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إمكانية تطبيق نمذجة معلومات المباني في تقدير تكاليف المشاريع في السودان

Applicability of Building Information Modeling In Project Cost Estimation in Sudan

A Thesis Submitted In Partial Fulfillment of Requirements for the Degree of Master of Science in Civil Engineering (Construction engineering)

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Abstract

So far, the construction industry in Sudan lacks and need to what can made it become the most important sector that help in the recovery of the economy of Sudan. In the last years the construction industry witnessed the appearance of new techniques to help in that. The most of these techniques are Building Information Modeling (BIM) which is considered universally as the best commander of the construction industry.

This research is based on introducing Building Information Modeling to the construction industry in the Sudan in an attempt to improve profits from it in all its aspects, spread awareness of the Building Information Modeling (BIM) among Architects, Engineers, and Contractors (AEC), industry stockholders, and to examine some of the barriers, as well as to access the benefits of BIM when applied to the cost estimation which is the most important elements of the project management.

In this study bibliography on Building Information Modeling taken from studies and research (literary magazines, articles or wrote for the paper, conferences and theses) is presented focusing on assessing the construction costs and benefits of the application of the BIM. This is extrapolated by a questionnaire as a tool for the data collection, where the distribution covered 92 audients. The questionnaire was distributed electronically through a site offering such services and has ousted 8 Questionnaires because of incomplete and the existence of some of the respondents who do not belong to the population.

The study focuses on the construction cost estimation and benefits of the implementing BIM. The benefit of Building Information Modeling that has been tested appeared that applicability of Building Information Modeling in Sudan is possible which that would be the lead to reform the problems that facing the construction industry in Sudan.

At last, the outcome of this research encourages all parties concerned in the construction industry to pay more interest in training, studies and research on buildings information Modeling . Finally, it is concluded that governments have a very important role in promoting the process of the application.

المستخلص

حتى الان، افتقار صناعة التشييد في السودان الى ما يمكن ان يجعلها رائده لكي تصبح اهم القطاعات المساعده في انتعاش الاقتصاد السوداني. ففي السنوات الاخيره شهدت صناعة التشييد ظهور تقنيات حديثه ساعدت على ذلك. اكثر ماتم تداوله حديثا هو نمذجة معلومات المباني حيث اعتبر عالمياً القائد الافضل لصناعة التشييد.

عمد هذا البحث الى تقديم نمذجة معلومات المباني الى صناعة التشييد في السودان في محاوله لتحسينها في جميع جوانبها المختلفه و نشر الوعي عن نمذجة معلومات المباني بين افراد صناعة التشييد من معماريين ومهندسيين ومقاولين وحتى اصحاب العمل ودراسة بعض العوائق التي من شأنها ان تعيق تطبيق نمذجة معلومات المباني، وايضا الوصول الى الفوائد التي تحققها نمذجة معلومات المباني عند تطبيقها في حساب التكلفة التي هي عنصر في اداره المشروع.

شملت هذه الدراسة مراجعه مختصره عن نمذجة معلومات المباني أُخذت من دراسات وبحوث ادبية (المجلات، مقالات او كتب ورقة والمؤتمرات الاطروحات) حيث عرضت بالتركيز على تقدير تكاليف البناء وفوائد تطبيق البيم عليها، وتم الاستعانه بالاستبيان كأداة لهذا لجمع البيانات، حيث غطى التوزيع 92 شخص . الاستبيان وزع الكترونيا عن طريق موقع يوفر الخدمه حيث تم إقصاء 8 استبيانات بسبب عدم إكتمالها ووجود بعض المستجيبين لا ينتمون لمجتمع العينه.

ركزت هذه الدراسة على بناء تقدير التكاليف وفوائد تطبيق نمذجه معلومات المباني .فقد تم التوصل من الفوائد التي تم اختبارها انه يمكن تطبيق نمذجه معلومات المباني لاصلاح المشاكل التي تواجه صناعة التشييد بتطبيق نمذجة معلومات المباني بصوره فعاله ، وبالاضافة الى ذلك، تشجع جميع الاطراف المعنية فى صناعة التشييد على إبداء المزيد من الإهتمام بالتدريب و الدراسات والابحاث عن نمذجة معلومات المباني والفوائد المترتبه من تطبيقها في مختلف جوانب الصناعة، ان للحكومات دور مهم جداً في تشجيع عملية التطبيق.

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Dedication

To my father, mother, brothers and
To my all friends
To my country-be better
and
To all those who are dreaming of a better future
I dedicate this work

Acknowledgements

First of all, I am grateful to ALLAH the Almighty for all blessings in this life and for giving me power and ability that were necessary to achieve this goal. All thanks and praises are due to ALLAH "Al-hamdulillah".

Would like to give all my appreciation to Dr.Salah Ajaban for supervising this research and helped to make it successes.

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I would like to express my very great appreciation to Sudanese Researchers Initiative represented in Dr. Omayma Hashim you are amazing woman thank you for mentoring my research and for your support.

Last but not the least; there are no words to describe how I'm so grateful to my beloved Father Engineer/ Ismail Abdul-Gadir and my beloved Mother Mrs. Samia Adam and my brothers Engineer\ Saif Eleslam, Dr\ Ahmed, Dr\ Ayman and Ashraf for the endless encouragement, support and attention throughout all my studies at university, and especially while writing this research. As well, my profound thanks must be expressed to my best friend Engineer\ Ahmed Yahiya and my best friend and sister Engineer\ Rabab Hamid.

SAMAR ISMAIL

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List of Abbreviations

Abbreviation	The interpretation of the abbreviation
AEC	Architecture, Engineering, and Construction
BIM	Building Information Model/ Modeling / Management
CAD	Computer Aided Design
D	Dimensional
2D	Two dimensions: x, y
3D	Three-dimensional: x, y, z (the height, length and width)
4D	Four-dimensional; 3D model connected to a time line (fourth dimension)
5D	Five-dimensional; 4D model connected to cost estimations (fifth dimension)
6D	Six-dimensional; 6D model which is 5D plus site (sixth dimension)
7D	Seven-dimensional; 7D model: BIM for life cycle facility management (seventh dimension)
nD	a term that covers any other information
QS	Quantity Surveyors
US	United States
FM	Facilities Management CSCM Construction
USA	United States of America
GIS	Geographic Information System
GDP	Growth Domestic Product

Chapter one

Introduction

1.1 Preamble:

Since many years ago construction industry in Sudan is developing slowly and while many changes happened around the world. The construction industry needs effective methods for gathering and utilizing performance information on industry, company, and individual project levels (Kärnä and Junnonen, 2016). Mohamed, 2015 mentioned that the construction industry in Sudan faces many problems and obstacles, such as: shortage of materials, fluctuation of construction materials prices, inaccurate estimation of the time, defects during the process of construction, cost overrun, too much pressure on project stakeholders, etc. Recently, a lot of technologies that would improve the construction process appeared. Latest of these technologies and the popular one is Building Information Modeling (BIM).

The United States' National Institute of Building Sciences (NIBS) defines BIM as "a digital representation of physical and functional characteristics of a facility. BIM is a revolutionary technology and process that has quickly transformed the way buildings are conceived, designed, constructed and operated (Hardin, 2009). This research gives a review about implementing BIM in construction sector and that will give solution for most of the sectors' problems.

Implementing BIM on cost estimation leads to accurate cost which leads to project success. The research begins with a (literature review about BIM) general introduction of BIM technology and the different ways it works compared with traditional CAD (Computer Aided Design) method, BIM application, measures the level of awareness in BIM and continues with evaluation of BIM tools.

1.2 Research Problem Statement and Rationale for the Research:

In the developing world, and more specifically in Sudan cost estimation is made with low accuracy, and the traditional cost estimation has been seen to fail to meet the expectations of project's clients. The outcome is that the construction regulations and the national development are suffering as a result of poor building information. Undoubtedly, the need to plan ahead in order to control the project completion is vital, since many of the low accuracy of cost estimation experience is quite substantial.

1.3 Research Objectives:

The research aims to identify the cost estimation tool that used in construction projects by implementing the Building Information Modeling (BIM). To fulfill this aim, several objectives must be achieved, and these are given as follows:

1 To define BIM and review how the construction industry has evolved to embrace its use,

2 To conduct an extended literature review of BIM applications in construction cost estimation.

3 To investigate the effects benefit of BIM on cost estimation

4 To find if there applicability of Building Information Modeling in cost estimation in Sudan.

1.4 Research Questions:

Basically, the objectives are designed to answer the following research questions:

- Do construction companies in Sudan implement BIM?
- Do construction companies in Sudan identify and assess any failures behind cost estimation with regard to accuracy at any stage of the project life cycle.
- Do construction companies identify any key success factors of BIM application to mitigate any project failures and to achieve efficiency?
- Do construction organizations use any frameworks or models based on BIM to enhance their cost estimation and control it during project implementation?

1.5 Research Importance:

The research is of importance in two main areas: It will raise the construction team expectations in terms of effective cost estimation and development strategy in Sudan and for any developing country. The findings will guide construction organizations in the Sudan and the region, particularly Construction project managers and practitioners to abandon inappropriate cost estimation processes and tools, and implement better technology in the field. Then, it will improve and open a new area of cost estimation accuracy research and contribute to enhance knowledge in the profession.

1.6 Research Hypothesis:

1. Construction industry members in Sudan have little level of awareness about BIM
2. based on the obstacles that faced construction industry in Sudan,

BIM might be solving A lot of these problems specially when

3. The benefits that will return from implementing BIM in cost estimation.

1.7 Research Methodology:

In order to achieve the objectives outlined above and answer the associated research questions, a qualitative approach is chosen in which a detailed literature review will be conducted in the first instance to identify the current gap on cost estimation practice. From the literature review the very complex nature of BIM applications for cost estimation will be investigated, and from this understanding, a questionnaire will be devised for professionals in construction organizations in the Sudan. Hence, the emphasis will be on qualitative methods of data collection in respect of the some suitable analysis tool. The sample will be guided by the criterion stipulated for cases in different construction companies that have been affected by the low cost estimation accuracy and late project completion.

2 Chapter two

Literature review

2.1 Review over construction industry

2.1.1 Introduction:

In this chapter present the different opinions about construction industry definition from different authors related to different aspect are presented.

2.1.2 Definition:

Construction can be defined as an activity of the physical structure of infrastructure; superstructure and related facilities (Wells 1984).The activities include the procuration of raw materials, the manufacturing of construction materials and components (Plescis 2002). We can say According to (UK Standard Industrial Classification of Economic Activities 2007) this industry definition includes general construction and allied construction activities for buildings and civil engineering works. It includes new work, repair, additions and alterations, the erection of prefabricated buildings or structures on the site and also construction of a temporary nature.

General construction is the construction of entire dwellings, office buildings, stores and other public and utility buildings, farm buildings etc., or the construction of civil engineering works such as motorways, streets, bridges, tunnels, railways, airfields, harbors and other water projects, irrigation systems, sewerage systems, industrial facilities, pipelines and electric lines, sports facilities etc. This work can be carried out on own account or on a fee or contract basis. Portions of the work and sometimes even the whole practical work can be subcontracted out. A unit that carries the overall responsibility for a construction project is classified here. Also included is the repair of buildings and civil engineering works.

Also, the construction industry can be defined as,

"the sector of an economy which, plans, designs, construction, alters, maintains, and eventually demolishes buildings of all kinds of civil engineering structures and other similar works" (Ofori 1990).

The international Standard Industrial Classification of all Economic Activities (1968, pp. 35-36) defines construction as follows:

“. Constructing, altering, repairing and demolishing building; constructing, altering and repairing highways and streets and bridges, ...and other types of heavy construction...mining services such as preparing and constructing mining sites and drilling crude oil and natural gas wells... specialist trade contractors'... activities...'

"The assembly and installation on site of prefabricated, integral parts into bridges, water tanks, storage and warehouse facilities,...Departments or other units of the manufactures of the fabricated parts and equipment which specialize in this work and which it is feasible to treat as separate establishments, as well as business primarily engaged in the activity, are classified in this group.

The international council for research and innovation in building and construction agenda 21 for sustainable construction in developing countries (Plessis, 2002) defines construction as:

"The board process/mechanism for realization of human settlements and the creation of infrastructure that supports development. This includes the extraction and benefaction of row materials, the manufacturing of construction project cycle from feasibility to deconstruction and the management and operation of the built environment".

Construction industry contains of persons and organizations that include individuals, companies, or firms working as consultants, main contractors, equipment suppliers, labors, builders, dealers, etc. (Construction industry policy 2004).

Considering the participants in the construction process, the different definitions seem to depict the industry as a progression of related yet discrete activities, persons, or organizations as shown in Fig.2.1

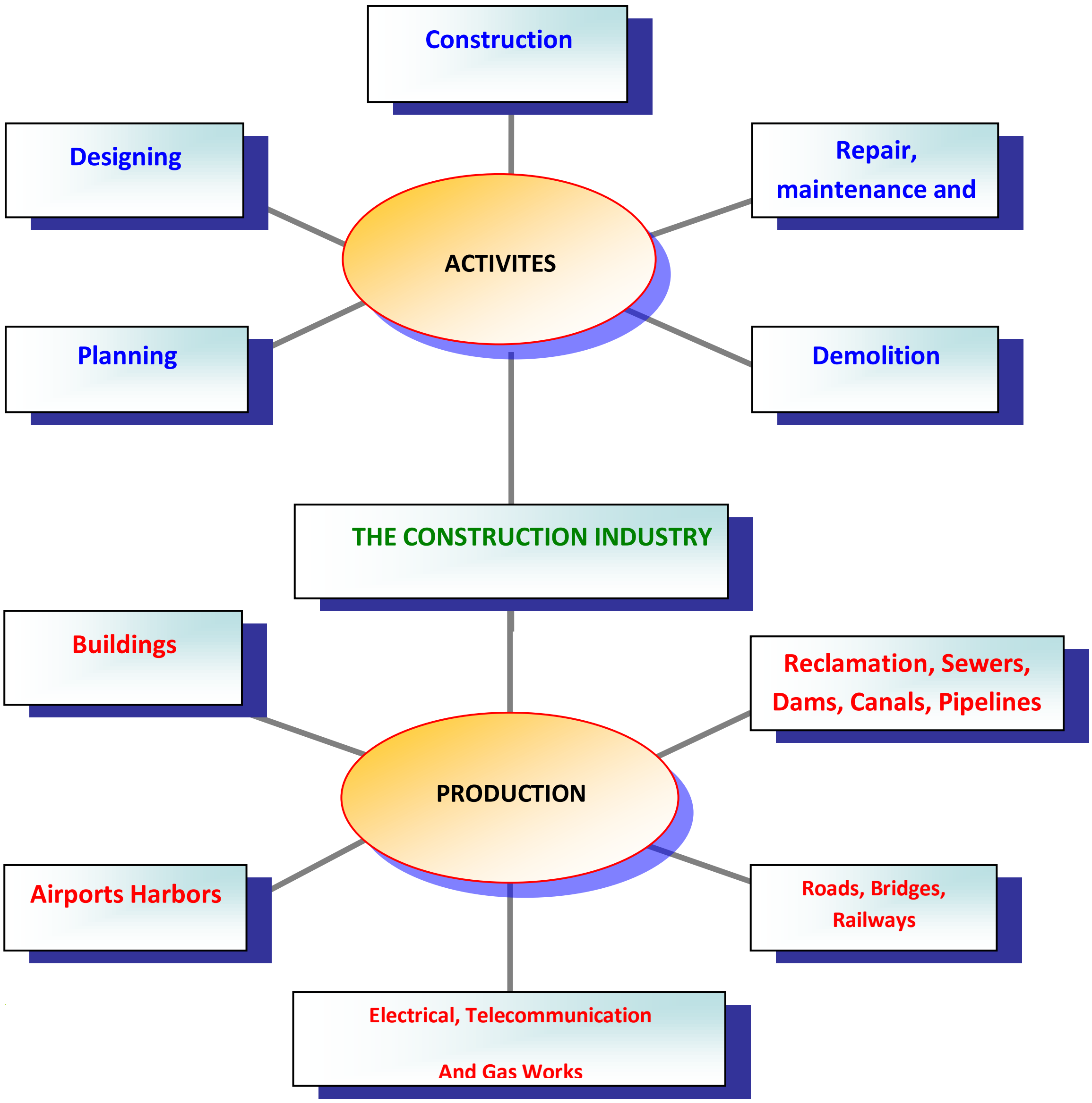

Figure 02.1The Construction Industry (Offori G., 1990, P, 20)

2.1.3 Importance of construction industry

The importance of the construction industry has also been recognized in the context of countries affected by natural hazards (Ruddock et al, 2010; Amaratunga and Haigh, 2010)

Turin, 1973; Palalani, 2000 mention that the construction industry must be satisfying the demand for:

a) Housing construction;
b) Building construction such as commercial, social uses construction; …etc.
c) Heavy engineering construction;
d) Industrial construction including factories… etc.

While the direct contributions of construction to development are significant, it also stimulates a sizeable amount of economic growth. Requirements of construction for goods and services from other industries are considerable; the development of the construction industry therefore stimulates these ancillary industries, thus encouraging for more economic growth (Moavenzadeh & Rossow 1975).

