ST. MARY'S UNIVERSITY

SCHOOL OF GRADUGATE STUDIES

BUILDING INFORMATION MODELING (BIM) PROJECT IMPLEMENTATION ASSESSEMENT: THE CASE OF ETHIOPIAN CONSTRUCTION WORKS CORPORATION (ECWC)

BY

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(SGS/0616/2011A)

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LIST ACRONYMS

2D	Two Dimensional
3D	Three Dimensional
4D	Four Dimensional
5D	Five Dimensional
AEC	Architecture, Engineering, Construction
BIM	Building Information Modelling
BSI	British Standards Institute
CAD	Computer Aided Drawing
CSG	Construction Solid Geometry
ERP	Enterprise Resource Planning
FM	Facility Management
GSA	General Service Administration
IFC	Industry Foundation Class
IT	Information Technology
LSG	London School of Economics
NIBS	National Institution of Building Science
PTC	Parametric Technologies Corporation
UK	United Kingdom
USA	United States of America

ABSTRACT

Building Information Modeling (BIM) is rapidly growing technology worldwide as a reliable instrument for improving the efficiency of construction industry. Developed countries are using BIM to overcome difficulties and achieve the benefits from implementing BIM. Currently, the Architecture, Engineering, and Construction (AEC) industry is considered one of the mega contributors to development in Ethiopia. However, the industry is facing major difficulties such as unfulfilled client requirement, delay in time, cost overrun, quality issues, conflicts among stakeholders, safety issues, high requests of change order, increasing in material wastes and project complexity. Since Ethiopian construction Works Corporation (ECWC) is one of the major contractor company in Ethiopia, it is characterized by the above difficulties. , therefore there is an urgent need to adopt the latest technologies and management strategies to eradicate the recognized problems and to improve the performance of the AEC industry in ECWC. This research used a primary data analyzed using descriptive analysis to rank the factors which are identified from different studies and determine the key pushing factors and key barriers to implement BIM in ECWC and inferential analysis to investigate the variance in perception of different respondent groups from a total of 74 respondents.

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Key words: BIM, AEC, pushing factors, barriers, implementation

CHAPTER ONE

INTRODUCTION

In the last decade, digital transformation has changed a wide range of industrial sectors, resulting in an amazing increase in product quality, product variety, productivity, and product variety. In the Architecture, Engineering, Construction (AEC) business, digital tools are highly adopted for designing, constructing and operating buildings and infrastructure assets. . However, the continual use of digital information on the whole method chain falls considerably behind different business domains. All too often, valuable information is lost because information is still predominantly handed over in the form of drawings, either as physical printed plots on paper or in a digital but limited format.

Such disruptions in the information flow occur across the entire lifecycle of a built facility: in its design, construction and operation phases as well as in the very important handovers between these phases. The planning and realization of built facilities is a complex undertaking involving a wide range of stakeholders from different fields of expertise. For a successful construction project, a continuous reconciliation and intense exchange of information among these stakeholders is necessary. Currently, this typically involves the handover of technical drawings of the construction project in graphical manner in the form of horizontal and vertical sections, views and detail drawings. The software used to create these drawings imitates the centuries-old way of working using a drawing board. However, line drawings cannot be comprehensively understood by computers. The information they contain can only be partially interpreted and processed by computational methods. Basing the information flow on drawings alone therefore fails to harness the great potential of information technology for supporting project management and building operation. A key problem is that the consistency of the diverse technical drawings can only be checked manually. This is a potentially massive source of errors, particularly if we take into account that the drawings are typically created by experts from different design disciplines and across multiple companies. Design changes are particularly challenging: if they are not continuously tracked and relayed to all related plans, inconsistencies can easily arise and often remain undiscovered until the actual construction – where they then incur significant extra costs for solutions on site. In conventional practice, design changes are marked only by means of revision clouds in the drawings, which can be hard to detect and ambiguous. The limited information depth of technical drawings also has a significant drawback in that information on the building design cannot be directly used by downstream applications for any kind of analysis, calculation and simulation, but must be re-entered manually which again requires unnecessary additional work and is a further source of errors. The same holds true for the information handover to the building owner after the construction is finished. He must invest considerable effort into extracting the required information for operating the building from the drawings and documents and enter it into a facility management system. At each of these information exchange points, data that was once available in digital form is lost and has to be laboriously re-created.

This is where Building Information Modeling comes into play. By applying the BIM method, a much more profound use of computer technology in the design, engineering, construction and operation of built facilities is realized. Instead of recording information in drawings, BIM stores, maintains and exchanges information using comprehensive digital representations: the building information models. This approach dramatically improves the coordination of the design activities, the integration of simulations, the setup and control of the construction process, as well as the handover of building information to the operator. By reducing the manual re-entering of data to a minimum and enabling the consequent re-use of digital information, laborious and error-prone work is avoided, which in turn results in an increase in productivity and quality in construction projects.

Other industry sectors, such as the automotive industry, have already undergone the transition to digitized, model-based product development and manufacturing which allowed them to achieve significant efficiency gains (Kagermann, 2015). The Architecture Engineering and Construction (AEC) industry, however, has its own particularly challenging boundary conditions: first and foremost, the process and value creation chain is not controlled by one company, but is dispersed across a large number of enterprises including architectural offices, engineering consultancies, and construction firms. These typically cooperate only for the duration of an individual construction project and not for a longer period of time. Consequently, there are a large number of interfaces in the network of companies where digital information has to be handed over. As these information flows must be supervised and controlled by a central instance, the onus is on the building owner to specify and enforce the use of Building Information Modeling.

Building Information Modelling (BIM) has received enormous attention from both academia and industry (Eastman et al., 2011).BIM not only brings technical benefits to the development process, but delivers an innovative and integrated working platform to improve productivity and sustainability throughout the project life cycle (Elmualim and Gilder, 2014). BIM enables owners to review the design and give feedback through the visualisation of a three-dimensional (3D) building information model before the facility is constructed. Second, BIM transforms conventional practice, which is often highly fragmented, to a better collaborative effort that strengthens the working relationship among project participants. In a BIM platform, team members have to share their own viewpoints of information with other members to form a reliable basis of decision making to construct a facility (NIBS, 2015).

A Building Information Model is a comprehensive digital representation of a built facility with great information depth. It typically includes the three-dimensional geometry of the building components at a defined level of detail. In addition, it also comprises non-physical objects, such as spaces and zones, a hierarchical project structure, or schedules. Objects are typically associated with a well-defined set of semantic information, such as the component type, materials, technical properties, or costs, as well as the relationships between the components and other physical or logical entities The construction industry requires to investigate techniques to decrease project cost, reduce project duration, increase productivity, and improve quality. BIM has been accepted in the construction industry as a new approach to achieving these objectives BIM involves the detailed and complete replication of a building in a digital environment with the sole goal of providing a collaborative platform for managing Building information throughout the lifecycle of a facility (Aouad et al., 2014). BIM is the process of creating a digital parametric model which represents the physical and functional characteristic of a building in full detail and further shared knowledge pool which can be used to form reliable decisions during the design, construction phases and throughout the life cycle of the facility (Eastman *et al.*, 2011; Suranga and Weddikkara, 2012).

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1.2 STATEMENT OF THE PROBLEM

Researchers and management professionals tried to identify gaps of the AEC industry such as teamwork fragmentations, ineffective coordination, poor communications, buildings low performance, energy overconsumption, unsustainable buildings (Latham, 1994; Egan, 1998). In addition to design errors and clashes, project overrun, low productivity, low building quality, the poor satisfaction of stakeholders /client/users and shortage or unauthenticated data for Facility Management (FM) during maintenance stage (Eastman, et al., 2008; Arayici, et al., 2012).

On the other hand according to a recent study at the London School of Economics (LSE) in UK report the management practice in Africa is poor as compared to Europe and North America. According to this report, Ethiopia is the second from the last followed by Mozambique which indicates that the management practice in Ethiopia is even far behind from those poor performing developing countries in Africa.

The international BIM implementation guide shows that global status of BIM adoption is 71% for North America, 44% Europe, 54% UK, and 40% Australia.

With these driving facts that North America and Europe have a better project management practice and relatively have high BIM adoption rate, there is an urgent need to adopt the latest technologies and management strategies to eradicate the recognized problems and to improve the performance of the AEC industry (Alhumayn, et al., 2017). This research will try to assess the implementation of BIM in Ethiopia construction works corporation (ECWC) its barriers and influencing factors for implementation of BIM.

1.3 RESEARCH QUESTION

- What are the pushing factors to implement BIM?
- What are the barriers to implement BIM?
- What should be the role of government in BIM implementation?

1.4 RESEARCH OBJECTIVE

1.4.1 GENERAL OBJECTIVE

The thesis aims at assessing BIM implementation and identifying barriers to implement BIM in ECWC.

1.4.2 SPECIFIC OBJECTIVE

- To identify whether BIM is implemented or not.
- Exploring the pushing factors to implement BIM.
- Identifying the barriers or challenges to implement BIM.
- Identifying the role of government to implement BIM.

1.5 SIGNIFICANCE AND RELEVANCE OF THE STUDY

The introduction of Building Information Modeling technology to the construction industry would have positive impact on cost, time and quality. Public projects would bring about environmental responsiveness, customer satisfaction and better city image. Design and construction professionals and companies in Ethiopia working in the traditional fragmented approach are also the benefit groups including ECWC.

This research could have policy impact on the way public projects are approached and designed.

