Development of a Facilities Management Framework for Sustainable Building Practice in Nigeria

By

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A thesis submitted in partial fulfilment for the requirements for the degree of Doctor of Philosophy at the University of Central Lancashire

July 2017

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ABSTRACT

Sustainable buildings in built environment require that the use of resources such as energy, water, and unwanted outputs such as greenhouse gases are minimised whilst maximising the health and wellbeing of users. Sustainable building refers to the application of sustainability principles to the design, construction and management of buildings so as to mitigate the environmental impact of buildings. There has been emphasis on sustainable building development recently as a means for the construction industry to contribute to greenhouse gas reduction. In addition, it is generally recognised that the stakeholders who are involved with built environment should corporately engage with this to ensure that sustainable building is holistically achieved in the future.

There is need for sustainable building practice in Nigeria as buildings generally show signs of poor design for ventilation, natural lighting, energy management, water management, waste management and other building services. These buildings under perform in relation to the purpose for which they have been built. Building users often complain that the buildings do not provide the required services such as functioning air-conditioning systems, effective water and energy management systems and waste management. Facilities management (FM) professionals in Nigeria have recognised the role that they can play in the practice of sustainable building as a way to proffering a solution to the above mentioned problems. However, there is a need to address some questions if this is to be achieved: what constitutes a sustainable building in the Nigerian context? What is the current FM role in achieving sustainable buildings in Nigeria? Are facilities managers in Nigeria competent in FM roles in achieving sustainable buildings?

The research therefore, aimed to develop a framework that can be used to achieve sustainable buildings in Nigeria through the facilities manager's role. As a result, six objectives were set for the study: to identify the constituents of sustainable building with reference to literature and internationally recognised standards; to evaluate the role of FM in relation to the sustainable building at the design, the construction and operations stages of the building life-cycle; to develop a conceptual framework that shows the facilities manager's role in sustainable buildings; to evaluate the perception of facilities managers in relation to their competence in achieving sustainable buildings; to investigate the drivers and barriers to the facilities manager's role in achieving sustainable buildings; and finally to develop and validate a framework for sustainable building practice for FM in Nigeria.

The methodology adopted for this research included a combination of extensive literature review, content analysis of relevant literature and the BREEAM-New Construction, LEED-New Construction, and Sustainability in Buildings and Civil Engineering Works — Guidelines on the Application of the General Principles in ISO 15392; in order to identify sustainable building constituents. It also included content analysis of the British International Facilities Management Professional Standards Handbook; the International Facilities Management Association

Complete List of Competencies: Global Job Task Analysis; the Facilities Management Association Australia Skills in Facilities Management Investigation into Industry Education; and the Royal Institute of Chartered Surveyors Assessment of Professional Competence Facilities Management Pathway Guide; in order to identify the facilities manager's role in sustainable buildings. Following this, 20 interviews and a questionnaire survey of 139 members of IFMA Nigeria were undertaken.

The findings of the research reveal 51 constituents that are critical to achieving a sustainable building such as management of waste, effective use of energy, and 44 specific roles of the facilities manager in the attainment of sustainable buildings and across the design, construction and operations stages. The findings reveal the present state of FM practice towards sustainable buildings in Nigeria and highlight that facilities managers believe that they are competent in all 44 identified FM roles in relation to sustainable buildings. However, this viewpoint is hindered by several factors, such as lack of acceptance of the FM role at the design and construction stages; a lack of incentives for sustainable building implementation among developers; a lack of awareness among the public about the FM role in sustainable building; a lack of government financial support and a lack of government policies or legislation to support the implementation of the FM role in sustainable building. The findings also reveal drivers that can encourage FM role in sustainable buildings and these include awareness of FM role in sustainable building among top management; demand for best building practices by government; high level of FM competencies; development of the economy; and the facilities manager's involvement at the design stage.

The findings of the research helped in developing a framework for the achievement of sustainable buildings through the facilities manager's role at the design, construction and operations stages of the building's life-cycle. The developed framework can be used as a non-prescriptive guide by facilities managers in achieving sustainable buildings in Nigeria in order to provide comfort and a sustainable environment for the building user. The framework provides improved knowledge and understanding of what constitutes a sustainable building and the facilities managers' role in the development of sustainable buildings at the design, construction and operations stages.

The study concludes that if the developed framework is work, facilities managers need to be involved in the development of sustainable buildings right from the design stage and through construction and operations stages, however, in collaborative effort with other building professionals. The study highly recommends that building professionals, the building owner and government needs to be knowledgeable in the constituents that make a sustainable building in order to encourage the drivers and mitigate the barriers to sustainable building practice. The framework is a much needed guide in the achievement of sustainable buildings in Nigeria.

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ACKNOWLEDGEMENT

I will like to use this medium to appreciate and say a big thank you to my supervisory team for their support and encouragement. I sincerely appreciate the learning opportunities provided to me as a result of the wealth of experience you brought together as a team. I cannot thank you all enough. Dr. Champika Liyanage, my Director of Studies, thank so much for all the work you put in to ensure that I complete my research and for always drawing my attention to arears of my work that needed improvement. Dr. Andrew Smith, thank you for being there for me at every stage of this research and for your encouragement and your gentle but firm persistence in addressing pertinent areas of my research. Prof. Akintola Akintoye, thank you for your tremendous support and much needed guidance in the course of my research. Thank you for ensuring that I am focused and for your various contributions to my work and always pushing me to do more and providing direction when needed. I will also like to thank Dr. Adebayo Oladapo and Dr. Chris Lowe for their timely advice at the different stages of my research.

A big thanks to all the members of the Reconciliation Ministries Preston; Thank you for providing the much needed spiritual support, I cannot express how wonderful you have all being. I wish I could put all your names in this acknowledgement. To every member of Foursquare Gospel Church, Morocco and Yaba Tech Area, I say a big thank you. I will to acknowledge the management of Yaba College of Technology for granting me study leave my PhD. I will like to appreciate Mrs. Margaret Kudi Ladipo, the Rector of Yaba College of Technology and Mr. Doherty for their contribution towards ensuring I start and finish my PhD. A special thank also to Mr. U. I. Inyang-Udoh, who also started me off on this journey and to Mr. B. A. Mafimidiwo who is a major contributor to where I am today. I thank Mrs. Falilat Idowu for her prayers and support and all teaching and non-teaching staff of the Department of Quantity Surveying, Yaba College of Technology. I appreciate all the staff of the School of Engineering and my colleagues in room KM 129 and especially Mrs. Dolapo Ogunsola.

I will like to appreciate my late father GABRIEL OLUKAYODE ARIYIBI who sacrificed a lot to ensure that I get the best in life and always pushed me to be the best that I can be. I miss you daddy and wish you were here. I will like to also thank my mother, Mrs. GLADYS ADENIKE ARIYIBI, the greatest mum in the whole wide world. Thank you mummy for encouraging me to start this journey, for your prayers and for always been there for my girls. A big thank you to my second parents Mr. and Mrs. Olaniyi Oladiran and all my brothers and sisters: Mr. and Mrs. Ope Ariyibi, Mr. and Mrs. Olukayode Ariyibi, Mr. and Mrs. Omiunu, Mr. and Mrs. Kuteyi, Mr. and Mrs. Odusolu, Mr. and Mrs. Dapo Olaniyi, Mr. and Mrs. Femi Fasina. Many thanks to Oreoluwa Sotade and every member of Glory Assembly Choir and also the staff of OJ&T Consulting Limited.

To my loving husband OLATUNDE OLANIYI, thank so much for your help and support all through the years. Without you I would not been able to start and finish this programme. I Love you dearest with all of my heart. I thank God continuously for the day I met you and for the many days we have spent together. My prayer is that we will spend much more many days together and we will always be there for each other. Thank you for bringing out the best in me and for sacrificing so much for me to finish this programme. To my two angels OLAOLUWATOFUNMI and OLUWATAMILORE OLANIYI, thank you for understanding the many times when I had to leave you for months in order to work on my research. Without your understanding and support, I would not have able to finish. We did this together.

Finally to God All Mighty, the Creator of the heavens and the earth, the Lord Jesus Christ and the Holy Spirit, thank you. For if not for your help and enablement, I would not have been able to do this study. Thank you Lord for strength, grace and wisdom; I am very grateful.

LIST OF ABBREVATIONS

ABGR	Australian Building Greenhouse Rating
BREEAM	Building Research Establishment Environmental Assessment Method
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CED	Cumulative Energy Demand
EMS	Environmental Management System
ERA	Environmental Risk Assessment
FM	Facilities Management
GBI	Green Building Index
GHEM	Green Home Evaluation Manual
GHG	Green House Gas
IOA	Input – Output Analysis
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
LEED	Leadership in Energy and Environmental Design
MFA	Material Flow Accounting
NC	New Construction
POE	Post Occupancy Evaluation
SB	Sustainable Building
SBAT	South African Sustainable Building Assessment Tool
SC	Sustainable Construction
SD	Sustainable Development
UK	United Kingdom
US	United States

CHAPTER 1: INTRODUCTION

1.1 Background of the Study

Nigeria like many countries is focusing on achieving a sustainable built environment (Dimuna and Omatsone, 2010; Akande *et al.*, 2015). This is the primary focus of building designers and professionals, in order to attain a high level of satisfaction of occupants' safety and comfort and to meet the sustainable development (SD) agenda requirements. SD has been defined in several ways and various authors have attached different meanings to it (Hopwood *et al.*, 2005; Alnaser *et al.*, 2008; Vander-Merwe, 1999; Shah, 2007; Sev, 2009). However, the Brundtland Report gave a worldwide accepted definition of SD as 'meeting the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987).

The Brundtland report gained recognition due to its focus on meeting the crucial needs of people in terms of food, clothing and shelter; and at the same time focusing on economic growth that does not harm humans. The report emphasised on population being within the limits of the earth's available resources and technological growth not at the cost of the environment (Elliott, 2006). The Brundtland report points out the interconnecting nature of the environment, economy and social issues (Burton, 1987; Baker, 2006; Ogujiuba *et al*, 2012, Kang *et al.*, 2015). Attaining this interconnectivity according to Pitt *et al*, (2009), promotes sustainability.

Sustainability, according to Robinson (2004) and Sharachchandra (1991), is the achievement of a continuous process involving the survival of the human race within environmental constraints. Bell and Morsel (2008) view it as the end-point of SD. SD is now a major part of the mission statement of many global organisations, national institutions, corporate companies, states and localities (Kates *et al.*, 2005). Companies are coming to the realisation that initiatives such as selection of building materials that are non-harmful and recyclable, should be both profitable and environmentally preferable (Owens and Cowell, 2002).

This has led to the development of the environmental, economic and social aspects of SD. The environmental aspect includes conserving natural resources, maintaining the ecosystems and monitoring the impact of economic development on the environment. The economic aspect includes economic growth, sustenance of resources, preventing the depletion of renewable resources and reducing the usage of non-renewable resources. The social aspect includes the elimination of poverty, ensuring population growth is to an acceptable level, and the adequate provision of social services such as health and general human well-being (Pânzaru and Dragomir, 2012; Harris *et al.*, 2001).

The Brundtland Report recognises that humans depend on the environment for security and basic existence (WCED, 1987). The environment should be kept in a state that future generations can benefit from. However, humans have never taken adequate steps to conserve it

(Brandon and Lombardi, 2005). The need for SD became obvious when it was clear that the world's environmental state was deteriorating due to human activities. These activities include those of the building industry and technological development, with little or no thought for future generations (Maiellaro, 2001).

Activities in the building industry have shown the role of buildings in the decay of the natural environment (Mora *et al.*, 2011). Buildings are responsible for the consumption of major amounts of energy, water, and land usage and are, therefore, responsible for a great part of the world's environmental problems (Anink *et al.*, 1996). A high percentage of non-renewable resources consumed across the world are used in the building industry, making it one of the least sustainable industries in the world (Edwards, 2010). The built environment accounts for nearly 40% of natural resources consumed, and 40% of waste and greenhouse gases generated (CIOB, 2004). Buildings use as much as 45% of generated energy to produce power for air-conditioning and heating (Wood, 2005; Reed *et al.*, 2011). Buildings also account for one-sixth of the world's fresh water usage, one-quarter of wood harvested and two fifths of all material and energy flows (Emmanuel, 2004).

