BIM processes and model management tools are combined with enterprise systems to produce information in a collaborative setting across the organization and project teams (Son H, et al., 2015).

2.4. Building Information Modeling in Ethiopia

BIM technology is in its very early stage in Ethiopia, According to (Denamo A.N, 2015) indicated that awareness and preparedness of AEC graduating students to use BIM in the Ethiopian AEC industry is very low. This is especially true with Civil Engineering graduating students who are responsible to design and manage construction of majority of infrastructure projects in the country.

There are some significant moves to bring the technology (SHIKUR.M, 2016). As of SHIKUR.M interview Implementation strategy for BIM technology in the AEC sector of Ethiopia is also included in Growth and Transformation Plan-II. There are also few private firms trying to utilize the technology in their respective expertise and also an international bid Document has been prepared by ECPMI for supply, installation and training of Building Information Modeling (BIM). The bid aimed at securing hardware, software and BIM experts to train professionals from the AEC industry in Ethiopia (ECPMI, 2015). ECPMI has also conducted its first BIM workshop in Addis Ababa in 2015. In its three days, the workshop focused on introducing BIM to the major players of AEC sector in the country. Private and public consulting firms, construction companies as well as government representatives attended the workshop.

Currently in 2019 ECMI prepare road map to adopt BIM in Ethiopian construction industry. As of technology transfer coordinator of ECMPI interview Vision one of the road map is to integrate BIM in middle scale projects (100milion-1 billion birr) until 2024.

The plan of ECPMI is to bring about BIM technology transfer via giving Training of Trainers for selected professionals from the local industry. The trained professionals then in turn train other professionals from the industry. The assumption is that the industry will accept the technology and would in turn have an impact in policy making.

2.5. Why Building Information Modeling?

Building Information Modeling (BIM) has been accepted as a new revolutionary theory and technology in the AEC (Architecture, Engineering and Construction) industry (Thomas M.F, 2010). It can be defined as a method to improve the project productivity and quality by generating and managing a digital model of a building through the lifecycle (Gao J & Fischer M, 2008). The successful use/adoption of BIM could be beneficial for all the project participants, the agreeable benefits of BIM could be summarized as reduced rework and shorten project duration (McGraw-Hill, 2012), cut down project cost (Sacks R, 2008).

The concept of BIM was incepted because of the recorded inefficiencies in the fragmented traditional system of designing, constructing and managing buildings.

The traditional CAD based 2D approach is known to cause unnecessary waste and errors in the design and construction of buildings. Poor field productivity, poor information flow, redundancy, imprecise quantity and cost estimation, inadequate interoperability are some of the problems associated with the traditional approach (Gao J & Fischer M, 2008).

But the BIM delivery approach gives a seamless exchange, integration & management of project information which in turn results in improvements in terms of program, productivity and quality. According to a study Stanford University Center for Integrated Facilities Engineering (CIFE) based on 32 major projects using BIM there was a 40% elimination of unbudgeted change; cost estimation accuracy within 3% at 80% reduction in time taken to generate it; savings of up to 10% of the contract value through clash detections and up to 7% reduction in project time were registered.

Through a wider and wider application of BIM, certain benefits have been found out and confirmed by researchers. The key benefit is its accurate geometrical representation of the parts of building in an integrated data environment allowing for a more coordinated production of documents in 2D and 3D, it provides a better visualization of the design which would help the owner to confirm if the final building would meet his/her expectations; meanwhile, BIM as an single integrated information resource, would make the communication and coordination among project participants much easier. Some other benefits of BIM are faster and more effective processes, better design, controlled whole life costs and environmental data, better production quality, automated assembly, better customer service and lifecycle data for facility management ((Azhar S, et al., 2011).

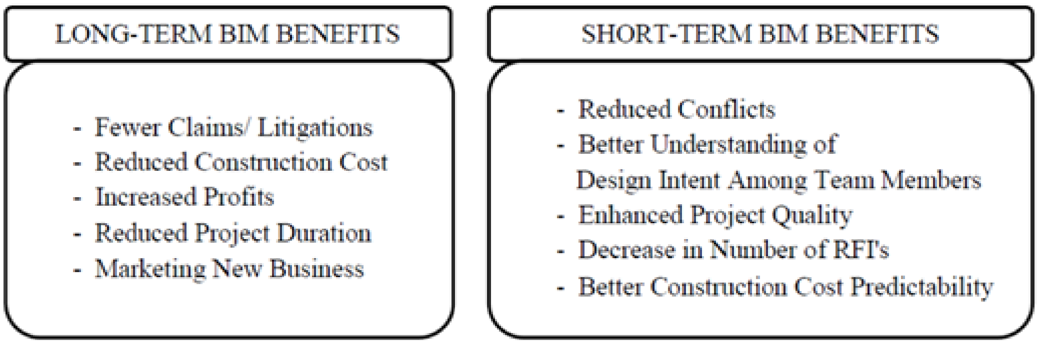

Figure 2. 2: Benefits of BIM. Sources: (Nanajikar, 2014)

2.5.1. BIM in Project Time Control

Time for the performance of a construction project is usually a particularly important consideration for the parties involved. However, it is very common that projects are rarely completed on time (Nassar K. M, et al., 2005).To minimize the disparity between the real practice and the original plan, a lot of researchers are dedicated to search for solutions. Currently, a number of tools regarding time control exist, some of which differ for their functions, and some of which are only designed for certain projects (Harmelink D & Yamin R, 2001). Researchers are still looking for a more integrated tool to unify the standards.

Critical path method (CPM) networks and bar charts are two basic approaches used to lay out the project schedules. The CPM schedule is mainly used from the beginning of the planning phase to the end of the project. It shows the logical relationships between project activities in the form of network diagrams, which can give the user a conceptual idea about how to carry out the project. However (Nassar K. M, et al., 2005) pointed out that the CPM scheduling is still lacking realistic expectation regarding actual performance. (Kim K & de la Garza J. M, 2003) stated the reason that CPM overlooks the limitation of resources in practice. I think information is the backbone to control time as many researchers describes communication barrier among stake holders are one cause of time delay to overcome these problem adopting BIM is incomparable with others.

2.5.2. BIM in Project Cost Control

Proper cost control is also a vital ingredient for a successful project. The first step of cost control is to identify the factors that affect project costs. The existing factors can be divided into two major categories: quantitative factors and qualitative factors. Currently, the AEC industry researchers have given many efforts to develop techniques that only consider quantitative factors and ignore qualitative factors such as "client priority on construction time, contractor's planning capability, procurement methods and market conditions including level of construction activity" (Elchaig T, et al., 2005; Zewdu Z.T & Aregaw G.T, 2015)

Due to a great number of factors that need to be considered, it is difficult to predict the exact cost to complete construction projects (Gould F. E, 2004). It is common to see that the final project cost is higher than the budgeted cost. It was reported that a cost overrun is one of the main problems in the AEC industry (Peeters W & Madauss B, 2008), (Reina P & Angelo, 2002), stated the biggest cause of cost overruns is inaccurate estimation at the beginning of a project.

An estimate is a general evaluation of the future project cost, and the budget represents the amount of money that the stakeholders would like to invest. The more accurate the estimate is, the closer the budget is to the actual cost, which means the profit is closer to what the project participant's expect.so as many researchers indicate BIM is functional from the very beginning stage to completion of the project (inception to commissioning).

2.6. Key drivers for adoption of building information modeling

According to (Robert, et al., 2013) drivers for BIM adoption grouped in to the following.

- Government pressure
- Client/competitive pressure
- Desire for innovation to remain competitive
- Improving the capacity to provide whole life value to client

- Streamlining Design Activities and Improving Design Quality
- Designing health and safety into the construction process
- Improving communication to operatives
- Cost savings and monitoring
- Time savings
- Accurate Construction Sequencing and Clash Detection
- Automation of schedule/register generation
- Facilitating increased pre-fabrication
- Facilitating facilities management activities
- Improving built output quality

2.6.1. Government pressure

When implementing electronic practices the public sector develops and publishes policy documentation to ensure good practice. In the case of BIM, the UK Government is making BIM mandatory on all publicly-funded projects starting from 2016 (Efficiency and Reform Group, 2011). In Australia government advisors have also adopted a similar approach by suggesting early 2016 as a start date for compulsory BIM use on public sector projects (buildingSMART Australasia, 2012). In most developed and developing countries adopting new technology pressured by the government this is an indication for our industry government stake holders.

2.6.2. Client/competitive pressure

The construction industry is highly competitive in this climate clients are asking contractors, not to demonstrate ability to offer BIM alone, but describe capacity through a track record of successfully managed BIM projects. (Lu and Li, 2011) suggest this can be achieved by indicating their position on the maturity triangle (People, Process and Technology). If clients require this deeper knowledge and application of BIM, strategic managers should be aiming to implement it before the stipulated Government deadline and to a higher level, in an effort to become “BIM experts” before the competition does. (Coates P, et al., 2010), cites this as one of the key reasons for BIM adoption in a case study of an architectural practice. (Liu R, et al., 2010) Further confirm that external forces from clients and competitors play a large role in BIM adoption. Here in our country Ethiopia government is the main client of so many huge projects with this reason our government stakeholders are double obligation by pushing BIM adoption ahead.

2.6.3. Desire for innovation to remain competitive

This type of driver used to be at the forefront of any competitors in the industry the overarching drivers for these firms were identified as being business goals and not technological goals. (TRADA, 2012) argue that current adopters of BIM are now in the latter stages of the 'early majority', heading towards the 'late majority'. (Ruikar K, et al., 2005) Further argue that the late majority are those firms who implement new technology only when they are required to, or to avoid being left behind**.**

2.6.4. Improving the capacity to provide whole life value to client

The most advanced BIM products currently available have the capability to deliver environmental, energy, cost, schedule and spatial analysis; and as such, can be used collaboratively by project stakeholders to deliver real whole life value (WLV) to clients (Azhar S, et al., 2011).

A paradigm shift from capital cost to whole life costing was proposed. The effect that building design can have on construction and business-operating cost is significant, with increases in operating productivity offering substantial savings for the client/end-user (Deutsch R, 2011).