2.1.4 The role of construction industry in nation development:

Turin (1980) and Toh (1988) state that: construction industry is the only sector of the economy that it appears twice in the national accounts: under GDP and also under Gross Fixed Capital Formation (GFCF). In Europe, it accounts for some 10% of Gross Domestic Product (GDP), and in Australia it employs about 8% of the nation's workforce (Proverbs et al., 1999). Productivity and profitability increases within construction would therefore have substantial benefits to the broader economy. Stoeckel et al. (1990) reported that if the

construction industry increased its effectiveness by 10% this could lead to an increase of up to 2.5% in GDP. As well, construction is one of the sectors of the economy covered by the quarterly and annual statements of national accounts.
In the development of any country, the construction industry plays vital roles in transforming the aspirations and the needs of its people into reality by implementing various physical structures (Ahmed, 2002).
The construction industry plays an essential role in the socio economic development of a country. The activities of the industry have great significance to the achievement of national socio-economic development goals of providing infrastructure, sanctuary and employment.
The role of construction in socio-economic development has been addressed by various writers and international bodies, many of whom have focused on developing countries (Turin, 1973; World Bank, 1984; Wells, 1986; Ofori, 1990; Palalani, 2000). Turin and Wells, using cross-country comparisons, both found an association between construction investment and economic growth.

The socio-economic signature of the construction industry can be gauged from a number of global indicators. Turin (1973) carried out the most comprehensive study on the role of construction in development through studying the economics of several countries. For the purpose of international comparisons, the most significant of these and those which are more readily available are;
The Contribution of construction to GDP; about 2-3% in developing countries, 5-7% in industrialized countries.
Value added by construction; 3-5% in developing countries, 5-9% in industrialized countries
Capital formation in construction; Represents 6-9% of GDP in developing countries, 10-15% for industrial countries, with an international average of about 55% of all capital formation
The Contribution of new construction assets to GDFCF; 45-60% in all countries

Intermediate inputs from other sectors in the economy;
50-60% of construction's inputs come from other sectors in the economy
Level of imports of intermediate inputs for construction accounts for 5-8% of all imports of intermediate inputs in developing countries, about 5% of all imports.
Employment share of construction sector; 6-10% of total employment in a majority of industrialized countries, and 2-3% in the less developed countries. When employment in the delivery of materials inputs is included, the share of construction employment can account for as much as 15% and 10% in industrialized and the less developed ones respectively (Hassan, 2006).

Expenditure on building materials can be calculated at some 4-6% of the GDP (Shaddad, 1979). In Africa, Asia, and Latin America the value of imported building materials ranged from 5-8% of the total value of imports (UNCHS, 1986). Since expenditure on building materials is 35% of the gross domestic product (GDP) in developing countries, it is clear that building materials, as compared with inputs for other industries, use up a disproportionate share of foreign exchange. In less developed countries, and Sudan is one of them, however of building materials and components may contribute 20-30% of the output value (Shaddad, 1979). The role of building materials industry in socio-economic development in Sudan needs to be investigated and researched thoroughly.
The contribution of the construction industry comes from the linkage between the construction sector and the economy on one hand and the inter-sectoral linkages between construction and other sectors on the other hand (Giang & Pheng, 2011). Using input-output analysis, many researchers analyzed the performance of construction sector in comparison to other sectors showing the strength of it forward and backward linkages in different countries.

2.1.5 Construction industry in Sudan:

In perspective of these, the construction industry in Sudan has ended up one of the most dynamic sectors in the country and experienced real growth over the past few decades. However, the activities of the sector became more intense as a result of the discovery of petroleum in the nation. Construction industry is an essential part which plays a conspicuous part in both developed and developing nations through the creation of employment, provision of social infrastructures such as bridges, highways, hospitals, schools, water resources, energy, residential and commercial centers, hence, contributing to the gross domestic product (GDP) of those countries

The construction sector has been thriving in Sudan lately. The sector is benefiting from the revamping of the urban infrastructure estimated to cost some US$ 7 billion. The Merowe Dam is one of the major infrastructure projects estimated to cost some US$ 2 million, with China heavily investing in it. Another example is the US$ 500 million the new Khartoum airport. In addition, a number of new projects targeting businesses and foreign investors are coming into the country. The current capacity of cement plants in Sudan is only about 500,000 tons, whereas the overall demand is projected to rise up to 4 million tons over the next few years (Abdalrahman 2009).

The Construction everywhere, given its special problems and requirement, fAECs problems and challenges are present a long side a general situation of socio-economic stress, chronic resource shortages, institutional weaknesses and a general inability to deal with the key issues (Ofori 2000).

(Elkhalifa, A. and Shaddad, M. Y, 2008) are pointed the Factors effect in construction industry in Sudan

- Instability is the main characteristic that dominates the performance of the Sudanese Economy. Since independence and till now, a number of plans were put under application, most of these plans weren't carried out properly and hadn't follow the time schedule set for the plans. The political instability was the main reason behind the failure in the application of different economical plans. The economic instability resulted clearly on higher inflation rates, instable and fluctuations in exchange rates, and low level of investments. Similar to many developing countries, corruption has been a major characteristic of the Sudanese economic scene.

- Sudan has been in near constant conflict since it became independent in 1956. The two most extensive conflicts have been those between the North and South. The war in Southern Sudan was the most critical to the Sudanese society socially, economically and politically. A final resolution of Sudan's civil war could greatly help the country's economy, lead to the lifting of various sanctions against the country, and encourage investment by foreign companies including oil companies.

In the developing countries, these difficulties and challenges are present alongside a general situation of socio-economic stress, chronic resource shortages, institutional weaknesses and a general inability to deal with the key issues. There is also evidence that the problems have become greater in extent and severity in recent years (Ofori, 2000) The difficulties that fAEC construction industries in developing countries and the proposed solutions have been extensively investigated by the international organizations such the United Nations (1981, 1984), International Labor Office (1987), the World Bank (1984), also by Turin (1973), Wells (1986), Ofori (1990) and (Sultan &

Kajewski, 2003 & 2004). The problems and challenges that fAEC the construction and building materials industries in developing countries are common (Sultan & Kajewski, 2003), Sudan isn't an exclude. These challenges include;

- Lack of capacity of the construction sector (Du Plessis, 2002);
- Inefficiency and/or absence of regulatory instruments and professional institutions (UNCHS, 1996);
- Absence or inefficiency of quality assurance system, national standards and quality specifications; meaning that the quality of products and services (i.e building materials and labor force) in the construction industry are questionable (Palalani, 2000), and (Okema, 2000);
- Poor organization of the construction industry with a large number of very small and inefficient firms (Wells, 1986);
- An unfavorable operating environment for construction enterprises, which is further aggravated by complex procedures and regulation, delays in payments and unsuitable contract documents;
- Contractors capabilities; lack of technical and managerial expertise, lack of adequate finance, difficulty in obtaining essential resources materials, equipment and skilled personnel, and inadequate supervisory capabilities (UNCHS, 1996);
- Lack of planning at all the levels of the construction process (Wells,1986);
- Low and fluctuating overall levels of construction activity;
- Lack of capacity and "economic rationality" in design, construction, and the production of building materials (Wells, 1986);
- Lack of Finance (UNCHS, 1996);
- Information scarcity and lack of accurate data (Du Plessis, 2002; Palalani, 2000);
- Under development of the national systems of innovation (Milford, 2000);

• Inadequate and integrated research and development (R&D) facilities and programs beside the poor linkage between research and practice (Du Plessis, 2002; Ofori, 1994);

• High rates of risks and uncertainty (Du Plessis, 2002; Okema, 2000) including; Macroeconomic risks and uncertainties, insurance industry risks and uncertainties, site production risks and uncertainties, natural calamities risks and uncertainties, bureaucracy and corruption risks and uncertainties, contract and contractual performance risks and uncertainties, project risk and uncertainty due to public demand, political and insecurity risks and uncertainties, and donor associated uncertainties;

• Corruption: it costs construction industry in the world a huge amount of money5 (TI, 2005).

Construction industries are particularly susceptible to corruption in licensing, taxation and obtaining government contracts, including bribery, fraud, embezzlement, and kickbacks (Sohail & Cailli, 2008). Beside the characteristics of the construction sector, the fragility of economies and ineffectiveness of the legal systems make developing countries prone to corruption (Fewings & Henjewele, 2008);

• Shortage of skilled labor due to absence of the training programs or failure to provide adequate rewards (Wells, 1986; Ofori, 1994); and

• Problems specific to the building materials industry:

- Inadequate capacity and inefficiency in the building materials industry, (Wells, 1986);

- Building Materials; expensive, high transportation costs, high production costs and energy costs (UNCHS, 1996);

- Availability and price of building materials, (Wells, 1986);

- Problems in availability of locally produced materials, (Wells, 1986);

- Unhealthy reliance on imported materials in fAEC of foreign exchange problems, (Wells, 1986); and

- Frequent shortage of construction materials resulting from the preference of users for conventional materials, most of which are imports.

(Elkhalifa, 2011) adds more problem it will face Sudan include: high construction costs; costs overrun; delays; lack of skilled labor; and quality of construction work.

The country in general suffers from the high level of taxes and fees on the production, transportation, and sales of building materials, taxation, custom duties, zakat, highway taxes, and provincial fees beside other types of fees contribute to the high prices of building materials (Elkhalifa & Shaddad 2008).

2.2 Review of Building Information Modeling

2.2.1 Introduction:

The construction industry has long sought to adopt techniques to decrease project cost, increase productivity and quality, reduce project delivery time, and eliminate waste (Azhar et al., 2008b). One of these techniques is Building Information Modeling (BIM). Azhar et al. (2008a) said that BIM has recently attained widespread attention in the AEC industry. With BIM technology, an exact virtual model of a building is digitally constructed. This model, known as a building information model, can be utilized for planning, design, construction, and operation of the facility. It helps architects, engineers, and constructors visualize what is to be inherent a reproduced situation to recognize any potential design, construction, or operational issues (Azhar, 2011). This literature review aimed to take over view about Building Information Modeling (history, definition, types, the awareness & the implementation, compare with CAD, tools, capability) and the relation between BIM & construction management.

Building Information Modeling is an idea anticipated during research in the late 1970's and started to grow in the mid of 1980's (Howard & Bjork, 2007).Virtual Modeling technologies became applicable for the architecture, engineering, and construction (AEC) industry in the late 1990s. At that time, the term Building Information Modeling (BIM) was coined to describe these technologies (Isikdag and Underwood, 2010a).since that, Building Information Modeling (BIM) become one of the most promising developments in the architecture, engineering, and construction (AEC) industries, (Eastman, 2011).

2.2.2 Definition:

Building Information Modeling is new feature that help to transfer ideas and plans into digital perspective to enhance project manager's jobs and project productivity.

Since the idea of BIM appears different writers, researcher and even organizations gave various definitions and thoughts about it. They defined it based on the specific way they work with BIM (Abbasnejad and Moud, 2013) and Due to the different perceptions, backgrounds and experiences of researchers and professionals in the AEC industry, they can define BIM in different ways (Khosrowshahi and Arayici, 2012).

Eastman et al. 2011 in the BIM Handbook, viewed BIM as more of a human activity, i.e., Modeling , instead of seeing it as an object oriented approach or being a particular software. Hardin (2009) said that BIM is a revolutionary CAD technology and building process that has transformed the way buildings are designed, analyzed, constructed, and managed. Khosrowshahi and Arayici (2012) agreed with Eastman et al. (2011) and Hardin (2009) that BIM is defined by various experts and organizations differently due to their perceptions, background and experiences.

The General Services Administration (GSA) of USA, 2006 defines BIM as:
"Building Information Modeling is the development and use of a multi-faceted computer software data model not to only document a building design, but to simulate the construction and operation of a new capital facility or a recapitalized (modernized) facility. The resulting Building Information Model is a data-rich, object-based, intelligent and parametric digital representation of the facility, from which views appropriate to various users' needs can be extracted and analyzed to generate feedback and improvement of the facility design."

But National Institute of Building Sciences (NIBS) of USA, 2007 is best to think of BIM as:
"A digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its lifecycle from inception onward. (Defined as existing from earliest conception to demolition)".

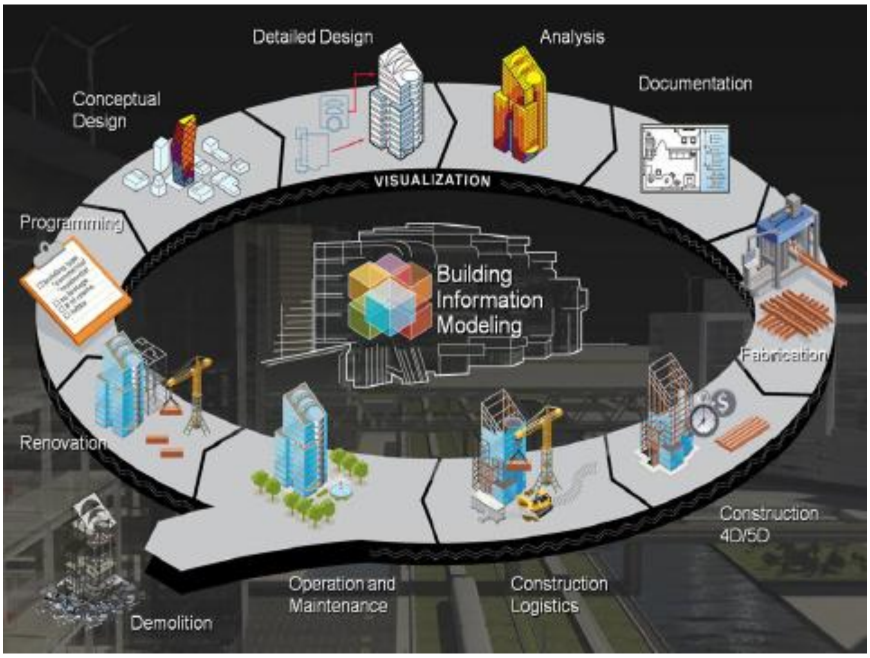

Figure 2.2 Building Information Modeling cycle life

Dzambazova et al. (2009) defined BIM in a different way, which is the management of information throughout the entire life cycle of a design process, from early conceptual design through construction administration, and even into facilities.

Royal institute of British architects of UK (RIBA), (2012) pointed out that BIM should be the abbreviation for 'building information management' and the term BIM (M) is alluding to 'Building Information Modeling and management'. On the other hand, it must be known that there is no definite definition of BIM; rather there are many ways of interpreting what BIM is.

2.2.3 BIM dimension:

Building Smart (2010) defined BIM as a set of information that is structured in a way that the data can be shared. BIM is a digital model of a building in which information about a project is stored. It can be 3D; four-dimensional (4D) (integrating time); or even five-dimensional (5D) (including cost); and right up to (nD) (a term that covers any other information). So, the previous definition pointed out the different type of BIM. Wang (2011) explained it as the following:

- 3D: three dimensional means the height, length and width.
- 4D: 3D plus time for construction planning and project scheduling.
- 5D: 4D plus cost estimation.
- 6D: 5D plus site. This would require the integration of geographic information system (GIS) and BIM. With the integration of GIS, all the items in the site model would carry the exact location and elevation information (X, Y, Z) as they are in the real construction world.
- 7D: BIM for life cycle facility management.

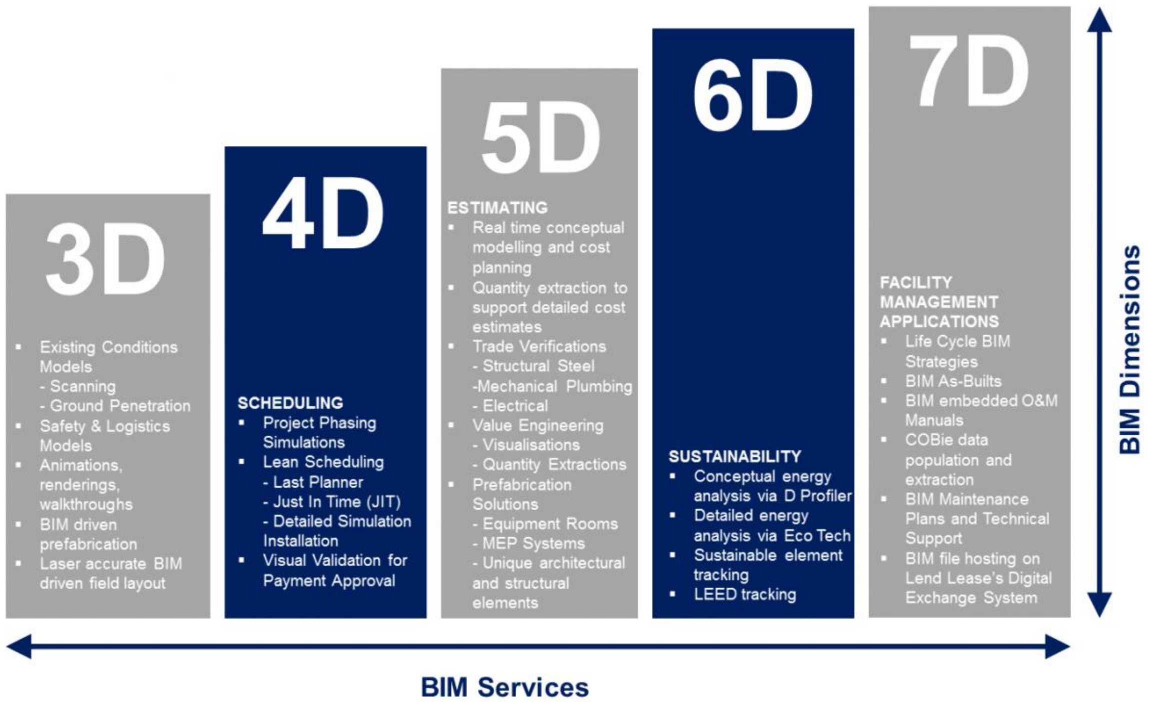

Figure 2.3 BIM dimension, source:(bim-dimensions-website - Waldeck Consulting : Waldeck Consulting, no date)

In addition to the parametric properties of 3D BIM, the technology also has 4D and 5D capabilities. Recent advancements in software have allowed contractors to add the parameters of cost and scheduling to models to facilitate value engineering studies; estimating and quantity take offs; and even simulate project phasing (Holness, 2006).

