UNIVERSITY OF NAIROBI

BUILDING INFORMATION MODELLING ADOPTION IN CONSTRUCTION PROJECT MANAGEMENT IN KENYA : A Case Study of Nairobi County

BY

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DECLARATION

I declare that this is my original work and has not been presented to any other university or institute of higher learning for examination or academic purposes.

Signature___________________________ ___________________

MARYLYN MUMBUA MUSYIMI **DATE**

REG. NO B53-68312/2013

This research proposal has been presented for examination with my approval as the University supervisor.

Signature___________________________ ___________________

ARCH. PETER NJERU **DATE**

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DEDICATION

I dedicate this project to Mr. & Mrs. Dominic Kioko, without whose encouragement I would not have undertaken or completed this endevour.

To my husband, Dennis, for his support.

ACKNOWLEDEMENTS

I thank God for through Him all things are possible. He has been faithful in completing the good work that He begun in me.

Thank you to my supervisor Arch. Peter Njeru, for your time and effort without which this work would not been possible.

I thank all that participated in the study, and my classmates and colleagues, for their invaluable insight and camaraderie.

To my employers Waweru & Associates and Mutiso Menezes International for according me the necessary support to complete my studies, thank you.

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I take full responsibility for this study. Any errors or shortcomings herein do not in any way reflect the contribution of the aforementioned.

ABSTRACT

Construction projects today are far more complicated than ever before and there is an urgent need to coordinate the efforts of all the participants in a project. Globally the Construction Industry is shifting from CAD to BIM. It is therefore important that we understand what this transition constitutes. Substantial research has been carried out on BIM use in allied construction professions of Architecture, Engineering and Quantity Surveying. This research seeks to address the gap in knowledge of BIM use for Construction Project Management, and in particular, in the Kenyan context, as well as how the adoption of BIM can enhance the delivery of projects.

The research was guided by four objectives within the study area of Nairobi County: to establish the extent of BIM use for Construction Project Management; to identify the challenges in adopting BIM for Construction Project Management; to identify the advantages in adopting BIM for Construction Project Management and to develop strategies to increase the adoption of BIM in Construction Project Management.

The research design employed was survey research which was exploratory in nature. Individual respondents from firms were asked about their perception and personal experiences as pertains BIM adoption. The major findings revealed that the organisation, processes and technology in use within a firm significantly affect the choice to adopt BIM.

Based on these findings, it is recommended that: construction industry regulators actively take up BIM implementation; that educators should train on the use and benefits of BIM; professionals should be encouraged to adopt BIM in their practices and finally, that professional bodies should be encouraged to include training on BIM in their Continuous Professional Development programmes. The following areas of further research are recommended: the re-modelling of contractual relationships to suit BIM adoption and research into the changing responsibilities of stakeholders in the adoption of BIM.

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CHAPTER 1: INTRODUCTION

1.0 Background of the study

Infrastructure development has been identified as one of the pillars for Kenya's vision 2030 development blueprint, GoK(2007). Infrastructure development and an active construction industry are indicators of a thriving economy. These two activities also promote the development of other industries within the economy through backward linkages. Park (1989), has confirmed that the construction industry generates one of the highest multiplier effects through its extensive backward and forward linkages with other sectors of the economy.

Construction projects often involve a combination of professionals, and a combination of factors for their actualisation. This involves the coordination of varied information at the various project stages for on-going implementation. This coordination necessitates a lot of back and forth communication between construction professionals and industry stakeholders which is both expensive and time consuming. Alshawi and Ingirige (2002) state that construction projects today are far more complicated than ever before. They involve large capital investments, embrace multi disciplines, engage widely dispersed project participants, operate on tighter schedules, and require stringent quality standards.

It was concluded in a study, that the top 30 potential problems contributing to poor project performance could be classified under five categories, out of which communication problems are listed as the third category and all five categories involve communications to some extent, Thomas et al. (1998). There is therefore a need to collaborate the efforts of all the participants in a project. This will reduce time and money spent on projects. Effective collaboration on construction projects will increase efficiency and savings, further accelerating economic growth in Kenya.

The nature of construction projects involves dynamic environments and varied disciplines. This, with limited time and budgets within which to deliver projects. This nature of the construction industry gave birth to two fields in the industry; Construction Project Management and Building information modeling, which are potential solutions to the challenges arising from limited time and budgets.

Over time, traditional 2- dimensional execution of projects has given way to CAD, computer aided design, which is faster and more efficient. Building information modeling (BIM) is the latest generation of Object Oriented CAD (OOCAD) systems in which all of the intelligent building objects that combine to make up a building design can coexist in a single project database ‘or virtual building’ that captures everything known about the building. ‘A building information model provides a single, logical, consistent source for all information associated with the building’, Luthra (2010).

Construction project management on the other hand, has developed as the professional discipline which separates the management function of a project from the design and execution functions, Chartered Institute of Building (2002). As projects became larger or more complex the need for separate management resulted in the evolution of construction project management. Over the years, a strong case has been made for the adoption of BIM in the construction industry and especially in Europe, North America and Australia. According to the National BIM Survey 2014, carried out in the UK, ‘awareness of BIM is now almost universal at 95% and adoption rates are accelerating with more than half of respondents (54%), now using it up 15% on last year, and 93% predicting adoption by 2016’.McGraw Hill Construction (2014).

1.1 Statement of the problem

Globally, the construction Industry is shifting from traditional CAD to BIM, as illustrated by McGraw Hill Construction (2014), ‘BIM use across the globe is accelerating powerfully, driven by major private and government owners who want to institutionalize its benefits’. It therefore is important, that we understand what constitutes a successful shift from CAD to BIM at project level.

A successful transition to BIM requires much planning and a completely different approach to project design and management. It requires development of new processes that support the coordination of all parties involved. Choice of project team members, design and collaboration platforms, in addition to new project delivery methods, become critical to managing an efficient and profitable building project. Whereas traditional CAD is based on traditional drawing and is in essence simply automating that process, BIM is focused on objects, and providing varying levels of information associated with those objects. It is consequently essential that the correct procedures are put into place to ensure the appropriate information to each project can be collected and utilized efficiently. Additionally, BIM involves more change management and consists mainly in coordination, time and cost estimation, programming and procurement. In summary, a successful transition to BIM requires the re-working of the organization, the technology and the processes in use within a firm for execution of projects.

Internationally, substantial research has been carried out on the use of BIM in related Construction professions such as Architecture, Engineering and Quantity Surveying. However, as The Project Magazine (2014) notes, 'up until now Project Managers have received insufficient attention in comparison to the other professions'. That is, the field of Construction Project Management has had little research carried out as regards BIM use, especially as compared to other construction professions. In addition, context is very important, as construction Industry organisation and culture varies from one country to another, necessitating this research based on Kenya. Hergunsel (2011) studied the various uses, advantages and setbacks of BIM use by Construction Managers. The research concluded that generally, the use of BIM is advantageous to Construction Managers although its implementation may be challenging. Lahdou & Zetterman (2011) examined how BIM can be utilized by Project Managers. They also examined how the project manager's role and the relationships to other stakeholders are affected when BIM is employed in construction projects. Locally, Ojwang' (2012) investigated Constructability review using BIM, with a focus on Commercial Projects. The findings of this investigation indicated that the Kenyan Construction Industry is dominated by the traditional method of project delivery which lends itself poorly to integration. Njagi (2013), studied the use of BIM by class A and B contractors in Kenya. This research established that the understanding of BIM amongst these contractors is unclear. Little research has been done in the Kenyan context on the use of BIM, and none for the use of BIM in Construction Project Management. This research seeks to address that gap. Furthermore, as Construction Project Management's role is primarily one of coordination and collaboration, that is, facilitating the working together of the various construction professionals on any given project, it is likely to benefit most from the adoption of the BIM platform. This, because BIM is conceived as a coordination and collaboration tool.

The proposed research is inspired by the current level of unawareness within the Kenyan Construction Industry, and specifically Construction Project Management, as to how BIM adoption can enhance the delivery of projects.

As the adoption of BIM in Kenya is a new concept, with very few projects undertaken using BIM, there arise a number of questions as to how BIM adoption can aid Construction Project Management in the Kenyan Context. First, what constitutes BIM adoption on any given project? Secondly, what is the current level of Construction Project Management Practice in Kenya? Thirdly, is there a framework for the use of BIM in Construction Project Management? Fourth, what differences are there between traditional Construction Project Management and BIM aided Construction Project Management? Finally, what benefits are there in the adoption of BIM for Construction Project Management in Kenya?

Based on the foregoing questions, there is need to examine the adoption of BIM in Construction Project Management in Kenya.

1.2 Purpose of the study

The purpose of this study therefore is to examine the adoption of BIM in the Construction Project Management Process in Nairobi County, Kenya.

1.3 Methodology of the study

The research design was both exploratory and descriptive. Exploratory where insights into the study were obtained though the review of literature. These insights were then used as a guide for the descriptive study. The main data collection tool was a semi-structured survey questionnaire that resulted in both quantitative and qualitative data.

1.4 Conceptual Framework

The conceptual framework below outlines the main variables to be studied and the presumed relationships between them, first in a graphical illustration and later in narrative.

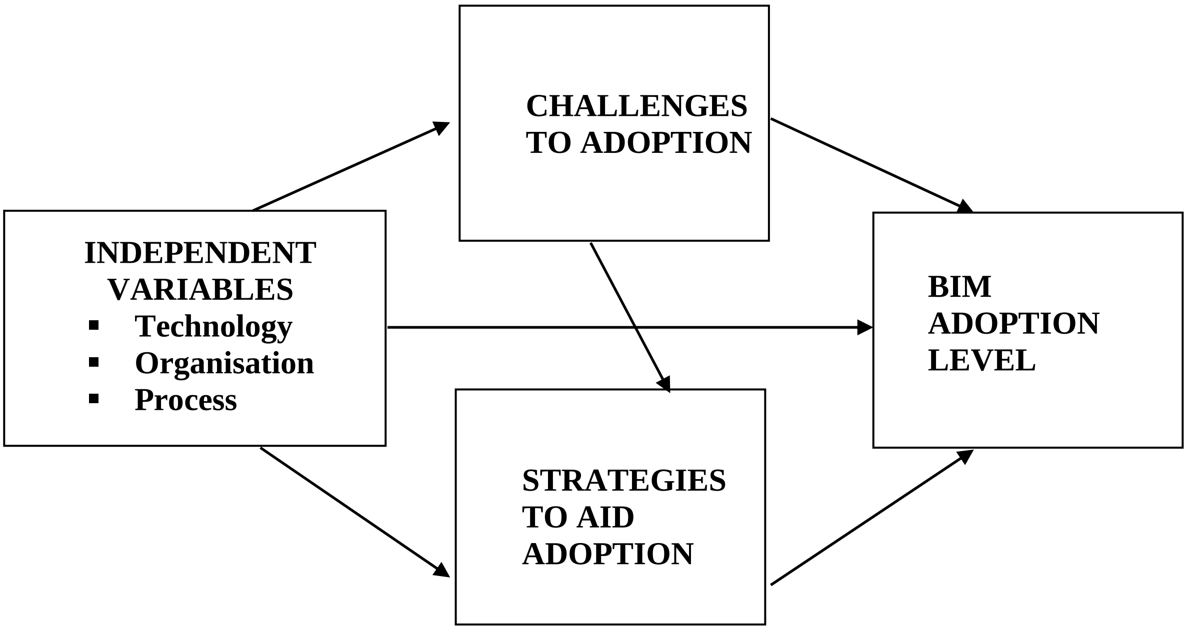

Figure 1.1: Conceptual framework

1.5 Operationalisation table

Table 1.1: Operationalisation table.

Variables	Performance Indicators	Assessment criteria	Category of measurement
1. Technology	Type of software in use	Software developer	Nominal
	Level of BIM maturity	BIM use levels	Ordinal
	Timing of adoption of technology during project lifecycle	Project stage when BIM is implemented	Nominal
2. Organisation	Size of firm	Number of employees	Nominal
	Appointment of BIM manager	Presence of BIM manager in firm	Nominal
	Number of technical staff in firm	Total number	Nominal
	Early involvement of all stakeholders	Specific project stage each is involved	Ordinal
	Sufficient information	Adequacy for BIM	Ordinal
	Shared goals and objectives	Presence of these	Nominal
	Appropriate information structure	Adequacy for BIM	Ordinal
3. Process	BIM implementation process	In-house or out-sourced	Nominal
	Facilitation of collaborative process	Presence of these	Ordinal
	Documentation of the process	Presence of these	Nominal
	Institution of formal processes & procedures	Presence of these	Nominal

Source: Author, 2015.

1.6 Hypotheses of the study

1. Null Hypothesis: The independent variables of technology, organisation and process do not have a significant effect on the level of BIM adoption in Nairobi County.

2. Alternative Hypothesis: The independent variables of technology, organisation and process have a significant effect on the level of BIM adoption in Nairobi County

1.7 Objectives of the study

1. To establish the extent to which technology, organisation and processes of firms affect adoption of BIM use for Construction Project Management within Nairobi County.
2. To identify the challenges in adopting BIM for Construction Project Management in Nairobi County.
3. To identify the advantages in adopting BIM for Construction Project Management in Nairobi County.
4. To develop strategies to increase the adoption of BIM in Construction Project Management in Nairobi County.

1.8 Research questions

1. What is the number of Construction Professionals using BIM for Construction Project Management in Nairobi County? How are they using BIM for Construction Project Management?
2. What are the benefits of the use of BIM in Construction Project Management in Nairobi County versus traditional Construction Project Management? What challenges are encountered in adopting BIM use for Construction Project Management?
3. How can Construction Project Management in Nairobi County benefit fully from BIM use? How can BIM adoption be encouraged for Construction Project Management in Nairobi County?

1.9 Significance of the study

It is hoped that this research will bring to fore examples of BIM use in Construction Project Management ,(CPM), in the local context, highlighting its' potential benefits, which may in turn increase the adoption of BIM for CPM. The study will also provide information on the current trends in CPM in Kenya. This information can be used as a basis for policy formulation both to regulate the CPM practice in Kenya and to facilitate it.

This research will provide information on BIM use in Kenya which can be used; as a basis for regulation of its' use; and to develop strategies to support its' adoption. The research is especially timely as it will promote the use of technology, that is, BIM, in the development of infrastructure, which is one of the pillars of Kenya's Vision 2030.

This research will demonstrate to Construction Project Management Professionals the usefulness of BIM and will serve as a basis or impetus for BIM adoption both at firm and policy level. This research will also be beneficial to BIM software developers and re-sellers as it will highlight the areas of need that BIM can address within the Construction Project Management practice.

For future research, this study will provide baseline information on the current adoption of BIM in CPM in Kenya.

1.10 Assumptions

This study will be guided by the assumption that participants' responses will be honest and truthful, this can be encouraged by ensuring participation is voluntary and information provided is guaranteed anonymity and confidentiality.

1.11 Limitations

A low response rate was encountered which the researcher tried to mitigate by sending out follow-up emails and extending slightly the field period. This resulted in a few conversions of non-respondents.

The time available to carry out the study is limited, and will therefore not allow for as much in depth study as would have been desired, also, the limited research duration limits access to project participants.

1.12 Delimitations

The study will focus on Construction Project Management as this field is relatively new in the Kenyan construction industry, and the body of knowledge specific to Kenya is still limited.

The study focuses on BIM adoption so as to establish the level of uptake as well as understand how BIM has been received in the industry as it a new comer in the Kenyan Construction Industry.

1.13 Definition of terms

CPM - Construction Project Management; for the purpose of this research is defined as,' the overall planning, coordination and control of a project from inception to completion aimed at meeting a client's requirements in order to produce a functionally and financially viable project that will be completed on time within authorized cost and to the required quality standards.' The Chartered Institute of Building (2002).