In spite of this negative impact of the building industry on the environment, it has a vital contribution towards achieving SD (Gibberd, 2002). It addresses basic human needs in terms of provision for housing and social infrastructure (Sinha *et al.*, 2013). It also determines the quality of housing and access to services and recreation, promoting healthy living and socially cohesive communities (Shah, 2007). According to Burgan and Sansom (2006), this is the reason for the very existence of the construction industry. However, with reference to Du Plessis (2007) the industry has a great challenge, not only to meet the need for adequate housing and rapid urbanisation but also to meet this need in a socially and ecologically responsible way.

It is, therefore, becoming a key consideration for building professionals in the industry to achieve the aim of increasing economic efficiency, protect, and restore ecological systems and at the same time, improve human well-being (Sinha *et al.*, 2013). There is public awareness more than ever, of the impact that buildings have on health and wellbeing, as people spend most of their time in them. In fact, people are beginning to aspire to live and work in comfortable, healthy buildings and buildings with energy saving measures (Roaf *et al.*, 2004).

Therefore, efforts towards achieving SD have led professionals in the built environment to make efforts to negate the activities causing harm to the environment. This has initiated sustainable construction (SC) which is '*the creation and responsible management of a healthy built environment based on resource efficient and ecological principles*' as cited in (Kibert, 1994). SC is seen as a way to create buildings in which the principles of SD are applied to the construction process and consequently produce buildings that are sustainable. It therefore, can be inferred that the quest for a more sustainable built environment has led to the creation of sustainable buildings.

Sustainable buildings can be defined as buildings that minimise the use of resources such as energy and water, minimise unwanted outputs such as greenhouse gas, and maximise the health and wellbeing of users (Eley, 2011). John *et al.,* (2005) describe it as the thoughtful integration of architecture with electrical, mechanical and structural engineering resources, considering the whole life of the building and taking environmental quality, functional quality, and future values into account. From the viewpoint of sustainability, sustainable building refers to the application of sustainability principles to design, construction and management of buildings so as to mitigate the environmental impact of buildings (Balaban and Puppim de Oliveira, 2016)

Sustainable buildings involve buildings being sustainable at the design, construction, operations and demolition stages. Mora *et al.,* (2011) and Dimoudi and Tompa, (2008) emphasise that a building can only be truly sustainable if it is designed with sustainable measures implemented at the construction stage. With reference to Zhang *et al.,* (2006), the construction stage is where some environmental impact occurs. However, the operations stage, which is the longest phase in a building life-cycle, has by far the greatest impact on the environment (Shah 2007; Zhang *et al.,* 2006). The impact is caused by energy usage and carbon emissions, making the operational phase of buildings to have the most adverse effect on the environment (Abigo *et al.,* 2012).

This claim is further expounded by Zhang *et al.,* (2006) who state that the environmental impacts during the operations stage are mostly caused by the operation of building services, namely; electricity consumption, water consumption, and waste management. Sustainable buildings are buildings that minimise the environmental impacts of these operations and at the same time, help provide a conducive indoor environment. They are buildings that aid the health, comfort and wellbeing of the building user, and maximise economic value (Billie, 2012).

Studies show that the facilities manager is a major contributor towards achieving sustainability in the built environment and which includes low environmental impact of buildings and comfort of building users (Hodges, 2005; Shah, 2007; Mohammed and Hassanain, 2010). The facilities manager can make useful contributions at the design stage and makes most impact at the operations stage in relation to reducing the negative impact that buildings have on the environment. This role makes the facilities manager a major contributor to achieving sustainable buildings (El-Haram and Agapiou, 2002). Therefore, it can be inferred that the need for the building industry to meet the demand of SD in terms of achieving a sustainable environment has led to the development of sustainable buildings and which can be achieved through the facilities manager’s role. This sets the theoretical background underlying this research study.

Nigeria as a country is beginning to appreciate the role of FM in achieving sustainability in buildings. However, there are not many studies that have been carried out in relation to the facilities manager's role and achieving sustainability in buildings in Nigeria; the few that have been conducted include (Ikediashi *et al.*, 2014; Abigo *et al.*, 2012; and Adewunmi *et al.*, (2012).

Facilities management as a profession has been defined by many as shown in Table 4.1. Armstrong (2002) defines it as the practice that coordinates the physical workplace with people and the work of the organisation, combining the principles of business administration, architecture and the behavioural and engineering sciences. Alexander (2003) describes it as the process by which an organisation ensures that a building, with its systems and services, supports core operations to achieve strategic objectives in changing conditions.

Becker (1990) and Pearson (2003) describe FM as the coordination of all efforts that relate to the planning, designing, and management of buildings, showing FM involvement in the building life-cycle. Kelly *et al*, (2005); Kamara *et al.*, (2001); Preiser (1995); and Nutt (1993) assert that FM starts at the briefing stage. Cotts *et al.,* (2010), El-Haram and Agapiou, (2002) and Shah (2007) argue that FM functions not only start at the briefing stage but continue through to the design, construction and operations stages. However, they emphasise that FM is mostly significant at the operations stage in reducing the negative impact of buildings on the environment (Murray and Langford, 2004).

Buildings in Nigeria generally show signs of poor management. The buildings are poorly designed for ventilation, natural lighting, energy management, water management, waste management and other building services. These buildings under perform in relation to the purpose for which they have been built (Olanrewaju and Anifowose, 2015). Building users often complain that the buildings do not provide the required services such as functioning air-conditioning systems, effective water and energy management systems and waste management (Adejimi, 2005; Ogunmakinde *et al*., 2013). Building owners are dissatisfied most of the time and complain of not getting value for money. Facilities managers are often challenged with managing these poorly designed buildings and tend to struggle with the building meeting purpose and satisfying the building users (Adegoke and Adegoke, 2013). Therefore, the focus of this research is on developing a framework that can ensure the development of buildings that provide a sustainable environment and comfort for the building user through the facilities manager's role. The framework is to aid the development of buildings that meet environmental friendly standards, and have been adequately designed for effective ventilation, energy and water management, and waste management and invariably aid the health of the building user and all at an affordable cost.

The role of the facilities manager in the management of buildings is examined because it is the facilities manager that stays longest with the building. Other building professionals such as the architect, engineers (mechanical and electrical), structural engineers, building surveyor, quantity surveyor etc. spend limited time in the life-cycle of the building by starting their role at the design stage and ending it at the construction stage. The facilities manager on the other hand, starts his role from the design stage by advising on measures that can ensure a buildings' sustainability through the life-cycle stages and comfort of the building user (Mohammed and Hassanain, 2010). The facilities manager at the construction stage can monitor progress of work in collaboration with the above mentioned building professionals to ensure that agreed designs are implemented on site. At the operations stage which is the longest stage of the building life-cycle, the facilities manager manages the building until its end of life (Shah, 2007).

In Nigeria, the facilities manager with his expertise in the management of buildings can contribute towards achieving sustainable buildings. However, there is need for him to know the specific roles that are required for achieving these types of buildings. The study by Abigo *et al.*, (2012) reveals sustainable practices carried out by facilities managers in Nigeria in relation to buildings. However, the study did not reveal how sustainable buildings can be achieved through the facilities manager's roles in order to achieve health and comfort for the building users. Therefore, this research seeks to develop a framework that can serve as a non-prescriptive guide, describing steps to be taken by facilities managers at the design, construction and operations stages of the building life-cycle in order to achieve sustainable buildings in Nigeria. This research evaluates the facilities manager's role in relation to sustainable building constituents at the design, construction and operations stages of the building's life-cycle. This research focuses on achieving sustainable buildings through the facilities manager's role in order to meet the need of the building user; it is an aspect of FM in Nigeria where there is limited research in previous studies.

1.2 Problem Statement

This research addresses a key problem in Nigeria and which is, while the rest of the world is rapidly moving towards a sustainable built environment, Nigeria is still battling with poor design and execution at construction, the use of harmful building products and materials, and poor maintenance and management of buildings (Abigo *et al.*, 2012). Building professionals do not adhere to building practices that help to achieve buildings that are functional, healthy, and comfortable, and fit for purpose (Jiboye, 2012).

This situation has resulted in the dissatisfaction of building users and their increasing efforts to provide a solution to the lack of functionality of the buildings they occupy. The situation has also resulted in the facilities manager being saddled with the burden of operating and maintaining poorly designed and constructed buildings and at the same time making all effort to achieve comfort for the building user. With reference to Adejimi (2005), none of the building professionals in the Nigerian building industry, take responsibility for these buildings. The architects, who usually lead the project team, believe that they adequately consider sustainability issues in their designs. However, most of the time, they do not consult the facilities manager who has experience in the management of buildings and concerning issues that relate to the performance of the building. The architects too often produce buildings that perform poorly and are difficult to maintain. The facilities manager plays little or no role during the critical phases of the design stage where decisions that affect the sustainability of the building are made. He is only called in at the beginning of the operations stage of the building (Olotuah, 2015). The services engineers on the other hand, consult with the facilities manager about building user requirement; however, they do not educate the facilities manager about the operations and maintenance of their installations (Ikedaishi *et al.*, 2012). Therefore, building services suffer and the situation is worsened by building services engineers as they do not inquire feedback from the building users about the performance of the building services in order for them to improve on their designs. They normally end their role at the end of the construction stage.

This research, therefore, focuses on the facilities manager's role at the design, construction, and operations stages in order to help produce buildings that perform effectively in the Nigerian built environment. This will help mitigate the negative impacts of buildings and at the same time achieve buildings that are healthy, comfortable and economical. The research identifies the facilities manager's role in the project team, as the professional that has the competence and takes up the responsibility of guiding the team in sustainable design and construction. Though, other professionals in the building team as mentioned above also have a contributory role in the achievement of sustainable design and construction, FM, as the co-ordinator of all efforts relating to the planning, designing and management of buildings (Pearson, 2003) is suggested as a way to achieve buildings that are sustainable in Nigeria. However, in order to conclude if FM is a way to achieve sustainable buildings in Nigeria, the research needs to answer the following questions:

1. What constitutes a sustainable building in the Nigerian context?
2. What is the current FM role in achieving sustainable buildings in Nigeria?
3. Are facilities managers in Nigeria competent in FM roles in achieving sustainable buildings?

The research aim and some objectives have, therefore, been set to help answer the aforementioned questions.

1.3 Aim and Objectives

The research aims to develop a facilities management framework for sustainable building practice in Nigeria. To achieve this aim, the set objectives are to:

1. Identify the constituents of sustainable building with reference to literature and internationally recognised standards.
2. Evaluate the role of FM in relation to the sustainable building at the design, the construction and operations stages of the building life-cycle.
3. Develop a conceptual framework that shows the facilities manager's role in sustainable buildings.
4. Evaluate the perception of facilities managers in relation to their competence in achieving sustainable building.
5. Investigate the drivers and barriers to the facilities manager's role in achieving sustainable buildings.
6. Develop and validate framework for sustainable building practice for FM in Nigeria.

1.4 Research Programme

The research programme comprises of three stages as shown in Figure 1.1. The details of the three stages and the methodological approaches adopted to address the objectives of each stage are further explained in Chapter 5. The findings of each of the stages are presented in subsequent chapters of this research.