The 4D scenario modeling can allow examination of facilities management, methods of demolition and decommissioning, or to innovative designs that lend themselves to versatile re-use. With an intelligent model employed by an experienced team which has the knowledge and competencies to fully exploit its capabilities; BIM can be instrumental in delivering WLV (Grilo A & Jardim-Goncalves R, 2010). Looking only on current capital cost not abettor way of managing building projects.

2.6.5. Cost savings and monitoring

One of the limitations of 2D drawings, even on CAD packages, is that it is only ever possible to present one view of the building at a time, (capbell D.A, 2007)Aside from the obvious issues regarding clarity of design information the traditional approach of presenting contractors with sections, elevations and details, referenced to overall plans, has proved to provide contractors with insufficient information, (BIMhub, 2012).Usually this leads to the submission of "Requests for Information" (RFIs) by the contractor. RFIs are often the cause of delays and occasionally require re-design, both of which are a cause of project cost overrun, (Dickinson J, 2010). A central BIM model with attached object information, if available for interrogation by all project actors, can reduce the number of RFIs drastically (Azhar et al, 2008; Deutsch, 2011). A report on the Morten son Group found that the use of BIM reduced RFIs by 32% (Applied Software, 2009). This leads to efficiency and cost savings through BIM .Projects by their nature are dynamic, and subject to change influenced by external and internal forces (Winch G, 2010)

2.6.6. Time savings

Time is a vitally important project parameter to the success of a construction project (Lock D, 2007)To save our project time we should manage our project together with our project stakeholders. The requirements to plan, re-plan, generate cost- and time-forecasts as a reaction to developments (or in fact crises) throughout the project, or in an effort to find savings, are ever-present in construction. Should a design change be required for any reason, the process involved would normally involve requesting a meeting with the design team, after which design alterations would be drawn up and issued to the contractors and Quantity Surveyors (QS) for costing; and then, perhaps, the repetition of the process until a satisfactory compromise between design and cost is achieved. With a 5-D BIM application, the client, PM, contractors and designers can even meet online to discuss design changes, and the cost can be altered immediately. A study by (Azhar S, et al., 2008) revealed that BIM can produce up to an 80% reduction in the time taken to generate a cost estimate.

It can be seen then, that the process of altering and agreeing the design change, cost estimation as a result of design changes, and production and updating of registers and schedules, could be reduced from days in duration to hours (BIMhub, 2012); (Eastman, 2011).

2.6.7. Accurate Construction Sequencing and Clash Detection

4-D BIM can be used to create detailed sequencing of construction works (BIMhub, 2012). BIM further proffers visualization of the interfaces between different elements of the built asset, referenced to time (BIMhub, 2012); (Eastman, 2011)However, BIM can produce visual representations and animated simulations of physical clashes between different elements of the building, and depending on model detail, between the building and temporary works (capbell D.A, 2007). Historically, clashes in structure, services and fabric were usually only noticed during the construction phase of the project resulting in redesign and rework, and often incurred non-recoupable costs (Azhar S, et al., 2008); (Azhar S, et al., 2011).Significant time and cost-savings can be achieved through effective and efficient production works scheduling (Azhar S, et al., 2011). When construction falls behind schedule on a particular building activity, it has effect on materials ordering, fabrication and delivery of follow-on building components.

The realistic sequencing and costing of construction works, saves significant time and money through reduced rework and delays to program. 4-D BIM offers detailed scheduling tools that can accurately predict the duration of each construction task, the upcoming tasks and the associated resource requirement; as well as allowing the programmer to factor in float for unforeseen events, delivery programs and severe weather (Azhar S, et al., 2011); Eastman et al, 2011); (Azhar S, et al., 2008)found that clash detection can offer savings of up to 10% of contract value and reduce project duration by up to 7%. These savings go some way towards the target of 15% project savings through BIM set by the UK Government (Efficiency and Reform Group, 2011) therefore those mentioned above factors are the common causes of disputes in the industry so by adopting BIM we can reduce dispute.

2.6.8. Automation of schedule/register generation

BIM allows programmers to generate new delivery schedules for each scenario enacted, creating efficiencies in document generation and distribution (Azhar S, et al., 2011)When things go wrong on a construction project, new schedules of works must be created, based on the predicted new duration of construction tasks. From these schedules, fabrication and delivery programs must be developed. This is a time-consuming activity and is prone to (Harris F & McCaffer R, 2006). The facility to quickly create new scenarios, and thus schedules, electronically, and then deliver them to project stakeholders, can significantly reduce the iterative tasks involved in managing change on construction projects.

2.6.9. Facilitating facilities management activities

Traditionally, the handover of a built facility from the contractor to the client involves the collation of ‘as -built’ drawings, operation and maintenance manuals, and warranties and guarantees (Crotty R, 2012).

Rather than replacing traditional Facilities Management systems, the BIM model can be linked to an existing FM system to provide an accurate and complementary “real-time” data set, that makes asset management faster and more accurate (Zhang X, et al., 2009). BIM can offer a data-rich, real-time platform from which to program and monitor preventative maintenance, and carry out space management activities. Real-time, preventive maintenance scheduling enables facility managers to proactively plan maintenance activities, appropriately allocate maintenance staff, and reduce corrective maintenance and emergency maintenance repairs. Provided that the information pertaining to building element maintenance is logged into the model correctly pre -handover, facilities managers can expect to save up to 70% on what would have otherwise been reactive maintenance (Lewis A, et al., 2010).

2.6.10. Improving built output quality

The benefits of improved design through BIM can lead to an improved build ability and end product, with the additional benefits of a reduction in complications during the construction phase (Bazjanac V, 2005) Given the prevalence of long-term PPP contracts, contractors can hope to avail of sustained savings throughout the duration of the contract, which can be used as a marketing tool when bidding for these types of contracts.

2.7. Barriers to BIM adoption

There are many problems affecting implementing BIM in the very fragmented AEC-industry and this is connected with many different barriers hindering effective adoption. According to (Gu N, et al., 2008) presents a way of categorizing relevant factors connected to the slow BIM adoption in the AEC-industry. These categories are; in terms of Product, Process and People. The reason for the slow BIM implementation is not simply one single issue, but rather the combination of several issues (Kiviniemi A, 2013). In order reduce severity of barriers for BIM adoption the AEC-industry must be considered and assessed all categories in well qualified manner.

2.7.1. Barriers linked to the BIM product

Many issues limiting the adoption of BIM in the AEC-industry is connected with the BIM tools and their development. These issues are mostly aspects of poor interoperability between different BIM programs and tools, but this is not the only areas of concern. Currently the user's demands on BIM are not always met by technical possibilities with BIM as it is currently supplied. (Gu N,et al.,2008).

- Interoperability.
- Different views on BIM.
- Poor match with the user's needs.

2.7.1.1. Interoperability

Information flow and exchange is crucial in construction projects. Traditionally it was done in the form of 2-D drawings and documentation. BIM is used not only as a design tool, but also as an interface for information exchange between different actors and phases of a project. The fragmented nature of the construction industry resulted in the need for varying design and construction management tools to be used by industry professionals. Each project Interoperability participant prefers tools which are specialized and tailored to their individual roles. The development of BIM tools for specific solutions and professions has resulted in a series of programs that do not interface well with each other. This led to the introduction of the Industry Foundation Classes (IFC), an open source international standard, developed by the "building SMART alliance". IFC is an attempt to achieve model-based interoperability through an accepted standard and covers a wide range of modeling information, not limited by the geometry of the objects, but also metadata related to other aspects of the building (J. Steel & R. Drogemuller, 2012)."Many software translators are not designed for multiple exchanges, and work only in one specified 'direction'. The software may convert the model well and export it, but then could return with corrupted files by merging the model back to its repository." (Golabchi A & Kamat V.R, 2013).The industry is still currently developing and optimizing interoperability standards. Building SMART is constantly improving interoperability standardization while software vendors try to catch up with these developments in order to become IFC-certified. A key to improving interoperability in the industry is for software vendors to actively participate in the further development of interoperability standards.

2.7.1.2. Different views on BIM

Research by (Gu N, et al., 2008) has concluded that the views on what BIM is depend a lot on the particular actor. Both the profession and size of the firm are factors of importance in regard to this difference of perception on what BIM is and how the actor wants to use it. Generally, large firms who will more likely be involved in large projects will prefer tools with greater flexibility in customizing project environments, smaller firms, on the other hand, are more likely to prefer more intuitive project environments. (Gu N & London K, 2010).

The professionals from the AEC-industry generally want BIM to incorporate all capabilities of CAD to be able to continue benefit from these which use they have maximized over the last decades. But there is also an interest in the new capabilities that BIM tools have the potential to provide. In other words they want BIM to contain new features while not removing old capabilities (Khemlani L, 2007).

Expectations on BIM also vary depending on the profession of the user. Design professionals view BIM as an extension on CAD, while project managers and contractors see BIM as a more intelligent document management system suitable for extracting and analyzing data directly from a CAD package. Even though BIM developers aim to integrate both of these aspects, the survey of (Gu N, et al., 2008)suggests that current BIM applications are not completely mature to satisfy either of the two. This result in a situation where the different actors have different expectations and demands on the new technology and no joint understanding of what BIM is (Gu N, et al., 2008).

2.7.1.3. Poor match with the user's needs

In a quantitative survey among architects by (Tse T. K, et al., 2005) it was revealed that a large part of the respondents did not find the tools in BIM to satisfy their needs, others simply stated that BIM is "not easy to use". The problems were largely connected with free form object that was hard or not possible to customize. With the current development of BIM, however, such object customizations are now possible but require training and an extended model construction time. This factor was believed by (Tse T. K, et al., 2005) to be a major barrier for BIM adoption, especially in more complex projects. Other connected results regarding BIM shortcomings included: "lack of customization", "not enough objects", and "speed of system is not fast enough" and "text and dimension compatibility with AutoCAD" (Tse T. K, et al., 2005).

2.7.2. Barriers linked to the BIM process

Adoption of BIM will require change of current work practice (Gu N & London K, 2010).New business processes have to be adopted and the roles of different actors will be affected. Legal issues with responsibility and ownership of the BIM model are also topics needing new processes to be effectively solved. These issues are categorized in this section.