2.2.4 BIM level of Awareness:

NBS International B.I.M 2013 made report led by Royal Institute of British Architects. The report compares between 4 countries: United Kingdom, Canada, Finland and New Zealand. In general, all countries have high level of BIM awareness. Finland has the lowest level of awareness and New Zealand has the highest.(LinkedIn, n.d.). Figure 2-4 shows the level of awareness in these countries.

Figure 2.4 Comparisons between Four countries

2.2.5 Implementation of BIM:

The key to an effective implementation of BIM is to ensure that all parties are collaboration from a common basis. Often, this is achieved through a document of understanding that is issued at the start of a project. Such a document details the tools that are to be used, methodologies for information interchange, and the level of detail required for each stage of project delivery (Allison, 2015). The successful implementation of BIM requires two parts to be assigned for the purposes of project management:

- Information manager: responsible for instituting BIM throughout the project and ensuring that all people involved are following the established protocols.
- BIM model manager: ensures all the participants' models are coherently shared and co-ordinated across the project.(Allison, 2015)

2.2.6 Difference between CAD & BIM:

To better understand what BIM is, it is worth comparing between the traditional CAD concepts versus BIM.

Computer Aided Design (CAD) has meant leaving pencils and papers to develop projects. The incorporation of computers and software was the principal change within CAD but, unexpected, the way of working still continue being the same (Real 2014), lines and drawings organized in different layers was the important improvement but, the lack of information in the model has been the drawback since CAD appeared.

Hardin (2009) said that BIM is a revolutionary CAD technology and building process that has transformed the way buildings are designed, analyzed, constructed, and managed. BIM model ties all the components of a building together as objects embedded with information that tracks its manufacture, cost, delivery, installation methods, labor costs, and maintenance (Smith and Tardiff, 2009).

BIM is focused on object – models with parametric features. This combination has supposed the start of the transition from CAD into BIM technology and process (Lee & Wu 2005). The start of a new way of working encouraged by the complexity of projects, the necessity of being more efficient managing resources, the demand of more sustainable solutions and, as a general reason the obligation of giving more reliability to the construction industry following some of the rules of the manufacturing industry, are the main motivations for companies acquire this technology of management.

The transition from CAD into BIM is a corporative and managerial decision and it implicates a process of changing (Real 2014).

The main difference between BIM technology and conventional 3D CAD is that the latter describes a building by independent 3D views such as plans, sections and elevations. Editing one of these views requires that all other views must be checked and updated, an error-prone process that is one of the major causes of poor documentation(Azhar, Khalfan and Maqsood, 2015). Figure illustrates the difference between CAD objects and BIM objects. Examples of object information that can be included are geometry, spatial relationships, geographic information, quantities and object properties such as material, weight, colour, unit cost, and assembly time (Azhar, 2012).

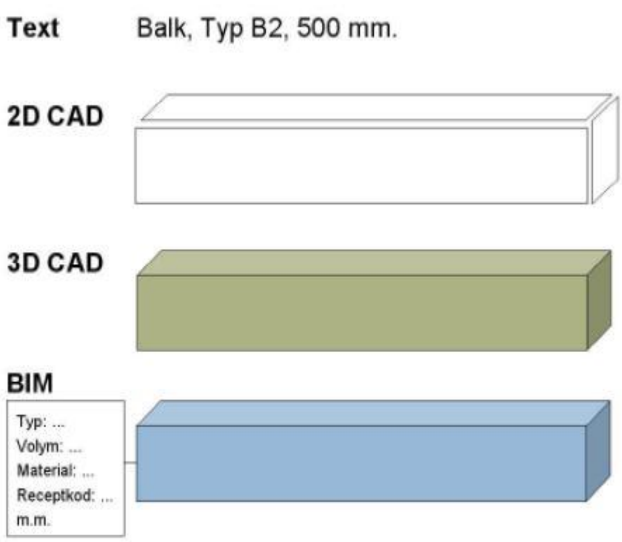

Figure4.5 Illustration of the difference between CAD objects and BIM objects. Source: Bengtsson and Jauernig (2008)

2.2.7 BIM Tool:

BIM is not an only one piece of software or model, but a new form of information processing and collaboration, with data embedded within the model. Each discipline or organization creates its own model, and these are successively amalgamated to provide a combined view of the entire project. (Allison, 2015).

BIM software can be broken down to three essential underlying technologies:

1) The 3D CAD technology,

2) The object-oriented technology, and

3) The parametric design technology. (Parvan, 2012)

The BIM system is already present in different software which makes interoperability a major concern for the multidisciplinary work (Crespo & Ruschel, 2007). Some of the major manufacturers of BIM are Bently, Graphisoft, VICO, VectorWorks, and Autodesk. Most BIM design applications also have interfAECs to other applications, for rendering, energy analysis, cost estimation, and so forth. Some also provide multiuser capabilities that allow multiple users to coordinate their work, (Eastman, 2011). This section provides general information about BIM software packages which are popular by users.

Autodesk's first BIM product—Revit Architecture™ was introduced to the industry in 2002 for the architectural design purpose and was quickly adopted by most architecture firms who were using BIM technology. After years of development, the Revit package has evolved into a product which can support multiple functions during the construction process—Revit Architecture™ for architectural design, Revit MEP™ for electrical engineering and plumbing design and Revit Structure™ for structural design. For the schedule and cost controls, Autodesk has Navisworks™ which allows users to simulate and manage the construction process and Autodesk Quantity Takeoff Software that supports cost estimating function. Other than these, Autodesk™ also developed software tools such as Autodesk 3ds Max for model visualization and Autodesk™ Inventor for data exchange to benefit the users from higher control level. Autodesk™ also provides free trial versions of the software and training webinars. (Jiang, 2011)

Bentley is another major software company that offers products for architecture, engineering and construction. The architectural designing tool in BIM, Bentley Architecture™, introduced in 2004, can be integrated with other software tools such as: Bentley Structural Modeler, Bentley Building Mechanical Systems, Bentley Building Electrical Systems, Bentley Facilities, Bentley Generative Components and Project Wise Navigator. Bentley offers a broad range of BIM software tools which are involved in almost all stages of building lifecycle. Bentley also provides product tours, training and online seminars for users to educate them about its products. (Jiang, 2011)

Tekla is a Finnish company founded in 1966 which has multiple divisions: Building and Construction, Infrastructure and Energy. The main product of Tekla is Tekla Structures™ which was formerly named Xsteel in mid 1990s. The basic functionality of Tekla Structures is for structural design. It allows users to create a complete digital model that depicts the structure combined with both physical model and analytical model, and then this structural model can be used for different types of structural analyses. Tekla Structures is also used by detailers, fabricator and manufacturers for generating detailed information for steel, precast and rebar detailing. The concurrent operation from multiple users is more complicated than a single user operation; these users need to be highly skilled to fully utilize the complex functions of this software. (Jiang, 2011)

Graphisoft is one of the earliest companies to market BIM capabilities. Its main product ArchiCAD™ is marketed since 1980s and is the only object-model-oriented architectural CAD system running on the Apple Macintosh (Eastman et al. 2008).

Today, ArchiCAD™ can serve both Apple Platform and Windows. One special feature of ArchiCAD™ is the Virtual Building Explorer, a real-time 3D navigation which is enhanced with gravity, layer control, fly-mode, egress recognition and pre-saved walkthroughs. ArchiCAD™ also includes a built-in analysis tool to conduct the energy analysis function on its BIM model. ArchiCAD supports a range of direct interfaces: Maxon for curved surfaces modeling and animation, ArchiFM™ for facility management and Sketchup™ for 3D sketching. It also contains object libraries for users with an Open Database Connection (ODBC) interface. MEP modeler™ is another key product from Graphisoft, the extension to ArchiCAD™, which is used for MEP Modeling pipes, fittings, ducts, and others. The company offers free trials and education opportunities to its potential users. (Jiang, 2011)

Vico's software Inc., product, this software to deal with construction management industry. This software content a package includes constructor, Estimator, Control and 5d presenter. This data important for constructing a 3D model to Estimator. Vico's has ability, including processing of quantities, tracking of model revisions, additions of margins, and creation of bid packages. Also, it integrates with other scheduling software and control by link to Microsoft Project or Primavera

2.2.8 BIM Applications:

There are 25 uses of BIM for consideration on a project that's according to BIM project execution planning guide by Pennsylvania State University (Marshall et al.2009) the explanation shows in figure 6 .the most important s to understand the main reason why BIM is used in the project and to set objective of adoption. After that, the use of specific BIM application can be selected. (GasmElkhalig, 2014). BIM technology can be utilized in different application areas such as visualization, design/Modeling, energy analysis, clash detection, cost estimation and construction scheduling. These multiple application areas in BIM can help users to improve the communication, reduce errors, and potentially save time and money. This section will explore important BIM application areas in various phases of the building lifecycle. (Jiang, 2011)

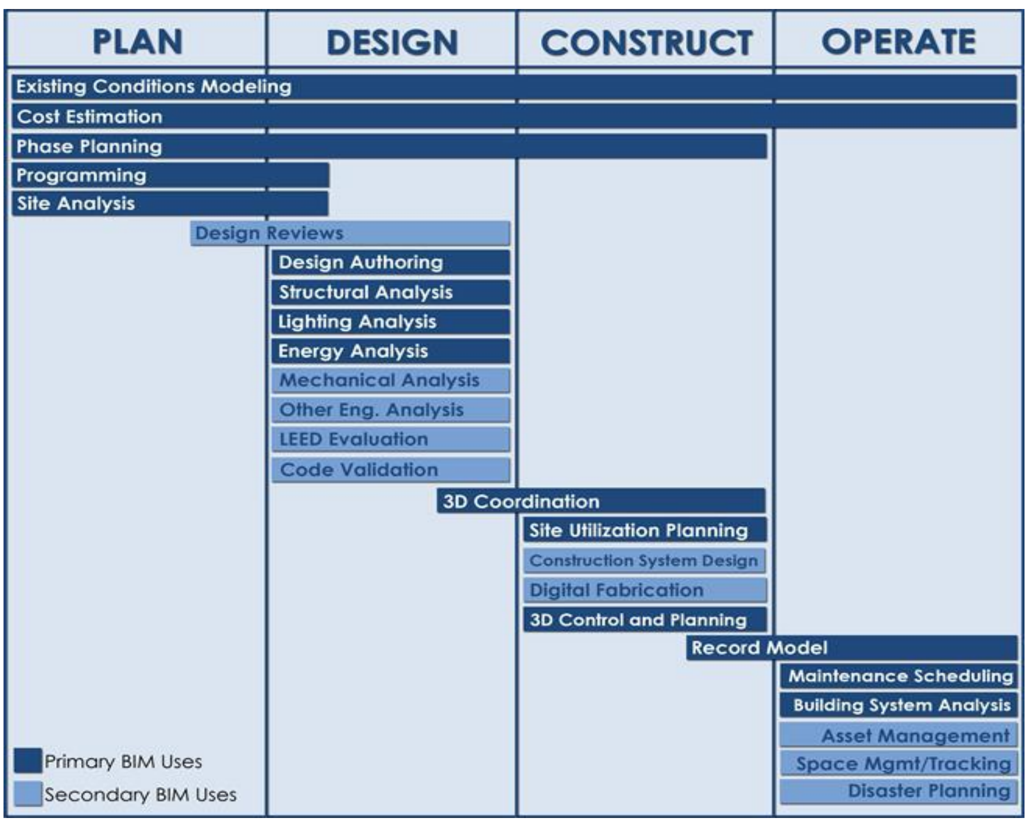

Figure 2.6 BIM application in project life cycle (BIM project execution guide, 2009)

Visualization

One of the basic applications of BIM is visualization through 3D models. This increases understanding among actors and can be helpful in the tendering stage since designers can get a better picture of the project scope and characteristics (Viklund, 2011).

Design/Modeling

The object-based parametric Modeling feature in BIM allows architects, MEP engineers, structural engineers and fabricators to leverage multiple functions on the same building model for their own use. With accurate building information and object models, the design/Modeling process is dramatically facilitated. The design accuracy and information sharing enhancement span all the phases of the design/Modeling process which also benefit the subsequent activities such as accurate quantity takeoffs that can be used in cost estimating and the construction phase can be automated for the project control. (Jiang, 2011)

Clash Controls

By clash controls, the building information models of different disciplines are brought together and checked for geometrical design inconsistencies.

Points where the models of different disciplines overlap each other when brought together are detected and can then be corrected. Also, visual errors which can lead to poor esthetical quality can be discovered and corrected (Eastman, et al., 2008).

Energy Analysis

The capability to link the building model to energy analysis tool allows users to conduct the energy analysis in the early design phase. Traditionally, a separate energy analysis would be conducted at the end of the design process and it is not possible for users to modify the design to improve the building's energy performance. By using BIM technology, the building model can be linked to energy analysis tools for the energy evaluation during the early design phase. The analysis allows users to make energy-conscious decisions and to test the energy-saving ideas without postponing the design process (Stumpf et al. n.d.).

Time Estimation BIM (4D BIM)

With time estimation, also called 4D BIM, the objects in a building information model are linked to the time plan. The linkage to time plan makes it possible to graphically visualize the projects schedule and users can simulate the building site and construction at any point in time. This type of simulation provides considerable insight and allows for early detection of planning errors. Instead of realizing planning mistakes later on in the construction phase, and having to resolve problems on site which can be very costly, mistakes can be eliminated already in the design phase (Eastman, et al., 2008).

Also, time estimation can be utilized to optimize the logistical aspects. Various alternative solutions of conducting the construction can be simulated and weighted against each other to find the most beneficial solution (Eastman, et al., 2008).

Cost Estimation BIM (5D BIM)

With cost estimation, also called 5D BIM, the objects in a 3D design can be connected with price lists for different materials. The price lists are mainly based on volume cost of materials, but can also include labor and equipment costs for more detailed cost estimates. This enables accurate cost estimation at any point in the design phase and creates understanding regarding financial implications of design decisions. Materials and construction solutions can therefore be evaluated from an economical perspective (Eastman, et al., 2008). BIM users can generate accurate and reliable cost estimates through automatic quantity takeoff from the building model and get a faster cost feedback on changes in design (Jiang, 2011). In the next section will provide more about cost estimating in BIM.

Facility Management BIM (6D)

Is the "as-built" BIM model which is important as part of the handover process to the building owner. This model is a fundamental part of the ROI for BIM as it provides accurate Facilities Management (FM) and Asset Management (AM). Each part within the building will have a lifespan and in the event of replacement, the easy identification of parts ensures that these processes may be performed efficiently (Eastman, et al., 2008).

2.2.9 Level of Detail:

According to Bedrick (2008), Level of Detail (LOD) of BIM models are defined as "the steps through which a BIM element can logically progress from the lowest level of conceptual approximation to the highest level of representational precision". Five levels of detail are determined to describe the BIM models, which are named from Level 100 to Level 500: Conceptual, Approximate Geometry, Precise Geometry, Fabrication and As-built. Table 1 provides LOD definitions in different project phases (Bedrick 2008, Leite et al. 2010). As the project progresses, the LOD of the models will be going to a higher level and the richness of the information will also be improved. It requires the cooperation among all parties involved in the project such as architects, estimators and schedules. Each party will embed the information in the model based on its own requirements.

Table 0.1 level of detail

Project Phase	LOD 100	LOD 200	LOD 300	LOD 400	LOD 500
Design	Non-geometric line, areas or volume zones	Three dimension-generic elements	Specific elements with dimensions, capacities and space relationships	Shop drawing/fabrication with manufacture, installation and other specified information	As built
Scheduling	Total project construction duration	Time-scaled, ordered appearance of major activities	Time-scaled ordered appearance of detailed assemblies	Fabrication and assembly detail including construction means and methods	
Cost Estimation	Conceptual cost estimation	Estimated cost based on measurement of generic element	Estimated cost based on measurement of specific assembly	Committed purchase price of specific assembly at buyout	As-built cost
Energy Analysis	Strategy and performance criteria based on volumes and areas	Conceptual design based on geometry and assumed system types	Approximate simulation	Precise simulation based on specific information	Commissioning and recording of measured performance

2.2.10 Benefit of BIM:

Azhar (2012) implies that if used in a greater extent, BIM will lead to a higher level of collaboration in teams which will give higher profitability, reduced costs, better time management, and better customer-client relationships. This is supported by Bryde et al (2013) that through performed case studies conclude that the most positively improved aspects from the implementation of BIM is cost management, time management, communication, coordination, and quality management. Furthermore, Olofsson et al (2008) state that all stakeholders gain from BIM, but that it in the end is the client who benefits the most. Therefore the process should be evaluated on project level and costs and benefits should be shared among all actors. This is also the opinion of Dehlin and Olofsson (2008) that argue that the most benefits of BIM will be available if focus is on costs and benefits for the project instead of for individual stakeholders.

BIM allows for an estimator to pull a fairly accurate bill of materials and square footages of spaces at any point in the design process for use in estimating. In the early design phases, most estimates are developed using unit costs as applied to square footages. As more details are added to the design, increasingly accurate and comprehensive estimates can be generated. BIM allows quantities to be obtained with much greater ease than by using a pencil and scale, and this makes it possible to continuously maintain a grasp on how design changes are impacting the overall budget for the project (Hartung, 2007). This ability not only aids the designers in designing within budget, but also helps the owner to understand what options or upgrades the budget will allow to be included in the project. At the end of design, this tool can also be used to assess the project to increase accuracy of future estimates or bids. “It is possible to make better informed design decisions regarding costs using BIM rather than a paper-based system.”
(Eastman et al. 2008).
The biggest single gain would seem to be simple coordination of components using clash detection software combined with a virtual build, which means mistakes are identified before work commences on site.(Ahmed Ata AbuHamra, 2015)
Farnsworth *et al.* (2014) explored the advantages and effects of using BIM within commercial construction by each of the different employee levels. The top advantages of using BIM were as follows: (1) improve communication; (2) more accurate scheduling; (3) improve coordination; (4) improve visualization; (5) clash

detection; (6) more accurate cost estimation; and (7) performing quantity takeoffs accurately.