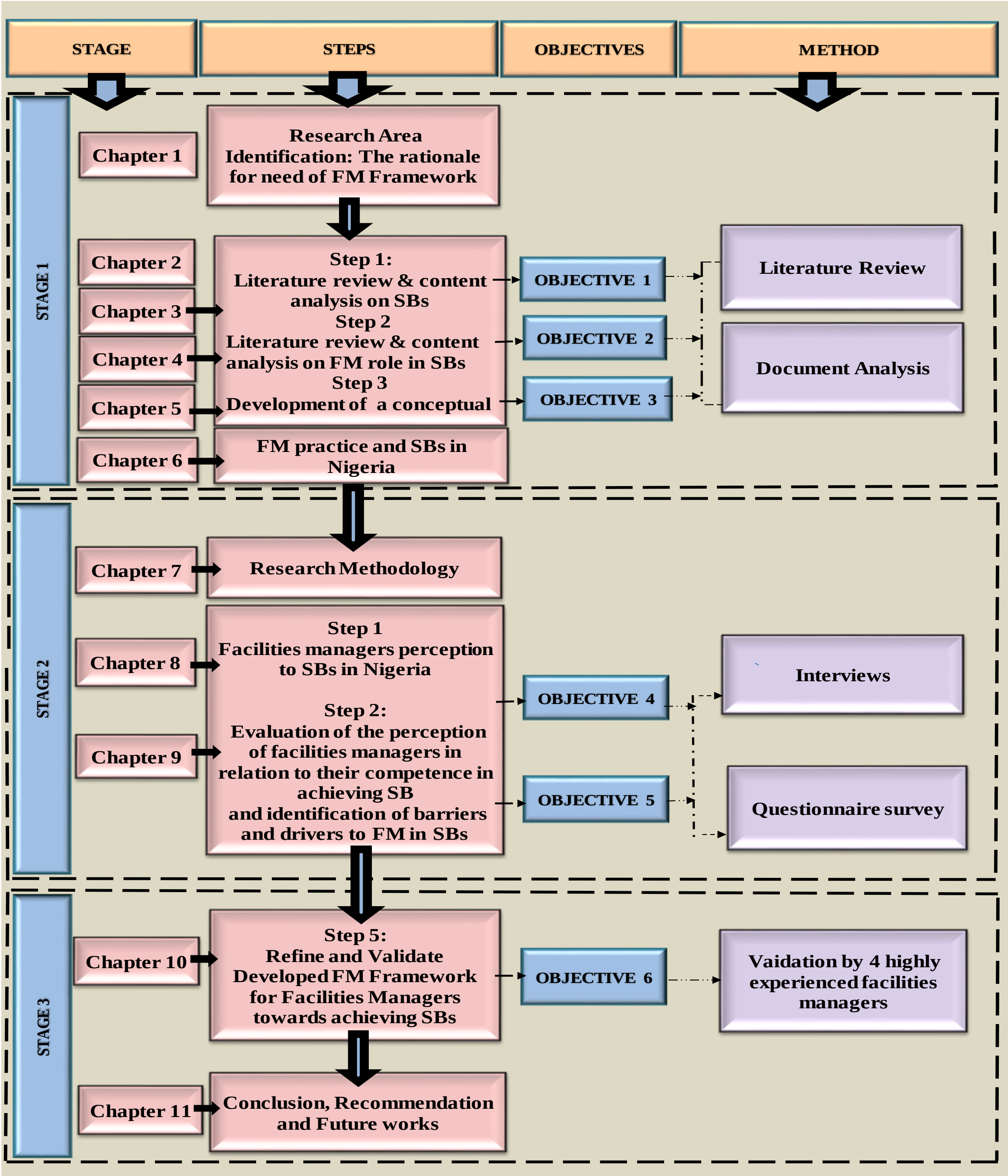

Figure 1.1 Research Flow Process

1.5 Scope and Limitations of the Study

There is a need for every research to state its boundaries of knowledge and basic assumptions underlying its study. FM in Nigeria has grown as a practice over the years and has evolved into a profession that coordinates support services in organisations such as cleaning services, space management, maintenance works and work processes that contribute to improved business performance. However, due to the concern of building users for a more sustainable environment and the need to meet their demand in terms of comfort and health, this research examines the facilities manager’s role in the management of buildings and its associated services in order to highlight the role of the facilities manager as a tool to producing buildings that meet sustainability standards. This research, therefore, focuses on the aspect of FM that relates to achieving sustainability in buildings through the facilities manager's role.

The scope of this study, therefore, lies within the experiences of facilities managers in Nigeria, in relation to their experiences in the management of buildings at the design, construction and operation stages of the building life-cycle. Though, facilities managers in Nigeria are often not involved in a building project until the beginning of the operations stage, this research study examines their role at the design, construction and operations stages. This is necessary because studies have revealed that the facilities manager's role starts from and is vital at the design stage and continues through to the construction stage. It is observed that it is most vital at the operations stage, as this stage is the longest and the most impactful in the building life-cycle (Cotts *et al.,* 2010; El-Haram and Agapiou, 2002; and Shah, 2007). The research study is limited to facilities managers who are registered members of the International Facilities Management Association Nigeria Chapter. It is believed that they have adequate knowledge about the state of FM practice in Nigeria and can answer the questions of this research study. They provide a good population for the purpose of data collection in order to meet the aim of the research.

1.6 Contribution to Knowledge

There is little evidence of documented literature in relation to what constitutes a sustainable building in the Nigeria context. There is also limited research in achieving sustainable buildings through the role of the facilities manager. There are few studies on the contributions of the facilities manager at the design and operations stages and even few considering the construction stage. The few previous studies that are available are not focused on Nigeria. This research has provided written evidence of what constitutes a sustainable building in Nigeria and also the achievement of sustainable buildings through the facilities manager's role. This research contributes to the existing knowledge on sustainable buildings in Nigeria, an area where little research has been previously conducted. It is expected that the identified sustainable building constituents will help building professionals in Nigeria have adequate knowledge of what a sustainable building is.

The research has developed a framework that can be used as a guide by facilities managers in achieving sustainable buildings in Nigeria for the benefit of the end user. The framework provides improved knowledge and understanding developing sustainable buildings through the facilities managers' role at the various stages of the building life-cycle as identified by the BIFM Operational Readiness (a best practice guide for facilities managers based on the RIBA Plan of Work 2013). The framework provides new knowledge on the facilities managers' role in relation to the environmental, social, economic, and management aspects of sustainable building.

The framework also provides other building professionals with an understanding of what constitutes a sustainable building in Nigeria and other parts of the world. This in effect will help provide a sustainable environment for the end users. The framework can be adopted by facilities managers in achieving sustainable buildings in different geographical locations other than Nigeria. It is also expected that the developed framework will be used by facilities managers in their efforts towards contributing to the SD agenda in relation to buildings. The developed framework will help facilities managers integrate better with the building project team particularly in collaborative efforts towards achieving sustainable buildings.

1.7 Structure of the Thesis

This thesis consists of eleven chapters and each chapter covers specific areas of the research. The contents of each of these chapters are summarised below:

- **Chapter 1** provides a general introduction to the thesis describing the nature of the research problem and including the rationale for the research problem. The chapter includes sections on the aim and objectives of the research and the contribution to knowledge. The chapter also includes an outline of the research process covering the three stages as shown in Figure 1.1.
- **Chapter 2** provides a review of sustainable development (SD) definitions and the development of SD. The chapter presents the impact of SD in the construction industry, showing the link between buildings and SD. The chapter also discusses sustainability assessment tools as part of the impact of SD in the construction industry. The chapter provides a background for the development of sustainable buildings through efforts to meet the SD agenda.
- **Chapter 3** presents various building sustainability assessment tools as efforts made by the construction industry with the aim to reduce the potential impacts of buildings on the environment. The Chapter also presents different views in relation to sustainable building definition and how sustainable buildings differ from green buildings. The constituents that make a sustainable building are identified in relation to the environmental, social, economic and management aspects of SD based on content analysis and related literature. Finally, to conclude, this chapter addresses and achieves Objective 1 of this research as shown in Section 1.3.
- **Chapter 4** presents a review of FM definitions and discusses the development of FM as a profession. The roles of facilities managers in sustainable buildings are identified in relation to the environmental, social and economic aspects. They are also identified in relation to the design, construction and operations stages of the building life-cycle based

on content analysis and the findings of Objective 1. The chapter addresses and achieves Objective 2 of this research as shown in Section 1.3. The chapter presents what constitutes a sustainable building in the Nigerian context and efforts made in Nigeria towards sustainable buildings and the barriers and drivers to sustainable building practice. The chapter discusses FM in relation to sustainable buildings in Nigeria and the barriers and drivers to FM role in sustainable buildings. The chapter also addresses Objectives 4 and 5 of the research.

- **Chapter 5** presents a conceptual framework that shows the facilities managers role in achieving sustainable buildings. The conceptual framework was developed from the findings of Objective 1 and 2 and achieves Objective 3 of the research study
- **Chapter 6** addresses the methods used for collecting data and the research methodology adopted for this research. It includes different methods adopted for data analysis in order to achieve the aim and objectives of the research. It establishes the theoretical framework in which the research was conducted. The chapter justifies the methods adopted for conducting this research. The methods of data analysis used for the study are described in detail in this chapter.
- **Chapter 7** discusses details of the data analysis conducted in relation to sustainable building constituents in the opinion of facilities managers. The chapter discusses the data analysis in relation to the environmental, social, economic and the management aspects. The chapter also discusses the findings of the results of the analysis and establishes the constituents that make a sustainable building in the Nigerian context.
- **Chapter 8** presents and discusses details of the findings of the questionnaire survey carried out in relation to the facilities manager’s role in sustainable building and the barriers and drivers to this role. The data analysis are presented and discussed. The chapter discusses the data analysis in relation to their role in the environmental, social, and economic and the management aspects. The chapter also establishes the facilities managers’ role in sustainable building and the barriers and drivers to their role and achieves Objective 4 and 5.
- **Chapter 9** presents the FM framework developed as a guide for facilities managers in achieving sustainable buildings. The chapter describes the framework developed from the findings of Objective 1, 2, 3, and 4. This framework is the final output of the research. The chapter addresses and achieves Objective 6 of the research.
- **Chapter 10** is the chapter that presents the conclusion of this thesis and presents the key findings of the research. It provides a summary of the whole research process used in this research and also presents the conclusions drawn from the research findings, recommendations, and suggestions for further research.

CHAPTER 2: SUSTAINABLE DEVELOPMENT

2.0 Introduction

Sustainable development (SD) is amongst the most relevant issues of our time. It has developed from the modest issues of protection of the environment to wider issues of social and economic development. It has also resulted in the demand for sustainable buildings. This demand is due to an accelerated depletion of natural resources, rising energy costs and greenhouse gas emissions, and improved awareness of indoor air quality. The chapter provides an overview of SD and its history. The chapter illustrates the impact of SD in the construction industry and how it has led to sustainable buildings. The chapter addresses Objective 1 of this research study by providing a theoretical background to the origin of the sustainable building concept.

2.1 The History of Sustainable Development

During the past thirty years, SD has grown into a major subject area for the society. There is ongoing research for evaluating its progress and how to achieve it. Meeting the goals of SD is one of the greatest challenges (Kardos, 2012). According to Fuentes-Nieva and Pereira (2010), there is a widespread understanding that SD relates with how an individual's current decisions affect what options become available in the future. The concept of SD can be traced back to the eighteenth and nineteenth century in the works of Malthus (1766-1834) and Williams Stanley Jevons (1835-1882). They were worried about resource scarcity especially in the face of population rise and energy shortages. In the 1960s and 1970s, a significant number of people especially in the industrialised nations began to raise their concerns about resource and energy depletion (Baker, 2006).

As a result of this growing concern, the United Nations (UN) an international organisation formed in the United States of America, to promote international peace and security have over the past 40 years demonstrated their support towards SD. The European Union (EU) which is a politico-economic union of 28 countries that are primarily located in Europe has also demonstrated their support for SD by initiating programmes that promote the development of the economy and healthy environment (Du Pisani, 2006). Table 2.1 shows the programmes initiated by the UN, EU and other international organisations in their efforts towards the achievement of SD.