- Changing work processes
- Risks and challenges with the use of a single model
- Legal issues
- Lack of demand and disinterest

2.7.2.1. Changing work processes

Building Information Modeling is a much more collaborative approach to design, procurement, construction, and facility management. This approach requires that project owners, contractors, end-users, and facility managers be incorporated into the design process in an active way. They need to be able to insert, extract, update, or modify information within the building model throughout the duration of the project. With so many actors simultaneously having direct access to the project design, there needs to be a method of effective management of their activity. To assist in this web based multi-discipline collaboration platforms are necessary. These products allow users to track changes and ensure that everyone is working on current and updated documents.

Additionally project participants can quickly and easily communicate with one another, eliminating the need for paper based RFI's. Most importantly the platform serves as a data repository where all project information can be stored securely (Dariusz Walasek and arkadiusz Barscz, 2016).

2.7.2.2. Risks and challenges with the use of a single model

Following the substantial change in work practice associated with BIM causes many risks. When all different stakeholders are inserting, extracting, updating or modifying the information in the BIM model there will be questions regarding who will be able to do and be responsible for the editing of data in the model. There is also a lack of developed standards for who will be responsible for inaccuracies in the model. Responsibility for updating the model and ensuring that it is accurate comes with a great deal of risk (Thompson D. B & Miner R. G, 2007).

Risks following use of the model for purposes not intended are also a problem. If for example information regarding the concrete base-structure is added and later used for procurement of a curtain wall, which it might not be suitable for, the results could be grave. To address this issue models are now often labeled with "for reference only" or another disclaimer of accuracy because designers are not willing to take on risks with warranting their use. The more disclaimers of this type, the less likely the other project participants are to use this new technology and designers will have more problems with receiving the additional compensation for the possible efficiency savings associated with BIM (Thompson D. B & Miner R. G, 2007).

2.7.2.3. Legal issue

To deal with the various legal challenges posed by the collaborative nature of BIM, it is necessary to adopt standardized contract documents which have been created with BIM in mind. The Consensus Docs Union is a group of more than 40 leading design and construction industry associations who jointly developed Consensus Docs. Consensus Docs publishes a comprehensive catalog of legal documents to aid in forming of a legal framework between all parties involved in a project. Consensus Docs 301 BIM Addendum was the first standard-form document ever to comprehensively address BIM. Legal documents drafted by Consensus Docs were achieved thanks to the input from various parties such as: designers, owners, suppliers, contractors, insurers, NBIMS, and construction lawyers. Standard legal documents have difficulty addressing intellectual property rights issues while maintaining collaboration amongst disciplines. “Under the framework set forth in the BIM Addendum, a license to reproduce, distribute, display or otherwise use a party’s model for the only purposes of the project is granted upstream and downstream to all parties working on the project. Also, the BIM Addendum is the first standard-form document to recognize that someone other than the design professional, such as the contractor or subcontractor, may have intellectual property rights in the project” (M.L. Bhatt, et al., 2013).Since BIM considerably changes the way in which project participants work, there is potential for legal issues to arise for this matter we should put the above mentioned legal standards.

2.7.2.4. Lack of demand and disinterest

It is suggested by (Tse T. K, et al., 2005) that one major reason for why architects are not changing towards BIM is the lack of demand from clients and other project team members. This connected with that a majority of architects agreed with the statement “existing entity-based CAD systems could fulfill their drafting and design needs” in their survey. Simultaneously, the same study indicated that architects would be more inclined to adopt BIM if they could see a large gain in productivity in contrast to conventional CAD systems as well as downstream applications of the building information (Tse T. K, et al., 2005).

The study by (Gu N, et al., 2008) showed that “The success of BIM adoption lies in the collective participation and collaboration from all the stakeholders in a building project”. Further their study have shown that lack of awareness, focus on BIM as an advancement to CAD and relative underdevelopment of BIM‟s document handling capabilities have inhibited the interest by non –design disciplines within the AEC-industry (Gu N & London K, 2010).

2.7.3. Barriers linked to the individuals using BIM

In order for BIM to be successful in its implementation all industry actors have to be informed about the potential benefits to their profession (Gu N, et al., 2008) Together with that, all people involved with BIM needs to be skilled in its use in order to utilize these benefit (Arayici y, et al., 2009). Therefore the third group of barriers limiting BIM adoption is connected with the individuals actually working with the new technology and their needs of new roles and training to support the change.

- The new role of BIM model manager.
- Training of individuals.

2.7.3.1. The new role of BIM model manager

Adoption of BIM will affect the roles and relationships of the participating actors as well as their work processes (Gu N & London K, 2010) One new role in construction project is presented by (Rizal S, 2011)in the form of a model manager. Connected to the change in technology there is a need for a coordinating role in the form of a BIM model manager (Gu N & London K, 2010).

The Role of model manager will deal with the system as well as the other project participants. Manager will provide and maintain technological solutions required for BIM functionalities, manage information flow and improve the ICT skills of the other stakeholders. This expert role will demand knowledge in both ICT and the construction process. This actor will not take part in the decision making regarding design or engineering solutions, or the organizational processes, but rather focus on the successful and collaborative use of BIM by all stakeholders (Rizal, 2011).

2.7.3.2. Training of individuals

When adopting BIM it is vital that the individuals are sufficiently trained in the use of the new technology in order for them to be able to contribute to the changing work environment (Gu N, et al., 2008) The importance of training was also one of the issues most often discussed in interviews for the implementation of BIM to be successful all affected members must be skilled in the use of BIM in regards to their specific field (Arayici y, et al., 2009).

Simultaneously a study by (Yan H & Damian P, 2008) revealed that most companies in their study who did not use BIM believed that the training would be too costly in regard to time and human resource. Further they argue that the issue of training is the largest barrier to BIM adoption because of the costs following the change. Decisions are mainly taken on the ground of business perspective, making a profit. Because of the insufficient number of case studies showing the potential financial benefit of BIM the AEC-industry is generally not very interested in investing. The stakeholder should think in developing their country beside the profit of the project.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Study Area

The study was conducted in Addis Ababa which is capital city of Ethiopia. The city is located at the geographical center of the country and it lies between $80^{0}55'$- $90^{0}05'$ north latitude and $38^{0}40'$-$38^{0}50'$ east longitude. Its average altitude is 2408 meters above the sea level.. The city is endowed with numerous streams that start from northwest and northeast running towards the south and draining to the Awash River. The city administration extends over 540 square kilometers with 10 sub-cities and 116 Woredas for administrative purpose. Based on the census data in 2007 the population of the city is 2.7 million and the total administrative area is considered to be urban.

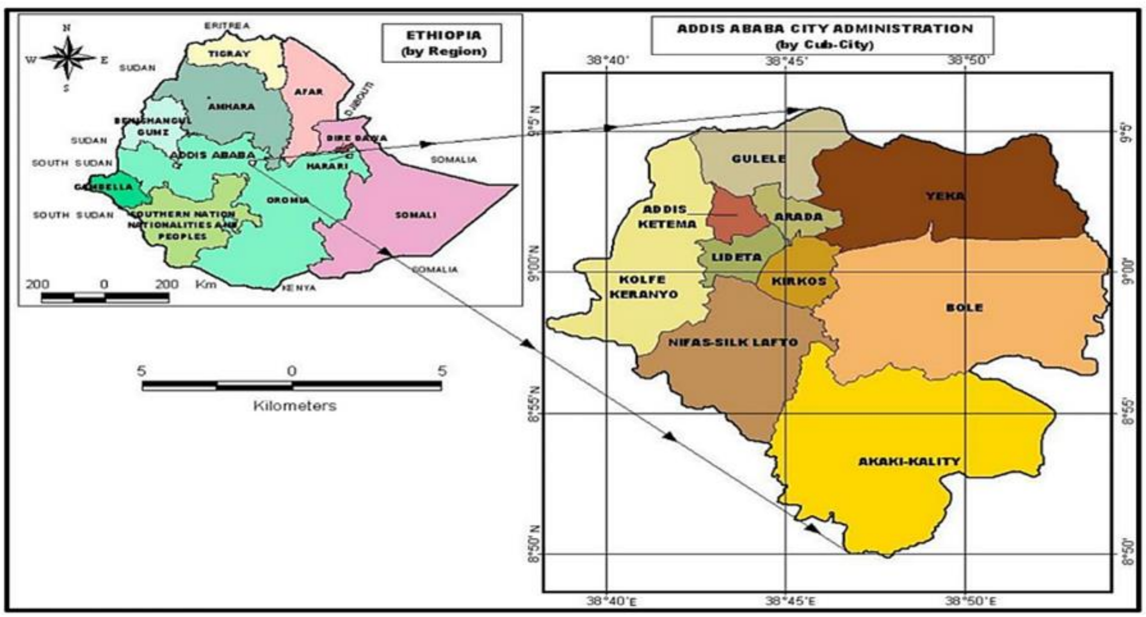

Figure 3. 1: Map of Addis Ababa city

3.2. Research Design

Research design is the arrangement considered for the collection and analysis of data to achieve the objectives of the research. A qualitative and quantitative survey design was used in this research. The research was qualitative type because it concerned on describe the gaining information about the building information modeling and it is a quantitative type because it tried to specify the results of deferent stakeholders point of view numerically.

3.3. Study Variable

Dependent Variable

Building Information Modeling

Independent Variables

- Driver of BIM
- Benefit of BIM
- Barriers of BIM

3.4. Population and Sampling Method

3.4.1. Study Population

The population of the study was building construction projects in of Addis Ababa the capital city of Ethiopia, there are questions which are answered by the respondents, and the respondents in the research shall be consultants, contractors, regulatory bodies and clients, with knowledge of construction according to their importance for successful accomplishments of the research study.

3.4.2. Sample Size and Sampling Procedure

Sampling is very important thing in a research because the research work cannot be undertaken without sampling the study of total population. Determining the proper sample size for this research was done through looking companies profile either adopt BIM or not, a network of individuals known in the industry and by asking information from Ethiopian construction project management institute ECPMI.

3.4.2.1. Sampling Procedure

The selection of the samples is based on non- probabilistic sampling method which is purposive sampling method was applied in this research paper. The selection of the participants is one of the initial steps taken towards data gathering and sampling.

3.5. Source of Data

Both primary and secondary data was collected, primary data were collected from questioner, interview, and secondary data were collected from literature review and other supportive documents.