CAD - Computer Aided Design.

OOCAD – Object Oriented Computer Aided Design.

BCF -BIM Collaboration Format

IPD – Integrated Project Delivery: A project delivery approach that integrates people, systems, business structures and practices into a process that collectively harnesses the talents and insights of all participants to optmise project results, increase value to the owner, reduce waste and maximize efficiency through all phases of design, fabrication and construction. Integrated Project Delivery, A Guide (2007)

CPM – Construction Project Manager.

IFC – Industry Foundation Classes:

RIBA – Royal Institute of British Architects

BIM – Building Information Modelling: the digital representation of physical and functional characteristics of a facility.

4D BIM- BIM plus time

5D BIM- 4D BIM plus cost

6D BIM- 5D BIM plus life cycle management

CIB – The Chartered Institute of Building

NBS – National Building Specification (owned by RIBA)

1.14 Outline of the study

The study is organized into 5 major chapters:

The **First Chapter** details an introduction to the aspect of study and the research problem. This part also spells out specific objectives of the study, study methodology, study hypotheses, study assumptions, justification of the study, the study scope and limitations.

The **Second Chapter** involves critical review of the relevant literature (books, magazines, journals and the internet). This chapter also looks at the detailed use of Building Information Modelling in Construction Project Management, the development of both fields of knowledge and how they come together.

The **Third Chapter** comprises of detailed research methods applied in this research. It also includes the research strategies, sampling procedures, data collection techniques, and data analysis and interpretation techniques.

The **Fourth Chapter** focuses on the analysis and presentation of data and results from selected case studies. These will include comparative tables and other data presentation techniques.

The **Fifth Chapter** comprises of the findings, recommendations and conclusions of the study. This chapter also proposes other areas for further research.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

BIM has been said to be the next big change for the construction industry after CAD. BIM is defined as, 'digital representation of physical and functional characteristics of a facility' (The National BIM Standard, 2006). BIM adoption has been studied substantially in the first world, however a lot of questions still beg as to its adoption in Kenya.

The literature review first defines information, its management, nature and transfer within the context of the construction industry. Secondly, it discusses construction information and BIM, how the two come together. It goes on to highlight the history of BIM, its definition and relationship to construction project management. This is contrasted with traditional construction project management, where the purpose and structure of construction project management within the construction industry is discussed. Levels of BIM use are discussed, along with the impact of BIM, international BIM initiatives, standards and guides contrasting them with those in Kenya. Finally, the literature review discusses best practices for BIM use in construction project management and how BIM use alters conventional work practices, leading up to the challenges BIM adoption faces and how adoption can be encouraged.

2.1 Information and Information Management

Valence & Best (eds. 1999), illustrate how the increasing complexity of buildings and the activities and services they house is tied to an increase in the range and numbers of participants in the buildings' procurement process. An increased number of participants naturally means more information going back and forth between these participants. This information must be managed efficiently to ensure successful projects. The example is given of the Great Synagogue in Sydney, Australia; the synagogue was built in the late 19th century with only a handful of architectural drawings; in contrast a project on an adjacent site 100 years later had nearly 57,000 drawings issued and 10,000 items of correspondence generated.

A further observation is made that, increased demand for timely and efficient collection, dissemination and storage of accurate and detailed information has resulted from increased time and money constraints as well as changing procurement systems and the need to build in value. Caution is given that in such an environment, poor communication leads to disputes, abortive work, re-design, on-site clashes and a myriad of other costly problems.

From the foregoing discussion, it is understood to be paramount that at the outset of every project a sound strategy is put into place to manage project information. This strategy should establish the pattern of information flow throughout the life of the project as well as identify the manner in which information will be managed through a single point of responsibility, ideally the construction project manager.

The conclusion therefore, is that; in order to come up with a sound strategy to manage project information, it is necessary that the construction project manager understands the nature of information in construction projects.

2.1.1 Nature of project information in construction projects.

As described by Mitchell & Miller (1999) information has the following characteristics within a projects’ life cycle; Information is longitudinal, that is, it passes from one phase to the next. The phases are; planning, design, construction and finally operation. Information is lateral, that is, it is constantly flowing between managers and designers and within and between different services; architectural, engineering, costing and so on. Information becomes refined over time, that is, initially information is vague and imprecise, but as a project is developed it becomes more detailed and exact. Information changes constantly, that is, during the entire design and construction process, there are many changes to both the design and documentation of the project. Some changes are unavoidable whilst others result from errors or misunderstandings. Information is presented in a variety of documents, that is, sketches, layouts, schedules, detailed drawings, reports, and so on. Information is generated and used in different work phases and organisations. That is, by people with different agendas, backgrounds, information levels and objectives. Bearing in mind these characteristics, the strategy adopted by the construction project manager to manage the project information must therefore take into account the above aspects of the nature of project information.

2.1.2 Transfer of project information

On a construction project, both people and machines use information for a variety of purposes. Mitchell & Miller (1999) opine that, project participants typically add to or enhance project information. This information is then used to create, manufacture, construct or operate some component of the building. Information is therefore processed while being passed back and forth between project participants. This back and forth constitutes collaboration on any given project. Currently, online collaboration is on the rise, moving away from traditional time- and labor-intensive communication methods, Herdunsel (2011), Basel (2011); from a document-based environment, to an integrated database working method.

Traditionally, the geometric model and scheduling software have been two separate databases. Design information, time information and cost information were all generated and communicated separately. It is essential that these three aspects of construction project management, time, cost and quality, be integrated. Integration of the three into a mode that allows for their simultaneous transfer will assist in better management of construction processes, as the relationship between the three will be more clearly seen and analysed, and will result in better decision making.

2.1.3 BIM and Construction Information.

The 'I' in BIM, stands for information. The fact that BIM is essentially centered on information is what makes it an appropriate tool for construction project management. In a construction project with its' varying participants and stakeholders, the more information can be communicated from a single source, the better. RIBA (2012) underscores this important connection between construction information and construction management:'*[i]t is important to note that some observers believe that BIM should be the abbreviation for 'Building Information Management' and others use the term BIM(M) alluding to 'Building Information Modelling and Management.'* In BIM, the aspects of quality, time and cost can now be combined; allowing construction project managers to work with automated data, and see the relationships between the three aspects and therefore deliver better projects all round.

2.2 BIM

2.2.1 History of BIM

The concept of BIM has existed since the 1970s (Eastman et al, 1974). BIM can be defined as, ‘the digital representation of physical and functional characteristics of a facility creating a shared knowledge resource for information about it forming a reliable basis for decisions during its’ life cycle, from earliest conception to demolition’ (Construction Project Information Committee. [CPIC], cited in RIBA 2012). BIM is applied for presenting and visualizing building components, construction sequences, resource allocation and other disciplines of the construction process in a virtual environment. According to Eastman(2009), BIM involves representing a design as combinations of "objects" – vague and undefined, generic or product-specific, solid shapes or void-space oriented [like the shape of a room], that carry their geometry, relations and attributes. BIM design tools allow extraction of different views from a building model for drawing production and other uses. These different views are automatically consistent, being based on a single definition of each object instance. BIM software also defines objects parametrically; that is, the objects are defined as parameters and relations to other objects, so that if a related object is amended, dependent ones will automatically also change. Each model element can carry attributes for selecting and ordering them automatically, providing cost estimates as well as material tracking and ordering.

For the professionals involved in a project, BIM enables a virtual information model to be handed from the design team to the main contractor and subcontractors and then on to the owner/operator; each professional adds discipline-specific data to the single shared model, Autodesk Live (2014). This reduces information losses that traditionally occurred when a new team takes 'ownership' of the project, and it ultimately provides more extensive information to owners of complex structures.

2.2.2 Definition of BIM

BIM means not only using three-dimensional intelligent models but also making significant changes in the workflow and project delivery processes, Hardin (2009). BIM is both a process and software. BIM is applicable on any project size. This paper puts forward that, BIM as a process can be used by construction project managers as an information management tool, while BIM as software can be used as an information transfer tool.

2.2.3 BIM as software technology

From technology perspective, a building information model is a project simulation consisting of the 3D models of the project components with links to all the required information connected with the project planning, design, construction or operation, Kymmell (2008). BIM as software technology is used to pass project information back and forth between the different stakeholders. For instance, BIM software such as ArchiCAD or AutoCAD can be used to pass project information from the Architect to the Quantity Surveyor for purposes of quantity estimating; or from the design team to the contractor for creation of a work schedule; or from the construction team to the client as a database of the project as built.

2.2.4 BIM as a process

The foundations of BIM are laid on two pillars, communication and collaboration. BIM involves the collaborative production and communication of information, RIBA (2012). In this sense, BIM involves not just the adaptation of technology, but the reconfiguration of the processes of work. The CPM can therefore use BIM to tailor the information transfer process to be most effective and efficient. BIM can be leveraged by the CPM to ensure timely and appropriate generation, collection, dissemination, storage and ultimate disposition of project information. This necessarily involves the re-organisation of work, legal relationships and responsibility sharing within the project stake holding.

2.3 BIM and Construction Project Management

BIM has the potential to significantly change the way projects are delivered. BIM involves a new approach to design, construction, and facility management in which a digital representation of the building process is used to facilitate the exchange and interoperability of information in digital format, BIM Handbook (2009). Although CPMs may not produce model information themselves, they manage this information. In other words, 'project managers are involved with the use, interrogation and analysis of the model', Nbs (2014). They look at model views and other information in formats such as the BIM Collaboration Format (BCF) which is a platform-neutral data reporting format, that is, it is independent of any particular software and can therefore view information produced on any BIM software. BCF is used for exchanging e.g. clashes or other problems, in isolation from the entire model;

thus assisting collaboration between different disciplines using different software applications.

2.3.1 Traditional construction project management

According to the PMBOK Guide (2013), Project management is the art of directing and coordinating human and material resources throughout the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time, quality and participation satisfaction.

This paper observes that in the Kenyan construction industry, the CPM has played the role of coordinator of information on projects. The CPM receives information from multiple consultants in different formats. For instance, a 3D model on ArchiCAD from the Architect, 2D Bills of Quantities on Microsoft Excel from the Quantity Surveyor, 2D Structural drawings from the Structural Engineer on AutoCAD and a 2D works programme from the contractor. This multiplicity of information formats complicates and lengthens the task of directing and coordinating the human and material resources throughout the life of the project. This status of Construction Project Management practice in the Kenyan construction industry frustrates the mandate of the CPM as time and quality are lost, costs increased and scope varied by the inefficiencies of poor information management and transfer.

2.3.2 Purpose of construction project management

The purpose of project management in the construction industry is to add significant and specific value to the process of delivering construction projects, CIB (2002). This value addition is achieved by the systematic application of a set of generic project-oriented management principles throughout the life of a project. This paper puts forward that, central to the application of management principles is project information. The Project Management Institute (PMI), (1996), outlines nine knowledge areas of project management to which project management principles are applicable. These are;

i. Project integration management
ii. Project Scope management
iii. Project Time management
iv. Project cost management
v. Project Quality management

vi. Project Human resource management

vii. Project Communications management

viii. Project Risk management

ix. Project procurement management

It is observed that, information management and transfer cuts across all nine knowledge areas. The role of Construction project management can therefore be summarised as one of leveraging information to add significant and specific value to the process of delivering construction projects. The technology and process of BIM are proposed by this research as an opportune platform to this end.

2.3.3Structure of construction project management

CIB (2002) explains that, construction projects involve the coordinated actions of many different professionals and specialists to achieve defined objectives. It is further suggested that, the task of construction project management is to bring the professionals and specialists into the project team at the right time to enable them to make their best possible contribution, efficiently. This right time, can be any of the four stages of a project; initiation, planning, execution or closure. While the professionals and specialists that contribute to the body of knowledge in a construction project are drawn from the following fields; Architecture, Finance, Building law, Civil engineering, Geo-technical engineering, mechanical and electrical engineering, Structural engineering, land surveying, interior design among others, the experience and knowledge which is brought into a project by professionals and specialists manifests itself in project information. The different bodies of knowledge and experience coming together in a project all have the potential to make important contributions to decisions at every stage of the project. For this to happen, the information being brought together has to be handled properly. All the above bodies of knowledge cannot be practically brought together at every stage. CIB (2002) points out that this creates a dilemma, because ignoring key bodies of knowledge and experience at any stage may lead to major problems and additional costs for everyone. The practical way to resolve this dilemma is to structure carefully the way professionals and specialists bring their knowledge and experience into the project team. This research puts forward that BIM can be a useful tool in structuring all the information on a project coming from the different bodies of knowledge at different stages.

The use of BIM software can simplify the information (often in numerous formats) coming from the different specialists at the different stages of a project into a single 3D model that carries all of this information. While it carries all the project information, this 3D model can be queried to provide stage specific or discipline specific information. For instance, the model can be queried to show just the structural elements of a building, and further to produce a bill of quantities for the materials to be used in constructing the said elements.

From the above example, it is shown that a CPM can with a few keystrokes and mouse clicks obtain, transfer and manage information that would have otherwise required him to liaise with the structural engineer, the quantity surveyor and possibly the contractor, a process that would have cost both time and money. How then does the application of BIM influence the role of the Construction Project Manager?

2.3.4 Functions of the Construction Project Manager

The adoption of BIM into the construction project management process is likely to alter the functions of the CPM throughout all the stages of a project. The functions of the CPM are expounded below, and the effect of BIM adoption analysed.

1. *Definition of project goals and scope*

The construction project manager must understand the client's goals for the project and communicate them to the project team, Lahdou & Zetterman (2011). Proper understanding of project goals helps in the definition of project scope. Project scope is defined by evaluating which deliverables should be included and which should be excluded. This can be a tedious exercise if the construction manager is to rely only on his intuition and prior experience. However, BIM can be applied to enhance this evaluation process. Enhanced analysis capability with BIM helps to determine the need for select specific facility elements by simulation of the building in use, this also helps to determine the magnitude and scale of elements and thereby define project goals and scope.

2. *Management of Human Resources*

The construction project manager is responsible for establishing the project Team by acquiring personnel with the necessary competence to complete project activities, (Tenstep 2010, cited in Lahdou & Zetterman 2011). BIM demands a high level of people-skills in the form of communication, collaboration and proactive approach. BIM therefore requires the recruitment of professionals with better people skills for the process to actually work. The construction manager therefore needs to understand the right BIM caliber when hiring for any role.

3. Management of communication

The construction project manager is responsible for providing and receiving information during the project process, Lahdou & Zetterman (2011). The construction project manager should also communicate with the client, team members, and other relevant involved parties regarding project progress and status. BIM helps the construction project manager to present information about a facility in a method in which it can be easily shared or exchanged. It eases the functions of communications planning, information distribution and performance reporting.

4. Management of risk

Risk refers to circumstances that would have a negative impact on project performance if they occurred. The ambition in any project is to identify and avoid risks. It is however impossible to foresee all risks. When problems occur the construction project manager is responsible for taking corrective action and to get the project back on track, Lahdou & Zetterman (2011). This can be a time consuming and expensive exercise where the construction project manager has to rely only on his own analytical skills or on those of his project team. BIM is a sophisticated and dynamic tool that can uncover conflicts in a project's design to flag constructability issues before they become too costly and time consuming to fix.

5. Management of schedule and budget

The construction project manager is responsible for delivering a project on time and within budget. The project schedule and budget are estimated based on the currently available information and should be continuously updated. These two components are key deliverables as they are criteria for project success and are generally closely connected; if the project is behind schedule it will usually also be over budget, Lahdou & Zetterman (2011). By the use of 4D and 5D BIM, which include time and cost components respectively, the construction project manager is able to more effectively manage those aspects of the project.

2.3.5 Uses of BIM in Construction Project Management

It is important to understand how the adoption of BIM is useful to the practice of Construction Project Management. RIBA (2012), in their publication,' BIM overlay to the RIBA Outline plan of work', aptly summarise how BIM can be integrated into the design and construction process. The aspects that concern project management are summarised in the table below;

Table 2.1: BIM Integration in the CPM process.