In 1972, the UN organised a conference in Stockholm, on the human environment and brought industrialised and developing nations together to define the rights of people to a healthy and productive environment. It was the first major global environmental meeting arranged by the UN. One of the results of the conference was the formation of the United Nations Environment Programme (UNEP, 1972). In 1980, the International Union for the Conservation of Natural Resources (IUCN) published the World Conservation Strategy (WCS) which herald the concept of SD. The WCS declared that the conservation of nature cannot be achieved without alleviating poverty and stressed the interdependence nature on development. It stated also that for development to be sustainable it must take account of social and ecological factors, as well as economic ones (IUCN, 1980).

Table 2.1: Historical international milestones on sustainable development

Year	Efforts Made towards SD	Brief description
1972	UN Conference on the Human Environment, in Stockholm (Stockholm conference)	Introduction of environmental challenges in the political development discourse
1980	International Union for the Conservation of Natural Resources (IUCN) published the World Conservation Strategy (WCS) which herald the concept of SD	Declaration of development to alleviate poverty and the interdependence of conservation and development
1982	IUCN published a comprehensive set of five requirements for SD	Publication of requirements of SD namely: Intergration of conservation and development; satisfaction of basic human needs; achievement of equity and social justice; provision for social self-determination and cultural diversity; and maintenance of ecological integrity
1982	Independent Commission on International Development Issues published a report, titled , North-South: A Programme for Survival	Publication of a report that expressed serious concern over the worldwide deterioration of the environment
1987	Our common future" - UN World Commission on Environment and Development Report (Brundtland report)	Introduction of a definition of sustainable development linking environmental challenges with economic and social development
1992	UN Conference on Environment and Development (UNCED), in Rio de Janeiro (Earth Summit)	Adoption by more than 178 governments on five main documents namely: • Rio declaration on environment and development, which presents 27 principles related with environment and development, for both industrialized and developing countries • Agenda 21 on sustainable development, composed by three "pillars" – economic, social, and environmental. Not a legally binding document but a "work plan," or "agenda for action," with a political commitment to pursue a set of goals on environment and development. The largest product of UNCED. • Convention on Climate Change (the basis for UNFCCC), signed by representatives from 153 countries. Formal international discussion for this convention began in 1988 with the establishment of the Intergovernmental Panel on Climate Change (IPCC). Entered into force in 1994. • United Nations convention on biological diversity • Statement of Princiiples for the sustainable management of forests
1997	UN General Assembly held a special session called Agenda 21 (Rio +5)	Appraisal of status of Agenda 21. The Assembly acknowledged progress on Agenda 21 as "uneven" and identified causes which included increasing globalisation, widening inequalities in income, and continued deterioration of the global environment. The meeting concluded with a resolution on further action.
2000	UN Summit on the Millennium Development Goals (MDGs Summit)	Adoption of a global action plan to achieve the eight anti-poverty goals by their 2015 target
2001	EU through the European Commission transformed the vision of SD into an operational strategy	Implementation of SD by limiting climate change and increasing the use of clean energy; addressing threats to public health;managing natural resources more responsibly; improving the transport system and land-use management; combating poverty and social exclusion; the dealing with the economic and social implications of an ageing society.
2002	EU through the European council added to the 2001 operational strategy	Improvement of the operatinal tsrategy by harnessing globalization trade for SD; (ii) fighting poverty; and (iii) promoting social development; and sustainable management of natural and environmental resources and also support of the Monterrey Consensus
2002	World Summit on Sustainable Development (WSSD), in Johannesburg (World summit) (Rio+10)	Adoption of the Johannesburg Declaration and the Johannesburg Plan of Implementation, focusing on poverty reduction as part of sustainable development strategy reaffirming the principles of Agenda 21 and the Rio principles
2005	EU through the European Commission published a critical evaluation of the progress achieved since 200l	Presentation and adoption of direction for sd action namely: evaluation of the progress achieved since 200l and presented the directions for action for the fiiture years: climate change, threats to public health, poverty and social exclusion, depletion of natural resources and erosion of biodiversity.
2005	Kyoto Protocol entered into force (Kyoto)	The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 (UNFCCC-COP3) and entered into force on 16 February 2005. The detailed rules for the implementation of the Protocol were adopted at COP7 in Marrakesh in 2001, and are called the "Marrakesh Accords."
2007	The Intergovernmental Panel on Climate Change publishes its fourth assessment report on climate change	The report posits that climate change policies are best addressed by integrating them within the broader framework of sustainable development strategies.

2009	EU through the European Commission adopted the 2009 Strategy	The 2009 Strategy emphasised mainstreamed SD into a broad range of its policies especially in the fight against climate change and the promotion of a low carbon economy.
2010	The 16th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change held in Cancún	The conference called for the establishment of a Green Climate Fund and a Climate Technology Center and network.
2012	United Nations conference on Environment and developemt (Rio+20)	Rio+20 (2012) was a 20-year follow-up to the 1992 Earth Summit / United Nations Conference on Environment and Development (UNCED) where attending members reaffirmed their commitment to Agenda 21 in their outcome document called "The Future We Want" and developing SD model on suggesting courses of action on the possibility of increasing production and consumption without creating a negative impact on the environment.
2014	World Conference on Education for Sustainable Development held in Aichi-Nagoya Japan	This conference marked and celebrated the end of the UN Decade of Education for Sustainable Development (DESD, 2005–2014). It also saw the launch of the Global Action Programme on Education for Sustainable Development and adoption of the Aichi-Nagoya Declaration. The DESD was established out of an agreement amongst Member States to strengthen the role of education in achieving SD at the World Summit on SD in 2002.
2015	United Nations Sustainable Development Summit held in New York	The theme of the summit was "Transforming our world: the 2030 Agenda for Sustainable Development". It was resolved at the summit to end poverty and hunger; to combat inequalities within and among countries; to build peaceful, just and inclusive societies; to protect human rights and promote gender equality and the empowerment of women and girls; and to ensure the lasting protection of the planet and its natural resources between 2015 and 2030.

Source: Fuentes-Nieva and Pereira (2010)

In 1987, the World Commission on Environment and Development (WCED) promoted the concept of countries all over the world depending on each other and the relationship between economics and the environment. The report interlaced global solutions with social, cultural, economic and environmental issues. The report acknowledged that the environment does not exist as a separate entity from human beings (WCED, 1987). The emphasis on the social, economic and environmental aspects was the focus in 1992 at Rio's Earth Summit, United Nations Conference on Environment and Development (UNCED), where an action plan for SD, called '*Agenda 21*' was launched. This is a programme of action for SD and recognises each nation's right for social and economic progress and addresses energy and the environment (Kates *et al.*, 2005 and Edwards, 2010). Until this time, energy had been the primary cause of concern because of its diminishing supply and its impact on global warming. However, at the Rio Summit, an agreement was reached to consider all factors involved in SD, particularly the environmental wellbeing of the planet (Edwards, 2010).

In 1997, the UN General Assembly held a special session called '*Agenda 21 (Rio +5)*' to evaluate the status of *Agenda 21*. The assembly acknowledged the efforts made in relation to *Agenda 21*. They concluded that *Agenda 21* had not yet been fully achieved and identified the causes of the non-achievement and which are: the increasing globalisation, widening disparities in levels of income, and continuous worsening of the environment. The meeting concluded with a resolution on further action. Commitment to SD was once again reaffirmed in 2000 at the United Nations General Assembly (UNGA) when the UN Millennium Development Goals were approved (UNCED, 1997).

In 2001 the European Commission at Gothenburg agreed to work towards SD from an operational angle. This strategy included combating climate change and increasing and promoting the use of clean energy; encouraging policies that promote public health; managing natural resources more responsibly; improving the transport system and land-use management; combating poverty and social discrimination (Hategan and Ivan-Ungureanu, 2014).

In 2002 at Barcelona, the European Council, improved on the operational strategy of 2001 by following three main objectives: increasing awareness SD globally; reducing poverty and promoting social development; and sustainable management of natural resources. In addition, the European Council which is made up of the Heads of states in the Union made commitments in support of the Monterrey consensus in relation to financing the achievement of the goals adopted by the UN in 2000 (Hategan and Ivan-Ungureanu, 2014). Also in 2002, in Johannesburg, ten years after the Rio Declaration, a follow-up conference of the World Summit on SD Rio+10 (WSSD) was convened to renew the global commitment to SD. UN affirmed their commitment to the full implementation of *Agenda 21* (UNCED, 2002).

According to Hategan and Ivan-Ungureanu, (2014) in 2009 the European Commission adopted the new strategy, called the 2009 Strategy. The strategy focussed on developing policies that encourage fighting against climate change and promoting a low-carbon economy. Rio+20 (2012) was a 20-year follow-up to the 1992 Earth Summit / United Nations Conference on Environment and Development (UNCED) where attending members reaffirmed their commitment to Agenda 21 in their outcome document called '*The Future We Want*' (UNCED, 2012). At the Rio+20 Conference, a SD model was adopted suggesting courses of action on the possibility of increasing production and consumption without creating a negative impact on the environment as compared to the traditional pattern of economic and industrial development, which consumes increasingly more natural resources generating pollution (Şoaită, 2010).

Another effort of the UN towards SD is the launching of 'The United Nations Framework Convention on Climate Change' (UNFCCC). This was approved at the Rio convention in 1992 and was implemented in 1994 and led to the adoption of the Kyoto Protocol in 1997 in Japan (UN, 1998). This was done to commit industrialised nations to reducing GHG emissions. However, the Kyoto Protocol was not implemented until 2005 when the required industrialised nations had signed its adoption. As a result of this, the years between 2008 and 2012 are the first GHG emissions commitment period. Programmes educating populace on the essence of SD are also being organised and of such is the World Conference on Education for Sustainable Development held in Aichi-Nagoya Japan in 2014. This conference marked and celebrated the end of the UN Decade of Education for Sustainable Development, that is, 2005–2014. A strong pursuit towards the achievement of eradicating poverty and hunger, protecting earth's resources and ensuring a more comfortable and habitable environment for humans was herald by the

United Nations Sustainable Development Summit held in New York in 2015. These various initiatives as discussed above have helped in the efforts towards achieving SD and a series of UN sessions held in Copenhagen, Denmark has also helped in reducing GHG emissions.

These various programmes as highlighted above have promoted the development of a healthy environment which invariably affects both the social and economic life of any nation. SD is being implemented in different sectors such as the agricultural industry, mining industry, manufacturing industry and the construction industry and consequently, these industries have benefited enormously from it. In spite of the long history of SD, it is most often being confused with sustainability. Section 2.2 differentiates between SD and sustainability and discusses the different opinions of SD definition.

2.2 Defining Sustainable Development

SD and sustainability are two terms that are usually used interchangeably. Various authors see SD and sustainability as terms that address the same problem and can be used interchangeably (Hill 2001; Bergha and Verbruggenb, 1999; Berardi 2013). However, some authors view them as two different concepts working towards the same end point (Sage, 1998; Robinson, 2004; Sharachchandra, 1991; Maude, 2004). According to Moldan *et al.*, (2012) SD ensures that human beings have a healthy and productive life in harmony with nature. SD is concerned with ensuring long-term human well-being, which involves confronting the challenges of limited natural resources and global poverty, having a good standard of living, a long and healthy life, access to education, participation in the social and political life of the community and well-paid work that provides people with the opportunities to achieve their goals, hopes and aspirations (Pérez-Ortiz *et al.*, 2014).

Sustainability, on the other hand, approaches issues from the environmental aspect. Robinson (2004) views sustainability as a campaigner of the preservation of the natural environment by advocating for a change in the lifestyle of individuals as a solution to pollution and resource scarcity. According to Sharachchandra (1991), it is a continuous process involving the voluntary involvement of the human race within environmental constraints towards an end point which is a sustainable world. Maude, (2004) describes it as maintenance into the future of environmental functions that support human life and human welfare’. This is also supported by (Ekins, 2000; Jacobs, 1991; Lowe, 1990; and Porritt, 2005). According to Baker (2006) sustainability originally belongs to ecology and is being referred to as the potential of an ecosystem to survive over time. However, Baker (2006) views that when development is added to sustainability then it shifts its focus from ecology to that of society. The primary focus of sustainability is on the society and its aim is to include environmental considerations and societal change and particularly towards the way the economy functions.