In a traditional computer aided design (CAD) system there are many different files that are used to document the parameters of building construction. Some files document the floor plans, others show the building elevations, still more show building sections, and yet others provide building details. Each of these types of sheets usually incorporates many pages. To implement a design change each page needs to be updated individually. This gives an extremely high probability that something may be missed on one or more of the pages creating confusion and potential change orders when the plan is implemented. BIM takes a different approach by combining all the information and relating it to a single file, thus guaranteeing a consistent model (Dzambazova, Demchak, and Krygiel, 2007).

Additionally, because the systems for all disciplines can be included in the BIM, third party software can be used to analyze and identify system collisions both systematically and visually. This allows the majority of incongruities in the construction plan to be dealt with before construction starts, resulting in better collaboration among systems, and significantly reduced costs. The cost savings are due to the elimination of the need to re-work and re-engineer systems and spaces in an attempt to accommodate conflicting systems. The entire construction process runs more smoothly by detecting and addressing conflicts beforehand (Eastman et al., 2008)

A building information model provides accurate quantities for all elements that have been modeled. These quantities can be used in conjunction with their specifications and properties to procure the materials from supply houses and subcontractors. This has been successfully done, primarily for steel and precast concrete components (Sacks et al., 2005). Software is being developed to allow other disciplines to benefit from this attribute. Using BIM in the procurement process allows for just-in-time procurement with less waste and greater accuracy (Eastman et al., 2008).

Additionally, the model’s digital file can be used to instruct computerized machines how to produce building components. Traditional CAD files need to be altered before they are sent to the fabricator. Models from BIM, however, can be sent directly to fabrication machines without having to produce shop drawings (Dzambazova, Demchak, and Krygiel, 2007).that’s will helped to reduce errors that will happened when transfer plans between design team and reduce the risk of missing items that will miss after update the plan.

Fast and simple material quantity take-offs represent an efficient method of checks and balances and often reduce bidding time (Holness, 2006). The (BIM) users’ perception concerning the benefits of BIM features to quantity surveyors (QS), (also referred to as cost consultants or cost engineers), was investigated in Australia by Aibinu and Venkatesh (2013). Data collected from a web-based survey of 180 QS firms with 40 responses and two in-depth interviews. Findings from the study showed that: (1) time savings is the most important perceived benefit nominated by 80% of the respondents. It reduces labor intensive quantity take-off, and increases the ability to identify and advise the design team on elements exceeding the cost target. Other benefits listed are: (2) increasing visualization (nominated by 40% of respondents); and (3) increasing productivity (nominated by 20% of the respondents).(Ahmed Ata AbuHamra, 2015)

2.2.11 The barriers of BIM Implementation:

Fear of fail can be as issue addressed to who will control the entry of data into the model and be responsible for any inaccuracies. Taking responsibility for updating building information model data and ensuring its accuracy entails a great deal of risk. Requests for complicated indemnities by BIM users and the offer of limited warranties and disclaimers of liability by designers are essential negotiation points that need to be resolved before BIM technology is used. Also, fear of fear could be pointed as a fear of fail when implement BIM in any project may be the owners will revues to use it because the lack of knowledge about BIM.

Keegan (2010) in his master's thesis identified several observed barriers to the utilization of BIM in this regard; namely: (1) the lack of knowledge about BIM by the owner; (2) the lack of the knowledge about the software; and (3) the cost of implementing and updating the system.

Choi (2010); Lee et al. (2009); Lee et al. (2007); Smart Market Report (2012) (cited in Lee et al., 2014) reported that the application of BIM in the construction industry has been slow in Korea due to the following obstacles: (1) unclear and invalid benefits of BIM in ongoing practices; (2) the lack of supporting education and training to use of BIM; (3) the lack of supporting resources (software, hardware) to use BIM tools; (4) the lack of effective collaboration between project stakeholders for Modeling and model utilization; (5) unclear roles and responsibilities for loading data into a model or databases and maintaining the model; and (6) the lack of sufficient legal framework for integrating owners' view in design and construction.

Likewise, Thurairajah and Goucher (2013) conducted a research to identify the challenges and usability of BIM for cost consultants, and its likely impact during cost Crowley (2013) conducted a questionnaire survey to ascertain the current position of the QS profession in Ireland directly relating to BIM use and awareness. When asked on a scale of "very important" to "not important" in relation to the potential barriers to BIM, the following responses were received (majority response very important): (1) lack of training / education; (2) BIM use by

Irish designers; (3) lack of client demand; (4) lack of government lead/direction; and (5) lack of standards.

Furthermore, Aibinu and Venkatesh (2013) have investigated the progress towards (BIM) of QS firms in Australia. They said that the overall level of BIM adoption by QS is low in Australia. Broadly speaking, it appeared that the barriers to the adoption of BIM by Australia QS are: (1) the cost of implementation; (2) the lack of awareness of the benefits from cost benefit analysis perspective; (3) the lack of demand by clients; (4) the lack of trust in the integrity of BIM; (5) the lack of standard for description of BIM objects and coding systems; (6) the lack of information on business process changes and how to change those processes; (7) the contract/legal issues and uncertainties; (8) skills shortage; (9) transformation and adaptation issues; and (10) the technology change and ability of firms to adapt to the change from cultural perspective and financial perspective.

Yan and Damian (2008) revealed that most companies in their study who did not use BIM are believed that the training would be too costly in regard to time and human resource. Many companies have not had sufficient time to consider and evaluate BIM because they had to focus on their existing projects (McGraw-Hill Construction, 2009). Löf and Kojadinovic (2012) emphasized that the time needed for training to work efficiently with BIM is one of the main challenges to adopt BIM. Kaner et al., (2008); Keegan (2010); and Aibinu and Venkatesh (2013) agreed that the high initial costs needed for training of the individuals to be able to deal with BIM are very high and this is a main challenge to adopt BIM in AEC industry.

2.3 Cost estimation in BIM:

BIM is an innovative solution for cost estimation. McCuen (2009) believes that BIM can provide a platform for integrated information exchange through a single model that reduces design errors and omissions with a significant reduction on preparation time in the design phase, and also minimizes the time for modification of cost estimates.

This section wills to discuss the multiple opinions about cost estimation and the approaches that wildly used in cost estimating process and allocate the main benefit of implement BIM on projects cost estimation.

2.3.1 Estimating with Traditional methods

Liming Wu mention that there are many software cost estimation methods available including algorithmic methods, estimating by analogy, expert judgment method, top-down method, and bottom-up method. No one method is necessarily better or worse than the other, in fact, their strengths and weaknesses are often complimentary to each other. To understand their strengths and weaknesses is very important when you want to estimate your projects. Staub and Fischer (2000) gave four primary methods used in construction costs: project comparison estimating, area and volume estimating, assembly and system estimating, and unit price and schedule estimating.

Most of this approach used the old style of estimation which depends on papers. For the reason that Errors in quantity and cost estimates may arise in the cost estimate process, such as forms of arithmetic errors (addition, subtraction, or multiplication), transposition errors (errors in copying quantities), omission (overlooking parts of the design), poor references (scaling from papers instead of using the dimensions indicated), and unrealistic waste factors (Halpin, 2006).

2.3.2 BIM and cost estimation

The cost estimate is one of the main elements of information for decision making at preliminary stage of construction. According to Samphaongoen (2009), cost estimating is essential for budgeting and tendering in any construction project. It reflects the inherent risks, direct costs of a project involving materials, labor, professional services, etc. Jrade and Alkass (2007) consider that cost estimating is one of the most essential and critical phases of a construction project and that a new cost estimate must be developed depending on the availability of design drawings and specifications during these phases: the conception phase, the development phase, the construction phase, and the disposal phase. Kwakye (1994) described cost estimating as the technical process or function undertaken to assess and predict the total cost of executing items of work in a given time using all available project information and resources.

Actually, estimates are prepared and used for different purposes including feasibility studies, tendering phase, avoidance misuse of funds during the project, etc. The primary function of cost estimation is to produce an accurate and a credible cost prediction of a construction project. However, the predicted cost depends on the requirements of a client and upon the information and data available (Elhag, et al., 2005). The other functions of cost estimate; that it allows the designer and engineer to be aware of the cost implications for the design decisions they make while still in the design phase. Reliable cost estimates also allow management to make an informed decision as to what items will be profitable and what items should be redesigned (Weckman, et al., 2010).

The main reasons of making cost estimation are; first, to ensure tenders received do not exceed the budget. This is achieved by making design decisions early with advice from the cost team. Changes made early in the design process can be accommodated without too much effect on other elements. Second, to collect cost information from a number of buildings, at various stages of development. thus improving the quality of cost data for future projects.

Notably, the quantity surveyors role related with the function of cost estimating, planning, preparation of Bills of Quantities and tender documentation, procurements, manage payments, contractual claims and final accounts (Ashworth and Hogg, 2007). Quantity surveyors have seen the potential of further enhancing their role and become more efficient and productive in performing their measurement and management oriented functions. As shows previously, cost estimator and quantity surveyor function related to each other. Most of estimator work includes surveyor work.

When using BIM for cost estimates, it is clearly desirable to have the general contractor and possibly key trade contractors who will be responsible for building the structure, as part of the project team. Their knowledge is required for accurate cost estimates and constructability insights during the design process (Eastman, 2011).

(Franco, Mahdi and Abaza, 2015) during study that they made, they conclude that the major benefits from BIM implementation in all type of projects are: accurate and precise takeoff that subcontractors can rely on confidently early in the design phase, return on investment, reduction of change orders, reduction of requests for information, time saving, easier communication and collaboration between all stakeholders resulting in a successful project, thereby incentivizing subcontractors to challenge the following obstacles from the study, literature and personal. Goucher and Thurairajah (2012) also identified the benefits of using BIM for cost estimates, including the ability to work collaboratively, the speed, improvement of visualization, advanced cost advisory services, and automated quantity take-off.

Recent BIM survey results reveal that many professions such as engineers and contractors are lagging behind the architects in adopting BIM (McGraw-Hill Construction, 2010; NBS, 2012). Notably, quantity surveyors are found to be slow to embrace the use of BIM. According to the RICS BIM survey (Matthews, 2011b), many quantity surveyors are still not aware of what BIM is and only small numbers (10%) claimed to have used BIM

In the preconstruction group of a CM, estimators would develop estimates based on quantity takeoffs off of the drawings provided by the architect and engineers. From the structural drawings, estimators could estimate the total cubic yards of concrete on the job, the amount of rebar in the concrete, or the tonnage of steel. From the architectural set, estimators could estimate all of the interior finishes and partitions and other architectural aspects from the project.

The development of early cost estimates is widely facilitated by BIM. Eos Group (2008) acknowledges that BIM rather enhances the QS expertise in cost estimating than eliminating it as sometimes claimed, since BIM is only able to automate quantification but not cost estimates (Autodesk, 2007). BIM technology allows early design models to be linked to software that enables the quantity surveyor to extract necessary quantities at the initial stages of a project (Eastman et al., 2011). A BIM model contains 3D objects with geometrical information, and hence it is easier to capture the quantities of the objects; the volumes and areas can be automatically and instantly extracted (Jiang, 2011; Kymmell, 2008). Quantities extracted then form the basis of an accurate cost estimate, after linking and mapping them with the quantity surveyor's internal built-in or external cost database.

BIM means changes to the manner buildings are designed, documented, analyzed, procured, constructed and managed as it unlocks new way of working for all construction disciplines, (Aranda-Mena et al., 2008; Hardin, 2009). Inevitably, it includes changing the way cost plans and estimates are produced as well.

2.3.3 Methods of Estimating with Building Information Modeling

(Jiang, 2011) addressed in his study that There are various means of collecting and quantifying data, but generally the estimator systematically moves through the plans, either with paper and pencil, or through a digitized version of the plans with computer software, to tally up system totals. These totals are then converted to estimate costs by processing them through a spreadsheet, or some other program that applies unique formulas to each quantity in order to arrive at an estimated cost. This system of collecting data is prone to human error through miscounting or missing details on the plans, resulting in a tendency to promote inconsistencies that creep into the tallies (Rundell, 2006).

Mapping the QTO list with cost databases, which can be built-in in BIM models or a standalone external cost database, estimators can generate a more accurate and reliable cost estimate of the building with minimal effort. There are three main options to leverage BIM for quantity takeoff and to support cost estimation. They include:

- Export building object quantities to estimating software
- Link the BIM tool directly to the estimating software
- Use a BIM quantity takeoff tool.

2.3.3.1 Export Quantities to Estimating Software

(Jiang, 2011) pointed in his study that It is identified by Eastman et al. (2011) that most BIM based estimating tools are capable of exporting the quantities to a spreadsheet or external databases, enabling the quantity surveyor to then begin the pricing work. These tools also include features to export quantity takeoff data to a spreadsheet or an external database. In the United States alone, there are over 100 commercial estimating packages that secure these needs and many are specific to buildings of certain occupancies (Eastman *et al.* 2008). Microsoft Excel™ is the most commonly used estimating tool which is also sufficient for most estimators to extract the QTO from the BIM Model (Christofferson 2000, Sawyer and Grogan 2002). For example, designers and architects can utilize Revit Architecture™ to easily export the material information—initial bill of quantities and material takeoffs—into MS Excel Spreadsheet, thus more accurate budget estimates will be available at the early stag1es of the project lifecycle. However, this approach requires significant setup and standardized Modeling process—such as sufficient information on the object model—in order to generate the intact QTO information from the model.

2.3.3.2 Directly link BIM Components to Estimating Software

(Jiang, 2011) addressed in his study that the second alternative is to use a BIM tool that is capable of linking BIM model directly to an estimating package in the plug-in or third-party tool. Many of the larger estimating software packages now offer plug-ins to various BIM tools. As an example, Innovaya™ (a BIM cost estimating tool) uses a plug-in tool to link to "Sage Timberline." This plug-in function allows the user to associate components in the building model directly with assemblies, recipes, or items in the estimating package in Sage Timberline™. The user will be able to use rules to calculate quantities for these items based on the component properties or manually enter data that was not extracted automatically from the building information model. The assemblies of building components will follow the rules in Sage Timberline, thus all information required to develop a complete cost estimate can be generated from the BIM Model directly and the building information will be highly integrated and assembled. In addition to that, there is no need for users to manually map the cost data with the building components, since the cost data will be mapped as soon as the quantities are generated and assembled. However, contractors may need to cooperate with subcontractors when they work on different estimating packages in this approach.

2.3.3.3 Quantity Takeoff Tool

A third alternative is to use a specialized quantity takeoff tool that imports data from various BIM tools. This approach associates with the use of specialized Quantity Takeoff (QTO) software, e.g. Autodesk QTO, Vico Office, and Exactal CostX, which transfer the BIM models and their embedded information from BIM design tools into their system. Similar to the previous approach, these tools can support both the automated extraction and manual take-off features. They can generate visual take off diagrams while providing visualization of models whereby the quantity surveyor can mark off the building components using colors enabling to cross check the take-off lists and to see which components have or have not been included in the estimate (Eastman et al., 2011). Users can choose a takeoff tool specially designed for their needs without having to learn all of the features contained within a given BIM tool .These takeoff tools typically include specific features that link directly to items and assemblies, annotate the model for specific 'object information', and create visual takeoff diagrams. These tools offer varying levels of support for automated extraction and manual takeoff features. The user assembles the objects in the model and dimensional data will be transferred from the model to QTO list for further pricing. Visualizing all the items being taken off reduces the chance of the estimator missing items. It also reduces the chance for transposition errors as the design changes the linked model updates the estimated quantities (Khemlani, 2006).

Example of this is: Autodesk QTO™ can automatically extract QTO from the building model according to category information leveled on the object model and it also allows manual modification of the takeoffs based on the users' own preference. After that, the QTO list can be exported to the MS Excel spreadsheet and users can associate the quantities with any suitable cost database. The QTO process in this approach can be finished automatically and categorize the objects based on the "Category" information leveled on the object model. After the automatic takeoff, users can also make some changes on the QTO list manually. One advantage of this approach is that users may not have to apply to the assemblies based on the specific cost estimating package; any suitable cost data can be mapped with the QTO list after the quantities are generated. However, compared to linking components to estimating software directly, this method may take more time on mapping the cost database. All that mention in (Jiang, 2011) thesis.

2.3.4 Benefit of BIM cost estimation

Based on structured interviews with the quantity surveyors in Auckland, Stanley and Thurnell (2014) found that 5D BIM provides advantages over traditional forms of quantity surveying by increasing efficiency, improving visualization of construction details, and earlier risk identification. Also, they pointed out that benefits of 5D BIM for quantity surveying can summed up in: (1) increasing visualization; (2) enhancing collaboration on projects as people need to work together to make the models effective; (3) improving project quality and BIM data quality; (4) making project conceptualization easier; (5) increasing analysis capability; (6) improving efficiency of take-offs during budget estimate stage; (7) improving efficiency of cost planning during detailed cost plan stage; (8) improving risk identification to be available in earlier stage; (9) increasing ability to resolve requests for information (RFIs) in real time; and (10) improving estimating and project options.