3.6. Data Collection Procedure

First the researcher collects some important and related literatures from journals, books and various documents which are helpful for the study. After collecting those data the researcher was prepare some questions in the form of questioner and distribute for the parties in the construction industries such as client, consultant and contractor and makes some interview with the construction parties for more clarification. There are two basic types of survey questions from which to choose: open-ended and closed ended. This questionnaire survey has both open-ended and closed-ended questionnaires. Data collection part of the research is the most tiresome part; the most difficult one is the respondents' reluctance to react as per their promised schedule. The time schedule that was allocated to the research and respondents reluctance not to respond quickly made the research stressful in the period of data collection. The questionnaire was carefully designed in light of getting high response rate from respondents. The answers for the structured part of the questionnaire are based on Likert's-scale of five ordinal measures of degree towards each statement (from 1 to 5) as shown in the following sections. The reasons for adopting this simple scale are:

- To provide simplicity for the respondent to answer, and
- To make evaluation of collected data easier

Likert's-scale is important to know respondents' feelings or attitudes about something. The respondents must indicate how closely their feelings match with the question or statement on a rating scale.

Table 3. 1: Values assigned for the Likert scale in the questionnaire

Item	Very low	Low	Medium	High	Very high
scale	1	2	3	4	5

3.7. Data Presentation and Analysis

The collected data from respondents was categorized at the time of data entry. As a result, the analysis had combined all groups of respondents (clients, consultants, contractors and regulatory boards) in order to obtain significant results. Data was analyzes by calculating frequencies and Relative Importance Index (RII). The Relative Importance Index (RII) was calculated as follows:

$$RII = \frac{\Sigma W}{AxN} = \frac{1*n1+2*n2+3*n3+4*n4+5*n5}{5xN}$$

Where; W = weight given to each factor by respondents

A = highest weight

N = total number of respondents.

Relative Importance Indices (RII) comparison table was used to rank the results by taking into account the average scores and the RII. The RII value had a range between 0<RII ≤ 1.

The collected data from different sources and results was analyzed and interpreted through charts, graphs, figures and tabular formats using excel and other management tools to evaluate the major importance of adopting building information modeling in the construction industry. The data will only being collected after ethical permission is given from ECMI and Construction Engineering and management Stream of Jimma University.

CHAPTER FOUR

Result and discussion

4.1. Introduction

The aim of this research project was to assess the potential adoption of building information modeling in Ethiopian construction industry in Addis Ababa city. The rationale for conducting the research was the need for a well-defined assessment of the potential adoption of building information modeling. The aim was achieved through the following specific objectives: by identifying both the key drivers and barriers hindering for BIM adoption on a construction project by determine advantages of adopting BIM in construction project verify the responsibility of stakeholder for the adoption of BIM.

These, the chapter present data analysis and findings from the interview, site observation and survey questionnaire. It begins with descriptive analysis of the demographics variables of participating firms and respondents. This is followed by analysis of problems and was related to benefit of BIM, measures key driver and barriers for adopting BIM The main statistical methods and tools used were relative index method. Data collected from the questionnaires were tabulated and analyzed according to their ranking on relative index. Charts were created, where appropriate, in support of the descriptive analysis to clarify their status. Again, ratings by respondents on the firms‟ scope of BIM usage were also discussed.

4.2. Respondents profiles

4.2.1. Respondents category

With twenty two questionnaires which were administered to the contractors, consultants, foreign contractor and government regulatory bodies, a total of 19 questionnaires were returned. Figure 4.1 shows the breakdown of the number of response received from the selected organizations. From the survey results 36.84% were received from contractors, 31.58 % received from consultants, 15.79%were received from foreign contractor and 15.79%were received from government regulatory bodies.

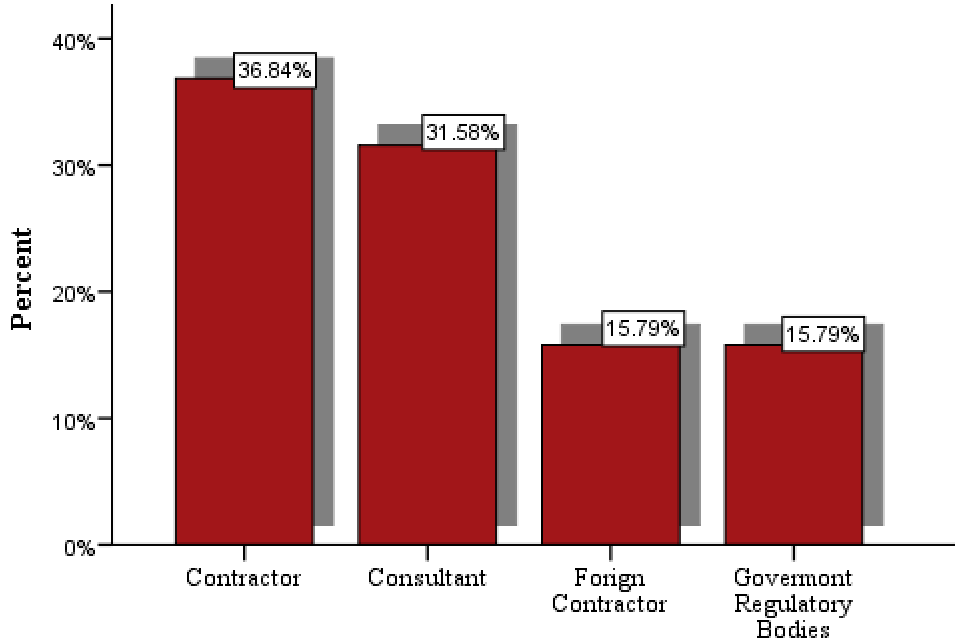

Figure 4. 1: category of organization

4.2.2. Role of Respondents in the Organization

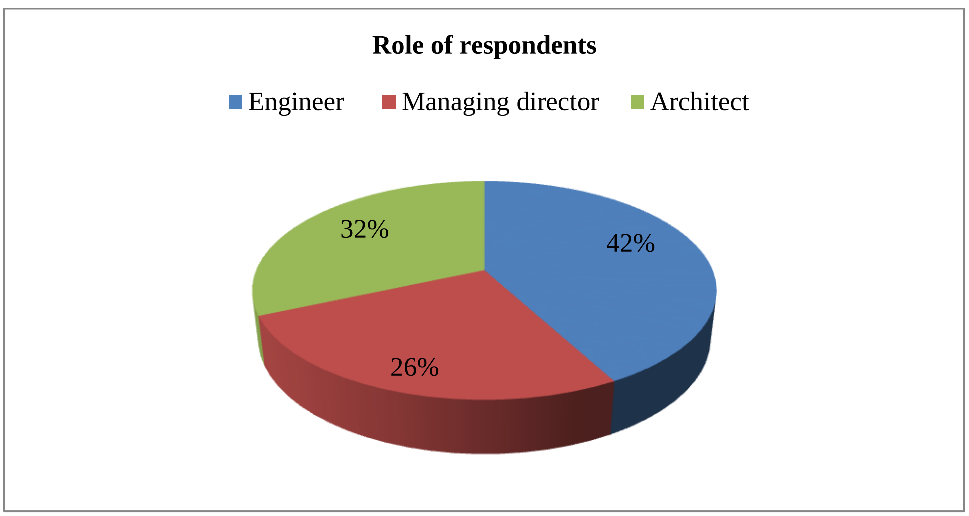

Figure 4. 2: Role of respondents

Again, the data analysis revealed that, positions of respondents in the organizations were represented in the survey. Considering the current positions in their construction project, 26.32%, were managing directors, 42.11% Engineer, 31.58% architect. The result tells that the knowledge of new technology mostly handled and controlled by small number of industry participants.

4.2.3. Adoption Status of Building Information Modeling

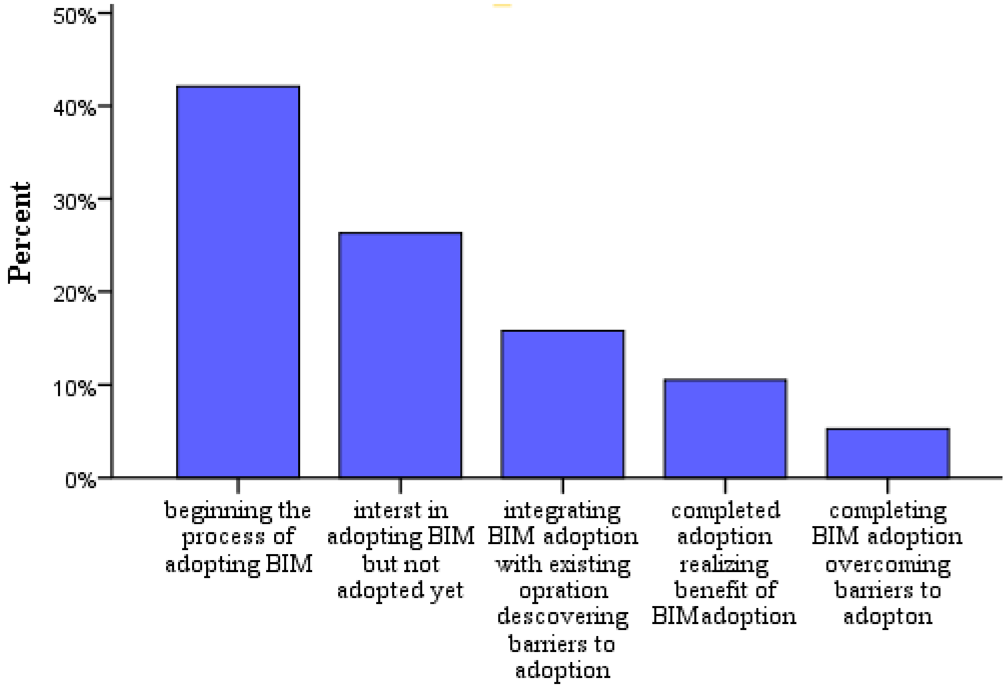

Figure 4. 3: Adoption status of building information modeling

Concerning organizations status of adopting BIM, figure 4.3, shows that (42.11%), were beginning the process of adopting BIM, (26.32%) were interest in adopting BIM (15.79%) were integrating BIM adoption with existing operation, (10.53%) completed adoption realizing benefit of BIM, (5.263%) completing BIM adoption over coming barriers. This shows in coming years adoption status of BIM in Addis Ababa construction projects will be increasing to keep this good result the government should prepare pushing factor to facilitate adopting building information modeling.