Then again, SD is viewed as a concept involving more processes such as economic progress, social change, technological progress and conservation of the earth's natural resources (Sage, 1998; Robinson, 2004; Sharachchandra, 1991; Maude, 2004). Robinson (2004) goes further to state that SD relies on the efficiency of technology to give a solution to problems of pollution and resource scarcity in the environment. As a concept, goal and movement, SD has been embedded in policies and plans, inviting countries to integrate its principles into national policies and programs. Locally and globally, SD is now a major part of the mission statement of countless international organisations, national institutions, corporate enterprises, sustainable cities and localities (Kates *et al.*, 2005).

Companies and facilities are coming to the realisation that initiatives such as proper materials and waste management, efficient process and product design, resource efficiency and recycling should be both profitable and environmentally preferable. In addition, new standards and mandates are encouraging companies to manage their environmental costs and considerations better. International standards are now making it a requirement that companies develop environmental assessment and management systems (Owens and Cowell, 2002).

Therefore, the concept of SD is not only a solution to battle global warming, but also the engine of socio-political development. In order for SD to attain this status, it generally requires five basic conditions that must be met namely: incorporating environment and economy, preservation of biological diversity and natural resource conservation, care, prevention and assessment of environmental measures and long-term focus partnership and participation in the transformation of SD into joined responsibility through actions at all levels of activity (Constantinescu and Platon, 2014). However, in order to integrate the aforementioned conditions, the management aspect of SD must be introduced. With reference to Lueg and Radlach (2016) unless certain processes under the environmental, social and economic aspects of SD are managed and serious efforts are made to enforce it, SD only remains a good intention.

Despite the different opinions on SD and sustainability, researchers seem to agree that what should be maintained is the ability of the environment to provide for the needs of people both now and in the future (Maude, 2004). In the context of this research, SD was mostly used because of the wider range of issues and processes that it covers. However, sustainability is also used from time to time to describe the sustainable state of a building, since sustainability itself literally means the ability to sustain.

IUCN (1980) defines SD as the conservation of biodiversity and ecological systems. This is supported by Rao (2000) who defines SD as the maintenance and sustainable utilisation of the resources provided by natural ecosystems and biospheric processes. These definitions relate more to the environmental aspect of SD. With reference to WCED (1987) in order to truly achieve SD, there needs to be the interconnectivity of the environmental, the economic and the social aspects. This supported by ISO (2008) which describes SD as the achievement of economic and social objectives whilst minimising adverse environmental impacts.

Constantinescu and Platon (2014) go further with the description of SD by stating that it is an integration of the social, economic and environmental aspects leading to a favourable society, a viable economy and a healthy environment that works. Hategan and Ivan-Ungureanu (2014) conclude that SD is a development that is enduring and lasting based on growth in the three aspects. This is reflected in the definition by Munasinghe and Lutz, (1991) who defines SD as the process that promotes improvements in the quality of human life, however, with minimum use of resources, in order for future generations to have more than enough in terms of natural resources. According to Strong (1992), these continuing improvements in the quality of life include positive changes in the social, economic and technological aspects influencing the relations between developed and developing countries.

Current definitions of SD also reflect the fact that SD shows concern for current and future generations. According to Bin (2017), SD is development that attends to the needs of both current and future generations and in the process makes efforts to ensure that the current generation benefit from these developments without future generations paying the price of meeting current interests. According to Steffen *et al*., (2015), this can only be achieved by balancing provision for human wellbeing as well as ecological needs of the environment. This in turn helps to reduce poverty and at the same time protect the environment (UN, 2015).

SD has been identified as a solution to the ever-growing environmental degradation, socio-economic issues that have to do with poverty and discrimination, and concerns for a healthy future for all mankind both in the developed and the developing countries (Hopwood *et al.*, 2005). These mounting problems have led the international community to deploy all necessary resources towards solving problems of biodiversity degradation, local community threats in terms of deteriorating health and well-being of individuals (Bell and Cheung, 2009). (Bell and Cheung, 2009) argue that SD is the response to the challenge of finding ways in which people on earth can live satisfactorily within the means of nature.

The concern for human well-being has led to definitions of SD by Vander-Merwe and Van-der-Merwe (1999) and Ortiza *et al.*, (2009). Vander-Merwe and Van-der-Merwe (1999) defines SD as a program for changing economic process and development so that a basic quality of life for all people is assured and the protection of the ecosystems and community is ensured. Ortiza *et al.*, (2009) describe SD as the process of improving the standard of living of people and providing a healthy environment that even future generations can benefit from. Therefore, SD can be defined as all processes involved in the improvement of the environment, economy and quality of life for people. SD leads to a healthy environment, economic growth and a better life for people.

The definitions above are based one way or another on the commonly cited Brundtland Report which defines SD as meeting the needs of the present generation without compromising the ability of future generations to meet their own needs (WCED, 1987). The Brundtland definition of SD has been widely accepted over the years due to its wide coverage of issues (Baker, 2006). These issues have helped it achieve international authoritative status. The factors include the merging of what seemed to be conflicting societal goals; the report emerging at a time when the problem of environmental deterioration, especially of pollution was on the political agenda; and the report supporting developing countries in their pursuit of economic and social improvement.

Baker (2006) highlighted the areas covered by the Brundtland report and which allowed the report's definition of SD to gain international status. These areas are: the link between environmental degradation with economic, social and political factors; the presentation of SD as a model of social change; the adoption of a global focus; the construction of the three-pillar approach: that is, reconciliation of the social, economic and ecological dimensions of change; the positive attitude towards environmental and economic development supporting each other: the emphasis on poor regions of the world; the recognition that the world's population can growth beyond the world limited resources; it challenges developed countries to reduce its consumption of resources in order to provide for developing countries, and it recognises the responsibility of present generations to future generations.

Even though the Brundtland's definition of SD is a generally acceptable definition, few authors challenge its meaning (Elliott, 2002; Elliott, 2006; Scott, 2003; Portney, 2003). Elliot (2002) argues that the needs of today's generation may likely differ from the needs of future generations. In addition they also question what need is being met. Is it natural resources, human capital or assets; the current needs in one place or in one part of the world may be different from the needs in another part of the world and may even be at the expense of another, such as those in the developing countries. The report aimed at influencing the quality of growth, meeting critical human needs, and population not going beyond a certain limit that will take it beyond the available resources (Elliott, 2006). However, Portney (2003) has concerns for what the limits are and how they are set, and whether they are technological limits, societal limits or ecological limits.

According to Sharachchandra (1991) Brundtland definition of SD suffers from significant weaknesses, namely; its categorisation of the problems of poverty and environmental degradation; its perception of the objectives of development, sustainability and participation; and the strategy it has adopted in the face of incomplete knowledge of human wants. Keijzers (2005) also challenges the Brundtland report, in the area where the report addresses today's world poverty and inequality level and at the same time addresses adequate preservation and possibly production of resources.

According to the Brundtland report, SD is linked to strong economic growth, impartial distribution of economic welfare and resources among present generations in developed and developing countries, limiting the growth of the world's population and originating production technologies to maintain resources within the world's capacity. Keijzers (2005) states that economic growth can be unsustainable and unpredictable due to the unstable nature of the economy and also this economic growth can be environmentally harmful.

The Brundtland report pointed out the interconnecting nature of the environment, the economy and social issues and linked them as dimensions of development (Burton, 1987; Baker, 2006; Ogujiuba *et al.*, 2012). Attaining this balance of interconnectivity between the environment, social issues and the economy, according to Pitt *et al.*, (2009), promotes SD. However, Sneddona *et al.*, (2006) argue that the Brundtland report was only able to ignite sustainable thinking and not practice. They argue that the report was not able to ensure changes in attitudes, in social values, and in aspirations towards SD.

According to them, only a few of Brundtland recommendations such as the reforming of national policies and institutions to reflect SD goals; strengthening the capacities of environmental bureaucracies to confront ecological problems; directing more funding towards environmental assessment, monitoring, and restoration; and emboldening international environmental agreements and organisations; have been endorsed. Those endorsed, have been done in an extemporised manner. Nevertheless, according to Shah (2007), SD drives for continuous improvement in everyday human activities and in a way that integrates economic, environmental and social objectives improving the quality of living as shown in Figure 2.1.

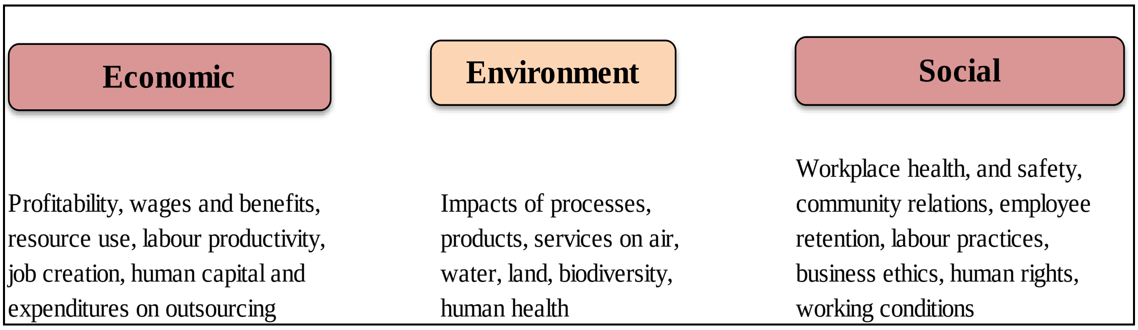

Figure 2.1: Economic, Environmental, and Social Issues Comprising Sustainable Development.
Source: Shah (2007)

Drawing from the Brundtland report, the overall objective of SD is the integration of the economic, social and environmental aspects (Ogujiuba *et al.*, 2012). Pânzaru and Dragomir (2012) add technology to the overall objective of SD in terms of its effect on the environment, the economy and social life. According to them, the economic aspect is about economic growth, maintaining resources, avoiding overexploitation of renewable resources and reducing the usage of non-renewable resources only to the extent that investment is replaceable. The social aspect is about the elimination of poverty and ensuring population grows to an acceptable level and that there is sufficient provision of social services such as health, gender equity, social accountability and participation (Pânzaru and Dragomir, 2012; Harris, 2000).

The social aspect also includes improving human well-being and quality of life in a socially acceptable and improving the economy and the environment in a sustainable way within the ecological limits of the planet (Pânzaru and Dragomir, 2012; Harris, 2000). The environmental system according to Mebratu (1998) involves the conservation of natural resources, maintaining the diversity of ecosystems and monitoring the impact of economic development on the environment; and the technological system is about ensuring that technology advancement stays within the limits of nature because around the world, efforts are being made to push for more environmentally conscious technological solutions (Owens and Cowell, 2002).

The Brundtland report stresses that humans depend on the environment for security and basic existence; that the economy and well-being of people now and in the future need the environment. It points to the fact that environmental problems are not limited to anyone's local environment but that they are global. Meaning that, actions implemented at one part of the world, have to be considered globally to avoid displacing problems from one part of the world to another. These actions include relocating industries that cause air and water pollution to other locations or using up more than a reasonable share of the earth's resources in one location. Environmental problems can threaten people's wellbeing, their source of income and can cause wars and threaten future generations (WCED, 1987).