PROJECT STAGE	KEY PROJECT TASKS	ADDITIONAL TASKS ENABLED BY BIM	RELATED BIM ACTIVITIES
1. APPRAISAL	1. Identification of client's needs and objectives. 2. Development of business case 3. Preparation of feasibility studies 4. Assessment of options.	1. Life cycle management 2. Facilities management.	1. Advise client on purpose of BIM 2. Agree level and extent of BIM.
3 CONCEPT DESIGN	1. Implementation of design brief. 2. Preparation of additional data. 3. Preparation of concept design. 4. Review of procurement route.	1. Agreement of project quality plan as pertains BIM 2. Agreement of change control protocols.	1. BIM pre-start meeting 2. Initial model sharing BIM data use environmental performance and area analysis 3. Identification of key model elements and creation of concept level parametric objects. 4. Enable design team access to BIM data.
4. DESIGN DEVELOPMENT	1. Development of concept design. 2. Design of services. 3. Update outline specifications and cost plans 4. Completion of project brief.	1. Using project BIM data to synthesise all aspects of design; structural, services, environmental etc.	1. Data sharing and integration for design coordination and detailed analysis. 2. Use of BIM data for environmental performance and area analysis.

PROJECT STAGE	KEY PROJECT TASKS	ADDITIONAL TASKS ENABLED BY BIM	RELATED BIM ACTIVITIES
5. TECHNICAL DESIGN.	1. Preparation of technical designs and specifications.	1. Use of BIM data for technical design.	1. Data sharing for design coordination, technical analysis and addition of specification data. 2. 4D and/or 5D assessment. 3. Export BIM data for planning application.
6. DETAILING (PRODUCT INFORMATION)	1. Preparation of specification and design details for construction.	1. Development of BIM data in sufficient detail to conclude coordination of design team inputs and enable performance specified works to begin.	1. Detailed modelling, integration and analysis. 2. Data sharing for conclusion of design.
7. TENDER DOCUMENTATION	1. Collation of tender documentation to enable a tender be obtained.	1. Development of BIM data to integrate performance specified works.	1. Embed specifications to BIM model. 2. Final review and sign off of model.
8. TENDER ACTION.	1. Identification and evaluation of potential contractor for the project.	1. Review of BIM information provided by contractors.	1. Review construction sequencing (4D) with contractor. 2. Integration of sub-contractor performance specified work model information into BIM model data.
9. MOBILISATION	1. Letting the building contract 2. Site handover	1. Use of BIM model for construction activities such as setting out	1. Implementation of working methods pretested on the BIM model for efficiency.
10.CONSTRUCTION TO PRACTICAL COMPLETION	1. Administration of building contract to completion	1. Clarification and resolution of design queries as they arise using the BIM model.	1. Use of 4D/5D data for contract administration
11. POST PRACTICAL COMPLETION	1. Administration of building contract after practical completion 2. Final inspections	1. Record of as built using BIM related technology.	1. Laser scanning of completed building to record exactly what has been built
12. MODEL MAINTENANCE AND DEVELOPMENT	1. Review of project performance in use	1. Comparison of project performance with BIM data 2. Analysis of data for use on future projects.	1. Issue of facilities management model data. 2. Study of parametric object information contained in model data.

Adopted from RIBA 2012

In addition to the above, BIM can also be utilized as follows to aid in construction project management as identified in the literature;

Use of BIM to enhance safety on construction sites: Interactive models allow the Construction Project Manager to take virtual tours of the project and "view "safety challenges and plan for them beforehand. This helps to reduce accidents on site, Krause (2013).

Use of BIM for value engineering: BIM allows for analysis of key elements of the project while early in the pre-construction phase when key resources are most flexible, thus providing value engineering to the project, Chiusano, J & Singh, C (2013).

Use of BIM on the jobsite to guide construction*:* A combination of construction GPS and BIM on site allows for functions such as laying out the site directly from the BIM Model, as dimensions are communicated directly to construction equipment, Harris (unpub).

Use of BIM on the jobsite to track construction progress*:* Using a combination of laser technologies that capture as built work, the CPM is able to feed this information into the BIM software to compare against the BIM model representing the completed construction works, and thereby establish actual construction progress. Laser scanning reduces measurement time and also provides more accurate information, Eastman et al (2008).

Use of BIM for management of Construction materials*:* radio frequency identification tags, RFID, or bar codes can be used to track materials delivered to site, their storage and finally their point of utilization within the construction works, Lin et al (2014).

Use of the BIM model for site, infrastructure and facilities management: BIM allows for a digital library of project information linked directly to the model. This model and the associated maintenance manuals, warranties and so on can be used to manage the actual building and perform routine maintenance, , Eastman et al (2008).

Estimating shop and field drawings by having disciplines work within a shared model environment: pre-fabrication from a shared model assures project team members that building elements will be prefabricated and installed just as modeled, Turner Construction Company (2012).

Using BIM to facilitate the regulatory process: The BIM Model can be used to check against regulatory standards for compliance before submission for approval, thereby reducing the back and forth that would arise as a result of non-compliance, RIBA (2012).

From the above illustrations, it is observed that with BIM use the CPM is able to better control both human resources and material resources. This ensures improved collaboration, safety, efficiency and communication among project stakeholders than is possible traditionally.

2.3.6 Levels of BIM use

It is critical that the scope and level of detail to be modeled is properly considered and that all parties are clear on what is expected of them. The American Institute of Architects (AIA) have grappled with this issue and developed the E202 BIM Protocol document that is meant to provide a practical tool for using BIM across the project. Specifically, the intent of the E202–2008 BIM Protocol document is to answer the following questions, AIA (2015).

1. Who is responsible for each element of the model and to what level of development?
2. What are authorized uses for the model?
3. To what extent can users rely on the model?
4. Who will manage the model?
5. Who owns the model?

From the literature reviewed, (Staub-French et al 2011, nbs 2014,& AIA 2015) the following levels of BIM were found to be existing;

Table 2.2: BIM Levels

BIM LEVEL	EXTENT OF BIM USE	PRIMARY USES OF BIM
LEVEL 1	Equivalent to conceptual design. BIM models consist of overall building massing. This level of BIM allows for whole building types of analysis, such as, orientation and cost per square metre.	1. Communication of design intent 2. Evaluation of design alternatives
LEVEL 2	Equivalent to schematic design. BIM models consist of generalized assemblies with approximate quantities. The BIM model allows for generalized analysis of systems.	3. Coordination of the different design disciplines.
LEVEL 3	BIM model elements are detailed enough for the generation of traditional construction documents.	4. Analysis of different elements and systems. 5. Allows for merging of designers models with sub-contractors models for prefabrication.
LEVEL 4	BIM models at this level are suitable for fabrication and assembly.	6. Fabrication and assembly of components as designed.
LEVEL 5	BIM Model at this point represents as built conditions.	7. Allows for maintenance and operations of the facility.

Sources: (Staub-French et al 2011, NBS 2014, & AIA 2015).

Along with the levels of BIM use, it is important to understand BIM maturity stages in implementation in order to establish an analytical framework for levels of BIM adoption in Kenya. Succar (2009) has identified 3 stages in BIM implementation.

Pre- BIM status: this is traditional construction practice, before BIM is implemented. This practice still experiences a lot of barriers and inefficiencies. Most information is still in 2-Dimensional format as drawings and written documents. This system is usually unstructured and difficult to use. During any one project, numerous documents are shared and often with many human errors and problems in version control and use. The result is incomplete understanding of the planned construction and therefore functional inefficiency of the project as a whole.

Stage 1: This is mainly characterised by object modelling. It is BIM use, but only within the context of a particular firm. For instance the Architect models the building and has parametric objects within his model. This model therefore contains information such as quantities and material descriptions. The CPM now requires a cost estimate from the Quantity Surveyor, so that along with the conceptual designs, he can discuss costs with the client. The Quantity Surveyor however is not BIM compliant and requests that the Architect's information is forwarded in 2-dimensional drawings for him to take off. This disconnect is what characterizes Level 1 BIM maturity, also called 'Lonely BIM' as only one consultant on a project is found to be using BIM.

Stage 2: This is characterised by model based collaboration. Here our Quantity Surveyor mentioned above would be BIM compliant and the Architect would therefore be able to share his parametric model directly with the Quantity Surveyor who would then use this same model for the cost estimates. This sharing of the model would be actual transfer of the Architect's model to the Quantity Surveyor either via internet or physical means such as a portable disk.

Stage 3: This is characterized by network based integration. Here the Architect and Quantity Surveyor mentioned would be on the same network and the model in question would actually be shared and available to both. There is therefore no need to transfer the model as it is simultaneously available to both consultants. This makes for a situation where seamless collaboration is possible, saving both time and money.

From the above illustrations, it is shown that as BIM maturity increases, multi-disciplinary teams experience less complexity in information transfer and management when compared with traditional practices. For BIM adoption to have an impact, it must be implemented properly both at an organisational level and at an industry-wide level.

2.3.7 Impact of BIM

The return on investment (RIO) for BIM was researched in McGraw-Hill (2008).The surveyed companies, who actively tracked their return on investment from BIM, said they were getting returns of 300% to 500%. 82% of respondents believed BIM had a positive impact on their company's productivity. In a follow-up survey by McGraw-Hill in 2009, they sought to identify the key areas where BIM was contributing the most value, McGraw-Hill (2009).The benefits summarised in the table below were found to be contributing most value to projects.

Table 2.3: BIM benefits in construction projects

Reduced conflicts during construction	**Reducing cycle time of specific workflows**
Improved collective understanding of design intent	Reducing overall project duration
Improved overall project quality	Fewer claims/litigation.
Reduced changes during construction	
Reduced number of RFIs (requests for information)	
Better cost control/predictability	

Source: McGraw Hill 2008, 2009.

Summarised into a single statement, the impact of BIM is that it increases project efficiency all round.

2.3.8 International BIM initiatives and Standards

i) United States of America

According to Staub-French et al (2011), the General Services Administration's requirement for BIM on all Federal Building Projects since 2007 has been a major driver for BIM adoption. There are a range of organisations supporting BIM adoption in the US, this has seen significant growth in BIM adoption in the past 10 years. These organisations range from State Governments such as Ohio, to Universities such as Indiana University and Professional organisations such as the AIA.

The BIM project execution planning guide: this was developed at the Penn State University to help project teams implement BIM. It provides an overall vision as well as a detailed outline of how to integrate BIM in the project delivery process.

ii) Canada

There are two organisations that drive BIM adoption in Canada. The Canada BIM council, CanBIM and the Institute for BIM in Canada (IBC), Staub-French et al (2011).

iii) The United Kingdom

The UK Government in 2011 announced that it would require collaborative 3D BIM on all of its projects by 2016. This was in a bid to advance BIM adoption as a strategy for increasing construction efficiency and value and especially in the public sector. This action of the government was based on the recommendations of the BIM Industry Working Group, which also developed a BIM maturity index. The BIM Maturity index characterized the different levels of experience with and approaches to BIM, (BCA 2011, p.3).

iv) Singapore

Here BIM adoption is driven by the Singapore Construction Productivity and Capability Fund Program, which supports BIM training and enhancement initiatives. Its major aim is to make the Singapore Construction Industry more sustainable. There are three aspects to the Singaporean initiative. First is training, second is mandatory BIM submission by 2013 and third is a BIM adoption target of 80% of the professionals by 2015, Staub-French et al (2011).

v) BuildingSMART International (bSI)

bSI' is a neutral, international and unique not for profit organisation supporting open BIM through the life cycle' bSI (2014).bSI has regional chapters in Europe, North America, Australia, Asia and the Middle East. BuildingSMART has developed a common data schema that makes it possible to hold and exchange data between different proprietary software applications. This buildingSMART data model standard is defined by Industry Foundation Classes (IFC), which is in the process of becoming an official International Standard ISO/IS 16739.

vi) The BuildingSMART Alliance (bSA)

bSA is a member of bSI and is responsible for developing the National BIM Standard (NBIMS) for the United States, bSI (2014).

The table below summarises the aspects of BIM covered by the standards and guidelines studied above;

Table 2.4: Standards and Guidelines coverage of BIM

1. General information on BIM	**Theory of BIM**
	Benefits of BIM
2. Requirements for BIM	Requirements for modeling
	BIM deliverables
	Quality control measures
3. BIM Data	Data exchange
	Data interoperability
	Data sharing and storage
4. Contents of the BIM Model	By discipline e.g Architecture, Engineering
	By project phase
5. Organisation for BIM Adoption	Management
	Legal Aspects
6. Process of BIM Implementation	Project team
	collaboration

Sources: Staub-French et al (2011), bSI (2014) & (BCA 2011, p.3)

From the literature, the BIM initiatives identified can be summarised as;

i. Requirement for adoption on government projects, the setting of adoption deadlines and mandatory BIM submission.
ii. Development of BIM implementation guides.
iii. Constitution of BIM championing bodies and organisations.
iv. Financial support towards BIM adoption.
v. BIM training and enhancement initiatives.

vi. Development of a common data schema that enables data exchange between different proprietary software applications, the IFC.

vii. Development of National BIM standards such as the NBIMS in the USA.

These initiatives form the basis for knowledge on the transfer and management of information on BIM platforms. They make the process of BIM adoption less daunting by charting the process and offering guidance and support along the way.

2.3.9 International BIM guides

The following BIM guides were identified during the literature review;

The BIM project execution planning guide, USA**:** this was developed by Penn State University, CIC (2010). The guide outlines a four step procedure;

Table 2.5: BIM procedure developed by Penn State University, USA.

Step 01	**Identify the appropriate BIM goals and uses on a project**
Step 02	Design the BIM execution process
Step 03	Define the BIM deliverables
Step 04	Identify the support infrastructure to successfully implement the plan

Source: CIC (2010)

The General Service Administration Guide Series, USA**:** developed under the National 3D-4D BIM Program which was driven by the fact that The National Institute of Science and Technology (NIST) in the USA had identified the lack of information interoperability as the main cause for inefficient rework and waste. The series were developed sequentially to build a comprehensive guide on all aspects covered by BIM, GSA (2011).

Table 2.6: Summary of BIM Guide developed by The General Service Administration, USA.

Series 01	**3D- 4D BIM Overview**
Series 02	Spatial program validation
Series 03	3D Laser scanning
Series 04	4D Phasing
Series 05	Energy performance and operations
Series 06	Circulation and security validation
Series 07	Building elements
Series 08	Facility management

Source: GSA, 2011.

National guidelines for digital modeling, Australia: these state that three areas of current practice will be affected by BIM implementation. Technology, policy and process, CRC for construction innovation, (2009). The guide focuses on process implications. In it there are four major BIM implementation stages.

Table 2.7: Summary of National Guidelines for Digital Modelling, Australia.

Stage	Subdivisions	Remarks
0-2D Documents	0A Manual drafting	Pre-BIM stage, still the pre-dominant mode of practice, not the focus of the guideline
	0B CAD 2D Drafting	
1- Modelling	1A 3D CAD Modelling	First stages in the adoption and use of BIM, represent part of the industry which is implementing BIM. Most practitioners are at stage 1b- major focus of the guideline.
	1B Intelligent 3D Modelling	
2- Collaboration	2A One-way collaboration	
	2B Two way collaboration	
3- Integration	3A Local Server	3A and 3B stages describe technologies and processes hosted on model servers.
	3B Web based server	

Source: CRC for construction innovation, 2009.

In summary, the guides studied address the following areas of BIM adoption; Adoption procedure, information interoperability and process implications on adoption.