The use of BIM enables these estimates to occur early on and to be continuously updated as changes are made to the model (Ashcraft, 2008). That's prevented errors and reduces missing items during changes.

Nassar (2010) examined the effect that BIM can have on the accuracy of project estimates in terms of time and cost. An analytical approach was taken to quantify the potential increase in accuracy. The results proved that BIM will increase the precision and accuracy of the quantity aspect of the estimate and it may very well also impact the precision and accuracy of the productivity aspect.

During a study made by (Alsharqawi, 2016), a case study presented to illustrate the cost planning and simulation processes in 5D BIM more appropriately during bidding stage, based on a BIM model of a reinforced concrete structure. He used RIB iTWO which is one of the BIM softwares. It provides opportunities to import 3D BIM models, and then carry out cost planning and simulations.

The main perceived benefits of 5D BIM were found in the studied case:

1. **Enhanced Visualization**

Contractors can have a clear understanding of the project due to visualization ability of 5D BIM to show the inside building with sections. This simplifies and facilitates the cost planning during bidding process, and it's opportunity to carry out collision checks.

2. **Automatic Quantification**

Procedure of QTO was economical on time at the bidding stage. This includes the potential time improvements through automatic processes and the possibility to access additional information, which helps to decrease the amount of time consumed. The ability to visualize quantities creates trust and is relied upon. Also the ability to update and change quantities quickly can be a major benefit for contractors in terms of cost planning due to dynamic link

3. **Detailed cost planning**

The cost estimation becomes more detailed and more accurate. That it enables contractor to add more specific costs to the project. Cost planning process in 5D BIM also includes evaluating conditions of the project which has an impact on costs and provides detailed 5D estimates and living cost plans, such as unique technical details and places with difficult access. On the other hand, Cost databases in 5D BIM provides the foundation for the quality, value of the services and a significant competitive advantage.

4. **Improved Simulations**

5D BIM simulation is dynamic and convenient when the project contractor gives the owner feedback regarding the progress of the project. Contractor then can make faster adjustments to the financial plan based on the changes in cost and schedule. This integration between cost and time elements can ensure that the contractor has enough financial resources even when there is a change in the design.

5. **Collaborative Working**

The full implementation of 5D BIM in bidding stage projects involves the sharing of information amongst project participants. The advantage of the use of 5D BIM is that several participations can work with the model by a common database.

Also, he mentioned that competitive tendering and bidding with 5D BIM models can reduce the risky gap that exists between project members due to the transparency and accessibility to project information and documentation.

3 Chapter three

Research Methodology

3.1 Methodology

The research methodology included the general benefit of applying BIM were adopted and selected from the theoretical part. The local construction industry suffers many obstacles and problems that need to be mitigated by using new technique and tools such as BIM. The goal of this research was to examine the uses and benefits of BIM and analyze BIM based cost estimation. First, the literature review included the definition and the use of BIM and its tools and concepts. Then, these benefits are assumed to be tested in the local experience, so the questionnaire comprises of questions about the issue. Hence, the emphasis will be on qualitative methods of data collection in respect of the same suitable analysis tool. . Merriam (1998) describes quantitative research as a means of interpreting data in a personal way in order to arrive at an explanation for the outcome. She suggests that by using the instrument of qualitative research six assumptions can be made: (1) Qualitative research focuses on the process and not solely the outcome or product, (2) This type of research is more focused on lived experiences and the meaning of those experiences, (3) The researcher is the primary instrument for data collection and analysis, (4) Qualitative research usually involves fieldwork, (5) It is descriptive in that it describes events, attitudes, and outcomes, and (6) It requires some deductive reasoning by the interpreter of the data. Overall, the literature review and questionnaire provided an insight on the benefits of using BIM and its applications.

3.2 Literature Review

In Chapter two, comprises of an overview about BIM history and definition, applications, and the discussion about the differences between BIM and CAD. Briefly, mention cost estimation definition, methods and some of the benefits from implementing BIM in cost estimation. In addition, mention causes of slow implementation of BIM in Sudan.

3.3 Data Compilation Using Questionnaire

3.3.1 Introduction

This chapter presents the data collection process and the obtained result, using formal questionnaire tool. A questionnaire is a research instrument consisting of a series of questions and other prompts for the purpose of gathering information from respondents (Gault 1907). Elkhalifa, 2011 defined it as a tool for collecting information to describe, compare or explain knowledge, attitudes or behaviors and/or socio-demographic characteristics of a target group the results of the questionnaire presented in charts and tables. The main advantage of using the questionnaire is because is the cheapest method for collecting data and easy way to reach a large number of people

3.3.2 Questionnaire Design

The questionnaire contains both type of questions; Open-ended questions and close-ended question. Open-ended question lets the respondent to answer in any form whatever content & to whatever extend (Fellows & Liu, 2008). It is used usual to break the ice of the survey and to let the responses to answer by them a word (Duval, 2005). Thus, open-ended questions are less likely to yield reliable data without additional time & effort (Derrington, 2009). On the other hand, closed-ended questions have a finite set of answers from which the respondent chooses (Fellows & Liu, 2008). On the other side there are close-ended questions. This kind of question have a limited number of answers the response chooses one or multi (Fellows & Liu, 2008).The closed-ended questions, in general, have five common formats (Duval, 2005), namely: rating scale or Likert-scale (to assess a person's feelings about something); multiple-choice (when there are a finite number of options); ordinal (to rate things in relation to other things); categorical (when the answers are categories); and numerical (for real numbers). Taylor-Powell (1998) adds the following sub-formats: two options responses (i.e., yes-no, agree-disagree, true-false…etc.); one best answer; paired comparison; matching (match responses to a list of items); ranking; and items in a series (presenting the responses in a table when several questions use the same response category). The questionnaire designed basically in English language, and then translated it into Arabic language. 15questions designed, Two questions use open-ended question, two questions use Likert-scale, 11qustions use multiple-choice. The questionnaire included two parts that were designed related to the objective of this study as follows:

Part one: is structured in order to investigate general information and background about the respondents' experience, age, level of education, position, and their work natural of the organization that they worked in.

Part two: is structured to measure the awareness of the AEC industry in Building Information Modeling (BIM) and the benefit of implementing (BIM) in construction project cost estimation in Sudan. A copy of the questionnaire is attached as an appendix.

3.3.3 Piloting of the Questionnaire:

Bell (1996) described the pilot study as: "getting the bugs out of the instrument (questionnaire) so that subjects in the main study will experience no difficulties in completing it and so that the researcher can carry out a preliminary analysis to see whether the wording and format of questions will present any difficulties when the main data are analyzed" (cited in Naoum, 2007). In order to avoid measurement errors and to make sure that the data collected was reliable, the questionnaire has been piloted by a professor at Sudan University of Science and Technology, that familiar with construction management, and BIM manager that familiar with Building Information Modeling.

The professor and the manager have commented on the validity and the suitability of the questions to the research objectives, as well as they have commented on the clarity of the instructions. The main aim of this process was to find out whether the questions were unclear ambiguous or uneasy to answer**.**

3.3.4 Pre-testing the Questionnaire

Pre-testing the questionnaire was done to make sure that the questionnaire is going to deliver the right data and to ensure the quality of the collected data. In other words, pre-testing the questionnaire was an important and necessary step to find out if the survey has any logic problems, if the questions are too hard to be understood, if the wording of the questions is ambiguous, or if it has any response bias, etc. (Naidoo, Ramseook-Munhurrun and Seegoolam, 2011). Baker (2003) recommends that the questionnaire should be easy to read, understand, well organized and without bias. Taylor-Powell (1998) suggests that wording the questions requires: use of simple words; avoiding the use of unfamiliar abbreviations, jargon or foreign phrases; avoiding too demanding and time consuming questions; and use mutually exclusive categories.

A draft of the questionnaire was prepared after a series of reviews and editing. Then, the questionnaire was distributed to 15 respondents who were broadly representative of the type of respondents targeted by the main survey. The questionnaire was sent by email as web-based questionnaire. The comments and suggestions made by those respondents were incorporated into the final version of the questionnaire. Some questions were deleted and some were rephrased. The average time required to fill-out a hard copy was about 2 minutes. Many respondents commented on the easy-flow of the questionnaire and the importance of the topic.

3.3.5 Questionnaire Administration

Generally, questionnaires may be administrated via different modes, including: face-to-face (personal contact); paper-and pencil; and computerized (E-mail or web-based) (Foddy, 1994).

These questionnaires were distributed through e-mail & web-based surveyor (https://surveyplanet.com/583401f6b054594fe9d6715a).

3.3.6 Research Population

The questionnaire targeted AEC industry members in Sudan. The survey distributes to individuals related to AEC Industry in Sudan. Each respondents work for public, private, or mixed sector. The questionnaire after being revised is distributed to the respondents in Khartoum state. The total of responses is 92 and 8 of them has been excluded because they were not related to the AEC industry. The total number of copies submitted for analyzed is 84 copies which represents 91.3% of the total distribution copies.

3.3.7 Research Sampling

Sampling concerned with process of selecting a group of individuals from within a population to tell something that the entire population would have told. The objective of sampling is to provide a practical means of enabling the data collection and processing components of research to be carried out whilst ensuring that the sample provides a good representation of the population (Fellows & Liu, 2008).

The selection of a target group to be surveyed involves either random sampling or non-random sampling of the population. A random sample is a one chosen by a method involving an unpredictable component where every individual in the population of interest has an equal opportunity (probability) of being selected for the sample. On the other hand, Engineers in construction firms in Khartoum state were selected as the targeted respondents for investigation; due to the state's position as the center of construction firms in Sudan, as well as for reasons of practicability and convenience perceived by the researcher. The respondents were selected by a random sampling method to represent the characteristics of the population systemically. The respondents were deemed to be an adequate representation of the population as they varied greatly in the characteristics, but they all work exclusively in the field of construction industry in Khartoum state.

4 Chapter Four

Data Presentation and Analysis

4.1 Introduction:

This chapter includes the analysis and discussion of the results that have been collected from the surveys. The total of 92 completed by respondents and 8 of them has been excluded because they were not related to the research population the valid response rate is 91.3%.

This chapter included the respondents' profiles and the awareness of the AEC industry in Building Information Modeling (BIM), and the benefit of implementing (BIM) in construction projects cost estimation in Sudan, quantitative analysis of the questionnaire this chapter also represents a restatement of the research questions, the research methodology used and a summary of the research results.

4.2 Data analysis:

4.2.1 Respondents' general information:

The targeted respondents of the questionnaire survey were (Architects, Civil engineers, contractor engineers, construction engineers, university staff, project manager and other engineers who work in the construction industry) in the Architectural, Engineering, and Construction (AEC) industry in Sudan. This section analyzed the demographic data of the 84 respondents

The majority of respondent's age is between 20-30 years with 63.7%. While those between "30-40" are 28.7%, "40-50" are 6.3%, and "More than 50" with

1.3%. These stats show that the representative sample of the population is for young people that had ability to accept any new knowledge and applied it in their fields.

Among the respondents, a large majority had “0-5 years” of working experience in the construction industry, with 53.8% and Those are “ 5-10", and “10-20 years” are 29.4% and 9.4%, respectively.

The education levels of the respondents were divided into four levels (Diploma, Bachelor's degree, Master's degree, Doctorate degree). The majority of the respondents' holds a Bachelor degree constitutes 70 %. The rest of the respondents are diploma 10%, master degree, 18.8 %, and finally doctoral degree with 1.3%.

Respondents for this study had a good understanding of construction works in the construction industry, and could thus provide reliable answers to the questionnaire. In terms of the nature of their workplaces, a majority of the respondents were working in the private sector with 60.8%, 15.2% were working in the public sector, 20.3% of them were working in mixed sector, and 3.8% were working in other places. This makes the obtained data promptly represent the population.

Table4.1 Characteristics of the respondents

General information	Categories	Frequency	Percentage
Position	Civil engineer	45	55.6
	Architect	16	19.8
	Contract engineer	1	1.23
	Project manager	2	2.47
	University teacher	1	1.23
	Survey engineer	1	1.23
	Engineer	4	4.94
	General manager	1	1.23
	Structural engineer	2	2.47
	Construction engineer	1	1.23
	Site engineer	2	2.47
Age	20-30	51	63.7
	More than 30-40	23	28.7
	More than 40-50	5	6.3
	More than 50	1	1.3
Years of experience	0-5	43	53.8
	more than 5-10	25	31.3
	more than 10-20	8	10
	more than 20	4	5
level of education	diploma	8	10
	Bachelor	56	70
	master	15	18.8
	doctoral	1	1.3
Nature of the organization	Public sector	12	15.2
	Privet sector	48	60.8
	Mixed sector	16	20.3
	other	3	3.8

4.2.2 BIM description in construction industry

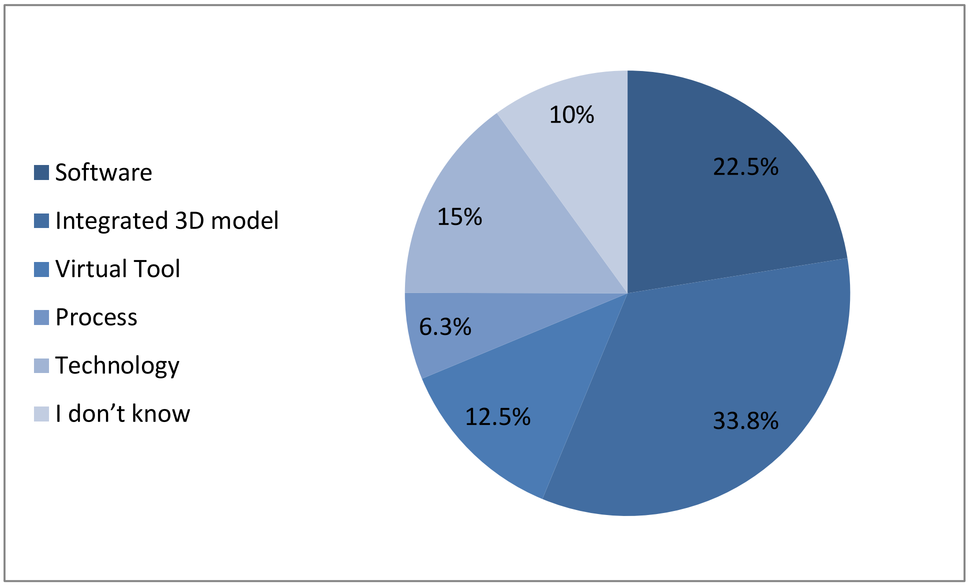

Figure4.1 Respondents Descript BIM

The above figure shows the best description for BIM from the responds perspective. The majority of the respondents identified that the BIM is an integrated 3D model with 33.8% and 19 respondents said its software with 22.5%. 15% of respondents defined it as a technology. 6.3% said it is a process and 10% answered. That they don't know what BIM means.

Eastman et al. (2011) identified that presenting a uniform definition of

BIM is difficult, as it provides different functions to different stakeholders in the construction industry. The variation of the percentage appears because most of the engineers don't know what BIM exactly mean.

4.2.3 Level of awareness about BIM

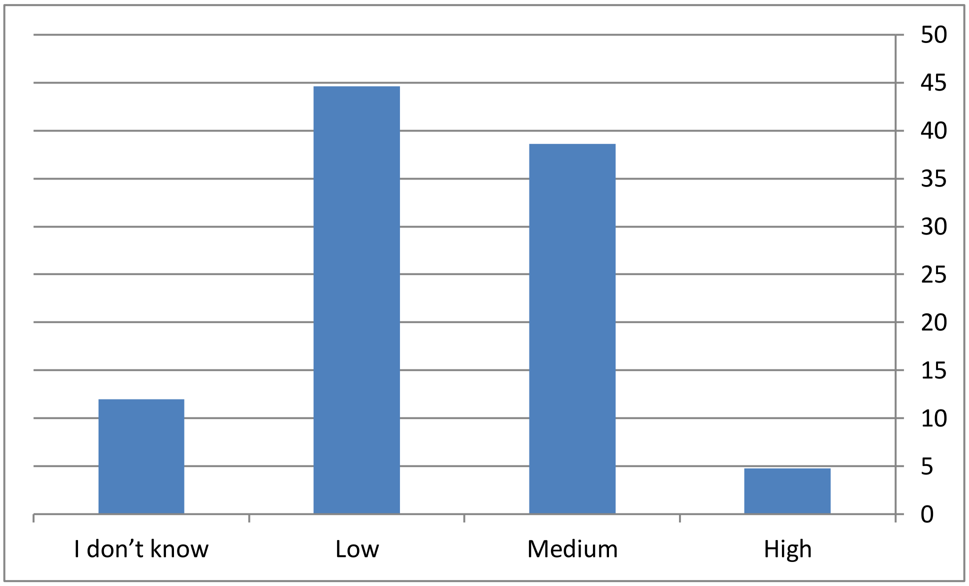

Figure4.2 Level of awareness about BIM

This figure shows the level of BIM awareness of the respondents' organization. They responded as follows: 3.8% of the respondents assessed the level of BIM awareness in their organization sites as high, 41% assessed the level of BIM awareness as medium, and 34.6% assessed BIM awareness as low and 11.5% replied that there were don't know. Depends on the figure we can see that the majority of respondents' organization have low awareness about BIM.

4.2.4 The purpose of using BIM technology responders the organization

Table 0.2 The function of using BIM technology in the organization

Purpose	Frequency	Percentage
1. Creation 3D Models	14	17.9
2. Rendering and perspectives	13	16.7
3. Automated Quantity Take off & Cost estimating	11	14.1
4. Construction site management	21	26.9
5. Schedule and project planning	4	5.1
6. Clash detection and conflict resolution	15	19.2

The above table presents the purpose of using BIM technology in the organization. 17.9% said there were use it in creating 3D models, 16.7% use it in Rendering and perspectives, 14.1% use it at Quantity Takeoff & Cost estimating, 26.9% use it in Construction site management, 5.1%use it in the Schedule and project planning, and 19.2% use it in Clash detection and conflict resolution. Obviously, the popular common purpose that using BIM among the respondents is Construction site management.