In spite of the criticisms of the Brundtland Report's definition of SD, it is still widely accepted for its wide coverage of issues. Shah (2007) supports the Brundtland Report's definition and states that SD as *'a process and a framework for redefining social progress and redirecting the economy to enable people meet their basic needs and improve their quality of life, while ensuring that the natural systems, resources and diversity on which they depend are maintained and enhanced, both for their benefit and for that of future generations'.*

This research study identifies with this definition of SD as it relates to the social, economic, and environmental aspects of SD. The research, however, adds the management aspect because it helps to manage and enforce the aforementioned aspects as stated in pp.17. The research study also identifies with the above definition as it relates to improving quality of life and which can be achieved by the development of buildings that ensure improved standard of living and at the same time are not harmful to the environment. This definition is introduced at this point because the study needs to draw attention to the need for an improved standard of living through buildings for both today and future generations without destroying the natural environment.

According to Shah (2007), a major determinant for quality living is the construction industry as it provides buildings for various purposes and especially shelter. Holden *et al.*, (2014), also identifies with this non-negotiable dimension of SD and which is satisfying the need for suitable shelter. This gives opportunity for SD to make an impact in the construction industry as its primary aim is to provide shelter.

2.3 The Impact of SD in the Construction Industry

The impact of SD in the construction industry can be measured by its suitability to meet people's basic needs in terms of housing and social infrastructure for communities, industries, and governments (Hategan and Ivan-Ungureanu, 2014). Meeting this need is the reason for the very existence of the industry and is of high economic value, however, having serious environmental and social consequences (Strong and Hemphill, 2006; Burgan and Sansom, 2006).

The industry is responsible for the emission of greenhouse gases, due to energy used for raw material extraction, transportation, construction, operations, maintenance, demolition, waste generation and so on (Rwelamila *et al.*, 2000; Sorrell, 2003). The industry has negative impacts on the environment, economy and people as shown in Table 2.2. In spite of this, the creation of the built environment remains vital to any country's economic development (Sev, 2009). This is confirmed by BSI (2008) where it states that the construction industry: is a vital sector in national economies; is a major tool to engaging the poor to be engaged in construction, operation and maintenance in order to help reduce poverty; is a major source of employment; an absorber of a considerable number resources; a major pollutant of the environment; and it provides countries, states, communities with their physical and functional environment.

Table 2.2: The Main impacts of the construction industry and buildings

Impacts	Environmental	Social	Economic
● Raw material extraction and consumption, related resource depletion	*		*
● Land use change including clearing of existing flora	*	*	*
● Energy use and associated emissions of greenhouse gases	*		*
● Other indoor and outdoor emissions	*		*
● Aesthetic degradation		*	
● Water use and waste water generation	*		*
● Increased transport needs depending on site	*	*	*
● Waste generation	*		*
● Opportunities for corruption		*	*
● Disruption of communities including through inapropriate design and materials		*	*
● Health risks on worksites and for building occupants		*	*

Source: Sev (2009)

With reference to Du Plessis (2007), the construction industry has a great challenge not only to meet the need for adequate housing and infrastructure but to meet this need in a social and ecologically responsible way. For this reason, SD is increasingly becoming a key consideration for building professionals and with particular emphasis on economic efficiency, protecting, and restoring ecological systems and improving human wellbeing (Sinha *et al.*, 2013). SD is becoming more and more necessary for the construction industry, as people are now aware of the strong link between themselves and buildings and are beginning to more than ever live and work in comfortable and healthy environments. Therefore, buildings need to be constructed in such a way as to meet minimum requirements for human wellbeing and minimum standards for reduced environmental impacts. This requirement has brought about the initiation for sustainable construction (SC).

Sustainable construction involves the integration of the economic, social and environmental aspects into the planning, construction and demolition stages of the building life-cycle. SC aims at providing buildings that are comfortable, healthy, affordable, accessible and environmentally friendly (Dickie and Howard, 2000; Sev, 2009; Ibrahim *et al*, 2013). SC was first defined at the first International Conference on SC held in November 1994 in Tampa, Florida as '*the creation and responsible management of a healthy built environment based on resource efficient and ecological principles*' (Kibert, 1994). Over the years more definitions have evolved and these include Vanags and Georgs (2011) who defines SC as the process of design, construction and demolition of a building, ensuring that the finished product conforms to the criteria of SD, which includes technical documentation, safety in the construction process, the finished product, high efficiency of resources, and minimal impact on the environment. Du Plessis, (2002) also defines it as a process in which the principles of SD are applied to the construction cycle, that is, from the mining of raw materials, to the planning, designing, and construction of buildings and even till demolition. These definitions show that SC deals not only with the construction process but also the design and demolition stages, with the aim of least impact on the environment. SC's positive impact on the built environment is pushing buildings that are sustainable to the forefront. Hence, the introduction of sustainable buildings, as it relates to the quality and characteristic of the actual structure created using the principles of SC.

Sustainable construction is the construction industry's contribution to SD; in summary it is the transition of the construction industry towards sustainability (Chang *et al*., 2016). According to Wibowo *et al*., (2017) SC focuses on the systematic fulfilment of future needs by the prudent use of natural resources. Kibert (2013) argues that the goal of SC is to create and operate a healthy built environment based on resource efficiency and environmental design. Sev, (2009) developed a framework for achieving SC and this involves: the principles of resource management (that is, the efficient use of energy, water, materials and land); life-cycle building design (that is, the use of the client's brief, planning and post-building strategies); and design for occupant use, which entails balancing human needs with the carrying capacity of the natural and cultural environments. This framework gives a holistic view of processes involved in SC as drawn from the definitions of SC above.

According to Du Plessis (2007), SC is a step in the right direction towards SD and can only be achieved if all stakeholders cooperate in its implementation. The stakeholders include the government, developers, clients, buyers, end-users, contractors, consultants (architects, other designers, engineers, quantity surveyors) and manufacturers and/or suppliers (Abidin, 2010). According to Parkin (2000), these stakeholders can only be supportive of SD, if they adequately understand SC so that their individual actions and decisions can help achieve a sustainable environment. According to Roaf *et al.*, (2004), until there is a clear commitment to SC, there will be no sustainable built environment. However, in order to have a strong commitment to SC, stakeholders need to be interested in it, acquire related knowledge and training, and attempt to improve on it, especially from lessons learnt and past experience (Abidin, 2010).

2.4 Sustainability Assessment Tools in Construction

In the move towards SD, it is important to assess a building's sustainable performance before they are built. There are various tools that have been developed over the years in relation to assessing a building's sustainable performance in support of SD in the built environment. These assessment tools have played an important role in raising public awareness and transforming the building industry for more sustainable building practices throughout the world (Carmody *et al.*, 2009). They contribute towards the achievement of sustainable buildings and are tools that encourage sustainable building design, construction, operation, maintenance and deconstruction. They aid a better integration of the environmental, social, economic concerns and other decision criteria (Braganca *et al.*, 2010).

They have been developed to measure objectively a project's impact in terms of a building's sustainable qualities, in order to encourage designers and builders to improve a building's functional performance. The development of these assessment tools date as far back as 15 years ago, in order to determine a building's sustainability across a broad range of factors (AlWaer and Kirk, 2012). According to Reed *et al.*, (2011) building sustainability assessment tools play a major role in determining the sustainability of buildings and help facilitate a more direct comparison of different levels of sustainability. Hastings and Wall (2007) grouped them into three categories namely: Cumulative energy demand (CED) systems, which focuses on energy consumption; Life-cycle analysis, which focuses on environmental aspects; and Total quality assessment (TQA) systems, which evaluates environmental, economic and social aspects.

2.4.1 Cumulative Energy Demand Systems

CED systems have been popularly known to assess the energy consumption in buildings; however, it does not cover some units of measurement such as exergy and emergy (Pulselli *et al.*, 2007). Exergy is the maximum useful work that brings a system into heat reservoir equilibrium, while emergy is the available solar energy directly and indirectly used in a transformation directly and indirectly to make a product or service (Tronchin and Fabbri, 2008). These units of measurement according to Marszal *et al.*, (2011) relate to thermodynamic principles of resource use, and may be more appropriate than energy in evaluating a building's consumption of heat. CED systems measure and evaluate the energy consumption of buildings such as heating, ventilation, air conditioning, water heating, lighting, entertainment and telecommunications (Berardi, 2012).

2.4.2 Life-cycle Analysis

As mentioned above, Life-cycle analysis focuses on the environmental aspect of SD and involves assessments of environmental impacts of materials and components in the buildings. These assessment methods include environmental assessment systems such as Environmental Risk Assessment (ERA), Material Flow Accounting (MFA), Input–Output Analysis (IOA) and Life Cycle Assessment (LCA) (Sonnemann, 2003). LCA is the most commonly used of the above systems (Seo *et al.*, 2006).

LCA divides a building into elementary activities and raw materials and assesses the environmental impact of the building over the entire life-cycle, that is, from cradle to grave. This means from the extraction and processing of raw materials; manufacturing, transportation and distribution; use, reuse, maintenance, recycling and final disposal (Consoli, 1993; Seo *et al.*, 2006). In addition to the above, LCA evaluates the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and materials used and wastes released to the environment. It also assesses the impact of products on the environment and identifies and evaluates opportunities to effect environmental improvements (SETAC, 1993).

Zabalza *et al.*, (2013) also add that LCA is an internationally recognized method for measuring the environmental impacts of materials and buildings over their entire lives. LCA allows design professionals to compare different building designs based on their environmental impacts and make informed choices about the materials they specify. According to them, LCA allows comparison of the environmental impact of different types of buildings in a particular location and different types of buildings located in different geographical zones.

With reference to Weißenbergera (2014), the LCA process is governed under ISO 14000, the series of international standards addressing environmental management and BS EN ISO 14040 (2006), describes LCA as the compilation and evaluation of inputs, outputs and the potential impacts of a product system on the environment throughout its life-cycle. According to Weißenbergera (2014), LCA consists of four interdependent steps namely; the goal and scope definition, the life cycle inventory analysis, the life cycle impact assessment, and the interpretation of the results. The goal and scope definition step involves defining the aim and the scope according to the standard specifications. The second step, which is the life-cycle inventory analysis, involves quantifying all inputs and outputs of substance and energy flow in a life cycle inventory analysis which is usually comprehensive. The third step is the life cycle impact assessment; in this step, the data collected in the life cycle inventory analysis (i.e., substance and energy flow analysis) are assessed with reference to their probable environmental impacts. Finally, the fourth step involves evaluating the results of the life-cycle inventory analysis and the life cycle impact assessment to derive environmental impacts and to give suggestions for decision makers (Weißenbergera, 2014). According to Khasreen (2009), LCA is one of the tools to help achieve sustainability.

2.4.2.1 Limitation of the Life Cycle Assessment System

According to Langston and Ding, (2001), LCA has been extensively used since 1990 as an important tool for assessing a building's environmental impact, yet it is less developed in the building sector than in other industries. With reference to Fava (2006), this is due to the specialist structure of LCA being expressed through chemical processes, making it not easily understood by construction participants. However, applying LCA in the building sector is a unique exercise in comparison to other industries and has now become a major focus area within LCA practice.

This is not just as a result of the complexity of buildings but a combination of the following factors: the long life span of buildings, making it more complex to apply LCA to the whole building life-cycle; the changes a building undergoes during its life-cycle and the ease by which these changes can be made and at the same time minimising the environmental impact of these changes; the environmental impacts of the building during its operational phase; and the many stakeholders in the industry that are to be satisfied, causing very little standardisation in whole building design. Hence, new choices have to be made for almost each stage of the building life-cycle (Khasreen, 2009).

Awareness is increasing in the adoption of LCA methods in relation to the selection of building environmentally preferable products, as well as for the evaluation and optimisation of construction processes (Asdrubali *et al.*, 2013). However, literature on LCA is very few (Cabeza *et al.*, 2014). Another limitation of LCA systems according to Khasreen (2009), is that it assesses the environmental paradigm of SD without considering social and economic impacts. To deal with this limitation, Berardi (2012) suggests a combination of LCA and life-cycle cost (LCC) analysis. The use of LCC is the ability to account for all the facility costs associated with the building or building system. It is a methodology for documenting the costs of all the building phases and typically reduces all those costs to present value. The reduction of all facilities costs allows comparisons between alternative building systems and compares the present value of a number of alternative systems (Hodges, 2005).