2.3.10 BIM Initiatives and standards in Kenya

In Kenya there exists no formal organisation towards the adoption or use of BIM. The only institutions pushing for BIM adoption, and carrying out related activities such as seminars are the re-sellers of BIM software with the support of the parent companies such as Autodesk and Graphisoft. BIM implementation and documentation in Kenya can therefore said to be largely market driven and the result of private sector initiatives.

Guidelines available within the construction industry are not BIM oriented, besides being targeted at segmented audience within the construction industry. That is, separate practice guidelines for Construction project managers, for architects, and for engineers. This can be attributed to the nature of the Kenyan Construction Industry which is segmented. There also exist different regulators for the different faucets of the industry. National construction Authority (NCA) for contractors, Board of Registration of Architects and Quantity Surveyors (BORAQS), Engineers Board of Kenya (EBK) and none for Construction Project Managers. The anticipated audience for BIM is therefore disintegrated and lacking a united focus. This situation results in a lack of capacity in terms of numbers agitating for and working towards BIM adoption.

From the literature reviewed, this paper puts forward that the best placed institutions to champion BIM adoption in Kenya are the Government, professional organisations and educational institutions. These can offer support financially, in capacity building by training and in research.

2.3.11 Best Practice in BIM use for CPM

In the absence of a regulator that would guide BIM adoption for CPM in Kenya, it is necessary to examine best practice in BIM use for CPM elsewhere as a basis for adoption in Kenya. Best practice is a method or technique that has consistently shown results superior to those achieved with other means, and that is used as a benchmark. According to Bogan & English (1994), Best practices are used to maintain quality as an alternative to mandatory legislated standards and can be based on self-assessment or benchmarking. The following best practices have been identified in the literature reviewed;

Sufficient information: This applies across the board, from the client to the professionals. Sufficient information facilitates effective communication. In turn, effective communication, according to Lu et al (2013) allows stakeholders to exchange, accurate, updated and clarified information for decision makers to form reliable decisions. In the Kenyan context, this will necessitate a paradigm shift in the way project stakeholders share information, from the current adversarial approach to an approach of openness and collaboration. Sufficient information also means that the project stakeholders are made adequately aware of what is required of them in implementing BIM.

Early Involvement: Of all the key disciplines, where each provides the necessary input early on, therefore optimizing the use of the model at subsequent stages, RIBA (2012). Applied to Kenya, this means a re-organisation of the project procurement process so that contractors, consultants and specialists are brought on projects earlier to allow for their input. Currently construction practice in Kenya divides building projects into two major phases of design and construction. This practice separates the input of the designers from that of the contractor and often tends to pit the two against each other.

Facilitation of the collaborative process: Development of appropriate collaboration contracts and incentivisation of team members to enhance collaboration, Staub-French (2011). This implies a review of the contracts used within the Kenyan construction industry to include BIM collaboration and the attendant shift in responsibility and risk sharing. It also implies a need for facilitation, whether financial or technical to enable those in the construction industry to adopt BIM use.

Level of BIM Maturity: Understanding the levels of maturity and deciding on the minimum level to be accepted on projects, Staub-French (2011). This means that a minimum level of BIM maturity should be set for the Kenyan construction industry, to ensure uniform adoption across the industry and therefore easier collaboration at industry level. Alternatively a progressive attainment of BIM maturity can be aimed at.

Shared goals and objectives: These should be clearly defined early on as part of the contract and project team organisation structure, RIBA (2012).For the Kenyan context, a reconfiguration of current project team organisation and methods of management from hierarchical organisation to matrix organisations which allow for sharing of goals and objectives both within participating organisations and across the particular project participants drawn from those organisations.

Documentation of the process: This involves both the reference to prior information on BIM implementation and the recording of the implementation process regularly to capture lessons learnt and build the BIM body of knowledge, Staub-French (2011). Applied to the Kenyan context, this will require that an institution is tasked with documenting the process of BIM adoption and implementation.

Appointment of a BIM manager: To devise strategies for BIM implementation and coordinate the efforts of the entire team, Staub-French (2011). This implies the recognition in the Kenyan construction industry of the need for this new project participant who will play the role of BIM coordinator.

Institution of formal processes and procedures: These allow for the management and coordination of the entire process. It involves the scheduling of coordination meetings and agreement on the mode of working among all the team members. This can be consultative forums held by Construction stakeholders in Kenya and perhaps facilitated by professional organisations to deliberate on, and come up with formal BIM processes and procedures.

Appropriate information structure*:* consideration of how information will be shared and managed, CIC (2010). This implies an evaluation of the technology or software in use for construction information transfer in Kenya. In addition, it also implies a re-evaluation of the process of information management to embrace both the role of the CPM and of BIM.

2.3.12 How does BIM alter conventional work practices?

Basel et al. (2011) noted that, BIM is a revolutionary technology, and to maximize its benefits, changes have to be made in the following areas: organization of work, legal relationships and sharing of responsibilities. This can only be achieved by redefining work practices and charting the process of implementation from management level. Peansupap & Walker (2006) concur, ‘Successful implementation at project-level requires organisational-level strategic planning that considers issues of technical support in terms of hardware and software rationalization for cost effective use, critical management support in terms of challenging embedded processes, a supportive workplace environment in the form of BIM champions to share experience and skill, and an understanding of users' individual-characteristics so that the framework processes offered can be effectively applied'. The above, indicates that the decision to adopt BIM in any practice will ultimately translate to effecting certain changes in the work practices of the firm. In summary, these changes will include, and not be limited to the following; the forms of contract adopted to establish legal relationships; the sharing of professional responsibilities; how work is organised and the sequence in which it is executed; the allocation of resources within the firm, both financial and manpower; and the organisational structure of the firm. The considerations that have to be taken in implementing BIM include; the experience of the project team, the maturity of the technology, the availability of resources such as finances, information exchange between team members, the procurement of 3D- 4D BIM services, timing of adoption of technology during project life cycle, contractual language, ownership and rights in data, roles and responsibilities and metrics for measuring the success of digital technologies, organisational barriers and individuals reaction to change. Staub-French (2011). In summary, BIM alters conventional work practices in three ways as follows: It creates new roles such as that of model manager; it creates new processes such as in procurement and organisation of work; and it creates new process documents such as the BIM execution plan and new forms of contract.

2.4 BIM adoption

2.4.1 Challenges to BIM adoption

i)*The fragmented nature of the construction industry in Kenya*: This effectively divides the 'would be' audience of BIM adoption into several distinct fields thereby limiting the effect of collective action towards adoption.

ii)*Traditional procurement systems such as design-bid-build*: These preclude the use of BIM until the visualization stage.

iii)*The temporary nature of projects*: This means that collaborative relationships developed on one project often cannot be carried into another, as the constitution of project participants will be different. The implication of this is that, the process of collaborating and building relationships must begin again and again, making it difficult to build on previous relationships.

iv)*The unique nature of projects*: Projects are a one off undertaking, each with different circumstances. This makes it difficult to build on lessons learnt working with BIM as the circumstances will be different for each project.

v)*Re-engineered processes*: the adoption of BIM requires the re-organisation of business processes and working relationships. This meets with resistance in most practices as it upsets processes and ways of working that have been proven to work before.

vi)*Adversarial contractual relationships*: These handicap collaboration. The adversarial nature is caused by how the work is organised, where design is separate from construction. Such an arrangement pits designers and builders against each other. Over the years this adversarial stance has been engrained in the industry, making a collaborative way of working hard to adopt.

vii)*Changed roles of project participants*: with the adoption of BIM, the role of builders in design is becoming more important. The role of the project manager also features prominently as the coordinator of all participants. In addition, there is the new role of the BIM manager. These new roles, and changing roles upset the balance that construction professionals have been used to, therefore creating resistance.

viii)*Software issues and coordination defects*: due to the uptake of different suites of software by different project participants, there arise problems with coordination and information sharing.

2.4.2 Benefits of BIM adoption

These can be divided into two main categories. Benefits at project level, and benefits at company level. They include the following;

1. Enhanced project collaboration and control among stakeholders; as information is now centralized in a single model making it easy to share and manage.
2. Improved productivity
3. Reduced re-work and conflicts
4. Better project quality and performance
5. Faster project delivery
6. Reduced wastage

7. Reduced construction costs

Benefits by project stage;

Table 2.8: Benefits of BIM Adoption.

Project Stage	Benefits
Pre- construction	Enhanced processes and reduced time at feasibility study, due to increased alternative evaluation capacity.
	Enhanced evaluation of buildability and performance.
Design	Earlier more accurate visualization, this helps in clear communication of design intent.
	Earlier collaboration and simultaneous work by diverse consultants, this saves time and ultimately improves buildability.
	Increased accuracy and consistency, as information is now being built upon rather than converted from one form to another for each consultants input, which leads to information loss or degeneration and information inconsistency.
	Capability for analysis such as energy efficiency and sustainability is increased. This results in better decisions on life-cycle cost matters such as material choice.
	Easier cost estimation
	Easier design intent checking both in terms of visualization and quantification of areas.
Construction	Synchronization of design and construction planning, helps increase safety on site, as safety can now be factored into design and be adequately planned for.
	Clash detection. This helps to identify early any areas where the different disciplines may clash during implementation and therefore adequately plan around such events.
	Cross system updates. These enable faster resolution of problems on site.
	BIM models can be used as a basis for fabrication of components speeding up production.
	Enables synchronization of design and procurement.
	Reduction of wastage during construction as processes have been

	simulated and reduced to the most effective and efficient.
Post- construction	Enhanced facilities management as all information on the bulding is contained within the BIM model making management easy
	The BIM model provides information database for possible future retrofits.

Source: Author, 2015.

Rodriguez 2011, Rosenbloom 2012 & Hardin 2009 point to the fact that cost saving from BIM is more likely to be realized by experienced users. McGraw Hill concurs, ‘Value and associated benefits of BIM are often perceived to be directly proportional to experience level of users’. Experience in this context, is experience in BIM and technology use, rather than experience in the construction industry. As Shenan (2012), puts it, ‘be warned of the danger that because of technology and working practices of BIM, that may be alien to older generations, those on the BIM frontline mat by default be younger staff who are comfortable with the tools, but have a shorter track record.’

2.4.3 Strategies to aid BIM adoption

Becerik-Gerber & Rice (2010) indicate a need for a consistent cost-benefit benchmarking framework associated with BIM process enhancements and innovations as a motivator for adoption.

a) *The encouragement of inter-organisational relationships*. This reduces the adversarial nature of the construction industry. This can be achieved through partnering, joint ventures, collaboration, and Public Private Partnerships. Inter-organisational relationships should be characterized by a willingness to share among other things, work practices and information, which before the advent of BIM had been considered, ‘private’.
b) *The encouragement of BIM use on publicly funded projects*. As a large percentage of construction projects are publicly funded, an initiative by the public sector to require BIM use on their projects would see a rise in adoption. This strategy has worked in the UK and Singapore.
c) *Increased funding for BIM initiatives*. Both from the private and the public sectors, will provide much needed resources for research, training and purchase of software and hardware.

d) *Increased and improved training on BIM*. The introduction of BIM in training institutions, and introduction of training at professional development sessions will contribute towards increased uptake of BIM.

e) *The development of national guides and standards on BIM use*. These can either be done in collaboration by the public and private sectors or championed by either of them with support from the other. Guides and standards will offer a reference as well as starting point for those choosing to adopt BIM.

f) *Benchmarking and learning from other countries* where BIM adoption has been and continues to be successful. To learn from the difficulties those countries have encountered and build on their successes, in seeking to apply best practice to the Kenyan context, it will be important to put into consideration the characteristics peculiar to its construction industry, that may not be common to the industries reviewed.

2.5 Conclusion

The literature reviewed discusses BIM adoption, the challenges it faces and how it can be encouraged. It proves that BIM can provide an effective support for design and construction, as well as an effective collaboration and communication platform that can be used as a management tool. By referring to the successful adoption of BIM in the construction industry in the first world, this research aims to propose means for increasing BIM adoption in Kenya by providing an understanding of the benefits of adoption and how challenges to adoption can be circumvented.

It is expected that this research can provide an incentive for the adoption of BIM in Kenyan construction project management practice.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction.

The methodology adopted in this research comprised of the following:

i) Study of literature and case studies in relation to BIM use in construction project management.

ii) Preparation of Questionnaires

iii) Site visits to selected practice offices and construction project sites.

iv) Questionnaire surveys and personal interviews with Construction Project Managers and other construction professionals like Architects and Quantity Surveyors (who also practice CPM). Data collection was via mailed questionnaires.

v) Analyzing the questionnaires.

vi) Qualitative analysis of data obtained and establishment of the adoption extent of BIM for Construction Project Management within Nairobi County.

vii) Presentation of BIM adoption strategies for Construction Project Management in Kenya for future reference.

viii) Conclusions, recommendations and suggestions for future study

3.2 Research Design

The research design employed was survey research, in which data from members of a population was collected to determine the current status of that population with respect to the variables under study.

The survey research was exploratory in establishing the adoption of BIM in construction project management within Nairobi County. This research design was appropriate as it sought to obtain information that describes the existing adoption of BIM in construction project management within Nairobi County, by asking individual respondents about their perceptions and personal experiences as pertains BIM adoption.

The main methodology adopted was survey questionnaires which were collected from construction project managers, in the various fields via e-mail. A thorough literature review was conducted prior to identify aspects of BIM adoption for Construction Project Management relevant to the study. Interviews with construction industry practitioners were also conducted to provide check measures for effectiveness of questionnaires.

3.3 Target population

The purpose of this study was to establish the extent of BIM adoption, and in particular, within Nairobi County. The choice of Nairobi County was because the city is both the economic and administrative capital of Kenya. Nairobi therefore boasts a variety of both Government and private sector construction projects of varying magnitudes and complexities.

The target population of the study was therefore all Construction Project Management Practitioners within Nairobi County. The accessible population was the practitioners registered with the relevant professional bodies of ICPMK (Institute of Construction Project Managers of Kenya) or the Construction Project Managers Chapter of the AAK (Architectural Association of Kenya).

3.4 Sampling Procedures.

Once the membership numbers of the above mentioned institutions had been established, it was decided to undertake a census as the number of the target population was only 55 and could be covered within budget and the time available.

3.5 Data Collection Methods

The study used a semi-structured questionnaire combining open and close-ended questions to collect primary data that addressed the study objectives. Data was collected through self-administration via e-mail. E-mail was preferred as it is relatively easy to administer, low cost, able to reach a large number of people, not susceptible to interviewer bias and allows easier data translation. Prior consent was sought from the respondents before administering the questionnaires. The questionnaires were completed by the staff and the management of firms undertaking construction project management through BIM. Personal Interviews were also used as an aid to the questionnaires. This involved the researcher asking pre-determined and structured questions and noting the answers of the respondents.

3.5.1 Data Collection Instruments

The study sought to collect mainly primary data. Different types of questions were presented on the questionnaire. These were; multiple choice /single response questions for mutually exclusive responses; multiple choice, multiple responses for independent responses; and likert scale questions with varying degrees of attitudes and extents of opinions on a specific statement or position. Depending on the question, the data collected was either numerical, categorical or scaled. The questions were used to identify characteristics of the respondents and to identify BIM practices in the firms under study. A cover letter was attached to the questionnaire to outline the aims and objectives of the study to the respondents.

3.5.2 Data Analysis

The data collected in the study was mostly primary data. The data collection tool (questionnaire) comprised of open ended and close –ended questions. The Close- ended questions resulted in quantitative data which was analyzed using quantitative techniques. The Open-ended questions resulted in qualitative data which was analyzed using qualitative techniques. The two approaches allowed for comparison of the study findings with the reviewed literature.

The questionnaires were first analysed for completeness and then coded. Once coded the data on the questionnaires was entered into an excel spreadsheet. Descriptive statistics was then used to describe and explain the data. This includes; frequencies and percentages. The research findings are finally presented using tables.