1.6 SCOPE OF THE STUDY

The scope of the thesis involves in identifying the factors that leads to BIM implementation and the expected barriers to implement BIM in ECWC. And also tries to identify the role of government in the process of BIM implementation.

1.7 LIMITATIONS OF THE STUDY

This study has some limitations. First, data analysis was based on respondents′ perceptions which can be impacted by some bias. Second, the sample was not stratified by different professionals, sector and firm; thus, the factors investigated on this paper could not be generalized for all firms and sectors. These limitations can lead to future works that includes the understanding of BIM knowledge among different professionals, sector and firm.

1.7 ORGANIZATION OF THE RESEARCH

The study is organized into five chapters. The first chapter deals with introduction presenting background information and justification of the study. Chapter two consists of review of some relevant literatures and documents which are found to be important and supportive to the objective of the study. This chapter provides extensive summary to the researches that are related to BIM implementation. Chapter three outlines the research methodology used to undertake the study. Major discussion and findings presented in chapter four. Finally, chapter five presents conclusion and recommendation.

CHAPTER TWO

LITERATURE REIVIEW

2.1 THEORETICAL REVIEW

2.1.1 OVERVIEW OF BIM

BIM has been defined in various ways (Abbasnejad & Moud, 2013; Almutiri, 2016). For example, It has been defined as a group of interacting policies, software, processes and technologies, (Jung & Joo,2011; Barlish & Sullivan, 2012) or as having a focus on applying information technology (IT) (Arayici& Aouad, 2010; Azhar, et al., 2015).

Whereas, Eastman, et al.(2011) defined BIM as a process that digitally manages the design, construction, and Operation and Maintenance. Azhar (2011) defined BIM as a virtual process that involves all aspects, disciplines, and systems of a facility within a single model that is shared with all stakeholders across the project lifecycle. Sabol (2008) defined BIM as a sophisticated software tool that helps to record information and to assist with its components.

Several researchers have cited the benefits of BIM as; leading to improved AEC industry performance and enhancing coordination and collaboration between various project parties. BIM is considered a revolutionary technology and management process, proposed as the potential solution to the current issues in the AEC industry (Liu, et al., 2010; Arayici, et al., 2011; Azhar, et al., 2015).

2.1.2 BACKGROUND OF BIM

The modeling of 3D geometry was a broad research goal that had many potential uses including movies, design, and eventually games. The ability to represent a fixed set of polyhedral forms shapes defined by a volume enclosing a set of surfaces for viewing purposes was developed in the late 1960s and later led to the first computer graphics film, *Tron* (in 1987). These early polyhedral forms could be used for composing an image but not for designing more complex shapes. In 1973, the easy creation and editing of arbitrary 3D solid shapes was developed separately by three groups, Ian Braid at Cambridge University, Bruce Baumgart at Stanford, and Ari Requicha and Herb Voelcker at the University of Rochester Known as solid modeling, these efforts produced the first generation of practical 3D modeling design tools. Two forms of solid modeling were developed and competed for supremacy. The boundary representation approach (B - rep) defined shapes using operations of union, intersection, and subtraction — called Boolean operations on multiple polyhedral shapes and also utilized refining operations, such as chamfering, slicing, or moving a hole within a single shape. The sophisticated editing systems developed from combining these primitive shapes and the Boolean operators allowed generation of a set of surfaces that together were guaranteed to enclose a volume.In contrast, Constructive Solid Geometry (CSG) represented a shape as a tree of operations and initially relied on diverse methods for assessing the final shape. Later, these two methods merged, allowing for editing within the CSG tree (sometimes called the *unevaluated shape*) and also changing the shape through the use of general purpose B – rep (called the *evaluated shape*) . Objects could be edited and regenerated on demand. The result is the simplest of building shapes a single shape hollowed with a single floor space with a gable roof and door opening. Notice that all locations and shapes can be edited via the shape parameters in the CSG tree, however, shape edits are limited editing operations. First generation tools supported 3D facetted and cylindrical object modeling with associated attributes, which allowed objects to be composed into engineering assemblies, such as engines, process plants, or buildings (Eastman 1975; Requicha 1980). This merged approach to modeling was an important precursor to modern parametric modeling.

Building modeling based on 3D solid modeling was first developed in the late 1970s and early 1980s. CAD systems, such as RUCAPS (which evolved into Sonata), TriCad, Calma, GDS (Day 2002), and university research based systems at Carnegie - Mellon University and the University of Michigan developed their basic capabilities.

Solid modeling CAD systems were functionally powerful but often overwhelmed the available computing power. Some aspects of production, such as drawing and report generation, were not well developed. Also, designing 3D objects was too conceptually foreign for most designers, who were more comfortable working in 2D. The systems were also expensive. The manufacturing and aerospace industries saw the potential benefits in terms of integrated analysis capabilities, reduction of errors, and the move toward factory automation. The current generation of BIM architectural design tools, including Autodesk Revit ® Architecture and Structure, Bentley Architecture and its associated set of products, the Graphisoft ArchiCAD ® family, and Gehry Technology ' s Digital Project ™ as well as fabrication level BIM tools, such as Tekla Structures, SDS/2, and Structure works all grew out of the object - based parametric modeling capabilities developed for mechanical systems design. These concepts emerged as an extension of CSG and B rep technologies, a mixture of university research and intense industrial development, particularly by Parametric Technologies Corporation ® (PTC) in the 1980s. The basic idea is that shape instances and other properties can be defined and controlled according to a hierarchy of parameters at the assembly and sub - assembly levels, as well as at an individual object level. Some of the parameters depend on user - defined values. Others depend on fixed values, and still others are taken from or relative to other shapes. The shapes can be 2D or 3D

2.1.3 TRADITIONAL METHOD VS BIM

The transformation from the traditional method to the BIM concept requires changes in many disciplines such as software and hardware upgrade, changes in processes, and changing the organizational culture to BIM benefits. The comparison between the traditional method process and the concept of the BIM process, in traditional methods, the considerable impact occurs in the construction documentation phases which in turn cause several issues to arise, delaying the project delivery and increasing the overall project cost. However, BIM process solves these issues at an early stage (Almutiri, 2016).

(Almutiri, 2016) claimed that the traditional methods suffer from many issues such as lack of project understanding, poor communication and data loss, problems in sharing information and poor collaboration between team members. (Duell, et al., 2013) illustrated the difference between the BIM and traditional methods in sharing data in which in case of traditional method data is transferred in a fragmented way that the stakeholders in a project obtain data from other stakeholder through different modes of communication and the data is mostly paper based data whereas in BIM concept information is obtained from a central database.

The other comparison is based on clash detection in which in case of traditional method clash is identified at construction stage However, BIM identifies clashes among various designs, early in the conceptual design phase, and before construction gets started that save time and money besides promoting the money value and efficiency (Abbasnejad & Moud, 2013).

2.1.4 SCOPE OF BIM

A common interpretation of BIM is missing in terms of its scope and definition between individuals and professionals. However the U.S. national institution of building science (NIBS, 2007) has divided the BIM scope into three commonly used categorizations;

- BIM as a product
- BIM as a collaborative process
- BIM as a facility lifecycle management tool

2.1.4.1 BIM AS A PRODUCT

BIM as a product refers to the actual model as an intelligent digital representation of data about a facility (NIBS, 2007). In order to qualify as intelligent is not just a 3D representation based on objects enough. It also has to include some information or properties beyond the graphical presentation and it is primarily this information in BIM that leads to the biggest benefits for the industry (Granroth, 2011). The view of BIM as a product is sometimes called the underdeveloped view of BIM due to that it just considers the model (WSP group, 2011).

2.1.4.2 BIM AS A PROCESS

The view of BIM as a process considers the process of developing a BIM model (the BIM product) and using it in order to reach project efficiency (WSP group, 2011). At this level of BIM also the social aspects such as; synchronous collaboration, coordinated work practices, and institutional and cultural framework are being dealt with. Most companies that today state that they are working with BIM are looking at this level of BIM and focus on finding processes that enable them to deliver good and profitable projects. The key point from this view is that BIM is a marriage between technology and a set of work processes.

2.1.4.3 BIM AS A FACILITY LIFECYCLE MANAGEMENT TOOL

The last and most demanding of these views is BIM as a facility lifecycle management tool. This view sees BIM as management tool, by focusing on a sustainable, verifiable, and repeatable information based environment in order to guarantee well-understood information exchanges, workflows, and procedures, throughout the building lifecycle (NIBS, 2007). Due to this long term perspective is this view extra interesting for client organizations

2.1.5 BENEFITS OF USING BIM

Many of the BIM advantages are observed as direct advantages; however the largest advantages really are the indirect advantages. The direct advantages include qualities, for instance the enriched imagination, conception and the concentration of building information in the project. In contrast, the indirect advantages are the essential for cooperation and giving the best result for project understanding, and reducing the project risk. Simulations authorize us that a design be planned checked virtually before the real project is constructed. A model can help us to have a visualization of the project. This visualization provides stimulation view in concerning the project needs that help to describe the project in an effective manner.