4.2.5 The lacks in the implementation of BIM

Table 4.3 The Lacks in the Implementation of BIM

	1	2	3	4	5
The lack of information about the strict BIM	36.70%	16.50%	15.20%	13.90%	15.20%
lack of training and experience	22.80%	21.50%	12.50%	16.50%	12.70%
The lack of support from senior leadership of the company	8.90%	11.40%	22.80%	11.40%	5.10%
high implementation costs	16.50%	5.10%	12.70%	16.50%	8.90%
Fear of failure	10.10%	8.90%	10.10%	6.30%	31.60%

The table presents respondents opinion about the barriers to the implementation of BIM. According to what came in the questionnaire the respondents believe that high implementation costs, lack of training and experience and the lack of information about the strict BIM are the reasons for the lack of implementing BIM. The percentages of each cause appear respectively as follows: 36.7%, 22.58% and 16.5%.

While, the senior leadership of the company being in the third rank depends on the responders choice with 22.8%. And, Responders take Fear of failure as the fifth rank by 31.6%.

4.2.6 Software used in Construction Industry

From the figures below the respondents assess that AutoCAD, Revit, 3d max and ArchiCAD are the most common software's do.

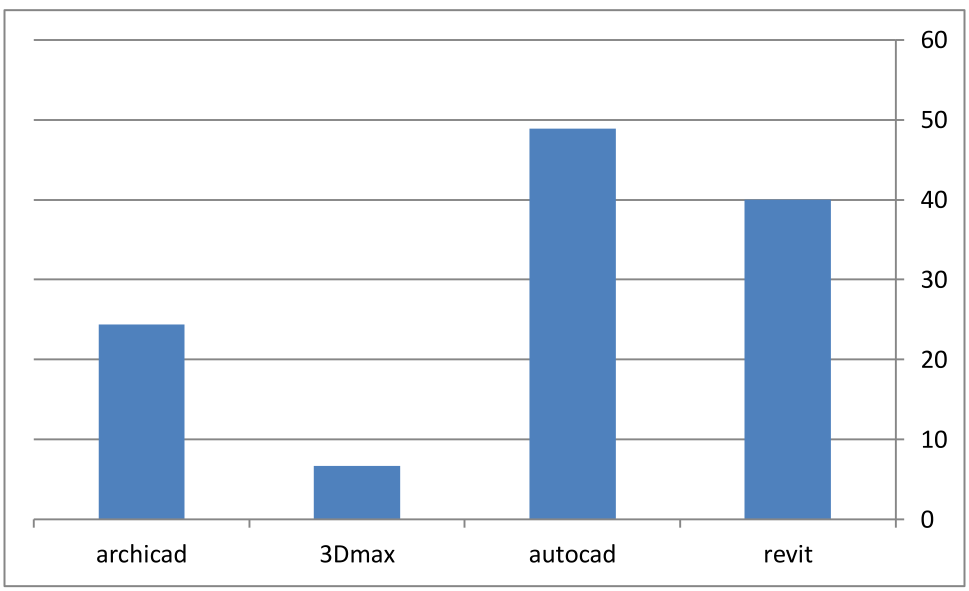

Figure 01. Software Used In Structural Design

Regarding the software used in structural design, the study shows that construction industry is biased to the AutoCAD as the most used software for structure design followed by Revit which both common used for drawing details of structural drawings. The result shows some acceptance for BIM tools showed in figure 4-4

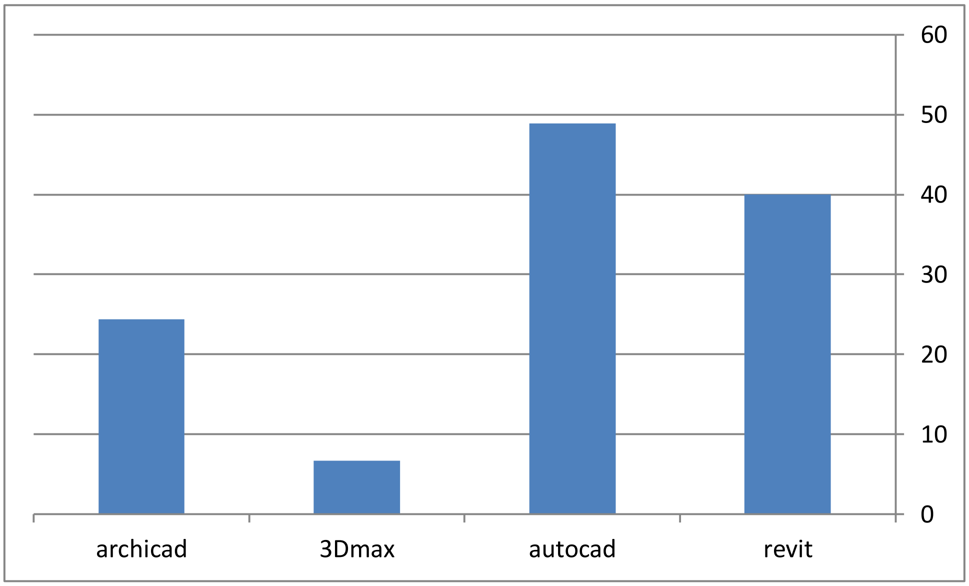

Figure4.2: Shows Software used in Architectural design

Figure 4-5 shows the response obtained from the questionnaire while indicates the construction industry use ArchiCAD, 3D Max and ArchiCAD as most preferred software and also the result shows the adoption for Revit in the construction industry, the respondents also reported that some other tools are also used based on the survey results. In other words, the result shows increment in Revit usage which is considered one of the most used software in BIM.

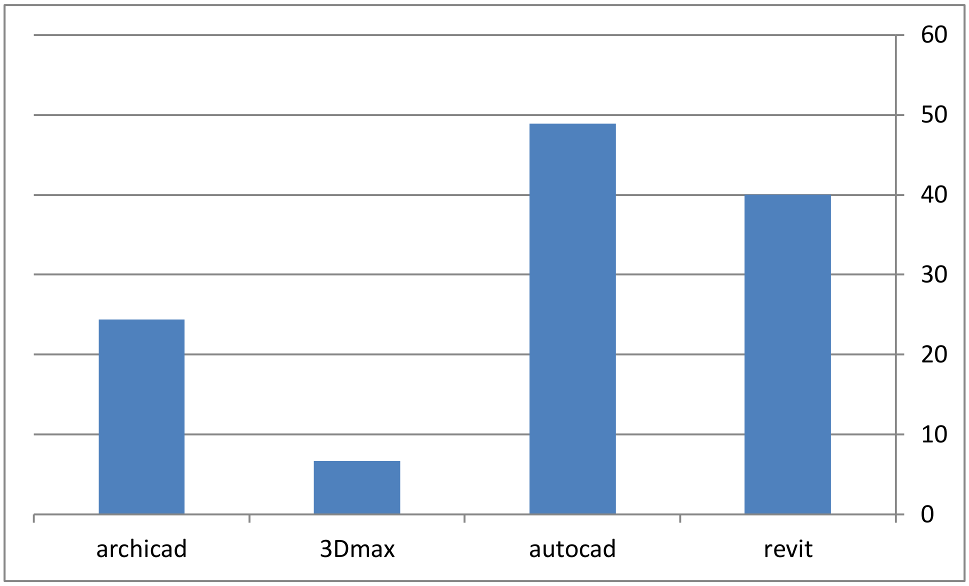

Figure 03. : Software used in cost estimation

Based on the result from this study regarding the cost estimation tools, 48.9% of the respondents mentioned that AutoCAD is used to calculate the quantities from, followed by 40% who prefer Revit. While, 24.4% use ArchiCAD for estimation. This indicated that these softwares are considered as a basis to Modeling and can extract quantities perfectly.

4.2.7 Methods of estimating project costs

The following figure presents the responds about the question: The Method of estimate project cost. The majority used manual Takeoffs from 2D drawings (i.e. AutoCAD) with 62.5%, 11.4 of the respondents used Manual Takeoffs from a BIM (i.e. Revit), 23.9% of the respondents used Automated Takeoff (Modeling software), and 2.3% of the respondents used Automated Takeoff (outside/extension of Modeling software)

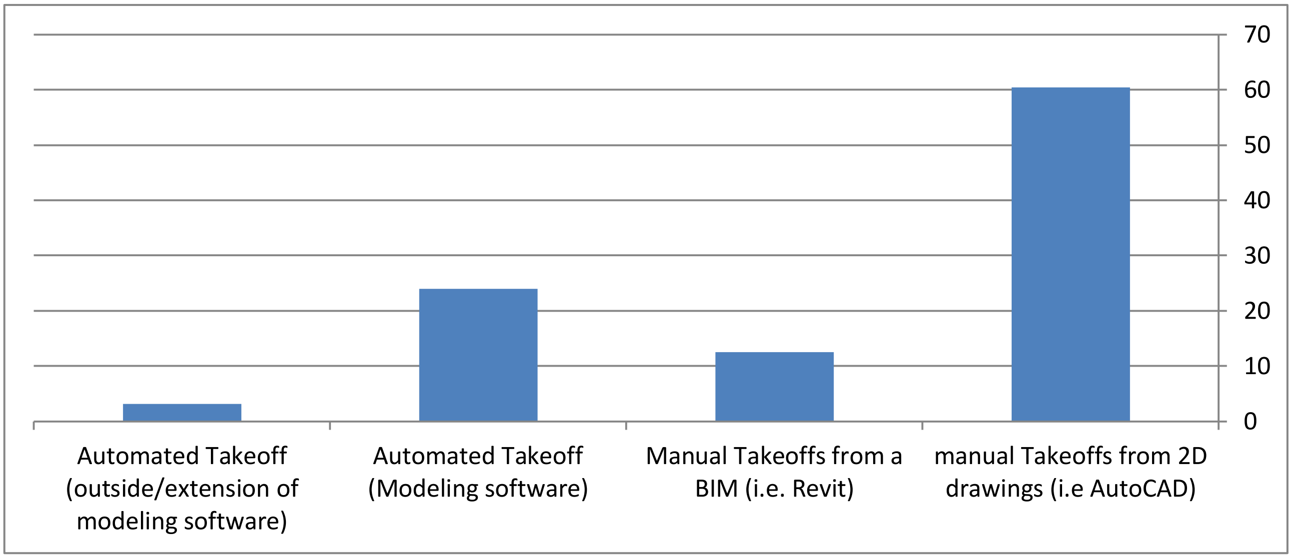

Figure 04.: Methods of estimating project costs

4.2.8 Using BIM software for estimating

The below figure present the Using of BIM software for estimating project costs. 46.8% answered that they were never use BIM software in estimating while 46. 8% usually use it, and 6.3% always use it.

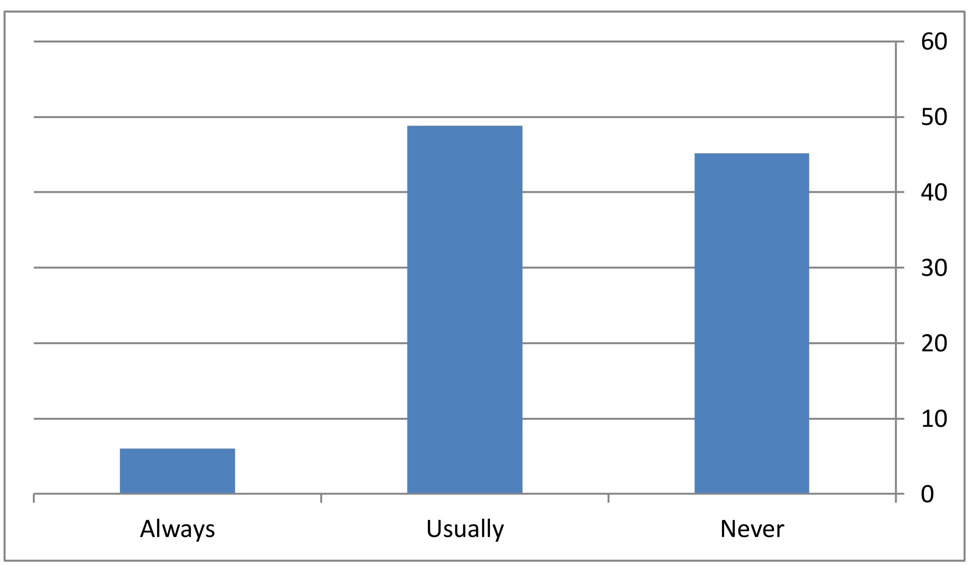

Figure 4.5 BIM software that Use for estimating

4.2.9 Future plan for using BIM in estimating project costs

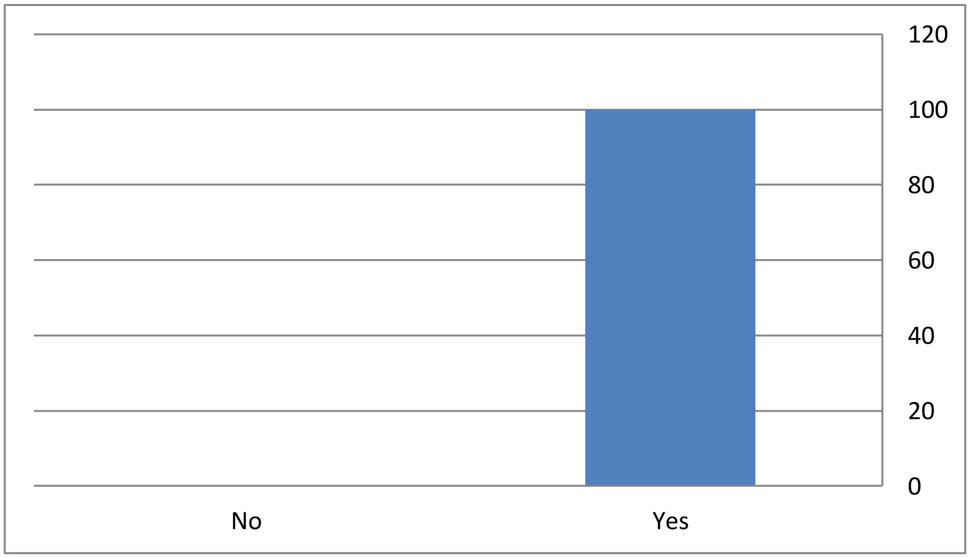

Figure 4.6 : The Future Use of BIM in Estimation

The figure shows the results of the question about Future plan for using BIM in estimation. All the responders replied that they planning to use BIM in estimating project costs. That's mean respondents accept BIM and aware about it benefits.

4.2.10 Building the model

Figure 4-10 show the results of the question about building the model where 61.8% replied by yes, they were built the model by themselves. While rest replied that they don't built the model.

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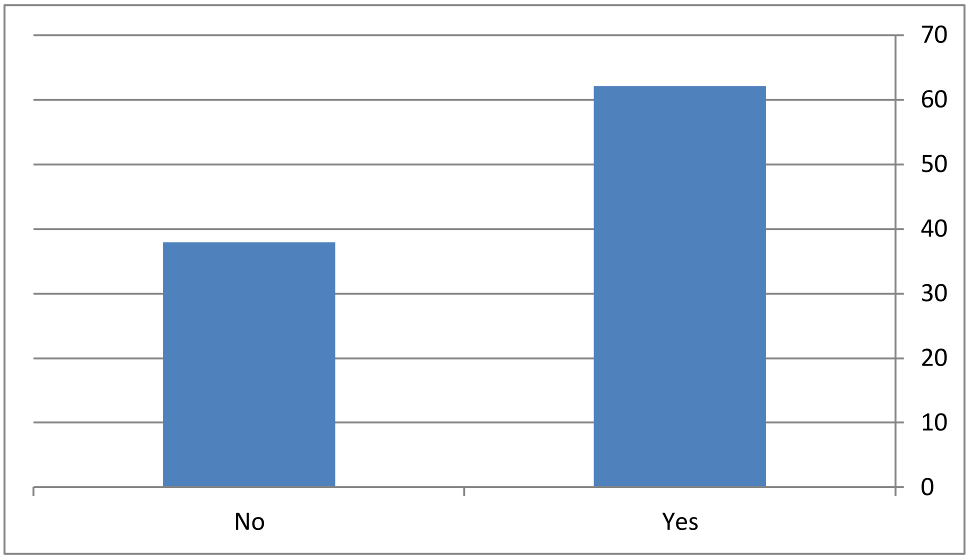

Figure 4.7 Building the Modeling

4.2.11 The benefit of the implementation of BIM in cost estimation

Table 04. The benefit of the implementation of BIM in cost estimation

#	Benefit	Disagree	Neutral	Agree
1	Improved cost estimating at each project stage	11.4	11.4	74.7
2	Reduced overall project cost	20.3	24.1	50.6
3	Improved productivity of estimator in quantity take-off	10.1	15.2	73.4
4	Easier quantity take-off	10.1	10.1	75.9
5	Value engineering	10.1	31.6	53.2
6	Collaboration with other roles	14	24.1	53.2
7	Reduce the lengthiness and complication of bill items in comparison with traditional BQ	10.1	11.4	73.4
8	Reduce the risk of missing items	10.1	19	65.8

9	Increase the efficiency of BQ preparation from consultant	10.1	7.6	72.2
10	Enable contractor's better understanding on the project through the visualization	10.1	15.2	70.9
11	Enhance the accuracy and enable more realistic estimation from contractor's	8.9	20.3	63.3
12	Saving costs at tendering stage	11.4	21.5	59.5
13	BIM had high accuracy	12.7	29.1	49.4
14	BIM concept had future in Sudan	20.3	24.1	50.6

The table above present's respondents' opinion for most benefit of implementing BIM. The question was answered by 79 responders. The results discussed in the figures below for each benefit.