3.6 Study and research Instruments Validity

Validity determines whether the research truly measures that which it was intended to measure; how truthful the research results are. In order to boost validity and reliability of the study, the questionnaire was tested by conducting a pilot survey on 10 construction professionals who were not part of the sample to ascertain its content validity. The pilot study tested the effectiveness of the data collection tool; for instance, the appropriateness of the language used in the questionnaire; whether the questions prompted the expected responses; and the difficulty of the items in the instruments. The researcher then made the necessary modifications to the tool thus improving the level of the instruments' validity.

External validity was improved by non-biased sampling, where the entire target population was included in a census due to its small number.

3.7 Reliability of research findings

Reliability is defined as the extent to which results are consistent over time and an accurate representation of the total population under study. In the study, data was collected using well tested and accepted procedures which have yielded consistent data when used on similar studies. The test retest method was used to ascertain the reliability of data. Test-retest measures consistency from one time to the next. During the pilot study, the research instrument was be administered twice to the same group of people. The instrument was modified accordingly until the results were consistent, and the scores similar.

3.8 Conclusion

The chapter started by outlining the methodology and research design, the survey method was selected because the study sought to obtain information that describes the existing adoption of BIM in construction project management.

The target population was all the Construction Project Management Practitioners within Nairobi County. The accessible population was the practitioners registered with ICPMK.

The chapter then proceeded to outline the procedure for data collection and outlined the method for data analysis.

CHAPTER 4: DATA ANALYSIS, INTERPRETATION AND PRESENTATION.

4.1 Introduction

This chapter presents data analysis and the interpretations of the findings. The statistical analysis employed was informed by the study objectives and research questions. The objectives of the study were: to establish the percentage of firms in Nairobi using BIM for Construction Project Management; to identify the challenges in adopting BIM for Construction Project Management in Nairobi County; to identify the advantages in adopting BIM for Construction Project Management in Nairobi County; and to explore strategies to increase the adoption of BIM in Construction Project Management in Nairobi County.

To address these objectives, the following research questions were used to guide data collection and analysis in the study:

1) What is the percentage of firms using BIM for Construction Project Management in Nairobi County? How are these firms using BIM for Construction Project Management?
2) What are the benefits of the use of BIM in Construction Project Management in Kenya versus traditional Construction Project Management? What challenges are encountered in adopting BIM use for Construction Project Management?
3) How can Construction Project Management in Kenya benefit fully from BIM use? How can BIM adoption be encouraged for Construction Project Management in Kenya?

The study utilized descriptive statistics in order to effectively address the research questions and the results of the analysis were presented in frequency tables. The decision to employ descriptive statistics was informed by the nature of this study which was entirely explorative.

4.2 Background

4.2.1 Response rate

The study population was the 55 registered members of the construction management professional body and since this number was small a census was undertaken where questionnaires were sent to all the respondents. From the 55 questionnaires sent, 20 were returned which represented a response rate of 36.4%. Whereas this response rate looks low, there is no definitive rate of response that is widely accepted as enough for mail and e-mail surveys. In addition, this response rate is not uncommon in studies conducted in the construction industry as posited by Akitonye (2000) and Dulami et al (2003) who indicated that the response rate for mail questionnaires often ranges between 20% - 30%.

Further, Fellow and Liu (2003) posit that the acceptable response rate for self-administered questionnaires is 25% - 35%. In addition, the response rate ranks favourably in comparison to other studies in the construction industry, Ofori and Chan (2001) reported a response rate of 26% while Takim, Akintoye and Kelly (2004) reported a response rate of 20.9%.

Response rate by profession is summarised in the table below;

Table 4.1: Response rate – Profession.

Profession	Frequency	Percent	Cumulative Percent
Construction Project Manager	5	25.0	25.0
Contractor or Builder	13	65.0	90.0
Architect	1	5.0	95.0
Engineer	1	5.0	100.0
Total	**20**	**100.0**	

Source: Author, 2015.

Majority of the respondents were Contractors/Builders at 65% closely followed by Construction Project Managers at 25%. There was only one engineer and one architect equal to 5% respectively among all the respondents. This shows the distribution of Construction professionals in the practice of Construction Management. This distribution can be attributed to the procurement system still in place in the Kenyan Construction Industry, that is, Design-Bid-Build. This effectively divides construction projects into two phases, with the first phase concentrating on design and largely managed by the design team. The second phase concentrates on construction and is largely managed by the contractors in conjunction with construction project managers. This second phase is what is perceived to require more management as opposed to the first phase hence the higher response from contractors and construction project managers.

Response rate by Years of experience is summarised in the table below;

Table 4.2: Response rate - Years of experience,

Years of experience	Frequency	Percent	Cumulative Percent
0-5	3	15.0	15.0
6-10	10	50.0	65.0
11-15	4	20.0	85.0
Above 15	3	15.0	100.0
Total	**20**	**100.0**	

Source: Author, 2015.

Majority of the respondents, that is, 50% had 6-10 years of experience in the construction industry while 35% had 11 years of experience and above. 15% had 5 or less years of experience. This can be attributed to the steady growth of the Kenyan construction industry in the past twelve years from 2004. According to Trading Economics 2016, 'the GDP annual growth rate in Kenya averaged 5.43% from 2004 until 2016'. Real estate and construction accounted for 13% of this growth. A majority of the respondents therefore naturally fell in the category of 6-10 years, having come into the industry during its' steady rise in the past 10 years. Response rate by Years of experience was analysed against response rate by profession. The results are summarised in the table below;

Table 4.3: Years of Experience versus Profession

Years of Experience * Profession						
		Profession				Total
Years of Experience		Construction Project Manager	Contractor or Builder	Architect	Engineer	
0-5	Count	0	3	0	0	3
	% within years of experience	0.0%	100.0%	0.0%	0.0%	100.0%
6-10	Count	2	7	1	0	10
	% within years of experience	20.0%	70.0%	10.0%	0.0%	100.0%
11-15	Count	2	2	0	0	4
	% within years of experience	50.0%	50.0%	0.0%	0.0%	100.0%
Above 15	Count	1	1	0	1	3
	% within years of experience	33.3%	33.3%	0.0%	33.3%	100.0%
Total	**Count**	**5**	**13**	**1**	**1**	**20**
	% within years of experience	**25.0%**	**65.0%**	**5.0%**	**5.0%**	**100.0%**

Source: Author, 2015.

Within the 50% respondents who reported to have 6-10 years of experience, 70% were contractors/builders while 20% were construction project managers. In the category of respondents with 0-5 years of experience, all respondents i.e. 100% were contractors/builders. In addition, most of the respondents i.e. 70% fell within the 6-10 years and 11-15 years of experience categories. It is seen that the highest number of respondents were contractors and with 6-10 years' experience, this is attributed to the system of procurement and to the growth of the Kenyan economy as explained above.

4.2.2 Involvement in Construction Project Management in Nairobi County

Of the respondents, 75% reported involvement in Construction Project Management, while 25% were not involved in Construction Project Management in Nairobi. From the responses it was seen that involvement was mostly in large scale projects either in housing, hospitality or industrial construction. This may be attributed to the perception that construction project management is only useful for large projects as established during interviews with construction industry practitioners

Table 4.4: Involvement in Construction Project Management in Nairobi County.

	Frequency	Percent	Cumulative Percent
Yes	15	75.0	75.0
No	5	25.0	100.0
Total	20	100.0	

Source: Author, 2015.

4.2.3 Knowledge of BIM

75% of the respondents reported that they knew what BIM was. From the responses, a majority of the respondents understood BIM as a process and collaborative way of working. This means that only a minority did not understand what BIM is, this means that of the barriers to adoption of BIM, knowledge and understanding of BIM plays a minimal role.

Table 4.5: Knowledge of BIM.

	Frequency	Percent	Cumulative Percent
Yes	15	75.0	75.0
No	5	25.0	100.0
Total	20	100.0	

Source: Author, 2015.

4.3 Use of BIM for construction project management

4.3.1 Percentage of firms using BIM for construction project management

The percentage of firms using BIM for construction project management is summarised in the table below;

Table 4.6: Firms using BIM for construction project management.

	Frequency	Percent	Cumulative Percent
No	15	75.0	75.0
Yes	5	25.0	100.0
Total	20	100.0	

Source: Author, 2015.

The results showed that 25% of the respondents were using BIM for construction project management. There appears to be, from the above responses, a very low uptake of BIM, despite the majority of the respondents knowing what BIM is. The study therefore further sought to establish the relationship between the knowledge of BIM and its' use.

To establish the relationship between use and knowledge of BIM, a cross tabulation was undertaken.

Table 4.7: Knows BIM versus uses BIM.

Know what BIM is * Uses BIM				
		Uses BIM		
Know what BIM is		No	Yes	Total
No	Count	2	0	2
	% within knows what BIM is	100.0%	0.0%	100.0%
Yes	Count	13	5	18
	% within knows what BIM is	72.2%	27.8%	100.0%
Total	Count	15	5	20
	% within knows what BIM is	75.0%	25.0%	100.0%

Source: Author, 2015.

The results showed that none i.e. 100% of the respondents who did not know what BIM is were using it for construction project management. Within the 90% out of the total respondents who knew what BIM is, only 27.8% were using it for construction project management in their organization. This is in line with the position of Panuwatwanich & Peansupap (2013), that,' although the benefits of BIM seem evident, its' diffusion within the Architecture, Engineering and Construction (AEC) Industry has been slow and its' current adoption has not been to its' full capacity'.

In order to establish the expected trend in the adoption of BIM in the construction industry in Kenya for construction project management in the next five years, a cross tabulation of responses for planning to adopt BIM and responses for does not use BIM was undertaken. The results are summarised in the table below;

Table 4.8: Planning to adopt BIM versus does not use BIM.

		Uses BIM	**Total**
Planning to adopt BIM		No	
No	Count	3	3
	% within uses BIM	20.0%	20.0%
Yes (in 0-3 years)	Count	8	8
	% within uses BIM	53.3%	53.3%
Yes (in 3-5 years)	Count	2	2
	% within uses BIM	13.3%	13.3%
Yes (in over 5 years)	Count	2	2
	% within uses BIM	13.3%	13.3%
Total	Count	15	15
	% within uses BIM	100.0%	100.0%

Source: Author, 2015

The results showed that within the 75% of respondents that were not employing BIM for construction project management, 80% were planning to adopt it within the next five years. In addition, 53.3% planned to adopt BIM within the next three years, 26.7% within three to five years while 20% were not planning to adopt the BIM technology at all. The above results demonstrate that there is an interest in BIM, and a majority of the respondents firms are gearing up to adopt. This is therefore the right time for these firms to receive support towards the adoption of BIM.

To contrast the relationship between BIM knowledge and planning to adopt BIM for construction project management in Kenya, a cross tabulation was undertaken.

Table 4.7 shows that 61.1% of the respondents who were familiar with BIM and were not using it in construction project management, were actually planning to adopt it within the next five years. In addition, 44.4% were planning to adopt BIM within three years, 16.7% between three and five years while the remaining 16.7% were not planning to adopt it at all.

According to Linderoth (2010), 'the adoption and use of BIM will be shaped by the interplay between the technology's features and the context in which it would be adopted and used.' This is consistent with this study's hypotheses that, The independent variables of technology, organisation and process have a significant effect on the level of BIM adoption in Nairobi County.

Table 4.9: Planning to adopt BIM versus knows BIM.

		Knows what is BIM	**Total**
Planning to adopt BIM		**Yes**	
No	Count	3	3
	% within knows what is BIM	16.7%	16.7%
Yes (in 0-3 years)	Count	8	8
	% within knows what is BIM	44.4%	44.4%
Yes (in 3-5 years)	Count	1	1
	% within knows what is BIM	5.6%	5.6%
Yes (in over 5 years)	Count	2	2
	% within knows what is BIM	11.1%	11.1%
NA	Count	4	4
	% within knows what is BIM	22.2%	22.2%
Total	Count	18	18
	% within knows what is BIM	100.0%	100.0%

Source: Author, 2015

4.4 Organisation

4.4.1 Number of technical staff

The study sought to establish the size of organisations by querying the number of technical staff. 80% of the respondents had between 1 and 10 technical staff while only 20% had more than 10 technical staff. This shows that the industry is comprised mainly of small firms. This structuring of the industry is posited to be one of the factors affecting the adoption of BIM.

Table 4.10: Number of technical staff.

No. of staff	Percent of firms	Size of firm
1-10	80.0	Small
10-50	20.0	Medium
50-100	0.0	Large
Above 100	0.0	Very large

Source: Author, 2015

4.4.2 Presence of a BIM manager within the organisation

Of the respondents using BIM, 40% had a BIM manager within their organisation while 60% did not have one. Staub-French (2011) puts forward that a BIM manager helps in the utilization of BIM to the maximum, thereby increasing efficiency. The conclusion may therefore be drawn that only 40% of the respondents using BIM are likely to be using BIM efficiently.

Table 4.11: Presence of a BIM manager within the organisation.

	Percent	Cumulative Percent
No	60.0	60.0
Yes	40.0	100.0
Total	100.0	

Source: Author, 2015

4.4.3 BIM usage areas in construction project management

Table 4.12: General applications of BIM.

Application of BIM	Yes	Percent	No	Percent
Facilitate regulatory process	0	0%	5	100%
Produce shop and field drawings	2	40%	3	60%
Manage site/ infrastructure/facilities/ project life-cycle	3	60%	2	40%
Manage construction materials	2	40%	3	60%
Track construction progress	1	20%	4	80%
Jobsite to guide construction/ for construction activities	0	0%	5	100%
Value engineering	3	60%	2	40%
Enhance safety on construction site	0	0%	5	100%
Synthesise all aspects of design	1	20%	4	80%
Technical design	3	60%	2	40%
Record as built information	1	20%	4	80%
Evaluate project performance/analyse data for future use & reference	0	0%	5	100%

Source: Author, 2015

The results showed a greater use i.e. 60% of BIM in construction project management to manage site, infrastructure, facilities and project life cycle; value engineering and in technical design and slightly less than average i.e. 40% to produce shop and field drawings; and Manage construction materials. Minimal use i.e. 20% was reported in tracking construction progress, synthesizing all aspects of design and record as built information. On the other hand, there was 0% use of BIM in facilitating regulatory process, in jobsites to guide construction/ for construction activities or in evaluating project performance/analyzing data for future use and reference. It is seen that BIM is largely used onsite related activities, this is consistent with the earlier findings that contractors are the most involved in BIM use, and ultimately points to the system of procurement in use, that is, Design-Bid-Build.

The table below summarises the use of BIM in Construction Project Management Areas.

Table 4.13: Use of BIM in construction project management areas.

Construction project management area	True	Percent	False	Percent
Definition of project goals and scope	2	40%	3	60%
Management of Human Resources	3	60%	2	40%
Management of Communication	4	80%	1	20%
Management of Risk	4	80%	1	20%
Management of Schedule and Budget	4	80%	1	20%

Source: Author, 2015

Greater use i.e. 80% of BIM was reported in management of communication, risk, schedule and budget; more than average use i.e. 60% of BIM was reported in human resource management while less than average i.e. 40% in the definition of project goals and scope. The above usage patterns can be attributed once again to the distribution of BIM among the different construction professionals. Communication, risk, schedule and budget are all areas that feature extensively at construction stage. As seen in Table 4.1, the majority of the respondents using BIM were contractors, and would therefore be using it for activities related to the construction stage of the project.

4.4.4 Changes made within organisations in order to adopt BIM

The table below summarises the responses received in regard to changes made within respondents' organisations in order to adopt BIM.

Table 4.14: Changes made within organisations in order to adopt BIM.