The main BIM benefits can be grouped as, elimination, visualization, and collaboration. There is actually much overlap amongst these classifications, but they have been selected as the principal thought around which all the advantages can be better realized. First of all, visualization mainly indicates the advantages for the improvement and an individual in her/his personal realization as a consequence of utilizing the BIM. Second of all, collaboration can be the cooperative behavior of some members in the team as the BIM is encouraging and facilitating it. Finally, elimination refers generally project-related advantages, for example decreasing the waste, risk, and conflicts

Richard et al. stated in brief BIM advantages and its tools which can be indexed as follows:

1. Materials take off should be simplified.
2. Complex details can be surveyed and analyzed.
3. The different trade components coordination can be reviewed for potential “hits.”
4. Sequence of placing a project with each other is expanded.
5. The 4D, which added time, can be merged to demonstrate how quickly a project can be put together.
6. Site work eminences among the ultimate eminence and existing conditions could be determined.
7. The best routing could be reviewed for pipes, lights, ductwork wires, cables, and sprinklers.
8. The site preparations with the hoists and cranes location can be analyzed.
9. Lift schedules would be determined for the steel, concrete, and huge mechanical and electrical equipment placement.
10. Developing the schedules and the associated argument will be expanded.
11. Problems of potential safety would be evaluated.
12. Alternatives can be assessed in more realistic terms.
13. Coordinating the trade’s former to perform the real work.

2.1.6 PILLARS OF BIM

When considering BIM, it can be helpful to consider these four significant factors:

- Policy
- People
- Technology
- Process

It is argued that only when these elements are integrated and working harmoniously that the true value of BIM will be experienced. If all four elements are fully considered within BIM adoption, it sets the initiative for a solid foundation of understanding.

Policy

Knowledge of Building Information Modelling (BIM) within the construction industry is on the rise. The yearly reports produced by the National Building Standards (NBS) are a valuable resource for learning more about the rate of BIM adoption in international context.

For instance, NBS (2012, 2013) reports demonstrate the decrease in number of construction workers not aware of BIM, with 6% unaware in 2013, down from around 40% in 2011. This shows the rising knowledge of BIM, and possibly, its usefulness.

Other statistics show that in the earlier years, about 74% of the industry was not clear enough on what BIM was. Yet, by 2016 about 54% were aware of and using BIM, with 42% at least aware of it, and just 4% neither aware of nor using BIM (NBS 2016). Meaning knowledge of BIM has risen over time.

Regarding the future of BIM, 73% of participants agreed with the statement ‘BIM is the future of project information’. These statistics indicate that although some gaps are still present, knowledge of BIM continues to rise. Realistically, awareness is not the only reason for adopting BIM in the AEC. However, awareness can influence policy changes to adopt BIM where necessary. In the UK for instance, awareness of BIM and its benefits has led to the government calling for BIM to be mandatory for public projects. This policy change has influenced the private sector to follow suit.

People

A core feature of working within a BIM environment is the drive towards encouraging multidisciplinary collaboration from the outset of a project. The benefits of all disciplines working together within one core BIM environment are substantial.

A major issue experienced within non-BIM design processes is the matter of conflicting design issues. The ethos of having a core central BIM model is to facilitate a smoother transition through these issues by identifying conflicts earlier on in the project stages, thus reducing the negative effects on schedule and costs.

From an early stage, projects can be visualized, allowing client and designer alike to gain an appreciation of how the design is going to materialize. This allows for important design decisions and alterations to be made at an early stage, when the cost repercussions are small or even zero.

Technology

BIM technology has, over the years, helped in carrying out all the pre-construction design analysis and interrogation, resulting in reduction of conflicts and changes made during the construction phase that usually have a detrimental effect on a project in terms of wastage, quality, time and costs.

At the same time, the stringent energy analysis that can take place in the early stages of a BIM project aims to improve the performance of a project in regards to low-impact design.

Finally, post project completion, a high-quality BIM model can continue to be utilized by an asset team to assist in the management of their assets in an efficient and environmentally conscious manner.

The efficiency of the effects of changes within documentation or design is greatly improved as any changes made that are linked to the main BIM package will automatically be carried through and updated to all corresponding linked documents and models.

Process

Having the design process completed within a BIM environment using a core 3D BIM model at the center of the project can lead to multiple benefits later in the process.

The models can be analyzed, allowing for a multitude of model interrogations to take place, including energy analysis, structural analysis, accurate schedules, and quantity take-offs.It is argued that using BIM processes for building projects will improve energy efficiency, improve scheduling, facilitate a reduction of waste, and facilitate a reduction in costs.

2.1.7 LIMITATIONS OF BIM

In spite of many approaches, the practical mechanism to adopt and implement BIM is still lacking. Perhaps, this can be justified by considering the status of BIM in both the developed countries (where BIM is mandated or nearly mandated) and developing countries (where BIM is still in its early stages), which show the need for a more practical and applied view of BIM rather than its potential benefits.

2.1.8 BIM LEVEL

The UK Government BIM strategy is making Level 2 BIM mandatory for all publicly-funded projects from 2016 onwards. This is to produce collaboration among the construction design team and reduce the fragmentation in the construction industry identified in Government reports (Wolstenholme et al, 2009; Egan, 1998; Latham, 1994). The BIM Industry Working Group (2011) state in the UK the levels of BIM are:-

Level 0 – Unmanaged CAD probably 2D, with paper (or electronic paper) as the most likely exchange mechanism.

Level 1 – Managed CAD in 2 or 3D format using BS1192:2007 with a collaboration tool providing a common data environment, possibly some standard data structures and formats. Commercial data managed by standalone finance and cost management packages with no integration.

Level 2 – Managed 3D environment held in separate discipline "BIM" tools with attached data. Commercial data managed by an Enterprise Resource Planning application (ERP). Integration on the basis of proprietary interfaces or bespoke middleware could be regarded as "pBIM" (proprietary). The approach may utilize 4D program data and 5D cost elements as well as feed operational systems.

Level 3 - Fully open process and data integration enabled by web services compliant with emerging IFC / IFD standards, managed by a collaborative model server. Could be regarded as iBIM or integrated BIM potentially employing concurrent engineering processes.

2.2 EMPIRICAL FRAMEWORK

2.2.1 BIM PERSPECTIVE BY OTHER COUNTRIES

USA

The US General Services Administration (GSA) formulated the National BIM Program way back in 2003. This program established policy mandating BIM adoption for all Public Buildings Service projects. GSA also actively partners with BIM vendors, federal agencies, professional associations, open standard organizations, and academic/research institutions to develop a community of BIM leaders within GSA. Today, 72% construction firms in the US are believed to be using BIM technologies for significant cost savings on projects.

And it’s not just the government that has been pushing for the power of visualization, coordination, simulation, and optimization in the construction, several US states, universities and private organizations are supporting the adoption of higher BIM standards. In 2009, the Architect’s Office at the Indiana University issued BIM Standards and Project Delivery Requirements. In the same year, the Penn State University also acquired a leadership role in articulating the use of BIM by facility owners.

UK

The UK has swiftly risen become the undisputed BIM champion of the world riding on the wings of clear national strategy and government support. The British Standards Institute (BSI) have formal relation with standards committees like the AGI and others. Since April 2016, as part of the Government’s Construction Strategy which aims to achieve 20% savings in procurement costs, all centrally-procured construction projects in the UK are required to achieve BIM Level 2. This mandate not only made the whole industry sit up and take notice, it also accelerated the process of BIM adoption in the country, because if you are not BIM Level 2 complaint, you just cannot get your hands on any government project in the UK.

Scandinavian countries

The Scandinavian countries of Norway, Denmark, Finland and Sweden count amongst the earliest adopters of BIM technologies, with public standards and requirements already in place.

In fact, Finland started working on implementing BIM technologies as early as 2002, and by 2007, the Confederation of Finnish Construction Industries had mandated that all design software packages need to pass Industry Foundation Class (IFC) Certification. It should be noted that IFC is a vendor-neutral file format which allows models to be shared and worked on independently of any specific piece of software.

To be fair, since all these countries are relatively smaller, convincing fewer market players and people to adopt BIM has been a clear advantage for the Scandinavian region.

GERMANY

According to a McGraw Hill Construction Report on BIM, 90% of project owners in Germany either often or always demand BIM. The survey also found out that rather than the government, the emphasis is more on commercial and residential buildings. However, the traditionally conservative German AEC industry hadn’t shown much inclination toward BIM adoption, and major public sector often went over-budget or would be late in delivery.

SINGAPORE

The government has created a central repository for building codes, regulations and circulars published by various building and construction regulatory agencies in Singapore. Through this Construction and Real Estate the Building & Construction Authority set out to implement the world’s first BIM electronic submission. Since 2015, BIM e-submissions have been mandated for all projects greater than 5,000 sq mts.

Not just that, since 2010, the Building & Construction Authority has been dispensing grants through the BIM fund as well, which covers the cost of training, consultancy, hardware and collaboration software.

FRANCE

France decided in 2014 that it would develop 500,000 houses using BIM by 2017. A budget of €20 million was also allocated to digitize the building industry. As the benefits from this project will be evaluated, there is a good possibility that BIM will be made mandatory in public procurement this year. The initiative was a part of the French government’s Digital Transition Plan for the construction industry, which aimed to achieve sustainability and reduce costs. Also in 2014, the government launched a research and development project in the construction area to develop BIM standards for infrastructure projects.

2.2.2 SUGGESTED METHODOLOGY FOR BIM IMPLEMENTATION

Arayici et al. (2011) claimed that setting clear guidance and a methodology guarantees the achievement of the ultimate benefits of BIM. Several researchers have developed frameworks, models, and methodologies to implement BIM as follows:

The strategy of Olugboyega (2017) to create a BIM environment can be summarized as:

(1) Acquiring BIM software technologies (according to the project goals) and BIM hardware,

(2) Developing a BIM contents library,

(3) Developing BIM standards, and

(4) Setting up a BIM platform (interoperability tools, collaboration tools, integration tools, coordination/ clash detection tools and communication tools) according to the types of BIM software and hardware.