According to Fawcett *et al.*, (2012) LCC originated with a concern for the economy; however, since the advent of SD in environmental impact decision-making, LCA has often been carried out as well. LCA takes the same life-cycle perspective as LCC, however, it focuses on the environmental impacts, such as greenhouse gas (GHG) emissions, in both the initial construction and during the service life, while LCC takes into consideration the economic aspect. LCA can be combined with LCC assessment in order to obtain a greater economic return on construction investment, contributing to an improvement in energy management in buildings. This corresponds to the well-established principle of life-cycle costing (LCC), which argues that when comparing alternatives the client should not select the cheapest option but the one that is most economical over the long-term, taking account of both the initial construction cost and the future costs and benefits during the service life (Zabalza *et al.*, 2013; Khasreen, 2009).

With reference to Fawcett *et al.*, (2012) the majority of the available tools used in the execution of LCC and LCA in the construction industry have limited applications, limited flexibility, and limited functionality. They argue that better tools for LCAs will contribute to the improved design and the achievement of SD. Also according to Collinge (2013), LCA is limited by the standard practice of applying static factors throughout the life-cycle inventory analysis and life-cycle impact assessment stages. According to him, the operating stage of a building which is the longest phase can have large environmental impacts, causing variations within this stage to be sometimes greater than the total impacts of materials, construction, or end-of-life phases.

2.4.3 Total Quality Assessment System

TQA systems aim at considering the three aspects of a buildings' sustainability, namely: environmental aspect involving GHG emission and energy consumption; economic aspect involving investment and equity; and social requirements such as accessibility and quality of spaces. TQA systems are also called multi-criterion systems (Newsham *et al.*, 2009). Multi-criterion systems include the Building Research Establishment Environmental Assessment Method (BREEAM) developed in the UK, Leadership in Energy and Environmental Design (LEED) developed in the US, Comprehensive Assessment System for Built Environment Efficiency (CASBEE) developed in Japan, Sustainable Building Tool (SBTool), Green Building Index (GBI) developed in Malaysia, Hong Kong Building Environmental Assessment Method developed in Hong Kong, the Australian Building Greenhouse Rating (ABGR), the Green Home Evaluation Manual (GHEM), the Chinese Three Star, the US Assessment and Rating System (STARS) and the South African Sustainable Building Assessment Tool (SBAT) (Shi *et al.*, 2012; Alyamia and Rezgui, 2012). These systems help in defining criteria for sustainable building as argued by Carmody *et al.*, (2009).

According to Hahn (2008), multi-criterion systems consist of several parameters by which a building's sustainability is measured. Each system has a certain number of available points weighed over the total assessment. The total evaluation of sustainability is the summation of the results of the assessed criteria. Hahn (2008) adds that a critical aspect of the systems is their process of summation, as they assign scores for positively evaluated elements. Multi-criterion systems are generally easy to understand and can be implemented in steps for each criterion, enabling the assessment of a building at several stages, that is, from design to construction, and in addition, can be used during construction as well (Berardi, 2012).

Srinivasan *et al.*, (2014) suggest three major categories of the multi-criterion system and these are; Assessment Frameworks, Analytical Evaluation Tools, and Metrics. According to them, *Assessment Frameworks* are integrated and structured assessment models that aid the comparison of various alternatives for projects. Examples include Environmental Impact Assessment and Strategic Environmental Accounting. The *Analytical Evaluation Tools* help in evaluating and giving possible solutions to specific problems that arise in the course of developing a building. These tools are categorised into reductionist and non-reductionist tools (Srinivasan *et al.*, 2014).

The reductionist tools included *Cost Benefit Analysis*, which evaluate performance by reducing a complex system to a smaller set of variables and integrating its measurable characteristics. The non-reductionist tools include *Multi-Criteria Analysis* which incorporates methodological choices that are partly subjective (Henrichson and Rinaldi, 2014). Finally, *Metrics* measure the achievement of a project in sustainability terms, which include Ecosystem Scale (such as ecological footprint and environmental sustainability index); Building Scale (such as net energy, zero energy, net zero energy and so on; and Building Environmental Scale (such as LEED, BREEAM and GREEN GLOBES, SBTool, GBI, SBAT and so on) (Srinivasan *et al.*, 2014).

This research focuses on the Building Environmental Scale such as BREEAM, LEED, SBTool, and CASBEE. According to Braganca *et al.*, (2010) and Alyamia and Rezgui, (2012) these systems are the most widely used assessment methods that provide the basis for a building's sustainability throughout the world. The justification for these sustainability building tools is given in Section 6.9. BREEAM, in particular, is the first and most widely used sustainability assessment tool used for buildings. It has been continuously developed over the past twenty years and is used all over the world (BRE, 2016). The primary features of each method mentioned above are illustrated in Table 2.3 below.

Table 2.3: Main features of BREEAM, LEED, SBTool, and CASBEE

ITEMS	BREEAM	LEED	SBTool	CASBEE
Location, year	UK, 1990	US, 1999	Canada, 1998	Japan, 2001
Developed by	BRE (non-profit third party)	USGBC (non-profit third party)	iiSBE (international non-profit collaboration)	JaGBC (joint of government, industry, academy)
Sustainable categories	Management, health and well-being, energy, transport, materials, water, waste, land use and ecology, pollution and innovation	Sustainable site, indoor environmental quality, water efficiency, energy and atmosphere, materials and resources, and innovation and design process	Site selection, project planning and development, energy and resource, environmental loadings, indoor environmental quality, service quality, economic and social aspects,	Building environmental quality: indoor environment, quality of service, outdoor environment on site; environmental load: energy, resources and materials, offsite
Assessed building	Residence, retail, industry unit, office, court, school, healthcare, prison, multi-function building,	Residence, school, retail, commercial building, multifunction	Almost any building	Residence (multi-unit), retail, industrial temporary construction, multi-
Flexibility	Flexible in the UK, and relatively overseas	Flexible in the USA, and relatively	High flexibility around the world	Flexibility in Japan, and relative low flexibility overseas
Approach to scoring criteria	Additive pre-weighted credits approach	Additive Simple approach (1 for 1)	Additive improved weighted scoring approach	Special
Ratings	Unclassified <30 Pass ≥30 Good ≥45 Very good ≥55 Excellent ≥70 Outstanding ≥85Unclassified <30 Pass ≥30 Good ≥45 Very good ≥55 Excellent ≥70	No rating 25 or less Certified 20–32 points Silver 33–38 points Gold 39–51 points Platinum 52-69 points No rating 25 or less Certified 20–32 points	1 = unsatisfactory 0 = minimum acceptable performance 5 = best practice 1–4 = intermediate performance levels 2 = normal default1–4 = intermediate	BEE = 3.0 (excellent) BEE = 1.5–3.0 (v. good) BEE = 1.0–1.5 (good) BEE = 0.5–1.0 (fairy poor) BEE = less than 0.5 (poor)
Reference	Mao *et al.*, (2009) and Cole and Larsson (2002)	Cole and Larsson (2002) and CASBEE (2011)	Cole and Larsson (2002) and Trusty (2000)	Laustsen and Lorenzen (2003) and Cole and Larsson (2002)

Source: Alyami and Rezgui (2012)

2.4.3.1 BREEAM

BREEAM which stands for Building Research Establishment Environmental Assessment Method was developed by the British Research Establishment (BRE) and has been used as a template for designing other sustainability assessment tools around the world, such as the Green Star in Australia and the HK-BEAM in Hong Kong (Grace, 2008). BREEAM is the world's foremost environmental assessment method and rating system for buildings (Yuhui, 2013), with over 425,000 buildings certified with BREEAM assessment tool and over two million registered for assessment since it was first launched in 1990. It has a comprehensive structure for the measurement and description of the sustainable performance of a building (BREEAM, 2012). BREEAM sets standards for best practice in the building industry. It assesses the performance of buildings in the following areas:

- Management: overall management policy, commissioning site management and procedural issues.
- Energy use: operational energy and carbon dioxide issues.
- Health and well-being: indoor and external issues affecting health and well-being
- Pollution: air and water pollution issues.
- Transport: transport-related carbon dioxide and location-related factors.
- Land use: green field and brown field sites.
- Ecology: ecological value conservation and enhancement of the site.
- Materials: environmental implication of building materials, including life-cycle impacts.
- Water: consumption and water efficiency.
- Innovation (Pitt *et al*, 2009).

The application of BREEAM involves the evaluation of the above listed environmental categories in terms of practices and level of performance, after which credits are awarded in the ten categories. Each category has different allotted criteria, with pre-weighed credits as shown in Table 2.3. The credits can either be cumulative or dependent on performance against certain specified standards. The weightings have been developed through the national consultative process in the United Kingdom (Sev, 2011). These credits are then added together to produce a single overall score on a scale of Pass, Good, Very Good, Excellent and Outstanding (BREEAM, 2012).

Table 2.4: BREEAM Environmental Weightings

Category	Weightings %	Credits Available
Management	12	10
Health and well-being	15	14
Energy	19	21
Transport	8	10
Water	6	6
Materials	12.5	12
Waste	7.5	7
Land use and ecology	10	10
Pollution	10	12
Innovation	10	10

Source: Sev (2011).

2.4.3.2 LEED

LEED which stands for Leadership in Energy and Environmental Design was developed by the United States Green Building Council (USGBC). According to USGBC, LEED has over 20,000 projects that have been certified and registered under them and is currently the world's second most widely adopted sustainability assessment method. With reference to Horvat and Fazio, (2005), the LEED assessment involves three levels of requirement within the credit system and these include:

- Pre-requisites: conditions that must be met before a project can be assessed,
- Core credits: credits given for meeting or exceeding the requirements in the first five categories as listed in the table and
- Innovation credits: credits given for exemplary performance, beyond core credits.

The LEED rating assessment was developed through a consensus process involving key stakeholders to provide a comprehensive simple framework for assessing building performance and meeting sustainability goals (Zimmerman and Kibert, 2013). The different categories of sustainability are all weighted equally and given different points and the credits assigned to each category are added together to give an assessment (Alyamia and Rezgui, 2012) as shown in Table 2.5.

Table 2.5: LEED Credits Distribution

Category	Possible points
Sustainable sites	26
Water efficiency	10
Energy and atmosphere	35
Materials and resources	14
Indoor environmental quality	15
Innovation in design	6
Regional priority	4

Source: LEED (2011).

With reference to Schweber (2013), BREEAM and LEED are tools in achieving SD in the construction industry. These assessment tools have contributed to the development of knowledge and understanding of SD in the building industry. However, Gifford (2008) indicates that BREEAM's scope of assessment is wider and its criteria are more difficult to achieve than LEED's. This implies that BREEAM is a more comprehensive tool compared to LEED. The LEED rating system has been criticised for the systems' poor consideration of building materials (Marsh, 2008) and energy-efficiency (Gifford, 2008).

2.4.3.3 SBTOOL

SBTool which stands for Sustainable Building Tool was developed by the International Initiative for a Sustainable Built Environment through the work of more than 20 countries. The tool has been designed to enable countries to develop their own locally-relevant rating systems, so as to take care of local climatic conditions and languages (Larsson, 2007). SBTool is generally considered as the most comprehensive of all sustainability assessment methods (Cole, 2004). It was formerly called GBTool and is structured in four levels, with the higher levels logically derived from the weighed aggregation of the lower ones, using 1 goal, 7 issues, and 29 categories (Chew and Das, 2008).

This is designed to enable users to reflect the different priorities, technologies, building traditions, and cultural values existing in the various regions and countries involved in the assessment process. For this reason, its benchmarks and weightings are improved by national teams by means of various methods such as the analytic hierarchy process as shown in Table 2.6 (Chang *et al*, 2007; Lee and Burnett, 2006). The criteria and sub-criteria of each performance issue are scored using a linear scale from −2 to +5.