Changes made within the organisation	Yes	Percent
Changes to contracts adopted to establish legal relationships	0	0%
Changes to the sharing of responsibilities among project stakeholders	3	0%
Changes to sequence of work	2	40%
Changes to how work is organised	3	60%
Changes to allocation of financial resources within the firm	1	20%
Changes to allocation of human resources within the firm	0	0%
Changes to organisational structure of the firm	1	20%

Source: Author, 2015

60% of the respondents reported that there was change to the way that work is organised. This was followed by 40% who reported that there was change to the sequence of work. This is in line with the postulation that BIM is not only technology but also a process. In order to adequately adopt BIM, it becomes necessary to reconfigure work organisation and processes to accommodate its' use.

A minority of the respondents, 20% reported changes to allocation of financial resources within the firm and changes to the organisational structure of the firm. This demonstrates that the largest impact of BIM adoption is in the work itself, with minimal change to the financial and the structural aspects of firms.

None of the respondents reported changes in the following: allocation of human resources within the firm, the sharing of responsibilities among project stakeholders and changes to contracts adopted to establish legal relationships. These are all suggested as areas of further study.

4.4.5 Shared project goals and objectives

Of the respondents 75% reported that they had shared goals and objectives while 25% did not.

Table 4.15: Shared project goals and objectives.

	Percent	**Cumulative Percent**
No	25.0	25.0
Yes	75.0	100.0
Total	100.0	

Source: Author, 2015

A majority of the respondents reported having shared goals. This indicates that they have embraced collaborative working which eases the adoption of BIM on projects.

4.4.6 The project stage at which different stakeholders are involved with the project

Table 4.16: The project stage at which different stakeholders are involved with the project.

Stakeholder / Design stage	Pre-construction	Design	construction	Post-construction
Owner	60%	40%	0%	0%
Construction Project Manager	40%	20%	40%	0%
Architect	20%	80%	0%	0%
Quantity Surveyor	0%	100%	0%	0%
Engineer	20%	80%	0%	0%
Contractor	0%	0%	100%	0%

Source: Author, 2015

The design stage was reported to have the most involvement of project stakeholders with all but the contractor being involved. This was followed by the pre-construction stage here again all but the Quantity surveyor and the contractor are involved. At construction stage, only the construction project manager and contractor were involved and at post-construction none of the stakeholders is involved.

Early involvement of the owner allows them to participate in decisions on BIM use and other resource planning that is likely to affect the use of BIM. Projects that have their owners involved early on can be said to derive most benefit from the use of BIM. This also leads to cost and time savings and the overall improvement of project quality.

The stage at which the CPM is involved determines the extent of BIM use. It is noted that none of the respondents involve the CPM at post-construction stage. The Architect is not involved in at either construction or post-construction, pointing to the fact that the Architect may not be viewed as essential at these stages, whereas he is in fact usually the initial author of the BIM model.

Generally, the above results show that the processes of work organisation have not changed much to accommodate BIM use.

4.5 Technology

4.5.1 BIM software used

Of the respondents, 50% reported using Graphisoft software, while the other 50% reported using Autodesk software. This is because these are the two BIM software manufacturers that have a heavy presence in Kenya.

Table 4.17: BIM software used.

	Percent	Cumulative Percent
Graphisoft	50.0	50.0
Autodesk	50.0	100.0
Other	0.0	
Total	100.0	

Source: Author, 2015

4.5.2 BIM level used by firms

The Table below summarises the responses received in regard to the BIM Level in use by firms, categorised from the basic Level 1 to the most integrated Level 5.

Table 4.5: BIM level used by firms in Kenya.

Level of Usage	Yes	Percent	No	Percent
Level 1: communication of design intent and evaluation of design alternatives	2	40%	3	60%
Level 2: coordination of the different design disciplines	4	80%	1	20%
Level 3: production of construction documents/analysis of different systems	2	40%	3	60%
Level 4: fabrication and assembly of components as designed	0	0%	5	100%
Level 5: for maintenance and operation of the facility	0	0%	5	100%

Source: Author, 2015

Greater usage i.e. 80% of BIM was reported at level two; coordination of the different design disciplines while there was less than average usage of BIM in level one and three i.e. communication of design intent and evaluation of design alternatives, and production of construction documents/analysis of different systems respectively. In addition, no firm interviewed reported using BIM at level four or five i.e. in fabrication and assembly of components as designed, and for maintenance and operation of the facility respectively. These findings may be attributed to the fact that there is no real push for the adoption of BIM within the Kenyan Construction Industry.

4.5.3 BIM usage by construction stage

The study sought to find out at what project stage BIM is used by the respondents. The table below summarises the result.

Table 4.19: Extent of BIM usage by construction stage,

Stage	Yes	Percent	No	Percent
Pre-construction	1	20%	4	80%
Design	4	80%	1	20%
Construction	1	20%	4	80%
Post- Construction	1	20%	4	80%

Source: Author, 2015

The results showed that BIM was majorly (i.e. by 80% of respondents interviewed) used in the design stage while minimal usage was reported in pre-construction, construction and post-construction stages respectively. This pattern of use suggests that BIM is in use as more of a drafting tool as opposed to an information management tool, in which case its' use would have cut across the four stages.

4.5.4 Opinion on what stage BIM can give most benefits

Table 4.20: Opinion on what stage BIM can give most benefits,

Stage	Percent
Pre-construction	20%
Design	60%
Construction	60%
Post- Construction	20%

Source: Author, 2015

A majority of respondents, 60% opine that BIM can give most benefits at design stage and construction stage. A minority, 20%, say that BIM can give most benefits at pre and post construction stages. These opinions are in tandem with the results in Table 4.19 where the most use was recorded at design stage. The respondents' opinion on what stage can give most benefits can be seen to relate to the stage at which the respondents reported using BIM most.

4.5.5 Firms' maturity in BIM implementation

Table 4.21: Firms' maturity in BIM implementation.

Maturity level	Percent
Pre-BIM status	40%
Stage 1	60%
Stage 2	0%
Stage 3	0%

Source: Author, 2015

A majority of the respondents, 60% reported that their firms were at stage 1 maturity. That is, object modelling and BIM use only within the firm. This was followed by 40% who reported that their firms were at pre-BIM status, that is, they were still engaged in traditional construction project management practice. None of the respondents' firms are at stage 2 and stage 3 maturity. According to Succar (2010), BIM stages are defined by their minimum requirements. Therefore for the majority of respondents that reported Stage 1 BIM maturity, this means, that they have at least deployed an object-based modelling software such as ArchiCAD or Revit.

4.6 Benefits of using BIM versus traditional Construction Project Management

The study sought to establish the comparative benefits of BIM use over traditional construction project management. The results are summarised in the table below:

Table 4.6: Comparative benefits: BIM versus Traditional.

Comparative benefits: BIM versus Traditional	**True**	**Percent**	**False**	**Percent**
Enhanced project collaboration among stakeholders	4	80%	1	20%
Improved Productivity	5	100%	0	0%
Reduced re-work and conflicts	4	80%	1	20%
Better project quality and performance	5	100%	0	0%
Faster project delivery	5	100%	0	0%
Reduced wastage	5	100%	0	0%
Reduced construction costs	3	60%	2	40%

Source: Author, 2015

All the respondents that reported using BIM indicated that using BIM leads to improved productivity, better project quality and performance, faster project delivery and reduced wastage when compared to traditional construction project management. Further, 80% of the respondents also indicated that employing BIM in construction project management instead of traditional construction project management would lead to enhanced project collaboration among stakeholders and reduce re-work and conflicts. The benefits that were queried are those that had been identified in the literature review, Azhar et al (2008). This suggests that indeed the use of BIM for construction project management has an advantage over traditional construction project management.

The study then sought to identify the most optimal stage for the use of BIM. This was done by querying the respondents on what stage they thought most benefits could be achieved by using BIM. The findings are summarised in the table below:

Table 4.23: Most optimal stage for using BIM

Project Stage	**Yes**	**Percent**	**No**	**Percent**
Pre-construction	1	20%	4	80%
Design	4	80%	1	20%
Construction	3	60%	2	40%
Post- Construction	1	20%	4	80%

Source: Author, 2015

By the responses received, the opinion of the respondents is that most benefits of employing BIM in construction project management would be reaped by employing the technology in the design stage (80% response) and the construction stage (60% response). In addition, employing BIM in the pre-construction and the post-construction stages would only result in minimal (20% response) benefits respectively. These responses reflect the knowledge that the respondents have on the benefits of BIM use across the different project stages. It is noted that the project stages at which BIM use is reported, Table 4.20, are consistent with the respondents perceptions of the project stages at which BIM can benefit them. This suggests that increased knowledge of the benefits that be attained by BIM use in the stages of pre and post construction would result in an increase in use at those project stages.

The study further sought to establish the level of maturity of firms in BIM implementation.

Table 4.24: Firm maturity in BIM implementation.

Level of maturity	**Yes**	**Percent**	**No**	**Percent**
Pre-BIM Status: Traditional Construction Project Management Practice	2	40%	3	60%
Stage 1: Object modelling and BIM use only within the firm	4	80%	1	20%
Stage 2: Model based collaboration between two or more firms	0	0%	5	100%
Stage 3: Network based integration on a shared network by several firms	0	0%	5	100%

Source: Author, 2015

The results showed that 80% of firms using BIM rated their maturity in BIM implementation to be at stage one i.e. object modelling and BIM use only within the firm while 40% rated their maturity at pre-BIM Status: Traditional Construction Project Management Practice. None of the firms rated their maturity at stage two; model based collaboration between two or more firms or stage three; network based integration on a shared network by several firms. This suggests a relationship between the perceived benefits and the firms' maturity in BIM implementation.

4.6.1 Challenges encountered in adopting BIM

The study sought to establish the challenges encountered in BIM adoption.

Table 4.7: Challenges of adopting BIM in Kenya.

Challenges in adopting BIM	Yes	Percent	No	Percent
The fragmented nature of the Construction Industry	2	40%	3	60%
Traditional procurement systems	3	60%	2	40%
The temporary nature of construction projects	2	40%	3	60%
The unique nature of construction projects	0	0%	5	100%
The re-engineering of processes required to adopt BIM	1	20%	4	80%
The adversarial nature of contractual relationships	1	20%	4	80%
The changed roles of project participants brought about by BIM adoption	1	20%	4	80%
Software issues and coordination defects	2	40%	3	60%

Source: Author, 2015

Majority (60%) of the firms using BIM in construction project management cited traditional procurement systems as the greater challenge followed by; the fragmented nature of the Construction Industry, the temporary nature of construction projects and software issues and coordination defects respectively. Further, re-engineering of processes required to adopt BIM, the adversarial nature of contractual relationships and the changed roles of project participants brought about by BIM adoption were all cited as minimal (20%) challenges. The unique nature of construction projects was not cited as a challenge to the adoption of BIM by any of the firms that reported using BIM in construction project management. These findings are largely consistent with those identified in the literature review for related construction professions of engineering, architecture and quantity surveying.

4.6.2 The effect of BIM adoption challenges on level of BIM maturity

To establish the association between the reported level of BIM maturity and challenges of adopting BIM in construction project management, a chi-square test of independence was undertaken.

The results are tabulated below:

Table 4.26: The association between BIM adoption challenges and level of BIM maturity.

BIM maturity rating					
Challenges	Chi-Square Tests	Asymp. Sig. (2-sided)	Cramer's *V*	Kendall's tau-b (τ)	Approx. Sig.
The fragmented nature of the Construction Industry	21.563[a]	.001	.734	.792	.005
Traditional procurement systems	27.500[a]	.000	.829	.899	.000
The temporary nature of construction projects	23.333[a]	.001	.764	.887	.000
The unique nature of construction projects	20.000[a]	.000	1.000	.898	.000
The re-engineering of processes required to adopt BIM	21.250[a]	.002	.729	.887	.000
The adversarial nature of contractual relationships	40.000[a]	.000	1.000	.828	.000
The changed roles of project participants brought about by BIM adoption	21.250[a]	.002	.729	.887	.000
Software issues and coordination defects	28.750[a]	.000	.848	.962	.000

Source: Author, 2015

The results showed that the adversarial nature of contractual relationships (χ=40.00, p≤.00; τ=.828, p≤.000), software issues and coordination defects (χ=28.750, p≤0.00; τ =.962, p≤.00) and traditional procurement systems (χ=27.500, p≤.00; τ =.899, p≤.00) were strongly associated with the level of BIM maturity reported compared to the rest of BIM adoption challenges. In addition, the adversarial nature of contractual relationships (*V*=1.00), the unique nature of construction projects (*V*=1.00), software issues and coordination defects (*V=.848*) and traditional procurement systems (*V=.829*) had the largest effect on the reported level of BIM maturity.

4.7 How Construction Project Management can benefit fully from BIM

The study sought to establish how construction project management can benefit fully from BIM. The results are summarised below:

Table 4.27: How construction project management can benefit fully from BIM.

	Yes	Percent	No	Percent
Sufficient Information and information sharing by project stakeholders	2	40%	3	60%
Early involvement of all key disciplines in every project	3	60%	2	40%
Facilitation of the collaborative process(development of collaboration contracts and incentives)	2	40%	3	60%
Setting a minimum BIM maturity level to be achieved.	2	40%	3	60%
Having shared goals and objectives as project team members	2	40%	3	60%
Documentation of the BIM implementation process	3	60%	2	40%
Appointment of a BIM Manager	2	40%	3	60%
Institution of formal BIM processes and procedures	2	40%	3	60%
Setting up of appropriate information structures for BIM adoption	3	60%	2	40%

Source: Author, 2015

Majority (60%) of the respondents using BIM indicated that employing practices that enhance early involvement of all key disciplines in every project, documentation of the BIM implementation process and setting up of appropriate information structures for BIM adoption would yield more benefits from usage of BIM in construction project management.

Further, 40% of the respondents using BIM posited that employing practices that enhance availability and sharing of information by project stakeholders, facilitation of the collaborative process (i.e. development of collaboration contracts and incentives), setting a minimum BIM maturity level to be achieved, having shared goals and objectives as project team members, appointment of a BIM Manager and institutionalizing of formal BIM processes and procedures, would also yield more benefits from usage of BIM in construction project management.

4.7.1 Encouraging adoption of BIM in Construction Project Management in Kenya

The study sought to establish what strategies could be employed to encourage the adoption of BIM in Construction Project Management in Kenya

Table 4.8: Strategies for encouraging adoption of BIM.

Strategy	Yes	Percent	No	Percent
Funding	0	0%	5	100%
Training/ Continuous Professional Development	4	80%	1	20%
Development of standards	3	60%	2	40%
Development of implementation guidelines	5	100%	0	0%
Helping to form BIM championing organizations	3	60%	2	40%
Development of common data schema to aid data exchange	2	40%	3	60%
Requirement for adoption in certain projects	1	20%	4	80%
Setting BIM adoption deadlines/ Setting mandatory BIM submission for approvals	1	20%	4	80%

Source: Author, 2015

Development of BIM implementation guidelines and training/continuous professional development, were cited by 100% and 80% respectively of the firms using BIM as the most significant strategies to aid the adoption of BIM technology in construction project management in Kenya. More than average of the firms using BIM also indicated that development of standards and helping to form BIM championing organizations would also encourage adoption of BIM technology.

Further, development of common data schema to aid data exchange, requirement for adoption in certain projects and setting BIM adoption deadlines/setting mandatory BIM submission for approvals was cited by minimal respondents as an aid to adoption of BIM while funding was considered to have no effect. To establish the association between these strategies and BIM adoption challenges, a chi-square test for independence was undertaken.

4.7.2 Association between BIM adoption challenges and encouragement strategies

A chi-square test for independence was undertaken to determine the association between challenges of adopting BIM and posited strategies to encourage adoption of BIM in construction project management.

Table 4.99: BIM adoption challenges.