Moreover, Alhumayn, et al. (2017) suggested strategies for implementing BIM in Saudi arabia which include providing legislation and a supportive regulatory environment, government funding, educating key players and gaining the experience of advanced countries using BIM. However, Arayici, et al. (2011) suggested that approaches should be undertaken with a bottom-up approach rather than top-down. Omar (2015) and Alhumayn et al. (2017) claimed that to accelerate BIM implementation, government should take the upper hand (top-down approach) by facilitating smooth information flow.

Wang, et al. (2013) developed a BIM user acceptance model applying a technology acceptance model (TAM).

Whereas, the EU BIM Task group suggested another strategic framework for BIM adoption in the public sector: growing capability, pilot projects, measuring and monitoring, case studies and embedding change (UK Construction Media, 2016). Furthermore, Jung and Joo (2011) proposed a BIM implementation framework as shown in Table 1.

Table2.1 The BIM implementation framework (Jung & Joo, 2011)

Technical (T)	Perspective (P)	Construction Business Function (C)		
1.Data Property 2. Relation 3. Standards 4. Utilization	1. Industry 2. Organization 3. Project	1. Research and development 2. General Admin. 3. Finance 4.Human resource management 5.Safety management	6. Quality Mgt. 7. Cost control 8. Contracting 9.Materials Mgt. 10. Scheduling	11. Estimating 12. Design 13. Sales 14. Planning

There are also many approaches such as frameworks (Kekana, et al., 2014; Succar & Kassem, 2015) and technology adoption (Masood, et al., 2014; Arayici, et al., 2011) being proposed to support the implementation of BIM.

2.2.3 PUSHING FACTORS FOR BIM IMPLEMENTATION

Several researchers have argued that the main factors for BIM implementation are recognizing the benefits of BIM and driving forces (external forces) imposed from externals and/or the surrounding environment. For example, competitors use BIM, and internal readiness including IT sophistication and top management support (Liu, et al., 2010; Eadie, et al., 2013; Omar, 2015). The most important factors for increasing BIM implementation are: improved interoperability between software applications, improved BIM software functionality, more clearly-defined BIM deliverables between parties, more owners asking for BIM, more 3D building product manufacturer content, reduced cost of
BIM software, more internal staff with BIM skills, more use of contracts to support BIM, more external firms with BIM skills and more entry-level staff with BIM skills (McGraw-Hill Construction, 2012).

Mehran (2015) argued that the main forcing factors for BIM implementation are government support, BIM contract, standards, and protocols, development of a BIM performance matrix and industry collaboration.

The following table illustrates the main factors BIM implementation uncovered by the literature review of International Journal of BIM and Engineering Science Volume: 2 Issue: 1; June - 2019

Table2.2 THE MAIN FACTORS INFLUENCING BIM IMPLEMENTATION

.PUSHING FACTORS	**AUTHORS**
External Push for Implementing BIM	
Government pressure (Intervention in mandating BIM)	(Eadie, et al., 2013; Omar, 2015; Willis & Regmi, 2016
Client pressure and demand for application of BIM in their projects	(Saleh, 2015; Almutiri, 2016)
Government support Coordinated government support and leadership (Smith, 2014; McPartland, 2017)	(Smith, 2014; Willis & Regmi, 2016; McPartland, 2017)
Developing industry-accepted BIM standards, best practices, and legal protocols	
Other external pushes	
Raising awareness (promotion and awareness of BIM)	(Azhar, 2011; Almutiri, 2016; Gerges, M, et al.,2017)
Internal Push for Implementing BIM	
Top Management support	(Gerges, et al., 2016; McPartland, 2017)
Cultural change	(Liu, et al., 2010; Gerges, et al., 2016)
Collaboration between all project participants	(Migilinskas, et al., 2013; Willis & Regmi,2016)
Improving built output quality	(McCartney, 2010; Saleh, 2015)
Perceived benefits of BIM	(Sebastian, 2011; Azhar, 2011; Omar, 2015)

Technical competence of staff Financial resources of organization The desire for innovation with competitive advantages and differentiation in the market. Improving the capacity to provide whole-life value to the client Safety in the construction process (to reduce risk of accident) BIM training program for staff Adapting existing workflows to lean oriented processes Deciding which tool to use Applying successful change management strategies Collaboration between all stakeholders Continuous investment in BIM Projects complexity and profit declination Approaches for adoption	(Arayici, et al., 2009; McPartland, 2017) (Eastman, et al., 2011; Succar & Kassem, 2015; Omar, 2015) (Liu, et al., 2010; Eadie, et al., 2013; Omar, 2015) (Omar, 2015; Gerges, et al., 2016) (Omar, 2015; Saleh, 2015) (Smith, 2014; Gerges, et al., 2016; Gerges, M, et al., 2017) (Arayici, et al., 2011; Eastman, et al., 2011) (McPartland, 2017) (Arayici, et al., 2011; Eastman, et al., 2011) (Gerges, et al., 2016; Willis & Regmi, 2016) (Ding, et al., 2015; Saleh, 2015) (Azhar, et al., 2015; Almutiri, 2016; Ball, 2017) (Arayici, et al., 2011)

Every research argued different key factors may be they agree with one or more factor, but do not agree with all the same factors. Therefore, this study will try to examine factors claimed by the previous researches and find further factors that have not been mentioned before.

BIM has significant benefits to construction projects through the project lifecycle. However, unfortunately, most projects do not achieve these benefits because of not adopting and implementing BIM. (Arayici, et al., 2011; Eastman, et al., 2011)

There are many limitations that slowed BIM implementation and BIM application is still in the beginning stage to some degree.

2.2.4 BARRIERS TO IMPLEMENT BIM

BIM is perceived as a complex, difficult to implement and expensive technology (Eastman et al., 2011; Lu and Li, 2011; Roper, 2012). Contrary to the clear benefits that BIM brings to a project are the difficulties faced in implementing BIM. Brewer (2010) articulates some of these difficulties and contrasts the chasm between the benefits suggested by the conceptual component of BIM and the difficulties of the applied reality. This concurs with Succar (2009) who coined the pejorative phrase “BIM-Wash” to describe the dislocation between BIM potential and BIM reality. With recognition to the difficulties of BIM adoption, research has also been undertaken to facilitate uptake (Gu and London, 2010; Roper, 2012). In the Malaysian context, the preliminary report shows the expense, lack of suitably skilled human resource and organizational and process difficulties as barriers to BIM adoption (Teo, 2012). Also in the Malaysian context, Baba (2010) identifies technical (interoperability), process, cost, legal, human resource skills as barriers and market demand. Besides, an increase in either technical, process or human resource perspectives will produce a marginal increase in BIM capability, but there is a symbiotic dependency on the other two perspectives to attain significant improvement.

Financial considerations

BIM typically requires new software and regularly requires new or upgraded hardware to run the processing intensive software (Autodesk, 2011; Eastman et al., 2011). There is a large technology component to a BIM implementation. Although concerns continue over the inoperability of some software and hardware platforms. This can be overcome by providing all players with the same software, or at the least, software from the same vendor. Any technical barriers to adoption can therefore be eliminated; however this repositions the problem as a financial issue, as such, there is a financial impact associated with adopting BIM.

The current USA price of Autodesk's BIM entry level software, Building Design Suite Premium, is US $6,825 (Autodesk, 2013). These cost indicated above is only for the purchase of basic BIM software and do not include costs for training and downtime as the company internalizes new working processes. Adoption of BIM is a major financial investment.

Human resource

Adopting BIM requires fundamental process change within an organization and with it, a complementary change in the skill sets of the human resource pool. Following the Bews-Richards Model or American Institute of Architects definition of minimum BIM, this will also entail concurrent capability increases along the project supply chain, including developers, other designers, contractors, approvals authorities, all having personnel with the competency to adopt BIM.

Legal factors

BIM requires collaborative working relationships between design and project team members. The UK's Construction-Industry-Council (2013, p. v) states as a key objective of its BIM Protocol, "In light of industry concerns in respect of IPR and the increased collaboration involved in a BIM project, clause 6 of the Protocol clearly sets out the IPR provisions required to enable the Models to be used as intended and to protect the rights of the Project Team Members against infringement".

Professional support

As evidenced by Bew and Underwood (2009), Young (2009) and Eastman et al. (2011) successful BIM implementations typically receive the support of knowledgeable persons or consultants that have specialist expertise.

2.2.5 EMPIRICAL REVIEW

Results of the study BIM for Infrastructure Sustainability in Developing Countries: the case of Ethiopia Denamo Addissie Nuramo, University of KwaZulu-Natal 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. According to the study Architecture students have better acquaintance and competence in using the program showing the prospects that Civil Engineering and Construction Technology and Management program can also enable their students gain the knowledge and skill their students need.

Opportunities And Challenges Of Implementing Building Information Modeling (BIM) In Addis Ababa Integrated Housing Development Project In this study, the concept of BIM, this has a great impact and importance in the construction industry. In this context, refereed journal articles including “BIM” and/or “Building Information Modeling” in their title and/or keywords were discussed in terms of different dimensions to evaluate the research tendency and gap in BIM literature. The results of this project to show Changing from the traditional approach to Building Information Modeling (BIM) implementation is not an easy process. It includes decision making and the change in management strategies.