The following figure 4:10 presents the responders' opinion on BIM Improved cost estimating at each project stage. 11.4% of respondents disagree. While 11.4% was neutral, and74.7% agreeing.

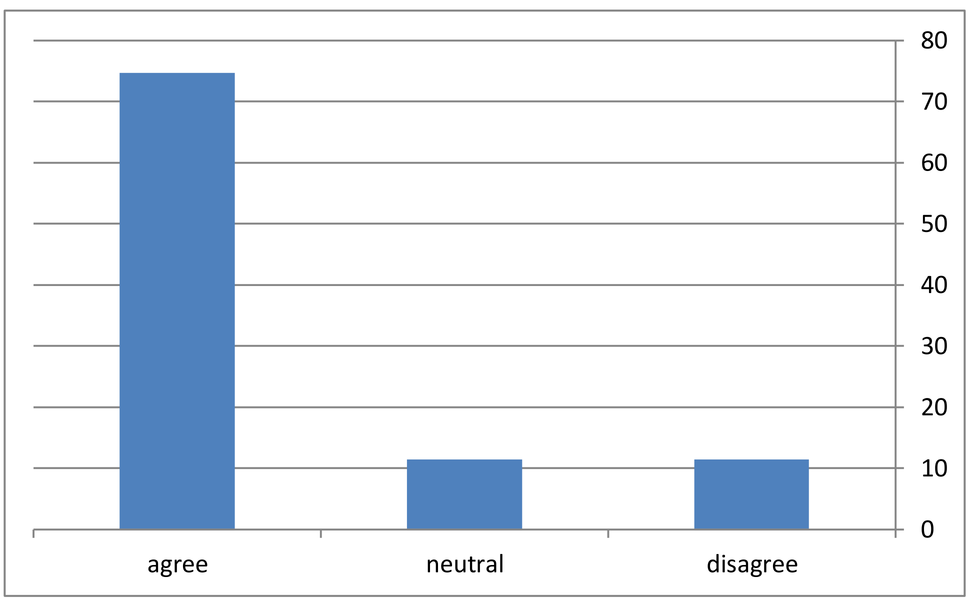

Figure 4.8 : Improved cost estimating at each project stage

Figure 4:11 presents the results of the responds to the question about BIM reducing overall project cost. The results are as follows: 20.3% were disagree, 24.1% were neutral, and 50.6% were agreed.

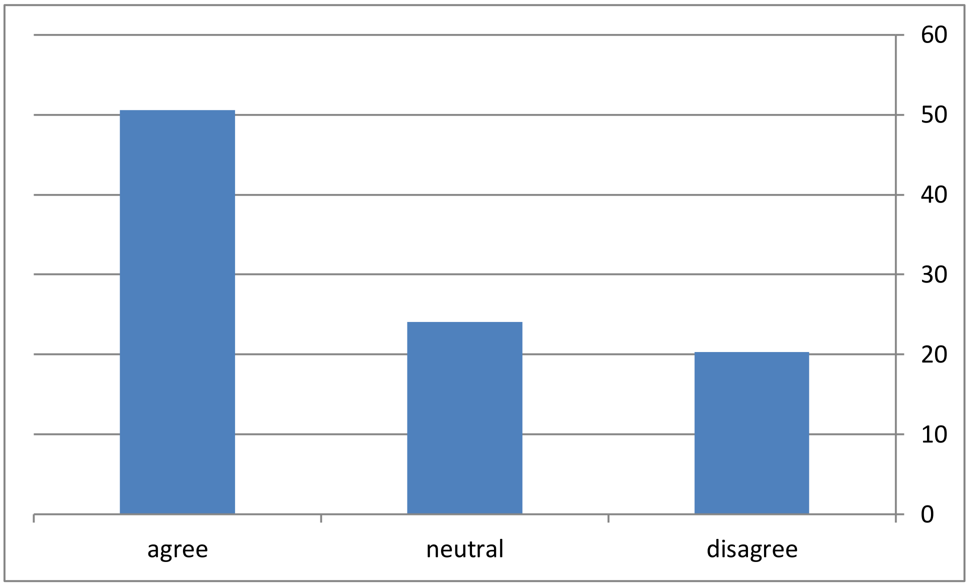

Figure 04.9 : Reduced overall project cost

Figure 4:12 below presents the results of the respondents' opinions. Their responds were as follow: 73.4% of the respondents believe that BIM will improve productivity of the estimator in quantity take-off, 10.1% of the respondents disagree with that, and 15.2% have neutral.

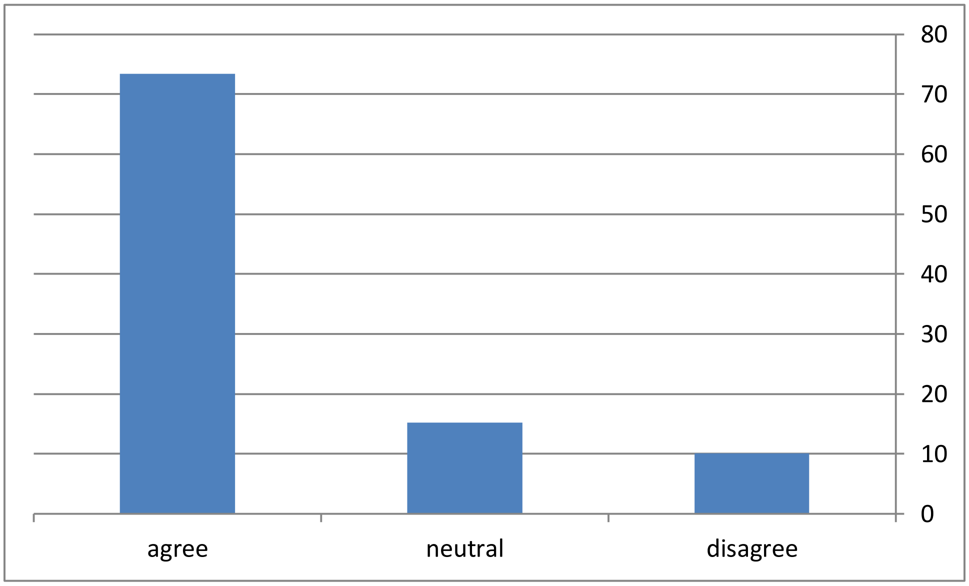

Figure 4.10 : Improved productivity of estimator in quantity take-off

The following figure presents the respondents' opinions about BIM Easier quantity take-off. 10.1% of the respondents disagree with this benefit, 10.1% of the respondents give neutral opinion, and 75.9% of the respondents did agree.

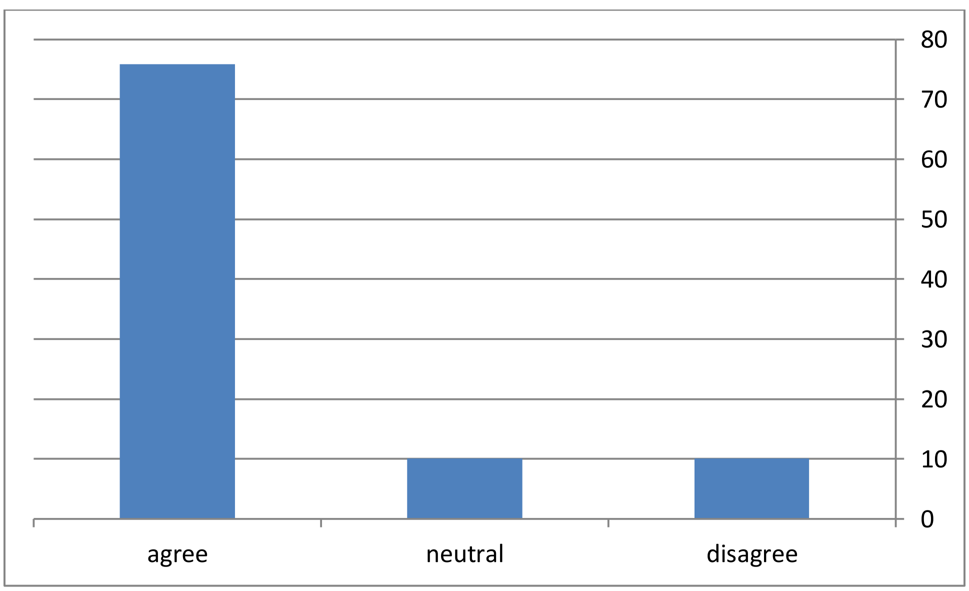

Figure 011. BIM Easier quantity take-off

The following figure presents the benefit of BIM with value engineer. The responds were 10.1% were disagreed, 31.6% were neutral, and 53.2% were agreed.

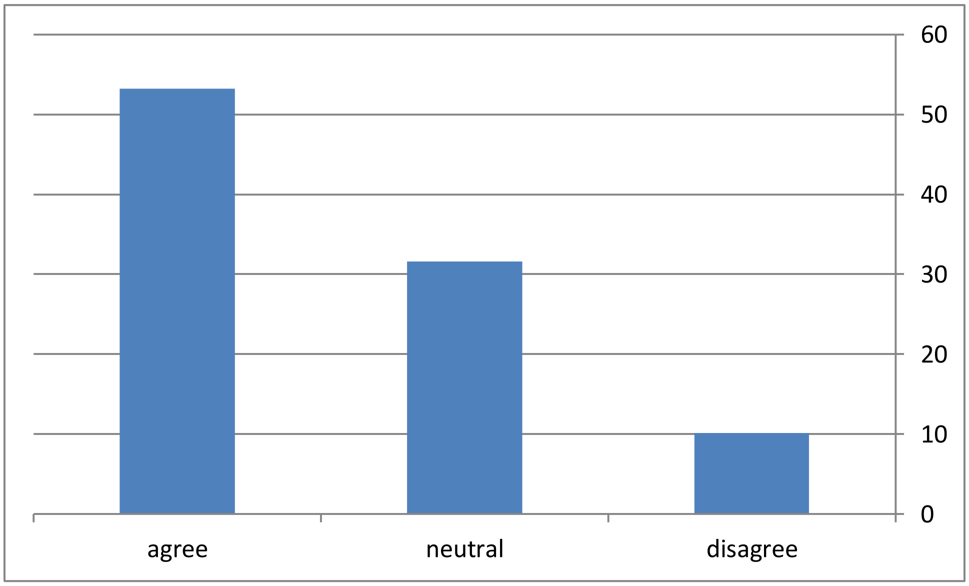

Figure 4.12 Value engineering

Figure 4:15 present the respondents' opinions about the BIM role in enhancing collaboration with other roles. 14% of the respondents disagree, 24.1% of the respondents give neutral opinion, and 53.2% of the respondents did agree.

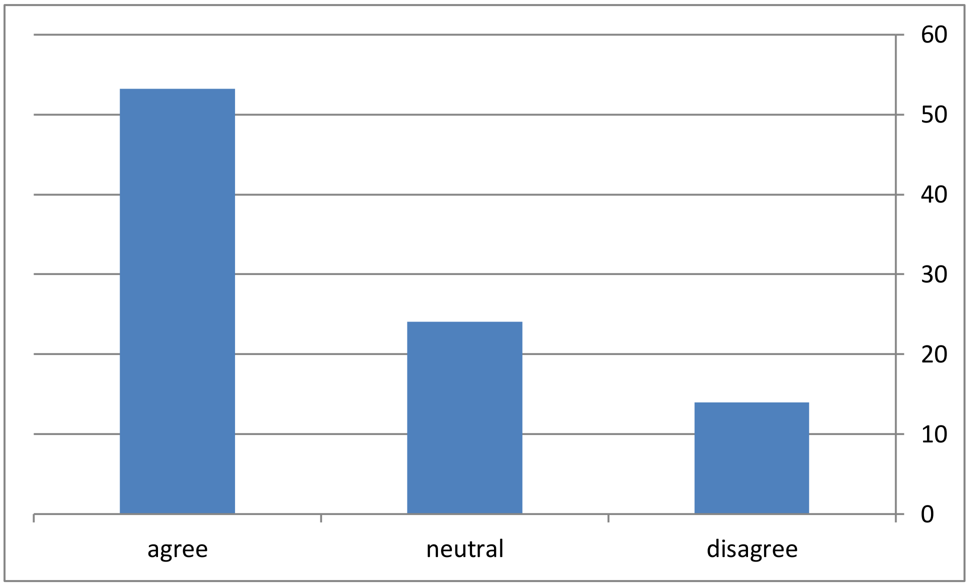

Figure 4.13 Collaboration with other roles

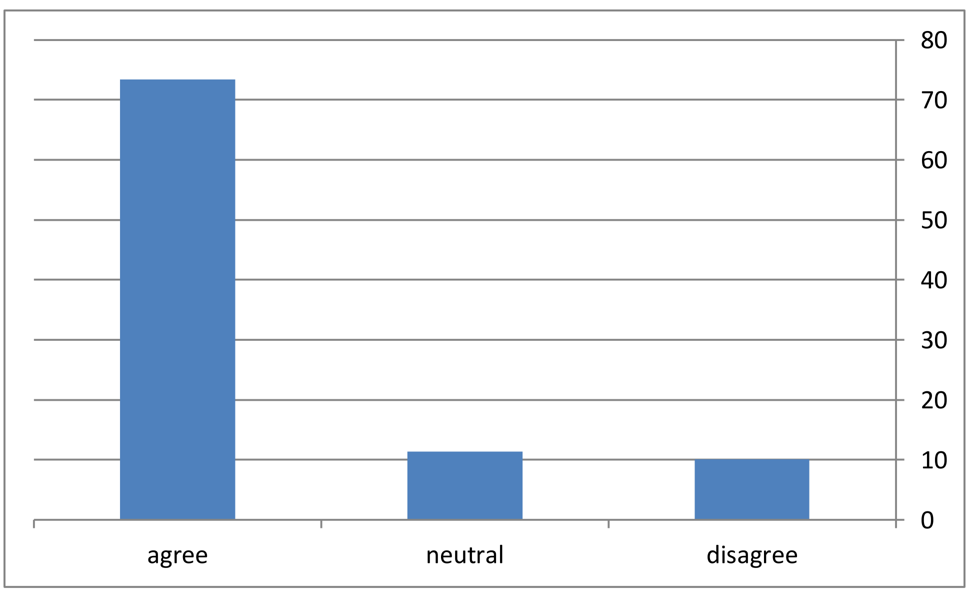

Figure 4.14 reduce the lengthiness and complication of bill items in comparison with traditional BQ

The above figure 4:16 presents the responders' opinion about BIM and how reduce the lengthiness and complication of bill items in comparison with traditional BQ.

The responds were 10.1% were disagreeing, 11.4% were neutral, 73.4% were agreeing.

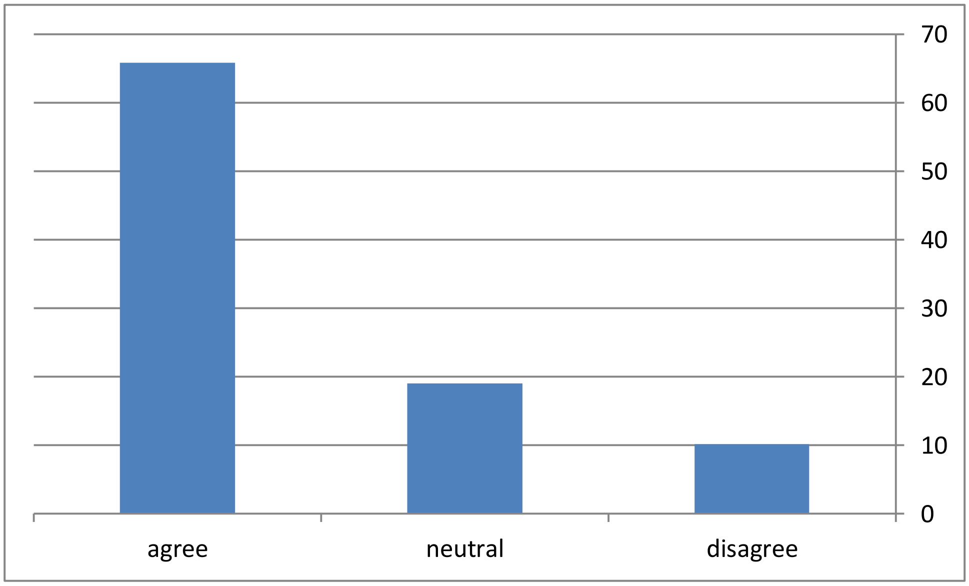

Figure 015. : Reduce the risk of missing items

Meanwhile, 10.1 % disagree on BIM will reduce the risk of missing items in the quantities, 19% take the neutral side, and 65.8% totally agree. That shows in the figure below.