BIM adoption challenges					
Strategies to encourage BIM adoption	Chi-Square Tests	Asymp. Sig. (2-sided)	Cramer's *V*	Kendall's tau-b (τ)	Approx. Sig.
Funding	20.000[a]	.003	1.000	.870	.000
Policy Formulation	40.000[a]	.000	1.000	.860	.000
Sensitization & Education/ Training/ Continuous Professional Development	40.000[a]	.000	1.000	.964	.000
Development of implementation guides	40.000[a]	.000	1.000	.838	.000
Benchmarking initiatives	40.000[a]	.000	1.000	.848	.000

Source: Author, 2015

The results showed that Sensitization and Education/ Training/ Continuous Professional Development on the benefits of BIM was the most correlated (τ=.964, p≤0.00) strategy to challenges of adopting BIM. All the strategies had a perfect effect size of (V=1.00) signifying that all these strategies would have a great effect on alleviating the challenges of adopting BIM.

4.8 Hypotheses testing

4.8.1 The effect of organization, technology and process factors on the level of BIM adoption.

Effect sizes provide an objective measure of the importance of an effect. Cohen (1990, 1994) made some widely accepted suggestions about what constitutes a large or small effect:

- τ = 0.10 (small effect): in this case, the effect explains 1% of the total variance.
- τ = 0.30 (medium effect): the effect accounts for 9% of the total variance.
- τ = 0.50 (large effect): the effect accounts for 25% of the variance.

Table 4.30: Hypotheses testing-Organization factors

Test for association						
			Has BIM Manager	Area BIM is used	Area BIM used CPM	Org. changes made to adopt BIM
Kendall's tau_b	Uses BIM	Correlation Coefficient	.802**	.870**	.762**	.939**
		Sig. (2-tailed)	.000	.000	.000	.000
		N	20	20	20	20
**. Correlation is significant at the 0.01 level (2-tailed).						

Source: Author, 2015

The results showed that each of the organization factors under study had a large effect ($\tau > 0.5$) on the level of BIM adoption and accounts for 25 percent variance in the level of BIM reported. Further, change in organization structure had a greater coefficient of association ($\tau = .939$, $p \leq 0.00$) with level of BIM adoption.

Table 4.31: Hypotheses testing-Technology factors

Test for association							
			BIM Software Used	Level BIM is used	Stage BIM used PLC	Stage BIM use most benefits	BIM maturity rating
Kendall's tau_b	Uses BIM	Correlation Coefficient	.825**	.945**	.956**	.879**	.898**
		Sig. (2-tailed)	.000	.000	.000	.000	.000
		N	20	20	20	20	20
**. Correlation is significant at the 0.01 level (2-tailed).							

Source: Author, 2015

All technology related factors had a large effect (τ >0.5) on the level at which the organizations were using BIM in their construction projects. In addition, the four stages of a project i.e. pre-construction, design, construction and post construction had a greater association (τ=.956, $p \leq 0.00$) with use of BIM in construction projects.

Table 4.32: Hypotheses testing-Process factors

Test for association						
			How BIM implemented in the firm	Received support collaborative process of BIM	Document BIM implementation process	Instituted formal process for BIM adoption
Kendall's tau_b	Uses BIM	Correlation Coefficient	1.000**	.884**	1.000**	.845**
		Sig. (2-tailed)		.000		.000
		N	20	20	20	20
**. Correlation is significant at the 0.01 level (2-tailed).						

Source: Author, 2015

The results showed that the approach (in-house or out-sourced) followed in the adoption of BIM and documentation of BIM implementation process had a perfect association (τ=1, $p \leq 0.00$) with the level of BIM implementation. In addition, the BIM implementation process factors had a large effect (τ>0.5) on the level of BIM adoption in construction projects.

4.9 Chapter summary

The response rate for the study was 36.4% and majority of the respondents were Contractors/Builders at 65% closely followed by Construction Project Managers at 25%. In addition, most of the respondents i.e. 70% fell within the 6-10 years and 11-15 years of experience categories.

The results showed that 25% of the respondents were using BIM in construction project management. Further, none i.e. 100% of the respondents who did not know what BIM is were using it in construction project management. In addition, within the 90% out of the total respondents who knew what BIM is, only 27.8% were using it in construction project management in their organization.

Greater use (i.e. 60% of respondents) of BIM in construction project management was cited in regards to managing site, infrastructure, facilities and project life cycle; value engineering and in technical design. Also, greater usage (i.e. 80% of respondents) of BIM was reported at level two; coordination of the different design disciplines.

Further, BIM was majorly (i.e. by 80% of firms interviewed) used in the design stage and most benefits of employing BIM in construction project management would be reaped by employing the technology in the design stage (80% response) and the construction stage (60% response).

All the firms that reported using BIM indicated that using BIM leads to improved productivity, better project quality and performance, faster project delivery and reduced wastage when compared to traditional construction project management.

The adversarial nature of contractual relationships (χ=40.00, p≤.00; τ=.828, p≤.000), software issues and coordination defects (χ=28.750, p≤0.00; τ =.962, p≤.00) and traditional procurement systems (χ=27.500, p≤.00; τ =.899, p≤.00) were strongly associated with the level of BIM maturity reported compared to the rest of BIM adoption challenges. Sensitization and Education/ Training/ Continuous Professional Development on the benefits of BIM was the most correlated (τ=.964, p≤0.00) strategy to challenges of adopting BIM signifying it would have a greater impact on the adoption and maturity levels of BIM in the construction industry.

Majority (60%) of the respondents using BIM indicated that employing practices that enhance early involvement of all key disciplines in every project, documentation of the BIM implementation process and setting up of appropriate information structures for BIM adoption would yield more benefits from usage of BIM in construction project management.

And finally, development of BIM implementation guidelines and training/continuous professional development, were cited by 100% and 80% respectively of the firms using BIM as the most significant strategies to aid the adoption of BIM technology in construction project management in Kenya.

CHAPTER 5: SUMMARY OF MAJOR FINDINGS; DISCUSSION; CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the findings, as well as discusses these findings. It concludes the study and offers recommendations based on the findings. Finally, it lists limitations of the study and suggests areas for further study.

5.2 Summary of major findings

The aim of this study was to establish the role of BIM in the Construction Project Management Process in Nairobi County, Kenya. The major findings of this research together with their corresponding objectives are listed in the table below;

Table 5.1: Summary of major findings.

Objective	Finding
1. To establish the extent to which technology, organisation and processes of firms affect adoption of BIM use for Construction Project Management within Nairobi County.	i) It was found that each of the organization and technology related factors under study, as well as the BIM implementation process had a large effect ($\tau > 0.5$) on the level of BIM adoption.
2. To identify the challenges in adopting of BIM use for Construction Project Management in Nairobi County.	i) Traditional procurement systems ii) The fragmented nature of the construction industry. iii) The temporary nature of the construction projects. iv) The re-engineering of processes required to adopt BIM. v) The adversarial nature of contractual relationships. vi) The changed roles of project participants brought about by BIM adoption. vii) Software issues and coordination

	defects.
3. To identify the advantages in adopting BIM for Construction Project Management in Nairobi County.	i) Enhanced project collaboration among stakeholders ii) Improved productivity iii) Reduced re-work and conflicts. iv) Better project quality and performance. v) Faster project delivery. vi) Reduced wastage. vii) Reduced construction costs.
4. To develop strategies to increase the adoption of BIM use for Construction Project Management in Nairobi County.	i) It was found that there are no Kenyan BIM standards or implementation guidelines. ii) It was also found that there are no institutions requiring BIM adoption on their projects, iii) Thirdly, it was found that there are no bodies or organisations driving BIM adoption in Nairobi County. iv) Ways in which BIM adoption can be encouraged

Source: Author, 2016

5.3 Discussion

The above findings suggest that the independent variables have an effect on the dependent variable. The discussion below explores the relationship between the independent variables and the dependent variable. The independent variables are the three aspects of Construction Project Management of technology, organisation and process, while the dependent variable is BIM adoption.

Infrastructure is one of the key pillars for Kenya's vision 2030 development blueprint. Infrastructure promotes development of other activities in the economy. Construction project management is key to efficient and affective infrastructure development. The purpose of construction project management is to add significant and specific value to the process of delivering construction projects. This is done by directing and coordinating human and material resources throughout the life of a project. One key aspect of this is the coordination of information on projects.

Information on construction projects comes in a multiplicity of formats and from multiple sources. The more this information can be communicated from a single source, the better. BIM allows construction project managers to do precisely this.

By enabling construction project managers to manage information centrally, BIM makes the project management process more efficient, therefore adding even more value to the delivery of construction projects.

This study therefore sought to establish the role of BIM in construction project management in Nairobi County, Kenya. It was found that 25% of those interviewed were using BIM. Of the 75% that were not using BIM, 80% were planning to adopt it within the next 5 years.

From the literature viewed, McGraw Hill Construction (2014), this shows a similar trend to BIM adoption in the UK, which was at 54% in 2014, and projected to be 93% by 2016.

This paper hypothesized that the independent variables of technology, organisation and process have a significant effect on the level of BIM adoption in Nairobi County.

5.3.1 Background

The majority of the respondents, while executing the construction project management on their projects where contractors/builders by profession. This can be attributed to the fact that this profession is the one that is actively involved in the construction phase of projects and in the day to day running of projects. Njagi (2013), in his study submitted that the understanding of BIM among class A and B contractors in Kenya is unclear. Therefore it can be assumed that while they are the most involved in the construction stage and therefore likely to benefit from BIM use, their understanding of it is low.

From Table 4.7 it is seen that none of the respondents who did not know what BIM is were using it for construction project management. However, within the 90% respondents who knew what BIM is, only 27.8% were using it for construction project management. This indicates a very low adoption rate compared with the UK which has a near equal awareness of BIM at 95% and adoption of 54%according to McGraw Hill Construction (2014). It is evident that more campaigns and initiatives to increase adoption are necessary.

McGraw Hill Construction (2014), projected that by 2016 adoption of BIM in the UK would be at 93%. When a cross tabulation of responses for ‘planning to adopt BIM’ and responses for,’ does not use BIM’ were undertaken, it showed that80% of those not using BIM were planning to adopt it in the next 5 years. This shows that there is interest in BIM and many firms are gearing up to adopt. This is therefore the right time for construction project management practitioners to receive education on adoption in the form of, guidelines for adoption, and training on adoption.

5.3.2 Organisation

i) Size of firms

It was found that a majority of firms were small, that is, they had between 1-10 technical staff. A small percentage are medium sized with between 10 and 50 technical staff. None of the respondent firms fell under the category of large (50-100) or very large (over 100) technical staff.

This shows that the Kenyan construction industry is comprised mainly of small firms, which could be seen as a factor influencing the adoption of BIM. According to Ofori (1990), small firms are generally uncommitted, transient, undercapitalized, have poor access to credit, operate within limited geographical areas and seldom apply modern management opportunities. Despite this, Ofori (1990) also notes that they play a key role in the construction industry and provide a useful framework for the development of the industries and particularly in developing countries.

It can be assumed that the proliferation of small firms in the Kenyan construction industry is the main reason for the low adoption of BIM, which is a modern management opportunity. This narrative can be altered by building the capacity of small firms in terms of technology, organisation, process and management.

ii) Presence of a BIM manager

According to Staub-French (2011), appointment of a BIM manager within an organisation is important as they devise strategies for BIM implementation and coordinate the efforts of the entire team. In the study it was found that only 40% of the respondents had a BIM manager within their organisations. This is consistent with the finding that none of the respondents documented their BIM implementation process or instituted formal processes and procedures in their firms to ease BIM adoption.

iii) BIM usage areas in construction project management

It was found that BIM is used mostly to manage site, infrastructure, facilities, project life cycle, for value engineering and in technical design. It was noted however that none of the respondents uses BIM for the regulatory process. This can be attributed to the fact that no approving body or regulatory body in Kenya has so far required the adoption of BIM for construction approval.

It was also noted that none of the respondents uses BIM on the jobsite either to guide construction or to enhance safety. As postulated by Njagi (2013), contractors have very little knowledge of BIM within Nairobi County and this could be the reason why uptake by construction project managers for site related functions is low.

Finally, it was noted that none of the respondents use BIM as an analysis and record tool. To record as built information and use this data for future reference and evaluation of project performance. As seen before, a large percentage of the respondents did not have a BIM manager and may therefore not be looking at the entire scope of work the process and technology of BIM is able to deliver.

iv) Use of BIM in Construction management areas

The greatest use for BIM was reported in the management of communication, risk, schedule and budget. Average use was reported in management of human resources, while the least use was reported for definition of project goals and scope. This can be attributed once again to lack of a spear-heading figure for BIM adoption. Therefore the CPM firms do not fully utilize BIM to define projects and scope.

Changes made within organisations in order to adopt BIM.

The greatest change reported was in the organisation of work, supporting the hypothesis that the variable of organisation has a significant effect on the level of BIM adoption in Nairobi County. This finding is also in line with the postulation that BIM is not only a technology but a process as well. In order to adequately adopt BIM it becomes necessary to reconfigure work to accommodate its' use. The next significant change reported was in the sequence of work, which ties in with the organisation of work.

No change was reported in the following areas: Contracts adopted to establish legal relationships, the sharing of responsibilities among project stakeholders and the allocation of human resources within firms. This shows that BIM is being adopted within the context of existing contractual relationships and existing structures for work sharing. This is proposed as an area for further study, to see how this affects the effectiveness of BIM use.

v) Shared project goals and objectives

A majority of the respondents, 75% reported that they had shared goals and objectives on their BIM projects. This indicates that a majority of CPM's have embraced collaboration which eases the adoption of BIM on projects.

vi) The project stage at which different stakeholders are involved.

The design stage was reported to have the most involvement of project stakeholders, with all but the contractor being involved. It is presupposed that involvement of the contractor at this stage would afford more effective use of BIM on the project. After the design stage, the pre-construction stage recorded the second highest involvement of stakeholders with all but the Quantity surveyor and the contractor being involved at this stage. Again it is presumed that early involvement of all the consultants on the project helps with the adoption of BIM. According to Talebi (2014), BIM requires enhanced integration of project teams and collaboration between all parties. He further suggests that the intimate collaboration of the prime players at the earliest stage is highly compatible with BIM capabilities.

At construction stage, only the construction project manager and contractor were involved, and at post-construction, none of the stakeholders is involved. It is important to note that the stage at which the construction project manager is involved determines the extent of BIM use.

The nature of project information provided by stakeholders

Only a minority, 20%of respondents reported that the information provided by other stakeholders on projects is adequate. This affects the usability of this information on a BIM platform. All the respondents reported that the information provided on projects was averagely complete. This means that are still gaps in the information which makes it less useful on BIM platform. Finally a majority of the respondents, 60% reported that the information provided on projects was only partially applicable to BIM use. A minority 20% reported that it was appropriate to BIM use, while another 20% reported that it was largely not usable with BIM. This reflects the different levels of BIM maturity within the Kenyan construction industry.

5.3.3 Technology

i) BIM software in use

Exactly half of the respondents reported using Graphisoft software, while the other half reported using Autodesk software. It can be presumed this is because these are the two BIM software manufacturers that have a heavy presence in Kenya. This can be attributed to their continued consistent and substantial marketing in the Kenyan market. This is through activities such as the sponsoring of the 'Annual building industry conference' by Graphisoft and 'Autodesk live seminars'.

Another reason why these two are the leading software is their use in tertiary institutions as the software of instruction for construction related courses. ArchiCAD mostly for Architectural courses and Autodesk for engineering courses.

ii) BIM level used by firms

The majority of respondents reported use of BIM at level2, which is characterised by model based collaboration between stakeholders on a project. In the UK, the Government construction strategy published in May 2011, stated that the '…Government will require fully collaborative 3D BIM as a minimum by 2016'. This requirement applies to all public sector asset procurement. However, as regards the Kenyan situation, Waigwa (2016) says,' it is very unlikely that the BIM agenda will be set by the Government here'. He foresees the agenda being guided by the industry and private developers

iii) Stages of BIM use

A majority of the respondents reported using BIM at the design stage with minimal use in the other stages of pre-construction, construction and post-construction. The stage at which BIM is used on a project reflects BIM maturity. The pattern of use, suggests that BIM is being used more like a drafting tool than a collaborative opportunity. Awareness is required by CPM's on the use of BIM in other stages of a project's lifecycle.

iv) Opinion on what stage BIM can give most benefits

A majority of the respondents were of the opinion that BIM can give the most benefits when employed at the stages of design and construction. A minority thought that BIM would give the most benefits when employed at the stages of pre-construction and post construction.