Challenges of Building Information Modeling Implementation in Africa: A Case Study of the Nigerian Construction Industry found that BIM is a great knowledge area within the design, construction and operation industry and a great deal with Architectural and Construction Engineering industry. It can be observed from the study that BIM adoption is low in the Nigerian construction Industry. However the identified challenges and approaches to overcoming them in the study will assist the Nigerian construction industry to plan for the effective utilization of BIM in their prospective projects.

Annual International Conference by the Associated Schools of Construction The study aimed to identify barriers associated with BIM adoption, after a thorough review of the literature. After analyzing the various research publications, the study was able to determine 36 barriers that influence BIM implementation. Most of the challenges, including the ones most commonly established in the literature, were determined at the organization level. This indicates that companies have to overcome higher resistance regarding BIM implementation than projects. Most of the significant barriers dealt with the training of employees, lack of national standards for BIM, management of data, and interoperability of the software. If these barriers are not tackled at the earliest by various public and private entities associated with the construction industry, there is a high probability that these obstacles could start impacting at the project levels and the overall BIM adoption within the industry. In addition, two of the three most commonly identified barriers “Time needed for hiring/training people to use BIM, and Cost of hiring or training people to use BIM” dealt with economic conditions of the company and its ability to invest in maintaining innovativeness and competitiveness. These two barriers can be crucial for small and medium sized design and construction companies.

A research The project benefits (BIM) by David Bryde which is conducted on 35 projects have found the benefits of BIM and summarized as the table below

Table2.3 BIM BENEFITS

Success criteria	Positive benefits		
	Total instances Total	Total number of projects	% of total projects
Cost reduction or control	29	21	60%
Time reduction or control	17	12	34.29%
Communication improvement	15	13	37.14%
Coordination improvement	14	12	34.29%
Quality increase or control	13	12	34.29%
Negative risk reduction	8	6	14%
Scope clarification	3	3	8.57%
Organization improvement	2	2	5.71%
Software issues	0	0	0.00%

2.3 CONCEPTUAL FRAMEWORK

BIM finds elements of a building for example windows, doors , slabs, stairs , and walls by applying their attributes such as usage, structures, and functions as well as utilizing parametric technology; Moreover, it can reflect any alterations in the elements of building instantly into the information about the building configuration by distinguishing the connections between those attributes. Accordingly, the building elements' specifications and their relative information can be gotten by using a simulation model, which provides it possible for making quick decisions pending a construction project.

Additionally, BIM not only prepares information with regard to amount, expenses, schedules, and materials but furthermore provides it possible to perform analyzing data that can depend on the structure and ambience. A BIM is a project simulation which consists the three dimensional

(3D) models of the project components by connecting with all the needed information linked to the project planning, constructing or operating, and decommissioning.

So far he best tool to simulate the construction project within a virtual environment is BIM. This simulation can have the benefit of taking place on a computer when we are utilizing a software package. Virtual building points that it can be possible for practicing construction, for experimenting, and for making regulations in the project before it is fulfilled. Those mistakes, which are virtual, do not normally have serious subsequences —provided that they are found and indicated early sufficient which they will be avoided "in the field". While a project is virtually planned and made, many significant features should be considered, determined and discussed as much as possible before the address instructions of construction are concluded. The computer simulations usage is revolutionary in the building construction subject. Several manufacturing in the industry have been very magnificently exerting simulation methods for many years ago. Furthermore, many companies mostly in Europe in the construction field have currently effectively used resembling methods in the building projects, even though faultfinders assert that simulations can only profit repetitious production processes, and that construction is by explanation exclusive.

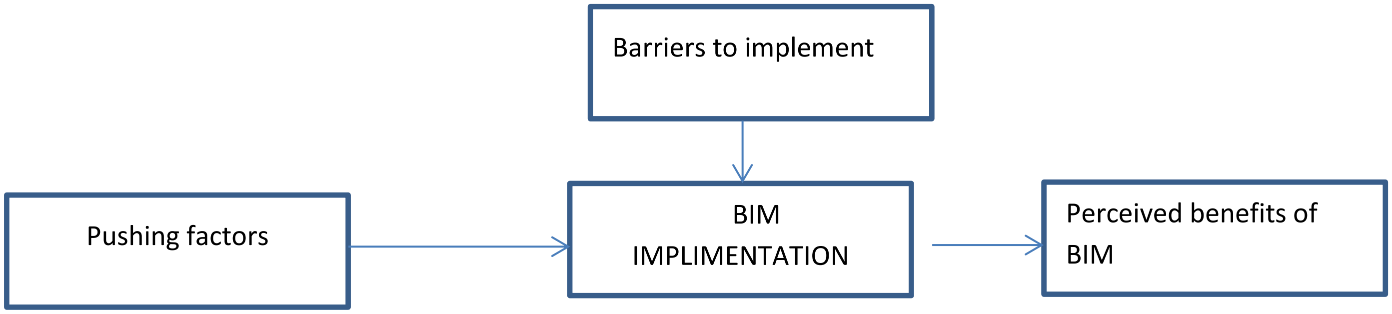

Fig 2.1 conceptual framework

CHAPTER THREE

METHODOLOGY

3.1 RESEARCH DESIGN

The thesis focused on the assessment of Building Information Modeling implementation in ECWC. The design to be used for the study is a descriptive .the first part of this work comprised of literature survey which was carried out to provide the background information on Building Information Modeling, and to identify the pushing factors and challenges or barriers to implement BIM. Information is obtained through literature search; this included books and articles in online materials. The second part of the study entail field survey and the main instrument employed is structured questionnaires.

3.2 RESEARCH APPROACH

This paper will used quantitative research approach. The obtained data collected by questionnaire is analyzed using statistical analysis to rank the factors and to identify the key factors.

3.3 METHOD OF DATA COLLECTION

This research consisted two phases .The first phase utilizes an extensive literature review to build a deep understanding and to cover the research scope. The second phase consists of, a questionnaire to investigate the research questions raise.

The structured questionnaire are distributed via mail and on hardcopy

3.4 DATA SOURCE AND INSTRUMENT

The research has relied on primary data sources. The primary sources involve self-administered questionnaires. The questionnaire is used because the research considers it to be more convenient as respondents could answer at their convenience. The questionnaire developed is based on the research questions and the literature the questionnaire begun with an introductory statement.

3.5 SAMPLING TECHNIQUE AND SIZE

The population of this research is professionals (engineers, architects, quantity surveyors…) working in ECWC.

The total number of professionals in the company is 81 who are working in projects located in ADDIS ABABA at head office. To use a statistical equation to calculate the sample size is not convenient since the population is small. Therefore census is used.

3.6 DATA ANALYSIS METHOD

From the collected data the weighted mean as a descriptive statistical analysis which is based on the items relative importance is used to rank the pushing factors and barriers to implement.

An inferential statistical test ONE WAY ANOVA a parametric statistical tool is used to investigate the differences in the perception of different respondent group.

3.7 RELIABILITY

Reliability is the overall internal consistency measure. The acceptance value for alpha if it equals to 0.70 or higher (Mirghani, 2016).

The Cronbach's alpha value for the study was 0.868 which is higher than the minimum threshold of 0.7 which implies the data collected from the questionnaire is reliable.

Table 3.1 Reliability

QUESTIONS	**Cronbach's alpha coefficient value**
Pushing factor to implement BIM	0.944
Barriers to implement BIM	0.792

3.8 VALIDITY

Validity is technical terms that refer to the objectivity and credibility of a research project. (Silverman, 2016). Validation of the data collected takes place throughout the process of data collection and analysis .since validity is one of the strengths of research as it defines the correctness of the information from the perspective of all the stakeholders of the research. In this research the logical process of constructing knowledge through brain storming is essential in providing concrete validity (Weston, et al., 2001). Furthermore, the questions in this research were developed from multiple literatures in the field of BIM.

3.9 ETHICAL CONSIDERATIONS

‘Some important ethical concerns that should be taken into account while carrying out research are: anonymity, confidentiality and informed consent’ (Sanjiri, et al., 2014, p. 1, my italics). Anonymity was achieved by not using any names of participants that contributed to this research; the participants were assigned codes in the transcription to maintain the anonymity (Saunders, et al., 2009) throughout the research. Additionally, no names or any other personal information will be used or distributed while making the presentation of the research. As part of keeping the confidentiality of the participants, no personal information was taken

Munhall (1988) argues that describing the experiences and information collected from participants in the most faithful manner is an ethical obligation to any researcher. This research has taken all the steps to keep the information true to its origin and has not been altered in terms of the meaning they carry.

CHAPTER FOUR

RESULT AND INTERPRETATION

4.1 INTRODUCTION

This chapter contains both analyses results and their interpretations. Under the descriptive statistics, the trends and overall performances of the variables are presented. The statistical tools such as tables, charts and graphs are used to describe the variables.

4.2 RESPONDENTS GENERAL INFORMATION

Respondent's position

The received responses are 74 from a total of 81 distributed questionnaires from which 2 responses are incomplete. This implies the response rate is 91.35%.