4.2.4. Year of BIM Adoption

Regarding the working experience of the organization surveyed, Figure.4.4 shows that (52.63 %) were less than one year, (15.79%) were one –two year, (15.79%) were three-four year and (15.79) more than four. The result shows many of respondent were trying adopting BIM that is good beginning in construction industry of Addis Ababa but they are late they should share knowledge and skill from those who realize BIM benefit.

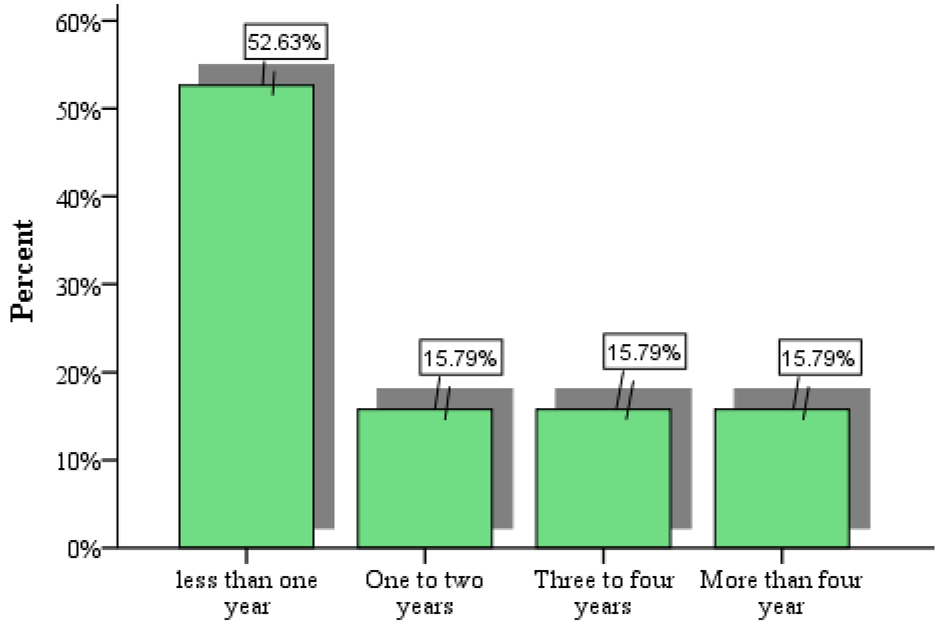

Figure 4. 4: Year of BIM adoption

4.2.5. Implementation plan for BIM adoption

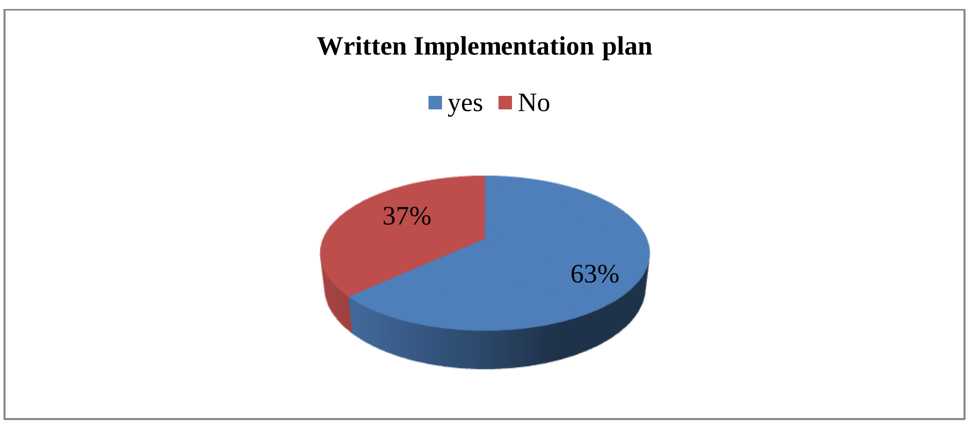

Figure 4. 5: Implementation plan for BIM adoption

According to Figure 4.5, (63.16 %) organization have written implementation plan for BIM adoption and the remaining (36.84%) of the organization tries to adopt BIM without preparing programed implementation plan. The finding tells that many of local contractor of Addis Ababa have no written implementation plan in adopting BIM this leads loss of competitiveness with early adopters.

4.2.6. Scope of Using BIM in the Companies

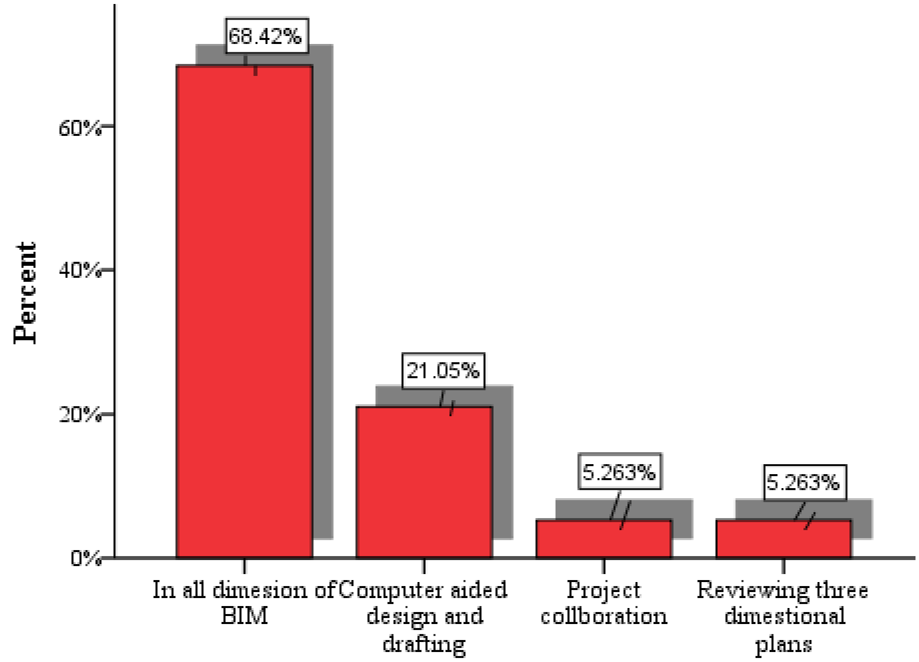

Figure 4. 6: scope of companies using BIM

Concerning scope of using BIM in the companies surveyed, figure 4.6, shows (68.42%) of companies were used in all dimensions of BIM, (21.05%) were used computer aided and design, (5.263%) were used for project collaboration and the remaining (5.263%) were used for reviewing three dimensional plans.

4.3. Findings Providing Ranked BIM Driver

The drivers were analyzed using Relative Importance Index (RII – Table 1).. The obtained results are shown below

Table 4. 1: Ranked Building Information Modeling driver

No	Factors	Likert Scale	W_i	Frequency (f_i)	$f_i * w_i$	$\sum_{i=1}^{19} fi * wi$	RII	Rank
1	government pressure	Very low	1	0	0	89	0.936	1
		Low	2	0	0			
		Medium	3	1	3			
		High	4	4	16			
		Very high	5	14	70			
2	accurate construction sequencing and clash detection	Very low	1	0	0	88	0.926	2
		Low	2	0	0			
		Medium	3	1	3			
		High	4	5	20			
		Very high	5	13	65			

3	automation of schedule/register generation	Very low	1	0	0	88	0.926	2
		Low	2	0	0			
		Medium	3	1	3			
		High	4	5	20			
		Very high	5	13	65			
4	improving built output quality	Very low	1	0	0	87	0.915	3
		Low	2	0	0			
		Medium	3	0	0			
		High	4	8	32			
		Very high	5	11	55			
5	time saving	Very low	1	0	0	84	0.884	4
		Low	2	0	0			
		Medium	3	0	0			
		High	4	11	44			
		Very high	5	8	40			
6	desire for innovation to remain competitive	Very low	1	1	1	70	0.736	5
		Low	2	1	1			
		Medium	3	6	18			
		High	4	6	24			
		Very high	5	5	25			

The top five drivers as perceived by those already using BIM were, government pressure, accurate construction sequencing and clash detection and automation of schedule/register generation and improving built output quality. The rankings indicate that government pressure (RII of 0.94) is currently the greatest driver for BIM. This shows that Addis Ababa construction industry government representatives have responsibility to set push factors in adopting BIM. According to UK (Efficiency and Reform Group, 2011) In the case of BIM, the UK Government is making BIM mandatory on all publicly-funded projects starting from 2016. Like other countries Ethiopian construction project management institute (ECPMI) in august -8 -2011 drafted road map to adopt BIM for middle scale projects starting 2012-2017 in Ethiopian calendar. Government has responsibility to set standards and policy to adopt BIM in the construction industry. Secondly ranked finding are both accurate construction sequencing and clash detection automation of schedule/register generation (RII of 0.93) the implication of the second finding are to minimize rework in the project the industry mostly faces rework and variation order related problem so should adopt BIM to realize the industry productivity. The 3rd finding is improving built output quality (RII of 0.915) this shows the importance adopting BIM to get desired structure as we all know the quality of our built structures are low standards as compared to international contractors so they should adopt

BIM to give owner need. The 4th finding is time saving (RII of 0.88) this finding indicate that to minimize the industry main problem which is time over run that many researcher agree as it is common to all contractors in construction project adopting BIM is key for to minimize the problem.

4.4. Ranked BIM Benefit Findings

The benefit were analyzed using Relative Importance Index (RII – Table 1).

Table 4. 2: Ranked benefit of Building Information Modeling.