These opinions are seen to be consistent with the stages at which the respondents are using BIM. It can be suggested that the respondents are only aware of the benefits they are currently reaping. More awareness is necessary on all the benefits that can be reaped from BIM use throughout a project.

v) Firm's maturity in BIM implementation

A majority of the respondents' reported stage 1 maturity for their firms. That is, 'object modelling and BIM use only within the firm' this finding is consistent with the findings on the stages of BIM use and the respondents opinions on what stage BIM can give most benefits.

5.3.4 Process

i) Mode of BIM implementation within firms

All the respondents reported that BIM implementation within their firms was an in-house effort. This demonstrates the initiative of the firms' in adopting BIM. It is suggested that any external push for the implementation of BIM would further boost the interest in and adoption of BIM.

ii) Support received for the collaborative process of BIM

It was found that this help was received mainly from the re-sellers in form of training that accompanies the purchase of the software. Other help was from independent BIM specialists in the market that carry out training on BIM use.

None of the respondents received support in terms of benchmarking. This suggests that the firms are not sharing knowledge on adoption of BIM. This sharing can be encouraged by professional bodies or industry regulators creating a platform to share knowledge of BIM adoption.

iii) Documentation of BIM implementation process

It was found that none of the respondents documented their process of BIM implementation. It is posited that the implication of this non-documentation on the construction project managers is as follows: they are unable to re-evaluate their implementation process by hindsight, they are unable to share the process with others, they are unable to refer to their process to fine tune it, and they may not know how to carry out documentation.

iv) Institution of formal processes and procedures in the firm to ease BIM adoption.

None of the respondents reported instituting any formal procedures in their firms to ease BIM adoption. BIM adoption is therefore both in-house and informal. It is suggested that formalization of the implementation of BIM can raise the general level of BIM maturity.

v) Perceived benefits of BIM use for construction project management as compared to traditional construction project management

The greatest perceived benefits were: improved productivity, better project quality and performance, faster project delivery and reduced wastage.

5.3.5 Awareness and opinion

It was found that none of the respondents were aware of any of the following: Kenyan BIM standards or implementation guidelines, institutions in Nairobi County. requiring BIM adoption on their projects or bodies driving BIM adoption in Nairobi County.

5.3.6 The extent of BIM use for Construction Project Management within Nairobi County.

The research established that 25% of construction professionals were using BIM for Construction Project Management in Nairobi County. Cross tabulation between use and knowledge of BIM was undertaken and the result showed that within the 90% of the total respondents who knew what BIM is, only 27.8% were using it for construction project management within their organisations.

5.3.7 Challenges in adopting BIM for Construction Project Management in Nairobi County.

Traditional procurement systems were cited as the greatest challenge in adopting BIM, followed by the fragmented nature of the construction industry, the temporary nature of construction projects, software issues and coordination defects respectively.

Further, re-engineering of processes required to adopt BIM, the adversarial nature of contractual relationships and the changed role of project participants were cited as minimal challenges.

The association between the reported level of maturity and challenges of adopting BIM in construction project management was tested and the results showed that the adversarial nature of contractual relationships, software issues and coordination defects as well as traditional procurement systems were strongly associated with the level of BIM maturity reported. It is therefore suggested that alleviation of these particular challenges can ease the adoption of BIM and raise the general level of BIM maturity within Nairobi County.

5.3.8 Advantages in adopting BIM for Construction Project Management in Nairobi County.

From the study, it was found that improved productivity, better project quality and performance, faster project delivery and reduced wastage were the greatest advantages reported after the adoption of BIM.

Others were enhanced project collaboration among stakeholders and reduced re-work and conflicts.

Finally, reduced construction costs were also minimally cited as an advantage accruing from BIM adoption.

5.3.9 Strategies to increase the adoption of BIM for Construction Project Management in Nairobi County.

The study revealed that sensitization, education, training and continuous professional development were the best strategies to encourage BIM adoption. These are the strategies that had the highest correlation to the challenges being encountered in the adoption of BIM.

Further, it was found that all the suggested strategies for increasing BIM adoption had a perfect effect size of (V=1.00) signifying that they all would have a great effect in alleviating the challenges of adopting BIM.

These strategies are: funding, policy formulation, development of implementation guidelines and benchmarking initiatives.

5.4 Conclusion

From the research the conclusion is drawn that, the organisation, processes and technology in use within a firm affect significantly the choice to adopt BIM.

5.5 Recommendations

Based on the findings of this research, the following recommendations are made:

Construction industry regulators in Kenya should actively take up the mantle on BIM implementation and provide support to construction practitioners by way of institutionalizing BIM implementation procedures and timelines for the country.

Educators should train on the use and benefits of BIM at the tertiary level, so that the construction professionals released into the market are aware of BIM and the benefits they can gain from its' use.

Professionals in the construction industry are encouraged to take the initiative to drive the BIM agenda within their private practices, to put in place formal processes for implementation and to share this knowledge with other professionals.

Professional bodies are encouraged to make training on BIM a part of their professional development programs. They are also encouraged to work with the regulating bodies to push for requirement of BIM adoption as a minimum standard for work.

5.6 Areas for further research.

Following this study it is recommended that further research into the contractual relationships entered into in construction work be carried out to establish how these can be remodeled to suit the adoption of BIM into the construction project management field.

It is recommended that research be undertaken comparing a project executed in Nairobi county using BIM and one executed without BIM, to quantify the gains of using BIM.

Further research into the changing responsibilities of stakeholders on the adoption of BIM would also be useful. An enquiry can also be made into the changes that are necessary to the allocation of human resources within firms once BIM has been adopted.

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APPENDICES

APPENDIX ONE: Letter of Introduction

Arch. Marylyn M. Musyimi
P.O.Box 1140, 01000
THIKA

To: Whoever it May Concern,

Dear Sir/Madam

RE: ASSISTANCE TO FILL ACADEMIC QUESTIONNAIRE

I am a master's student in the department of construction management at the University of Nairobi. I am conducting an academic research titled '**Building Information Modelling Adoption in Construction Project Management in Kenya- A case study of Nairobi County'.** I kindly request your assistance in filling in the attached questionnaire. The objective of the research is to establish the extent of BIM use for Construction Project Management in firms within Nairobi County.

Your participation in this research would be greatly appreciated but is voluntary. Your confidentiality and anonymity are ensured. Your identifiable information contained in the survey will only be used during the data collection phase of this study. If a survey is less than half completed you may be contacted to verify that it was your intention not to complete the survey, otherwise you will not be contacted. During the analysis portion of the study, you will not be individually identified with your questionnaire or response. All collected data will be aggregated and grouped.

There are no known risks associated with participation in this study. Your responses to the survey may contribute to greater understanding of BIM adoption in the Kenyan Construction Industry.

Thank You.
Arch. Marylyn Musyimi.

APPENDIX TWO: Questionnaire

SECTION A: BACKGROUND INFORMATION

1. What is your profession? (tick as appropriate)

☐ Construction Project Manager ☐ Architect ☐ Quantity Surveyor

☐ Contractor/ Builder ☐ Engineer ☐ Other(please specify)____________

b) Number of years of experience

☐ 0-5 ☐ 5-10 ☐ 10-15 ☐ Above 15

2. Are you involved in Construction Project Management in Nairobi County? (tick as appropriate)

☐ Yes ☐ No

b) If Yes (Please Specify) ____

____

3. Do you know what BIM (Building Information Modelling) is?

☐ Yes ☐ No

b) If Yes (Briefly define/describe it in your own words) ______________________

____

4. Do you use BIM in your organisation?

☐ Yes ☐ No

b) If No, Does your firm plan on adopting BIM in the future?

☐ Yes (in 0-3 years) ☐ Yes (in 3-5 years) ☐ Yes (in over 5 years) ☐ No

SECTION B: ORGANISATION

5. How many technical staff do you have within your organisation? (tick as appropriate)

☐ 1- 10 ☐ 10- 50 ☐ 50- 100 ☐ over 100

b) Do you have a BIM Manager within your organisation? (tick as appropriate)

☐ Yes ☐ No

6. For what do you use BIM in your organisation? (tick as appropriate)

☐ Use BIM to facilitate regulatory process

☐ Use BIM to produce shop and field drawings

☐ Use BIM to manage site/ infrastructure/facilities/ project life-cycle

☐ Use BIM to manage construction materials

☐ Use BIM to track construction progress

☐ Use BIM on the jobsite to guide construction/ for construction activities

☐ Use BIM for value engineering

☐ Use BIM to enhance safety on construction site

☐ Use BIM to synthesise all aspects of design

☐ Use BIM for technical design

☐ Use BIM to record as built information

☐ Use BIM to evaluate project performance/analyse data for future use & reference

☐ Other (Please Specify) ____________________

7. In your organisation, BIM is utilized in the following Construction Project Management Areas. (tick as appropriate)

	TRUE	FALSE
i) Definition of project goals and scope	☐	☐
ii) Management of Human Resources	☐	☐
iii) Management of Communication	☐	☐
iv) Management of Risk	☐	☐

v) Management of Schedule and Budget ☐ ☐

8. What changes have you had to make within your organisation in order to adopt BIM? (tick as appropriate)

☐ Changes to contracts adopted to establish legal relationships

☐ Changes to the sharing of responsibilities among project stakeholders.

☐ Changes to sequence of work

☐ Changes to how work is organised

☐ Changes to allocation of financial resources within the firm

☐ Changes to allocation of human resources within the firm

☐ Changes to organisational structure of the firm.

9. Do you have shared project goals and objectives (such as cost, time and quality) among stakeholder on a project? (tick as appropriate)

☐ Yes ☐ No

b) If Yes, (please give an example) ____

____

10. At what project stage are the following involved with the project? (tick as appropriate)

	Pre-construction	Design	Construction	Post- Construction
Owner	☐	☐	☐	☐
Construction Project Manager	☐	☐	☐	☐
Architect	☐	☐	☐	☐
Quantity Surveyor	☐	☐	☐	☐
Engineer(s)	☐	☐	☐	☐
Contractor	☐	☐	☐	☐

11. In the experience of your firm, which of the following best describes the information provided by project stakeholders throughout the life of a project? (tick as appropriate for each category)

- ☐ Adequate
- ☐ Inadequate
- ☐ Complete
- ☐ Incomplete
- ☐ Appropriate for BIM use.
- ☐ Inappropriate for BIM use.

SECTION C: TECHNOLOGY

12. What BIM software do you use? (tick as appropriate)

☐ Autodesk ☐ Graphisoft ☐ Other, (Please Specify) ___________________

13. At what level is your firm utilising BIM? (tick as appropriate)

- ☐ Level 1:communication of design intent and evaluation of design alternatives
- ☐ Level 2:coordination of the different design disciplines
- ☐ Level 3:production of construction documents/analysis of different systems
- ☐ Level 4:fabrication and assembly of components as designed
- ☐ Level 5:for maintenance and operation of the facility

14. At what stage do you employ BIM in the project life-cycle? (tick as appropriate)

- ☐ Pre-construction
- ☐ Construction
- ☐ Design
- ☐ Post- Construction

15. At what stage do you think the use of BIM can give the most benefits? (tick as appropriate)

- ☐ Pre-construction
- ☐ Construction
- ☐ Design
- ☐ Post- Construction

16. How would you rate your firm for maturity in BIM implementation? (tick as appropriate)

- ☐ Pre-BIM Status: Traditional Construction Project Management Practice
- ☐ Stage 1: Object modelling and BIM use only within the firm

☐ Stage 2: Model based collaboration between two or more firms

☐ Stage 3: Network based integration on a shared network by several firms

SECTION D: PROCESS

17. How was BIM implemented within your firm? (tick as appropriate)

☐ In- House ☐ Out-sourced

18. Have you received any support for the collaborative process of BIM? (tick as appropriate)

☐ Financing ☐ Implementation guidelines

☐ Education/ Training ☐ Benchmarking opportunities

☐ Policy guidance

☐ Others, (Please Specify) ____

19. Did you document your BIM implementation process? (tick as appropriate)

☐ Yes ☐ No

20. Have you instituted formal processes and procedures in your firm to ease BIM adoption?

☐ Yes ☐ No

21. BIM offers the following benefits when used for Construction Project Management as compared to Traditional Construction Project Management. (tick as appropriate)

	TRUE	FALSE
i) Enhanced project collaboration among stakeholders	☐	☐
ii) Improved Productivity	☐	☐
iii) Reduced re-work and conflicts	☐	☐
iv) Better project quality and performance	☐	☐
v) Faster project delivery	☐	☐
vi) Reduced wastage	☐	☐
vii) Reduced construction costs	☐	☐

viii) Other (Please Specify) ____________________

____

b) Please list other benefits you have experienced in using BIM.

____

____

SECTION E: AWARENESS AND OPINION

22. In your opinion, what are the challenges to BIM adoption for Construction Project Management in Nairobi County? (tick as appropriate)

- ☐ The fragmented nature of the Construction Industry
- ☐ Traditional procurement systems
- ☐ The temporary nature of construction projects
- ☐ The unique nature of construction projects
- ☐ The re-engineering of processes required to adopt BIM
- ☐ The adversarial nature of contractual relationships
- ☐ The changed roles of project participants brought about by BIM adoption
- ☐ Software issues and coordination defects
- ☐ Other, (Please Specify) ____________________

____

23. In your opinion, BIM adoption for Construction Project Management in Nairobi County can be encouraged by? (tick as appropriate)

- ☐ Funding
- ☐ Training/ Continuous Professional Development
- ☐ Development of standards
- ☐ Development of implementation guidelines
- ☐ Helping to form BIM championing organisations
- ☐ Development of common data schema to aid data exchange
- ☐ Requirement for adoption in certain projects
- ☐ Setting BIM adoption deadlines/ Setting mandatory BIM submission for approvals

☐ Other, (Please Specify) ______________________________

____

24. Are you aware of any Kenyan BIM Standards or Implementation guidelines?

(tick as appropriate)

☐ Yes ☐ No

b) If Yes, (Please Specify) ______________________________

____

25. Are you aware of any institutions requiring BIM adoption on their projects? (tick as appropriate)

☐ Yes ☐ No

b) If Yes, (Please Specify) ______________________________

____

26. Are you aware of any bodies/ organisations driving BIM adoption in Nairobi County?

(tick as appropriate)

☐ Yes ☐ No

b) If Yes, (Please Specify) ______________________________

____

27. In your opinion, in what ways can BIM adoption in Nairobi County be supported?

(tick as appropriate)

☐ Funding

☐ Policy Formulation

☐ Sensitization & Education/ Training/ Continuous Professional Development

☐ Development of implementation guides

☐ Benchmarking initiatives

☐ Other, (Please Specify) ______________________________

____

28. In your opinion, which of the practices below can help Construction Project Management in Nairobi County benefit fully from BIM use? (tick as appropriate)

☐ Sufficient Information and information sharing by project stakeholders

☐ Early involvement of all key disciplines in every project

☐ Facilitation of the collaborative process(development of collaboration contracts and incentives)

☐ Setting a minimum BIM maturity level to be achieved.

☐ Having shared goals and objectives as project team members

☐ Documentation of the BIM implementation process

☐ Appointment of a BIM Manager

☐ Institution of formal BIM processes and procedures

☐ Setting up of appropriate information structures for BIM adoption