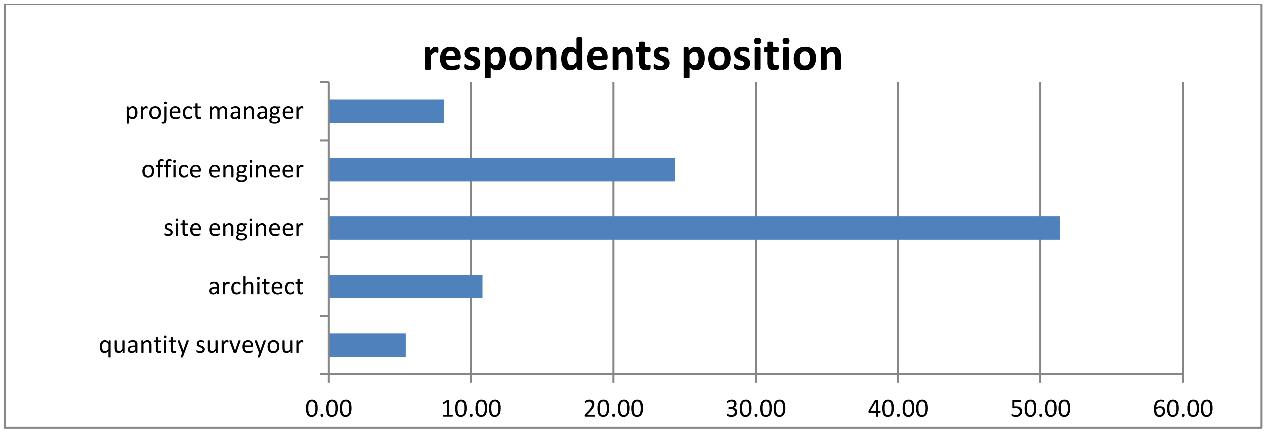

FIGURE 4.1 RESPONDENTS POSITION

From the respondents position the majorities are site engineers with 51.35% followed by office engineers 24.32%.

Respondent’s educational level

Most of the respondents’ educational level is B.Sc. (69.85%) and the rest of respondents are MSc holders with 24.32% share from the total

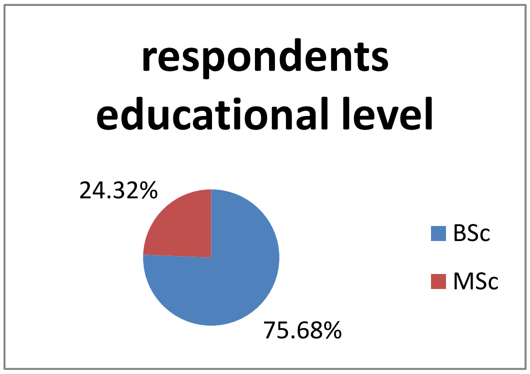

FIGURE4.2 RESPONDENTS EDUCATIONAL LEVEL

Respondents work experience

Most of respondent’s years of experience are 1-5 years (60.81%) the remaining 36.49% have 6-10 years of experience and 2.7% of the respondents have 11-15 years of experience.

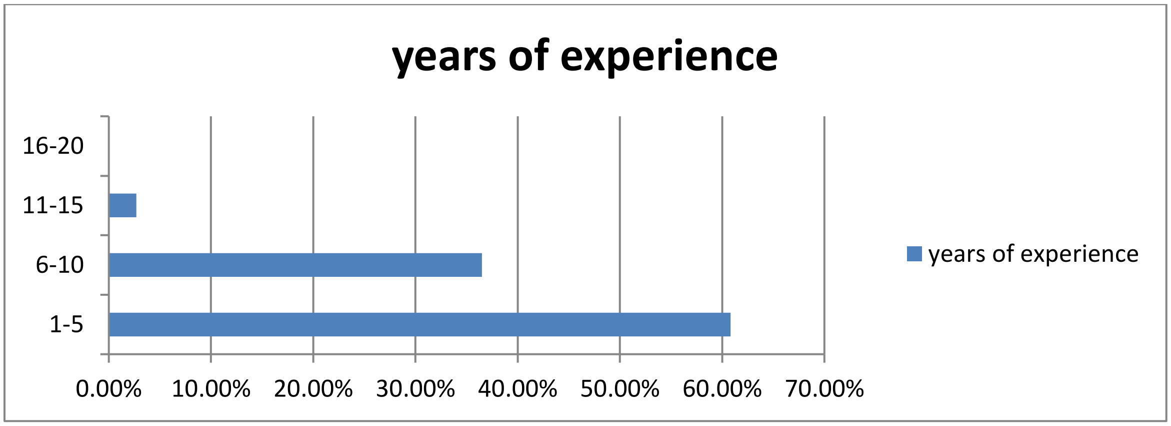

FIGURE 4.3 RESPONDENTS WORK EXPERIENCE

4.3 REASON FOR NOT USING BIM

As obtained from the questionnaire result, there is no BIM practice in ECWC and the reason for not using BIM is summarized in the table below.

TABLE 4.1 REASONS FOR NOT USING BIM

REASON	FREQUENCY	PERCENTAGE
Lack of awareness	26	16.88%
No pushing force to implement	43	27.92%
Cost of implementation is high	12	7.79%
Satisfied with the existing software	31	20.13%
Perceived benefits of BIM are unknown	23	14.94%
BIM is complicated	19	12.34%

The largest percent reported is for" No pushing force to implement" which is 27.92%.Hence, this percentage implies raising the pushing force influence the BIM adoption and implementation. And the second largest percentage shows that respondents are satisfied with the existing software. Therefore the advantage of BIM over the existing software should be described briefly. And also the reason that there is "lack of awareness" implies that raising of awareness through promotion or other means will have a positive effect on BIM implementation.

4.4 PUSHING FACTORS

Based on the response the weighted mean and standard deviation are calculated in order to rank and identify the key pushing factors to implement BIM and presented in figure 5.

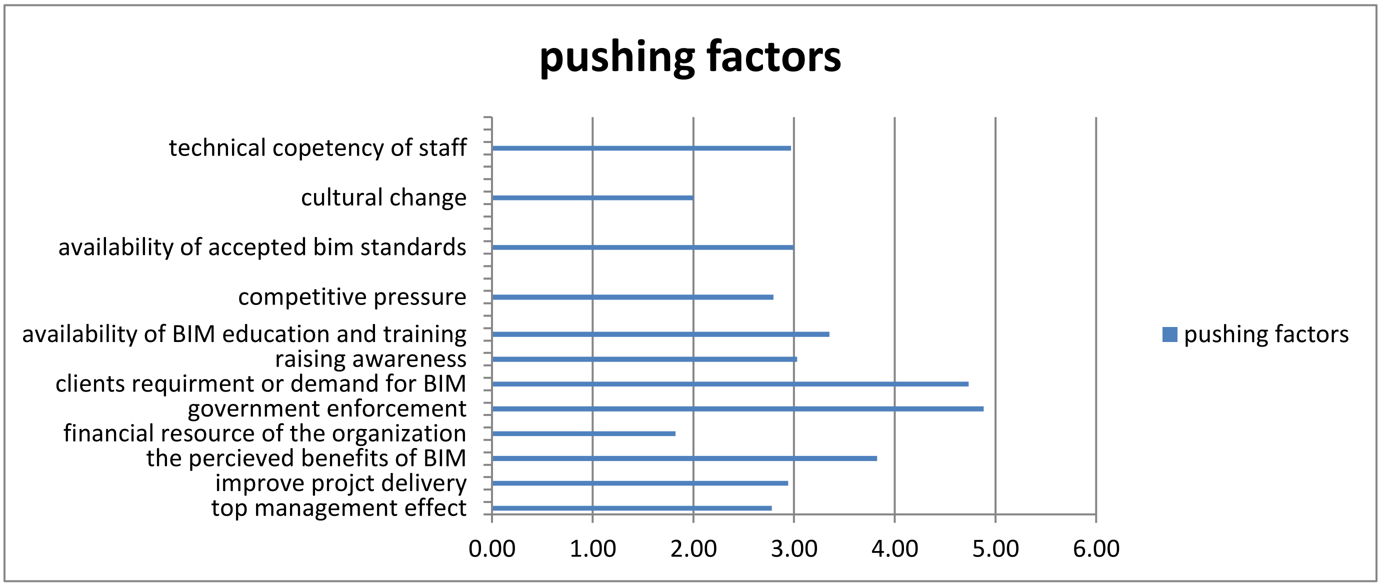

FIGURE 4.4 PUSHING FACTORS

From the above listed factors, the key pushing factors are identified in the table below.

TABLE 4.2 KEY PUSHING FACTORS

KEY PUSHING FACTORS								
pushing factors	Strongly agree	Agree	Neutral	Disagree.	Strongly disagree	weighted mean	standard deviation	rank
Government enforcement	62	4	2	0	0	4.88	0.993	1
	91.18%	5.88%	2.94%	0.00%	0.00%			
Client requirement or demand for BIM application	56	10	0	0	2	4.74	0.975	2
	82.35%	14.71%	0.00%	0.00%	2.94%			
The	14	42	0	10	2	3.82	0.895	3

perceived benefit of BIM	20.59%	61.76%	0.00%	14.71%	2.94%			
Availability of BIM education and training	0	34	24	10	0	3.35	0.886	4
	0.00%	50.00%	35.29%	14.71%	0.00%			
Raising of awareness e.g. promotion	0	26	22	16	4	3.03	0.881	5
	0.00%	38.24%	32.35%	23.53%	5.88%			

From the above table it is clearly identified that the key pushing factors are government enforcement ,client demand ,perceived benefits of BIM ,availability of BIM education and training and awareness whose mean and standard deviation ranges 4.88 and 0.993 to 3.03 and 0.88 respectively. From this result the respondents are waiting for external pushing factors (government and client) that force them to implement and use BIM in their project. This result may arise from that the respondents are from a contractor company and BIM system must be applied in the design stage, and the contractor cannot start working on BIM from scratch because of the long time required for modeling.