No	Factors	Likert Scale	W_i	Frequency (f_i)	$f_i * w_i$	$\sum_{i=1}^{19} fi * wi$	RII	Rank
1	make project communication easier	Very low	1	0	0	91	0.957	1
		Low	2	0	0			
		Medium	3	0	0			
		High	4	4	16			
		Very high	5	15	75			
2	shorten projects duration	Very low	1	0	0	86	0.905	2
		Low	2	0	0			
		Medium	3	1	3			
		High	4	7	28			
		Very high	5	11	55			
3	decrease delay in project	Very low	1	0	0	84	0.8842	3
		Low	2	0	0			
		Medium	3	2	6			
		High	4	7	28			
		Very high	5	10	50			
4	increase project quality	Very low	1	0	0	83	0.873	4
		Low	2	1	2			
		Medium	3	0	0			
		High	4	9	36			
		Very high	5	9	45			
5	reduced rework	Very low	1	0	0	81	0.852	5
		Low	2	0	0			
		Medium	3	2	6			
		High	4	10	40			
		Very high	5	7	35			

The top five benefit as perceived by those already using BIM were, make project communication easier, shorten projects duration and decrease delay in project The rankings indicate that make project communication easier (RII of 0.96) ranked 1st order from interview importance of BIM discussed by the participants was the project coordination and collaboration with crew. Which means that by adopting BIM we improve our exchange of information between stakeholders and employers. According to (Azhar s 2011) BIM used as a single integrated information resource, would make the communication and coordination among project participants much easier. By digitalizing our information system we will reduces time taking by exchanging letters through-out projects. The second and 3rd ranked findings are shorten projects duration (RII of 0.91) and decrease delay in project (RII of 0.88) from the interview many of the participants believes that adopting BIM advantageous in improving the performance of construction project with respect to time, cost and quality. According to (Gao J and Fischer M, 2008.)the traditional CAD based 2D approach is known to cause unnecessary waste and errors in the design and construction of buildings poor information flow, redundancy, imprecise quantity and cost estimation, are some of the problems associated with the traditional approach. Therefore adopting BIM will reduce and eliminate the above mentioned traditional system problem this leads to minimize delay in construction project. The fourth ranked benefit is increase project quality (RII of 0.873) according to (azhar s 2011).the key benefit is its accurate geometrical representation of the parts of building it provides a better visualization of the design which would help the owner to confirm if the final building would meet his/her expectations. This shows that adopting BIM is serve as a tool to control our industry project quality. Fifthly ranked BIM benefit is reduced rework (RII of 0.85) adopting BIM reduce reworks by digitalizing communication and by sharing information at the same time to all stakeholders our local contractors should adopt BIM to improve their productivity through-out the project by reducing rework in project.

4.5. Ranked greatest barrier to BIM adoption

Table 4. 3: Ranked Barriers to adoption of Building Information Modeling

No	Factors	Likert Scale	W_i	Frequency (f_i)	$f_i * w_i$	$\sum_{i=1}^{19} fi * wi$	RII	Rank
1	lack of expertise	Very low	1	0	0	84	0.884	1
		Low	2	0	0			
		Medium	3	1	3			
		High	4	9	36			
		Very high	5	9	45			
2	lack of training	Very low	1	0	0	83	0.873	2
		Low	2	0	0			
		Medium	3	1	3			
		High	4	10	40			
		Very high	5	8	40			
3	Different view on BIM	Very low	1	1	1	77	0.810	3
		Low	2	1	2			
		Medium	3	1	3			
		High	4	9	36			
		Very high	5	7	35			
4	No client demand	Very low	1	0	0	71	0.747	4
		Low	2	3	6			
		Medium	3	6	18			
		High	4	3	12			
		Very high	5	7	35			
5	changing work processes	Very low	1	0	0	71	0.747	4
		Low	2	2	4			
		Medium	3	7	21			
		High	4	4	16			
		Very high	5	6	30			
6	Initial cost	Very low	1	0	0	70	0.736	5
		Low	2	3	6			
		Medium	3	4	12			
		High	4	8	32			
		Very high	5	4	20			

The top five barriers affecting the slow adoption of BIM in the AEC-industry are presented; Lack of expertise, lack of training, different views on BIM, changing work processes and no client demand. The rankings indicate that lack of expertise (RII of 0.88) is currently the greatest barriers to adopt BIM. From interview question asked on critical issues why our industry late to adopt BIM 45.45% of participant agree that the capacity of the country in terms of expert and finance is the main reason of Bing late to adopt BIM. According (Rizal et al 2011) one new role in construction project is presented in the form of a model manager and expert role; this expert role will demand knowledge in both

ICT and the construction process. During adoption and working with BIM experts will provide and maintain technological solution for functionality. The second ranked barrier is lack of training (RII of 0.87) from the interview 36.36% of participant believes that lack of training leads to be late in adopting BIM. Also (Gu et al.2008) believes that when adopting BIM it is vital that the individuals are sufficiently trained in the use of the new technology in order for them to be able to contribute to the changing work environment. This indicate giving training for concerned body to their specific filed leads to achieve desired objective but will incur additional cost of training.so that the government representative obliged to prepare training to stakeholder to enhance construction industry profitability. The third ranked finding is different views on BIM (RII of 0.81) this indicates that different stakeholders have different perception on BIM. Research by (Gu et al. 2008 and 2010) has concluded that the views on what BIM is depend a lot on the particular actor, Both the profession and size of the firm are factors of importance in regard to this difference of perception on what BIM is and how the actor wants to use it.no joint understanding of BIM between professionals of the industry. To mitigate this problem local industry representative should make discussion with stake holders to come to middle point. changing work processes and no client demand are 4th ranked finding with (RII of 0.747) and the 5th ranked finding is initial cost (RII of 0.736) this indicates that adopting BIM is initially costly, this problem faces all countries AEC industry stakeholders, like other countries local construction industry stakeholders they should face initial cost of adopting BIM by thinking future productivity of the construction industry.

4.6. Identification of responsibility to adopting building information modeling in Addis Ababa construction industry.

To answer responsibility related objective the researcher prepare survey questioner and interview questions the researcher was able to identify 11 individuals who had extensive BIM knowledge and have adopted BIM in their companies. All interview notes for specific participants were clearly labeled.

This question was discussed with participants to get their attitude on their institute responsibility is the government institute should make building information modeling BIM as one criteria to provide public projects. Based on the result (96.67%) of the participants' were responded yes public representative should follow BIM as one criterion to providers because to manage cost, time, quality related issues in digitalized way (3.33%) of participant were believes the public sector not BIM as criterion because there is many limitation with respect to financial and expert capacity. The finding result indicates that many of respondent need to set the government BIM as criterion which tells the government is more responsible in facilitating adopting BIM.

This question was aimed to find out about the participants' perspective on their industry representative responsibility by motivating companies or individuals to adopt BIM. Considering over the answers, there seems to be similar patterns of ideas observed between seven participants reasoning that their representative should prepare training, creating awareness, Bing a model by introducing the system. The remaining four respondents have idea on we all are responsible in creating good environment to adopt BIM. And also 36.8% of survey question respondent believes that government bodies are fully responsible to adopt BIM, 21%of respondent are believes that all stakeholders are responsible to adopt building information modeling in construction industry. Therefore from interview and survey question result tells as the government has more responsible in adopting BIM.

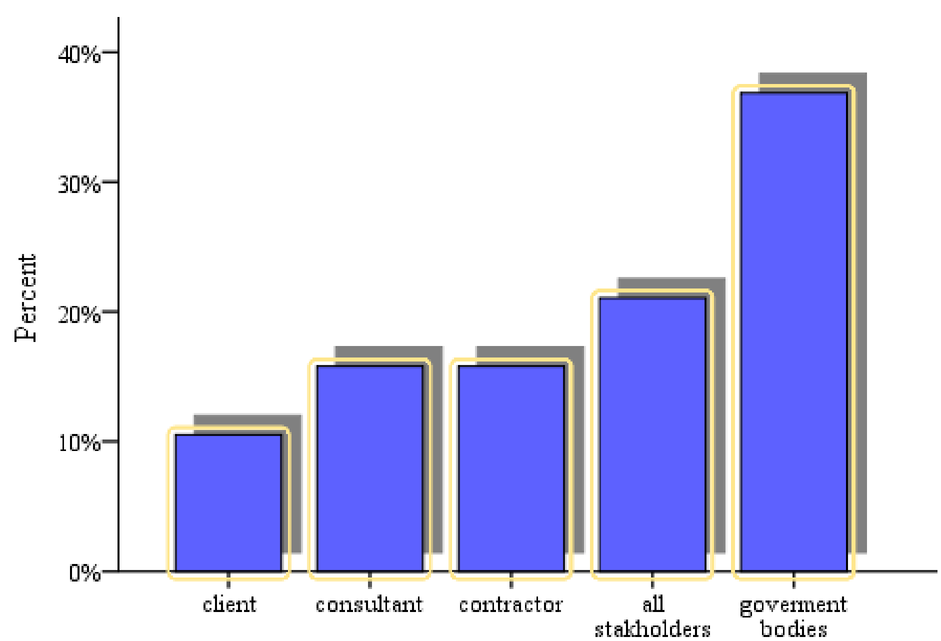

Figure 4. 7: Identification of responsibility to adopt BIM

CHAPTER FIVE

Conclusion and Recommendation

5.1. Conclusion

Currently the AEC industry throughout the world is attempting to adopt BIM as the future standard for building design, construction, and operation.

The paper identified the key drivers to the adoption of Building Information Modeling. It proved that relatively high ranked driver; Government pressure, Accurate construction sequencing and clash detection, automation of schedule/register generation, improving built output quality and time saving are ranked (1st ,2nd , 3rd ,4th and 5th respectively) were the most important drivers for BIM adoption. If the factors identified are considered, it will lead to successful adoption of BIM in the Addis Ababa construction industry.

Building information modeling is currently emerging when project stakeholders understand the benefits of BIM-based project management they will ensure that BIM is implemented to its fullest potential from the earliest phases of the project. In this paper the benefit of BIM also assessed and obtained, the top five benefits are make project communication easier, shorten projects duration, decrease delay in project, increase project quality and reduced rework (1st ,2nd,3rd,4th and 5th) respectively were relatively high ranked benefit gained from adoption of Building Information Modeling.

This BIM technology beneficial for the industry however the adoption rates of this technology have been lower than expected due to various barriers impeding implementation. In this paper the research identified barriers of adopting BIM; lack of expertise, lack of training, different views on BIM, No client demand and changing work processes , are ranked (1st, 2nd, 3rd, 4th and 5th respectively) were relatively high ranked barriers hindering adoption of Building Information Modeling. It is important to note that no one single barrier is solely responsible for hindering BIM adoption. Instead, the potential for these barriers to be able to impact adoption is project specific and varies from project to project.