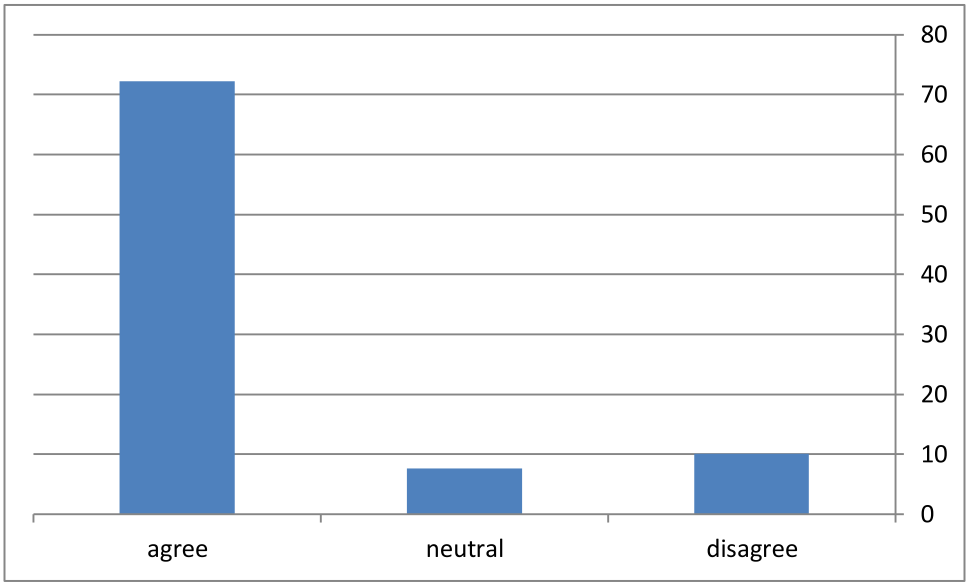

Figure 4.16 Increase the efficiency of BQ preparation from consultant

Figure 4:19 shows the responders opinion about the benefit of BIM for contractors. 70.9% from responders saw that BIM Enable contractor's better understanding on the project through the visualization. While, 10.1% disagree with that, and 15.2% were neutral. In figure 4:20, the responders agree with 63.3% that BIM Enhance the accuracy and enable more realistic estimation from contractors, 8.9% was disagree and 20.3% take the neutral side.

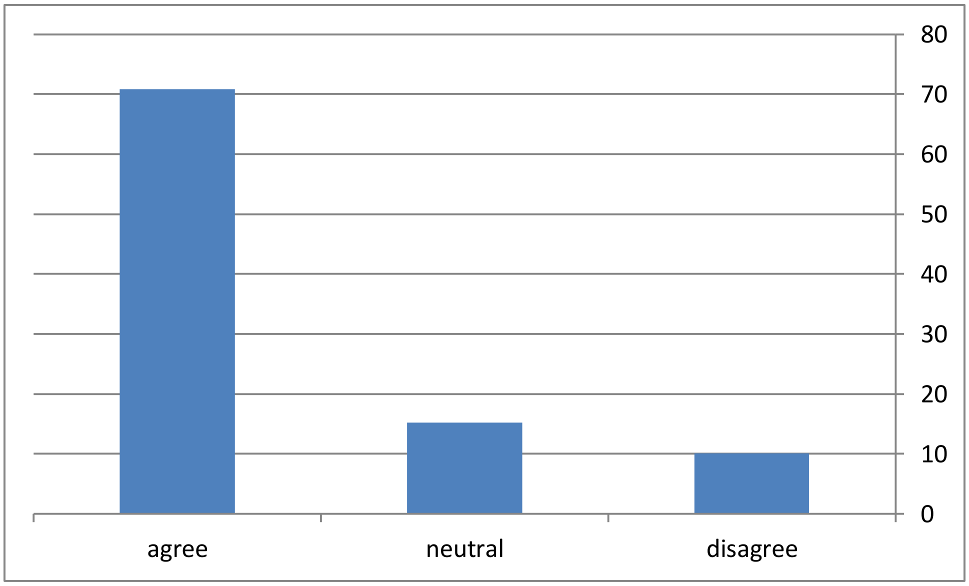

Figure 4.17: Enable contractor's better understanding on the project through the visualization

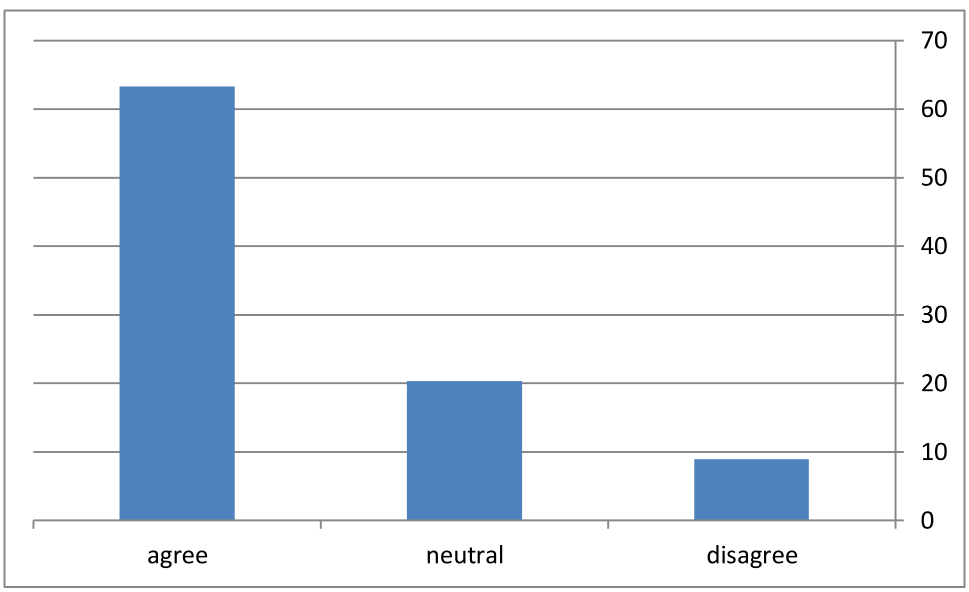

Figure 4.18 : Enhance the accuracy and enable more realistic estimation from contractors

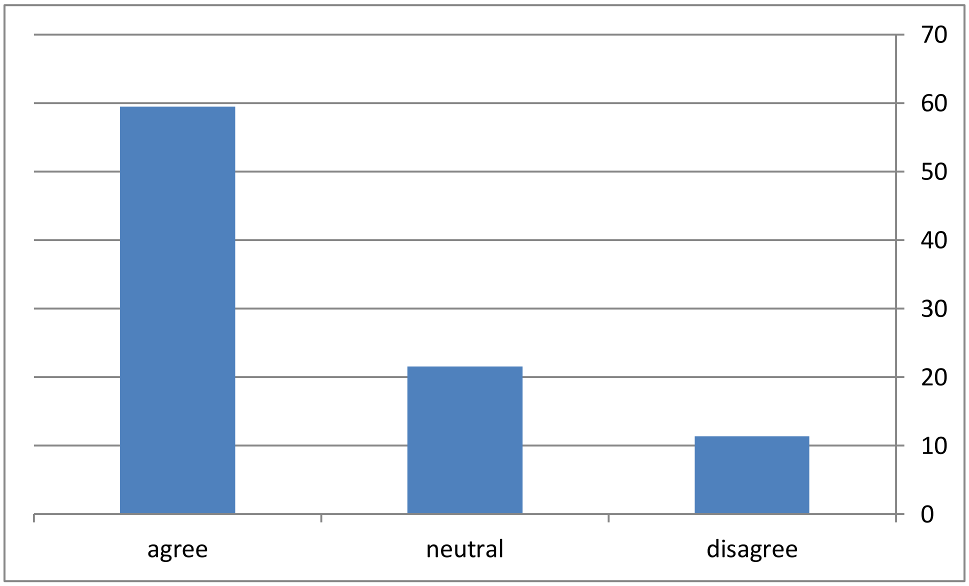

Figure 4.19 saving costs at tendering stage

The above figure 4:21 presents the responders' opinion about BIM and it role in tendering stage. The responds were 11.4% were disagreeing, 21.5% were neutral, 59.5% were agreeing.

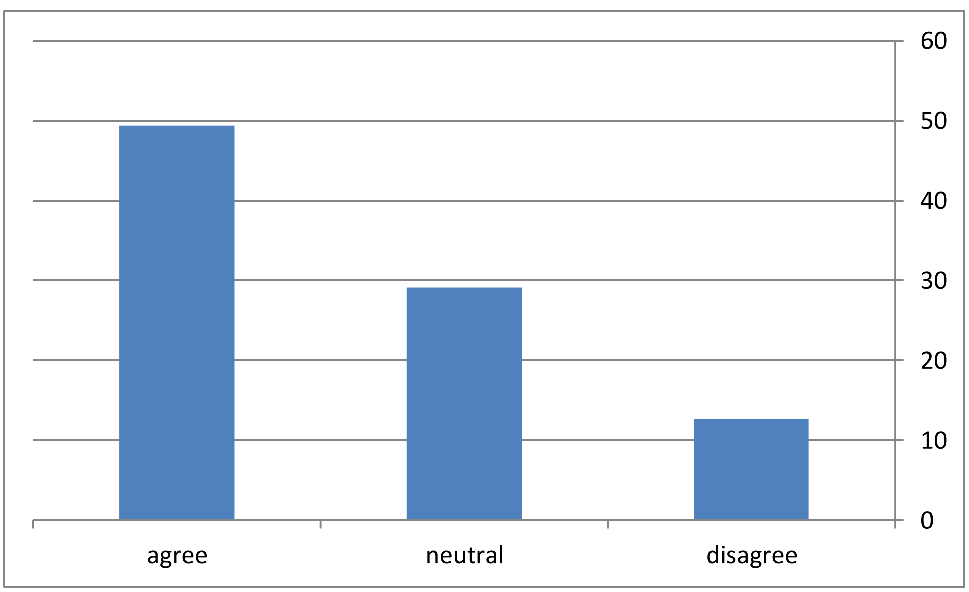

Figure 4.20: BIM had high accuracy

The above figure 4:22 presents the responders' opinion about BIM and it role in tendering stage. The responds were 11.4% were disagreeing, 21.5% were neutral, 59.5% were agreeing.

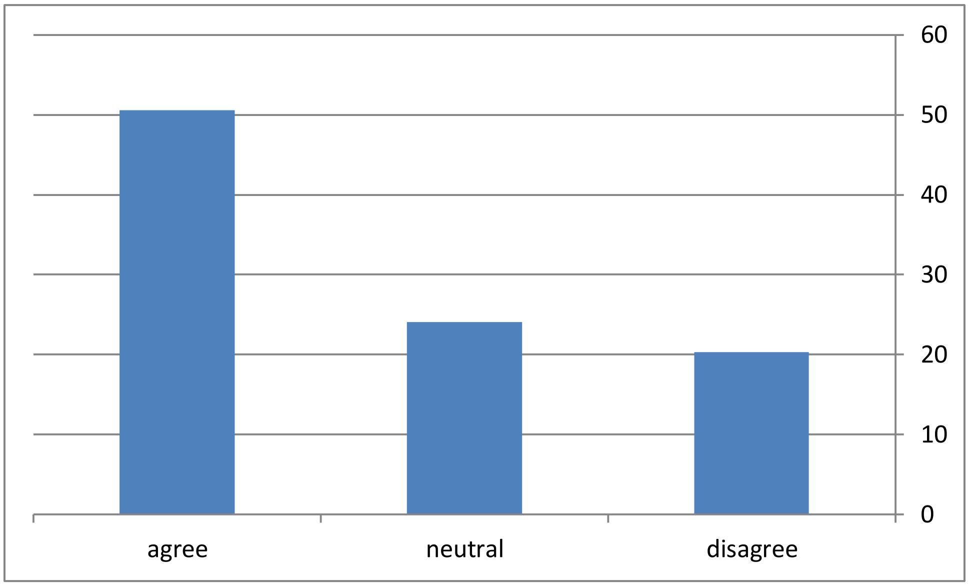

Figure 4.21 BIM had future in Sudan

50.6% totally agree that BIM had a future in Sudan. Thus, maybe they faced the lack of development in the construction industry in Sudan. 24.1% responders were neutral, and 20.3% disagree.

Generally, the figures and the table show that most of the responders agreed with most of benefits that discussed. That means the AEC industry members know about BIM but need encouragement to implementing into the industry.

5 Chapter five

Conclusion and Recommendations

5.1 Introduction:

The purpose of this chapter is to state the most important conclusions of this study. The conclusions /will correlate to the objectives of the thesis and bring up subjects relevant to the aims. Furthermore, suggestions for further research will be proposed. Based on the review many problems were identified in implementing BIM.

5.2 Conclusion:

As the purpose of this research was to find out; the awareness of the AEC industry about Building Information Modeling (BIM) and implementation of (BIM) in construction projects cost estimation.

After the results discussion and interpretation were conducted, the study concluded the following:

- The study results indicated that the awareness level of BIM by professionals in the AEC industry in Sudan is <u>low</u>.
- Findings indicated that BIM functions are significantly needed and important for professionals in the AEC industry in Sudan as well as BIM benefits are significantly valuable for them. BIM function that got top ranking according to overall respondents is <u>construction site management</u>.
- The majority of respondent assess that <u>ArchiCAD, AutoCAD and Revit</u> are the most common use software they use.

- Different methods of estimation were tested, the respondents using manual takeoff from 2D drawings which is popular method for them.
- The majority of respondents reply that they use BIM software in estimation usually which they use it in building models. In addition, the respondents who reply that they never use it they have future plans to adopt it.
- On the other hand, the study findings demonstrated that BIM barriers are greatly affecting the adoption of BIM in the AEC industry in Sudan. The top barrier to adopting BIM in the AEC industry in Sudan from the point view of the respondents is the lack of awareness of information about BIM.
- Finally, Regarding BIM benefits in cost estimation, the BIM benefit in cost estimation that got top ranking according to overall respondents is: improving cost estimation at each project stage.

At last, from the results we can conclude that the applicability is possible in Sudan.

5.3 Recommendation:

Based on the findings of the study, the researcher recommends the follows:

- Application of Education and training programs to increase BIM awareness.
- Adopting BIM need more research, workshops and seminars in order to rise up knowledge about BIM among AEC industry members.
- Government should encourage companies to invest in BIM.
- Government has to made protocols and strategies to use BIM in the industry.
- It is important to Link BIM with other managing methods such as; lean construction and value engineering might improve the productivity and solve the obstacles that face construction industry in Sudan.
- Case studies would be appropriate to explain more about BIM applications and benefits.

5.4 Recommendation for future studies:

It is recommended that future researchers addressing BIM application in other construction industry aspects should be conducted. It should specify more studies, such as:

- Studying the subject of BIM adoption from a consultant's or contractor's perspective.
- study can be conducted about using BIM in planning
- making an accurate comparison in a defined step (such as cost estimation or quantity take-off of materials) in a project that constructed without BIM and then construct a BIM model for the same project to be able to make comparisons in the same step.
- Discuss the benefits that would back from application BIM in tender process.

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Appendix

Subject: a Questionnaire Survey about: “**applicability of Building Information Modeling in project cost estimation”** a Thesis submitted in partial fulfillment of requirements for Master's Degree in Construction engineering, Civil Engineering

Name (Optional): ....

Organization name (optional): ....

Position: ....

Part 1: General information

1. How old are you?

- ☐ 41-50years
- ☐ More than 50 year
- ☐ 20-30 years
- ☐ 31-41 years

2. How many years of experience do you have?

- ☐ More than15-20 Years
- ☐ More than 20 years
- ☐ 0-5 Years
- ☐ More than5-10 Years
- ☐ More than10-15 Years

3. What is your educational level?

- ☐ Master degree
- ☐ Doctoral degree
- ☐ Diploma
- ☐ Bachelor

4. What the nature of your organization?

- ☐ Mixed sector
- ☐ Other………………………
- ☐ Public sector(government)
- ☐ Privet sector

<u>Part 2:</u> The awareness of AEC industry in Building Information Modeling (BIM) and implementing (BIM) in construction projects cost estimation.

1. What is the best description for BIM?

- ☐ Process
- ☐ Software
- ☐ Technology
- ☐ Integrated 3D model
- ☐ I don't know
- ☐ Virtual Tool

2. How would you measure the level of BIM awareness in you organization?

- ☐ Low
- ☐ High
- ☐ I don't know
- ☐ Medium

3. What do you think that may lack the implementation of BIM?

Organize it from 1 to 5

#		1st	2nd	3rd	4th	5th
1	The lack of information about the strict BIM					
2	lack of training and experience					
3	The lack of support from senior leadership of the company					
4	high implementation costs					
5	Fear of failure					

4. What software do you use for?

a) Architectural design………………………………………

b) Structural design ………………………………………..

c) Cost estimating………………………………………..

5. How do you estimate project costs?

- ☐ manual Takeoffs from 2D drawings (i.e AutoCAD)
- ☐ Manual Takeoffs from a BIM (i.e. Revit)
- ☐ Automated Takeoff (Modeling software)
- ☐ Automated Takeoff (outside/extension of Modeling software)

6. Do you use BIM software for estimating?

☐ always ☐ Never

☐ Usually

a) If never, do you plan on using BIM in the future for estimating?

☐ No ☐ Yes

b) If always, do you build the model yourself or get it from the architect

☐ Never

☐ Always

☐ Usually

7. The implementation of BIM affected the tasks below? **(Please rate them in an importance scale of 1-5, where 1=”very disagree” and 5=”very agree”)**

#		Very disagree	Disagree	Neutral	Agree	Very agree
1	Improved cost estimating at each project stage					
2	Reduced overall project cost					
3	Improved productivity of estimator in quantity take-off					
4	Easier quantity take-off					
5	Value engineering					
6	Collaboration with other roles					
7	Reduce the lengthiness and complication of bill items in comparison with traditional BQ					
8	Reduce the risk of missing items					
9	Increase the efficiency of BQ preparation from consultant					
10	Enable contractor’s better understanding on the project through the visualization					
11	Enhance the accuracy and enable more realistic estimation from contractor’s					
12	Saving costs at tendering stage					
13	BIM had high accuracy					
14	BIM concept had future in Sudan					

Thank you in advance for your valuable time and contribution to this research work.

Researcher