The other key pushing factor is BIM benefit. This implies that understanding the advantages and benefits of BIM results in using the system.

And finally increasing the BIM education and training institutes and rising of awareness may results in BIM implementation.

To investigate the differences in the perception of respondents groups, i.e. quantity surveyor, architect, site engineer, office engineer and project manager, analysis of variance (ANOVA) is performed with 95% confident and the result is presented in the following table.

TABLE 4.3 ANOVA FOR PUSHING FACTORS

Source of Variation	SS	df	MS	F	P-value	F critical
Between Groups	0.886475	4	0.221619	0.188079	0.943642	2.539689
Within Groups	64.80799	55	1.178327			
Total	65.69447	59				

From the above table the p-value is greater than the alpha value (0.05) which implies that there is no significant difference in perception between the groups.

4.5 BARRIERS TO IMPLEMENT

The following figure shows respondent's claims over barriers to implement BIM. Based on the response the weighted mean and standard deviation are calculated in order to rank and identify the key barriers to implement BIM.

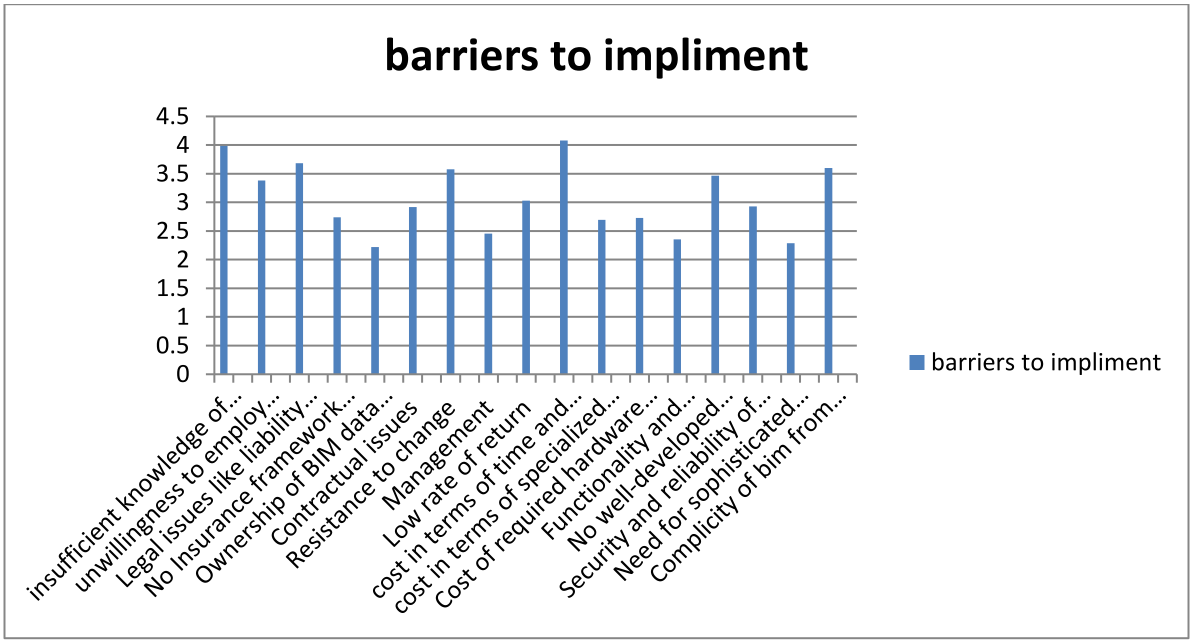

FIGURE 4.5 BARRIERS TO IMPLEMENT

From the above table the key barriers are extracted bay ranking the barriers based on their weighted mean.

Table 4.4 KEY BARRIERS

key barriers								
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Weighted mean	Standard deviation	Rank
cost in terms of time and training	18	46	6	3	0	4.08	0.607	1
	24.66%	24.66%	24.66%	24.66%	24.66%			
insufficient knowledge of BIM technology and definition	20	32	15	3	0	3.99	0.599	2
	28.57%	28.57%	28.57%	28.57%	28.57%			
Legal issues like liability issues, need for regulation and intellectual property	13	34	16	7	2	3.68	0.578	3
	18.06%	18.06%	18.06%	18.06%	18.06%			
Complicity of BIM from existing software	9	37	17	6	3	3.6	0.574	4
	12.50%	12.50%	12.50%	12.50%	12.50%			
Resistance to change	11	29	21	10	0	3.58	0.573	5
	15.49%	15.49%	15.49%	15.49%	15.49%			

From the above table it is clearly identified that the key barriers are cost in terms of time and training, insufficient knowledge of BIM technology and definition, Legal issues like liability issues, need for regulation and intellectual property, Complicity of BIM from existing software and Resistance to change whose mean and standard deviation ranges 4.08 and 0.607 to 3.57 and 0.573 respectively.

To investigate the difference sin the perception of respondents groups, i.e quantity surveyor, architect, site engineer, office engineer and project manager, analysis of variance (ANOVA) is performed with alpha 0.05 and the result is presented in the following table.

TABLE 4.5 ANOVA FOR BARRIERS TO IMPLEMENT

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	11.7622	4	2.94055	3.829662	0.00672	2.485885
Within Groups	61.42683	80	0.767835			
Total	73.18903	84				

As the table shows the p- value which is 0.00672 is less than the alpha value 0.05.this implies that there is a significant difference between the groups.

TABLE 4.6 ROLES OF GOVERNMENT

ROLE OF GOVERNMENT	FREQUENCY	PERCENTAGE
enforce stakeholders to use BIM	33	27.97%
start BIM implementation from public projects	41	34.75%
set policy	29	24.58%
promoting BIM user companies	12	10.17%
Should not be involved	3	2.54%

From the above table showing the results on the role of government to BIM implementation implies that first implementing BIM on public projects have the highest percentage followed by enforcement of stakeholders to use BIM and setting policy for BIM implementation

And the table below shows that most of the respondents believed that BIM should be implemented soon.

TABLE 4.7 BIM IMPLEMENTATION

BIM should start implemented soon		
response	frequency	percentage
yes	51	68.92%
No	23	31.08%
	74	100.00%

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECCOMENDATION

This chapter as a whole presents the summary of findings, concluding remarks for the main findings in chapter four and important recommendations respectively.

5.1 SUMMARY OF FINDINGS

The research found that there is no BIM practice in the company (ECWC).

The questionnaire respondents ordered the key factors pushing the BIM implementations as (1)Government enforcement (2) Client requirement or demand for BIM application (3)The perceived benefit of BIM (4)Availability of BIM education and training (5)Raising of awareness e.g. promotion

Parallel to the literature and questionnaire respondents identified the barriers as;(1) cost in terms of time and training (2)insufficient knowledge of BIM technology and definition (3)Legal issues like liability issues, need for regulation and intellectual property (4)Complicity of BIM from existing software (5)Resistance to change.

In finding the key pushing factors for BIM implementation there is no significant difference in respondents group whereas in case of identifying barriers there is a difference in respondents group.

Questionnaire respondents identified the role of government on BIM implementation as (1) enforce stakeholders to use BIM with 34.75% (2) start BIM implementation from public projects with 27.97% and (3) set policy with 24.58%.

And finally the questionnaire respondents suggested that the company (ECWC) should start implementing BIM soon.

5.2 CONCLUSIONS

BIM technology has showed a very quick development over the last decade. It has been widely used in many large construction projects in developed countries, which have showed that great benefits can be obtained by implementing BIM. However, there must be enough pushing factor to implement BIM and there are many barriers limiting the application of BIM.

According to the findings of this research the main pushing factors to implement BIM comes from the external factors which are government enforcement and client's requirement for BIM. Therefore government should enforce to use BIM and encourage companies who have implemented BIM.

For internal pushing factors which are the perceived benefits of BIM, education and training availability and rising of awareness, a strong and aggressive promotion work should be done for consultants, contractors, public institutes, universities and other parts in the construction industry.

The process of finding barriers has resulted in identifying the key barriers which are

- cost in terms of time and training
- insufficient knowledge of BIM technology and definition
- Legal issues like liability issues, need for regulation and intellectual property
- Complicity of BIM from existing software
- Resistance to change

5.3 RECOMMENDATIONS

The adoption of BIM by the AEC industry requires a broader framework of laws and regulations to structure the use of the technology throughout the chain of services and professionals involved in the building process. The participation of academic institutions is a fundamental phase not only offering the necessary knowledge during professional education but also as a research hub, functioning as a resource to AEC industry in general. On the other end of this spectrum, laws and regulations are important mechanisms that need to be implemented fostering a business environment in which the incremental management of building data becomes a valuable condition throughout the construction industry.

The government can play a massive role to present convenient practical strategic plans for BIM implementation by providing a timeframe to mandate BIM as an obligatory requirement in the AEC industry projects. Also, the government could support the entities to overcome the barriers that hinder the BIM implementation. For instance, the government can aid entitles to overcome the initial BIM implementation cost, providing insurance for companies who implemented BIM, setting implementation standards and policy.