Finally this paper identify who is responsible to adopt Building Information modeling The finding result indicates that many of respondent need to set the government BIM as criterion for future projects and They expect the industry representative should prepare training, creating awareness, Bing a model by introducing the system. The researcher interviewed Ethiopian construction project Management Institute (ECPMI) Technology transfer director According to the director like other country Ethiopia construction industry public representative were drafted Road map to set Building Information Modeling as criterion in all middle level public projects @ 2024.

Therefore the success of adopting BIM depends on many factors but all stakeholders should be responsible in facilitating adoption of Building information Modeling because which will lead to improve profitability, reduce costs and better time management of for construction projects.

5.2. Recommendation

The government representative of Addis Ababa construction industry should actively take up the mandate on BIM adoption and provide support to construction practitioners by way of institutionalizing BIM adoption procedures and should prepare a standard BIM contract document should be made for construction project to ensure cooperative use of BIM by all professionals.

The Ethiopian construction project management institute ECPMI as one of the industry research center should show the government to focus on learning and implementation of evolving technology in respect to construction processes in order to enable the construction industry to better benefit from BIM.

The Professionals in the construction industry are encouraged to take the initiative to drive the BIM adoption within their private practices, to make training on BIM a part of their professional development programs and to share this knowledge with other professionals.

The stakeholder of construction industry everyone is to take responsibility of adopting new innovation come to the industry to remain competitive both internationally and nationally They are also encouraged to work with the regulating bodies to push for requirement of BIM adoption as a minimum standard for work.

Jimma institute of Technology (JIT) as one of government institute should take responsibility to train the industry stakeholders about Building Information Modeling.

REFERENCE

Adams R.H, 2004. Economic growth, inequality and poverty: estimating the growth elasticity of poverty, World Development. P. 32.

Ahmed H. Elyamany, 2016. Current practices of building information modeling in Egypt. Int. J.Engineering Management and Economics, 6(1).

Amaka C.O & Dubem I.I, 2017. The Future of BIM Technologies in Africa:Prospects and Challenges. Pp. 307-314.

Amaka Chinweude Ogwueleka & Dubem Isaac Ikediashi, The Future of BIM Technologies in Africa: Prospects and Challenges) 2017 book chapter 307-314.

Arayici y, khosrowshahi F, ponting A. M & Mihindu s, 2009. “Towards implementation of building information modelling in the construction industry”.

Arayici, k. P. &. M. S., 2009,2011. Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. Leadership and Management in Engineering. Issue 11(3).

Aregaw Z. T & Zewdu G. T, 2015. Causes of Contractor Cost Overrun in Construction Projects The Case of Ethiopian Construction Sector. Int. J. Bus. Econ Res, 4(4), p. 180–19.

Azhar S, Carlton W, Olsen D & Ahmad I, 2011. Building Information Modelling for Sustainable design and LEED Rating Analysis. Automation in Construction, Volume 20(2), pp. 217-224.

Azhar S, Hein M & Sketo B, 2008. Building Information Modeling (BIM): Benefits,Risks and Challenges,.

Azhar.S, Khalfan.M & Maqsood.T, 2012. Building information modelling (BIM): now and beyond. Australasian Journal of Construction Economics and Building, pp. 15-28.

World Bank, 2015. How does the World Bank classify countries. [Online] Available at: https://datahelpdesk.worldbank.org/knowledgebase/articles/378834 [Accessed 15 December 2018].

Bazjanac V, 2005. Model based cost and energy performance estimation during schematic design. S.l., Institute for Construction Informatics,.

Bimhub, 2012. Benefits of BIM.

Buildingsmart Australasia, 2012. National Building Information Modelling Initiativ.

Capbell D.A, 2007. Building information modeling the web 3D application for AEC.

Chan C, 2014. Barriers of Implementing BIM in Construction Industry from the Designers Perspective. Journal of System and Management Sciences, Volume 4, , pp. 24-40.

Coates P, et al., 2010. The limitations of BIM in the architectural process.

Crotty R, 2012. The Impact of Building Information Modeling.

Eastman C.M, 1975. The Use of Computers Instead of Drawings in Building Design. AIA Journal, Issue 63 , pp. 46-50..

Eastman, 2011. BIM Handbook.

Ede A.N, 2014. Building information modeling: case study of a duplex project in Nigeria. Int. J.IT Eng.Appl. Sci. Res., 3(4), pp. 25-28.

Elchaig T, Boussabinaine B & Ballal T, 2005. Critical determinants of construction tendering costs: Quantity surveyors' standpoint. International Journal of Project Management, Issue 23(7), pp. 538-545.

Gao J & Fischer M, 2008. Framework and Case-studies Comparing Implementations and Impacts of 3D/4D Modeling Across Projects. Http://cife.stanford.edu/node/141.

Golabchi A & Kamat V.R, 2013. Evaluation of Industry Foundation Classes for Practical Building Information Modeling Interoperability. ISARC.

Gould F. E, 2004. Managing The Construction Process: Estimating, Scheduling, and project control.

Grilo A & Jardim-Goncalves R, 2010. Value proposition on interoperability of BIM and collaborative working environments. Automation in Construction. Issue 19 (5), p. 522–530.

Gu N & London K, 2010. Understanding and facilitating BIM adoption in the AEC industry. Automation in construction. Issue 19(8),, pp. 988-999.

Gu N, et al., 2008. BIM: expectations and a reality check. S.l., Tsinghua University Press.

Gwaya A. O, Masu S. M & Wanyona G, 2014. A Critical Analysis of the Causes of Project Management Failures in Kenya.

Harmelink D & Yamin R, 2001. Development and application of linear scheduling techniques to highway construction projects. West Lafayette, Indiana: Purdue University.

Harris F & mccaffer R, 2006. Modern Construction Management. Pp. 677- 688.

Steel J & Drogemuller R, 2012. Model Interoperability in Building Information Modeling. Queensland University of Technology Old 4001,Australia.

Wells J, 2001. The construction industry in the twenty first century: Its image,employment prospects and skill requirements. International Labour Organization.

Kaner I, Sacks R, Kassian W & Quitt T, 2008. Case studies of BIM adoption for precast concrete design by mid-sized structural engineering firms.

Khemlani L, 2007. Top Criteria for BIM Solutions. 22 November .Issue october.

Kim K & de la Garza J. M, 2003. A new approach to resource constrained scheduling.Towards a Vision for Information Technology in Civil Engineering. Issue doi:10.1061/40704(2003)48.

King T. D, 2015. Poor Project Management Performance," no. 303. Issue 303.

Kiprotich C.J, 2014. An investigation on building information modelling in project management:challenges, strategies and prospects in Gauteng construction industry. M.Sc. Thesis,University of Witwatersrand.

Kiviniemi A, 2013. Public clients as the driver for open BIM adoption-how and why UK government wants to change the construction industry.

Latiffi A.A, Mohd S, Kasim N & Fathi M.S, 2013. Building Information Modeling (BIM). International Journal of Construction Engineering and Management, pp. 1-6.

Latifi A.A, Mohod S, Kasim N & Fathi M.S, 2013. Building Information Modeling (BIM) Application in Malaysian Construction Industry. International Journal of Construction Engineering and Management, Volume 2, pp. 1-6.

Lee S, kim K & yu J, 2014. BIM and ontology based approach for building cost estimation.

Lewis A, Riley D & Elmualim A, 2010. Defining High Performance Buildings for Operations and Maintenance.. International Journal of Facility Management, , Volume 1(2),, pp. 1-16.

Liu R, Issa R & Olbina s, 2010. Factors influencing the adoption of building information modeling in the AEC Industry. University of Nottingham.

Lock D, 2007. Project Management.

M.L. Bhatt, A. Borrmann, R. Amor & J. Beetz, 2013. Architecture Computing, and Design Assistance. Automation in Construction, Issue 32, pp. 161-164.

Matarneh & Hamad.J, 2017. Exploring the adoption of BIM in the Jordan construction industry.

Mcgraw-Hill, 2012. The business value of BIM in North America. Construction.

Mcgraw-Hill, 2014. The business value of BIM for construction in major global market. Construction .

Michael G, et al., 2017. An investigation into the implementation of building information modeling in the middle east. Journal of Information Technology in Construction.

Mutonyi N & Chris C, 2018. Adoption of Building Information Modelling in the construction industry in Kenya.

Nassar K. M, Gunnarsson H. H & Hegab M. Y, 2005. Using weibull analysis for evaluation of cost and schedule performance. Journal of Construction Engineering and management , Volume 131(12).

NBIS, 2007. National Building Information Modeling Standard, Transforming the Building Supply Chain through Open and Interoperable Information Exchanges.

Opoko A. P, et al., 2019. Appraisal of The Use of Building Information Modelling (BIM) in the Construction Project Planning in Lagos State. Journal of Digital Innovations & Contemp Res. In Sc.,, 7(1), pp. 1-12.

Peeters W & Madauss B, 2008. A proposed strategy against cost overruns in the space sector: The 5C approach. Space Policy. Issue 24(2), pp. 80-89.

Reina P & Angelo, 2002. Megaprojects need more study up front to avoid cost overruns. ENR: Engineering News-Record, Issue 249(3), p. 11.

Rizal S, 2011. Changing roles of the clients, architects and contractors through BIM. Engineering,Construction and Architectural Management 18.2, pp. 176-187.

Robert, E. Et al., 2013. Analysis of the drivers for adopting building information modelling.

Ruikar K, Anumba C & Carrillo P, 2005. End-user perspectives on use of Project Extranets in construction organisations, Engineering, Construction and Architectural Management. Volume 12(3), pp. 222-235.

Sacks R, 2008. Evaluation of economic impact of three-dimensional modeling in the precast concrete engineering. J. Computing Civil Eng, Issue 18(4), pp. 301-312.

Saracar M, Rao K. M & Narayan K. L, 2008. Computer aided design and manufacturing. S.l., PHI Learning Pvt. Ltd.

SHIKUR.M, 2013. A Contextual Application of Building Information Modeling In the Architectural Design Stage for the 40/60 housingproject of Addis Ababa.

Smith D.K & Edgar A, 2008. Building information modeling (BIM).. Natonal Institute of Building Sciences, Washington.

Son H, Lee S & Kim C, 2015. What drives the adoption of building information modeling in design organizations? An empirical investigation of the antecedents affecting architects' behavioral intentions. Automation in Construction, Issue 49, pp. 92-99..

Succar B, 2009. Building information modelling framework: a research anddelivery foundation for industry stakeholders. Automation in Construction, Issue 18 (3), p. 357–375.

Tatjana D, Eday K & Grey D, 2010. Introducing reviet architecture BIM for bigeners.

Taxén L & Lilliesköld J, 2008. Images as action instruments in complex projects. International Journal of Project Management, Issue 26 (5), p. 527–536.

Thomas M.F, 2010. The Impact of Emerging Information Technology on Project Management for Construction. Automat. Constr, Volume 19(5), pp. 531-538.

Thompson D. B & Miner R. G, 2007. Buildinginformation modeling—BIM: Contractual risksare changing with technology.

TRADA, 2012. Construction Briefings: Building Information Modelling.

Tse T. K, Wong K. A & Wong K.F, 2005. The utilisation of building information models in nd modelling: A study of data interfacing and adoption barriers. Volume 10, pp. 85-110.

Weygant R. S, John Wiley & Sons, 2011. BIM content development: standards, strategies, and best practices.

Winch G, 2010. Managing Construction Projects.

Yan H & Damian P, 2008. Benefits and barriers of building information modelling.

Zewdu Z.T & Aregaw G.T, 2015. Causes of Contractor Cost Overrun in Construction Projects : The Case of Ethiopian Construction Sector. Int. J. Bus. Econ.Res., 4(4), pp. 180–191,.

Zhang X, et al., 2009. Integrating BIM and GIS for large scale (Building) Asset Management: a critical review.

ANNEX

Questioners

I Would Like To Thank You In Advance for The Time and Effort Involved in Your Participation In This Research Your Willingness To Fill the Questionnaires And Returning Back On Time. This Questioner Prepared To Obtain Information From Informants The Information Is Required for Academic Research Entitled **Assessment On Adopting Building Information Modeling In Ethiopia Construction Industry Case In Addis Ababa City.** All information you provide will kept in secrete confidentially and only used for academic research. Please feel free to answer the questions with what you know and what you think in your mind.

Part one: General about company and respondents profile.

1. Name of respondent (optional): ____
2. Your Company's name : ____
3. ProjectName:____
4. Date and time: ______________________________
5. Your level education (optional): _____________________________
6. Phone no ___________________________________
7. Please describe the category that best describe your organization
   - ☐ Consultant
   - ☐ Contractor
   - ☐ Owner
   - ☐ Regulatory bodies
8. What is your role with the company?
   - ☐ Manager
   - ☐ Engineer
   - ☐ Architect
   - ☐ owner

Part two:

1. The adoption status of BIM in your organization to be (adoption stage and description).

    - ☐ Beginning the process of adopting BIM
    - ☐ Integrating BIM Adoption With Existing Operation: Discovering Barriers To Adoption
    - ☐ Completing BIM Adoption Overcoming Barrier's To Adoption
    - ☐ Completed Adoption Realizing Benefit Of BIM Adoption

2. how many years ago did your organization adopt BIM
    - ☐ less than one year
    - ☐ one-two
    - ☐ three- four
    - ☐ more than four

3. Does your organization have a written implementation plan for BIM adoption?
    - ☐ Yes
    - ☐ No
4. Does your organization require BIM for any new project?
    - ☐ Yes
    - ☐ No
5. Please indicate the ways in which your company is using, or would consider using, BIM. (Check all that apply)
    - ☐ Computer-aided design and drafting
    - ☐ Project collaboration
    - ☐ Reviewing three dimensional plans
    - ☐ In all dimensions of BIM ___________________________________

6. After integrating building information modeling in your organization please rate the benefits of BIM which are listed below.

Benefit of using BIM	Very High	High	Medium	Low	Not at all
Decrease delay in project					
Decrease total cost of the project					
Improve project productivity					
Increase project quality					
Reduced rework					
Shorten project duration					
Make the communication and coordination among project participants much easier					
If other please specify below					

7. Here are list of Barriers which affect the adoption of BIM please rank their degree by putting (✓) mark on the provided space.

Barriers to adopt BIM?	Very High	High	Medium	Low	Not at all
Cost					
No client demand					
Lack of expertise					
Lack of training					
Changing work processes					
Risks and challenges with the use of a single model					
Legal issues					
Poor match with the user’s needs					
Interoperability					
Different views on BIM					

8. Driving factors for BIM adoption in the construction industry are listed below, from your experience please rate according to your agreement on the points.

BIM drive factor	Very high	High	Medium	Low	Not at all
Government pressure					
Client/competitive pressure					
Desire for innovation to remain competitive Improving the capacity to provide whole life value to client					
Cost savings and monitoring					
Time savings					
Accurate Construction Sequencing and Clash Detection					
Automation of schedule/register generation					
Facilitating facilities management activities					
Improving built output quality					
If others please specify below					

9. Which of the following are more responsible in adopting BIM (possible to tick more than point)
   - ☐ Government bodies
   - ☐ Client
   - ☐ consultant
   - ☐ contractor
   - ☐ architects

Table 4.1 the drivers were analyzed using Relative Importance Index (RII)

No	Factors	Likert Scale	W_i	Frequency (fi)	$f_i * w_i$	$\sum_{i=1}^{19} fi * wi$	RII	Rank
1	government pressure	Very low	1	0	0	89	0.936	1
		Low	2	0	0			
		Medium	3	1	3			
		High	4	4	16			
		Very high	5	14	70			
2	client/competitive pressure	Very low	1	2	2	68	0.715	6
		Low	2	3	6			
		Medium	3	3	9			
		High	4	4	16			
		Very high	5	7	35			
3	desire for innovation to remain competitive	Very low	1	1	1	70	0.736	5
		Low	2	1	1			
		Medium	3	6	18			
		High	4	6	24			
		Very high	5	5	25			
4	cost saving and monitoring	Very low	1	0	0	87	0.915	3
		Low	2	0	0			
		Medium	3	1	3			
		High	4	6	24			
		Very high	5	12	60			
5	time saving	Very low	1	0	0	84	0.88	4
		Low	2	0	0			
		Medium	3	0	0			
		High	4	11	44			
		Very high	5	8	40			
6	accurate construction sequencing and clash detection	Very low	1	0	0	88	0.926	2
		Low	2	0	0			
		Medium	3	1	3			
		High	4	5	20			
		Very high	5	13	65			
7	automation of schedule/register generation	Very low	1	0	0	88	0.926	2
		Low	2	0	0			
		Medium	3	1	3			
		High	4	5	20			
		Very high	5	13	65			

8	facilitating facility management activities	Very low	1	2	2	62	0.652	7
		Low	2	5	10			
		Medium	3	2	6			
		High	4	6	24			
		Very high	5	4	20			
9	improving built output quality	Very low	1	0	0	87	0.915	3
		Low	2	0	0			
		Medium	3	0	0			
		High	4	8	32			
		Very high	5	11	55			

Table 4. 2: Summary of the literature on benefit of BIM

No	Factors	Likert Scale	W_i	Frequency	$f_i * w_i$	$\sum_{i=1}^{19} fi$	RII	Rank
1	decrease delay in project	Very low	1	0	0	84	0.8842	3
		Low	2	0	0			
		Medium	3	2	6			
		High	4	7	28			
		Very high	5	10	50			
2	decrease total cost of project	Very low	1	0	0	76	0.8	7
		Low	2	0	0			
		Medium	3	5	15			
		High	4	9	36			
		Very high	5	5	25			
3	improve project productivity	Very low	1	0	0	80	0.842	6
		Low	2	0	0			
		Medium	3	3	9			
		High	4	9	36			
		Very high	5	7	35			
4	increase project quality	Very low	1	0	0	83	0.873	4
		Low	2	1	2			
		Medium	3	0	0			
		High	4	9	36			
		Very high	5	9	45			
5	reduced rework	Very low	1	0	0	81	0.852	5
		Low	2	0	0			
		Medium	3	2	6			
		High	4	10	40			
		Very high	5	7	35			
6	shorten projects duration	Very low	1	0	0	86	0.905	2
		Low	2	0	0			
		Medium	3	1	3			
		High	4	7	28			
		Very high	5	11	55			
7	make project communication easier	Very low	1	0	0	91	0.957	1
		Low	2	0	0			
		Medium	3	0	0			
		High	4	4	16			
		Very high	5	15	75			

Table 4. 3: Ranked Barriers to BIM adoption The greatest barrier was analyzed using Relative Importance Index (RII – Table 1). The obtained results are shown below

No	Factors	Likert Scale	W_i	Frequency	$f_i * w_i$	$\sum_{i=1}^{19} fi * wi$	RII	Rank
1	Cost	Very low	1	0	0	70	0.736	5
		Low	2	3	6			
		Medium	3	4	12			
		High	4	8	32			
		Very high	5	4	20			
2	no client demand	Very low	1	0	0	71	0.747	4
		Low	2	3	6			
		Medium	3	6	18			
		High	4	3	12			
		Very high	5	7	35			
3	lack of expertise	Very low	1	0	0	84	0.884	1
		Low	2	0	0			
		Medium	3	1	3			
		High	4	9	36			
		Very high	5	9	45			
4	lack of training	Very low	1	0	0	83	0.873	2
		Low	2	0	0			
		Medium	3	1	3			
		High	4	10	40			
		Very high	5	8	40			
5	changing work processes	Very low	1	0	0	71	0.747	4
		Low	2	2	4			
		Medium	3	7	21			
		High	4	4	16			
		Very high	5	6	30			
6	risks and challenges with the use of a single model	Not at all	1	2	2	60	0.631	7
		Low	2	3	6			
		Medium	3	5	15			
		High	4	8	32			
		Very high	5	1	5			
7	legal issues	Not at all	1	1	1	63	0.663	6
		Low	2	5	10			
		Medium	3	3	9			
		High	4	7	28			
		Very high	5	3	15			

8	Poor match with the user's needs	Not at all	1	1	1	63	0.663	6
		Low	2	3	6			
		Medium	3	6	18			
		High	4	7	28			
		Very high	5	2	10			
9	interoperability	Not at all	1	1	1	63	0.663	6
		Low	2	3	6			
		Medium	3	6	18			
		High	4	7	28			
		Very high	5	2	10			
10	different views on BIM	Not at all	1	1	1	77	0.810	3
		Low	2	1	2			
		Medium	3	1	3			
		High	4	9	36			
		Very high	5	7	35			