Organizational decision makers have to support the staff (for example train the staff (short term), and put strategic plans to implement BIM. Every individual has to improve his/her BIM competencies. These results help every project parties to be highly aware of BIM and understand its benefits, barriers and the main push factors to implement BIM

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APPENDIX

QUESTIONNAIRE

ST. MARY'S UNIVERSITY
SCHOOL OF GRADUATE STUDIES

BUILDING INFORMATION MODELING (BIM) PROJECT IMPLEMENTATION ASSESSEMENT: the case of ETHIOPIAN CONSTRUCTION WORKS CORPORATION (ECWC)

Greetings to all,

The following questionnaire targets to investigate the pushing factors for the implementation of building information modeling (BIM) and barriers to implement BIM in ETHIOPIAN CONSTRUCTION WORKS CORPORATION (ECWC), it is a part of my dissertation required Master of Arts in Project Management of Saint Mary's University.

The collected information from this questionnaire will be used for scientific research only. Therefore, i am looking for your assistance to collaborate with each other to make an immense contribution. You are kindly requested to reply the following questions with level of accuracy.

Thanks a lot for your highly appreciated support.

Sincerely

Million Bayou
Email;moviliab83@gmail.com

I appreciate your effort.

PART 1 Questions related to you and your company

1. Which of the following best describes your company?

Local authority ☐

Consultancy ☐

Contractor ☐

Architectural practice ☐

2. Select the size of your company

1-20 Employees ☐

21-50 employees ☐

51-100 Employees ☐

101-200 Employees ☐

>201 Employees ☐

3. What is your educational status

BSc ☐

MSc ☐

PHD ☐

4. What is your role in the company?

Quantity surveyor ☐

Architect ☐

Engineer ☐

Site manager ☐

Project manager ☐

5. How many years hove you worked as a professional?

1-5 years ☐

6-10 Years ☐

11-15 Years ☐

16-20 Years ☐

>21 Years ☐

PART 2 implementation of BIM

6. Are you currently using BIM?

Yes ☐ No ☐

7. Is there a project in your company which uses BIM??

Yes ☐ No ☐

If yes, indicate the cost of the project

☐ <5 million birr

☐ 6-20 million birr

☐ 21-50 million birr

☐ 50-100 million birr

☐

101-200 million birr

☐ >201 million birr

If no why do you think BIM is not implemented?(multiple selection is possible)

☐ Lack of awareness

☐ No pushing force to implement

☐ Cost of implementation is high

☐ Satisfied with the existing software

☐ Perceived benefits of BIM are unknown

☐ BIM is complicated

PART 3 PUSHING FACTORS

8. How do you explain the following factors that they can push BIM implementation

statement	**Strongly agree**	**agree**	**neutral**	**disagree**	**Strongly disagree**
Top management effect					
To improve project delivery					
The perceived benefit of BIM					
Financial resource of the organization					
Government enforcement					

Client requirement or demand for BIM application					
Raising of awareness e.g. promotion					
Availability of BIM education and training					
Competitive pressure					
Availability of accepted BIM standards					
Cultural change					
Technical competency of staff					

9. How do you explain the following factors that are challenges or barriers for BIM implementation?

Statement	**strongly agree**	**agree**	**neutral**	**disagree**	**strongly disagree**
insufficient knowledge of BIM technology and definition					

unwillingness to employ the new technology					
Legal issues like liability issues, need for regulation and intellectual property					
No Insurance framework for BIM applicant					
Ownership of BIM data and its copyright					
Contractual issues					
Resistance to change					
Management					
Low rate of return					
cost in terms of time and training					
cost in terms of specialized software					
Cost of required hardware upgrade					

Functionality and accessibility of BIM tool					
No well-developed practical strategies and standards					
Security and reliability of BIM					
Need for sophisticated data management					
Complicity of BIM from existing software					

10. What should be the role of government in implementing BIM?(multiple selection is possible)

- ☐ Set policy
- ☐ Enforce stakeholders to apply BIM
- ☐ Start implementing first from public projects
- ☐ Promoting BIM user companies
- ☐ Should not be involved

11. Do you think BIM should be implemented soon?

Yes ☐ no ☐

PUSHING FACTORS RANK RESULT

pushing factors	strongly agree	agree	neutral	disagree	strongly disagree	weighted mean	standard deviation	rank
Top management effect	0	6	45	13	4	2.78	0.89	10
	0.00%	8.82 %	66.18 %	19.12%	5.88%			
To improve project delivery	0	14	36	18	0	2.94	0.88	8
	0.00%	20.59 %	52.94 %	26.47%	0.00%			
The perceived benefit of BIM	14	42	0	10	2	3.82	0.9	3
	20.59%	61.76 %	0.00%	14.71%	2.94%			
Financial resource of the	0	0	4	48	16	1.82	0.96	12
	0.00%	0.00 %	5.88%	70.59%	23.53%			

organization								
Government enforcement	62	4	2	0	0	4.88	0.99	1
	91.18%	5.88%	2.94%	0.00%	0.00%			
Client requirement or demand for BIM application	56	10	0	0	2	4.74	0.97	2
	82.35%	14.71%	0.00%	0.00%	2.94%			
Raising of awareness e.g. promotion	0	26	22	16	4	3.03	0.88	5
	0.00%	38.24%	32.35%	23.53%	5.88%			
Availability of BIM education and training	0	34	24	10	0	3.35	0.88	4
	0.00%	50.00%	35.29%	14.71%	0.00%			
Competitive	0	16	28	18	6	2.79	0.89	9

pressure	0.00%	23.53%	41.18%	26.47%	8.82%			
Availability of accepted BIM standards	0	32	18	4	14	3	0.88	6
	0.00%	47.06%	26.47%	5.88%	20.59%			
Cultural change	0	0	14	40	14	2	0.94	11
	0.00%	0.00%	20.59%	58.82%	20.59%			
Technical competency of staff	0	16	38	10	4	2.97	0.88	7
	0.00%	23.53%	55.88%	14.71%	5.88%			

BARRIER RANK RESULTS

barriers	Strongly agree	Agree	Neutral	Disagree.	Strongly disagree	weighted mean	standard deviation	rank
insufficient knowledge of BIM technology and definition	20	32	15	3	0	3.985714	0.599084	2
	28.57%	45.71%	21.43%	4.29%	0.00%			
unwillingness to employ the new technology	13	23	20	13	4	3.383562	0.565527	7
	17.81%	31.51%	27.40%	17.81%	5.48%			
Legal issues like liability issues, need for regulation and intellectual	13	34	16	7	2	3.680556	0.578222	3
	18.06%	47.22%	22.22%	9.72%	2.78%			

property								
No Insurance framework for BIM applicant	6	14	19	23	11	2.739726	0.565796	11
	8.22%	19.18%	26.03%	31.51%	15.07%			
Ownership of BIM data and its copyright	0	8	23	18	23	2.222222	0.593215	17
	0.00%	11.11%	31.94%	25.00%	31.94%			
Contractual issues	5	21	22	13	12	2.917808	0.561862	10
	6.85%	28.77%	30.14%	17.81%	16.44%			
Resistance to change	11	29	21	10	0	3.577465	0.572933	5
	15.49%	40.85%	29.58%	14.08%	0.00%			
Management	1	10	26	20	16	2.452055	0.578205	14
	1.37%	13.70%	35.62%	27.40%	21.92%			

Low rate of return	2	22	29	16	4	3.027397	0.560904	8
	2.74%	30.14%	39.73%	21.92%	5.48%			
cost in terms of time and training	18	46	6	3	0	4.082192	0.607207	1
	24.66%	63.01%	8.22%	4.11%	0.00%			
cost in terms of specialized software	3	19	13	27	10	2.694444	0.56726	13
	4.17%	26.39%	18.06%	37.50%	13.89%			
Cost of required hardware upgrade	0	8	43	16	6	2.726027	0.566219	12
	0.00%	10.96%	58.90%	21.92%	8.22%			
Functionality and accessibilit	4	16	0	35	18	2.356164	0.583938	15
	5.48%	21.92%	0.00%	47.95%	24.66%			

y of BIM tool								
No well-developed practical strategies and standards	12	24	25	10	2	3.465753	0.568254	6
	16.44%	32.88%	34.25%	13.70%	2.74%			
Security and reliability of BIM	2	22	19	23	4	2.928571	0.561718	9
	2.86%	31.43%	27.14%	32.86%	5.71%			
Need for sophisticated data management	0	4	27	28	14	2.287671	0.5885	16
	0.00%	5.48%	36.99%	38.36%	19.18%			
Complicity	9	37	17	6	3	3.597222	0.573875	4

of BIM from existing software	12.50%	51.39%	23.61%	8.33%	4.17%			

DECLARATION

I, **MILLION BAYOU TADDESSE**, would declare this thesis is my original work prepared under guidance of **BUSHA TEMESGEN (PhD)**. All source materials utilized for this thesis exertion have been duly recognized. I similarly confirm that this thesis hasn’t be given to either partially or entirely too any other learning institutions for obtaining any degree.

Million Bayou Taddesse ___________________________

Name Signature

St. Mary’s University, Addis Ababa, **August, 2020**

ENDORSEMENT

This thesis has been submitted to St. Mary's University, School of Graduate Studies for examination with my approval as a university advisor.

BUSHA TEMESGEN (PhD) ____________________

Advisor Signature

St. Mary's University, Addis Ababa August, 2020