Table 2.6: SBTool Environmental Weightings.

Category	Weightings %
Site selection, project planning and development	7.6
Energy and resource consumption	21
Environmental loadings	25.2
Indoor environment quality	21
Service quality	15.1
Social and economic aspects	5
Cultural and perceptual aspects	5

Source: Trusty (2000)

2.4.3.4 CASBEE

CASBEE which stands for Comprehensive Assessment System for Built Environment Efficiency is a rating tool that uses a weighting system that allows environmental issues to be placed in order of their given context. CASBEE is an assessment method developed by the input of government, academia, and industrial sector in Japan. It was established under the Ministry of Land, Infrastructure and Transport Provisions for the purpose of evaluating a building's environmental performance (CASBEE, 2011). The main four aspects of CASBEE include energy efficiency, resources efficiency, local environment and indoor environment which comprise a total of 80 sub-criteria. These are further re-categorised into two main groups: Q (Quality), and L (Loadings) (Horvat and Fazio, 2005). CASBEE is differentiated from other assessment systems by its unique approach to the completion of its final result. Instead of just simply adding credits together, the CASBEE as shown in Equation 2.1 introduces the concept of Building Environmental Efficiency (BEE) with weighting coefficients for the assessment of different kinds of building. These are based on the outcome of a questionnaire survey of key stakeholders such as designers, building owners, and operators. Subsequently, the responses are analysed by analytic hierarchy process (CASBEE, 2011).

$$BEE = \frac{\text{Building Environmental Quality}}{\text{Building Environmental Loadings}}$$

Equation 2.1: Building Environmental Efficiency Equation.
Source: IBEC, (2008).

2.4.4 Need for Continuous Development of Building Sustainability Rating Tools

More than 600 sustainability assessment systems are available all over the world (BRE, 2008). However, none of these systems will thrive well if used in countries where it was not originally designed to work (Saunders, 2008). Each tool needs to be tailored to take into account the local environment for which it is being designed. Also, comparisons of actual individual projects assessed under each method should be carried out in order achieve sustainability. However, Saunders (2008) notes that direct comparison of rating classifications under each method is not straightforward and is costly. New systems are continually proposed and the most dispersed ones receive a yearly update (AlWaer and Kirk, 2012).

This evolving situation has led to the release of the sustainability standards in building construction namely; Framework for Methods of Assessment of the Environmental Performance of Construction Works – Part 1: Buildings (ISO 21931 – 1, 2010) and Sustainability of Construction Works – Sustainability Assessment of Buildings – General Framework (ISO15643 – 1, 2010). Systems for sustainability assessment span from energy performance evaluation to multi-dimensional quality assessment (Berardi, 2012).

The sustainability of a building should, therefore, be assessed for every subcomponent such as the services, the frame structure and the building in its entirety; hence, the need for different assessment and rating tools (Langston and Ding, 2001). These differences among the systems have led to the creation of the Sustainable Building Alliance, in order to establish common evaluation categories and to improve comparability among systems (Berardi, 2012). Even though sustainability assessment tools have helped increase the number of sustainable buildings, Rumsey and McLellan (2005) and Schendler and Udall (2005) both criticise the unscientific criteria selection involved in their assessment process. Bower *et al.*, (2006) also argue that there is a lack of overall life-cycle perspective in the evaluation process of these assessment systems.

The US National Institute of Standards and Technology (NIST) carried out an analysis of the LEED system from an LCA perspective; they conclude that it is not a reliable sustainability assessment system due to its limited scientific scoring point system (Scheuer and Keoleain, 2002). This is also confirmed by Stein and Reiss (2004) who states that LEED certifies buildings on a simple scale of Silver, Gold, and Platinum. Buildings that are given more LEED points are not necessarily more environmentally friendly than buildings that are given fewer points. This according to Leu (2012), has resulted in building professionals just pursuing after the points and not necessarily interested in achieving more sustainable buildings.

However, Pulselli *et al.*, (2007) state that this is not the case. They argue that the points system allows for a good enough assessment and is known for its credibility among construction industry experts. (Bowyer, 2007) state that building professionals have validated the relevance of LEED as a standard environmental performance measure of buildings and that it has become a reference system for the design, construction, and operation of sustainable buildings in the US and beyond.

LEED is continuously being improved upon to address a building's sustainability performance. There is now LEED New Construction (LEED-NC) for building design and construction which can be adopted for new construction of schools, residential houses, hospitals, data centers, and warehouses and so on. There is also LEED for exterior designs, LEED for existing building, and LEED for new land development projects (USGBC, 2016). BREEAM too has been improved on over the years. The first BREEAM document was about 20 pages and addressing a handful of issues, now there is BREEAM New Construction (BREEAM-NC) which is a document with over 400 pages and can be used for public, private, residential or commercial buildings and including building extensions (Parker, 2012). There is BREEAM IN-USE for existing non-residential buildings and BREEAM Communities which have been developed to address sustainable design into the master planning of new communities or regeneration projects. There also exists BREEAM International Refurbishment and Fit-Out Technical Standard for the refurbishment of existing buildings (BREEAM, 2016).

Building sustainability assessment tools, definitely have their limitations, an example of such is their adaptation in locations that are different from where the tool was originally developed for (Berardi, 2012; Hellstrom, 2007; Steurer and Hametner, 2011). In spite of this, attention for sustainable buildings is encouraging the adaptation of these tools in countries that have not yet developed their own.

2.5 Chapter Summary

This chapter addresses Objective 1 of the research by providing a theoretical background to the origin of the sustainable building concept. The chapter sets the background underlying this research study and which is SD as the initiator of sustainable buildings. The chapter has explored the varying definitions of sustainable development (SD) and in doing so has presented a history of SD. In addition, it has reviewed the various criticisms of the Brundtland Report's definition of SD. This chapter concludes that despite various criticisms, the Brundtland definition of SD is still widely accepted for its extensive coverage of issues and its integration of the economic, social and environmental aspects. This research study is therefore, based on these three aspects of SD and the management aspect as identified in Section 2.2. Other definitions of SD were reviewed, which led to this research's definition of SD as, the process of economic growth that improves the well-being of people, and yet, has less impact on the environment. However, the research moves forward with the definition by Shah (2007) as stated in Section 2.2 due to its support of the Brundtland report criteria for SD (the environmental, social and economic aspects) and its reference to improved standard of living by the development of sustainable buildings.

This chapter has discussed the development of sustainable buildings as a result of the impact of SD on the building industry and which has informed the environmental, social, economic, and management aspects. The chapter shows how these aspects have been applied to the building industry and how it evolved into the sustainable construction (SC) process. However, SC is of itself has been discovered not to be sufficient, as it is only a process that needs to be is applied in order to reach an ultimate goal which is the development of sustainable buildings. Sustainable buildings provide a culmination for the SC process and which involves the development of building sustainability assessment tools. In moving forward, the following chapter focusses on examing what makes a sustainable building based on the environmental, social and economic aspects of SD as highlighted by the Brundtland Report and the management aspect as recognised by this research study.

CHAPTER 3: SUSTAINABLE BUILDING CONSTITUENTS

3.0 Introduction

In order to achieve Objective 1, the research finds it necessary to identify constituents that are necessary in meeting the sustainable building criteria. The chapter discusses sustainable construction (SC) as an offset of sustainable development (SD). The chapter discusses the different definition of sustainable building and identifies and discusses sustainable building constituents in relation to the environmental, social, and economic and management aspects of SD and in relation to the building life-cycle. The chapter fulfils Objective 1 of this research study and which is to identify the constituents of sustainable building with reference to internationally recognised standards.

3.1 Sustainable Construction

The impact of SD in the construction industry has produced SC which aims to satisfy the need for shelter, working environments, and infrastructure without compromising the ability of future generations to meet their own needs in times to come. Sustainable construction also improves the quality of living by adhering to sustainable standards for achieving sustainable buildings (Al-Yami and Price, 2006). It is seen as a way for the construction industry to contribute to the effort of achieving SD. In addition it is increasingly becoming a major focus for building practitioners with the objective of increasing economic efficiency, protecting and restoring ecological systems and improving human well-being (Sinha *et al.*, 2013).

According to Kibert (2005), the goal of SC is to create and operate a healthy built environment based on resource efficiency and environmental design. Sev (2009) developed a framework on SC principles and strategies which include resource management (efficient use of energy, water, materials and land); life-cycle building design (use of pre-building strategies, building strategies and post-building strategies); and design for humans, which entails balancing human needs with the carrying capacity of the natural and cultural environments. Creating a capable and viable construction sector and the sector responding to the demands of SC in its activities is a step in the right direction towards SD. However, this can only be achieved if all stakeholders cooperate in its implementation (Du Plessis, 2007). According to Parkin (2000), stakeholders in the construction industry can be supportive of the SD agenda, if they adequately understand SC. Their individual actions and decisions can help lessen the negative impact on the environment. According to Roaf *et al*., (2004) until there is a clear commitment to SD right from the client's brief, there will be no effective sustainable value.

The achievement of SC requires that stakeholders start from the design process and this has led to interests in sustainable building design. Sustainable building design ensures that current decision-making for the construction process takes account of the long-term performance of a building (Guy and Kibert, 1998). It differs from conventional building design, in that, it involves not only what is consider as good quality design but the building's contribution to environmental, social and economic sustainability (CABE, 2007). Principles of sustainable building design include the use of previously used sites for new buildings, minimal use of water, and use of sustainable building materials, ensuring indoor air quality, minimal use of resources and the use of renewable resources (Fowler and Rauch, 2006). Sev (2009) suggested a life-cycle approach to the practice of sustainable building design and these includes pre-building, building and post-building strategies of design. The pre-building strategy includes; selecting the appropriate site, flexible design, and selecting sustainable material and products. The building strategy includes; minimising site impact, using nontoxic construction materials and products and waste management. Finally, the post-building strategy includes; adaptive reuse of an existing building, reusing building materials and components and recycling materials.

The processes of sustainable building design have resulted in sustainable buildings (Sev, 2009). Sustainable buildings involve active processes where policies developed by the government and voluntary organisations support SC. It also involves investors, developers and building users being are aware of sustainability in buildings and taking active roles in encouraging SC (UNEP, 2009). The following sections discuss sustainable buildings and its constituent parts.

3.2 Sustainable Building Defined

With reference to Berardi (2011), a sustainable building is a building that preserves and maximises functionality and serviceability. It is designed to maximise aesthetic quality and life-cycle cost. When a building is designed to achieve the purpose for its use with minimum environmental impact, it will contribute to achieving sustainable building (Feige *et al.*, 2013). With reference to OECD (2003), a sustainable building should target being resource efficient, energy efficient (including greenhouse gas emissions reduction), pollution preventive (including indoor air quality and noise abatement), and environmental friendly.

Baldwin (1996) highlighted some criteria for sustainable building on the basis of a document written in the UK on indicators of SD and these include: Building material recycling or their re-use during construction and renovation; Elimination or reduction of waste on building sites; reduce use of new sites in order to preserve ecological value of land; targeting good indoor environment in buildings in relation to ventilation and minimal noise; Protection against radioactivity; Optimum use of non-renewable resources and maximum use of renewable resources; and building in such a way that will enable future generations to meet their needs.

CIB (2010) also set ten standards that a sustainable building should meet and these include: (1) Application of the general principles of sustainability (environmental, social and economic); (2) Collaboration of building professionals, so as to meet occupants' needs individually and collectively; (3) Integration into existing layout of local town planning and infrastructure services; (4) Building design covering planning, design, construction, operation and maintenance, renovation and end of life; (5) Minimisation of environmental impact minimized over the estimated service life of the building; (6) Achievement economic value over time, after considering life-cycle costs of operation, maintenance, refurbishment and disposal; (7) Provision of social and cultural value over time for building occupants; (8) Achievement of healthy, comfortable, safe and accessible building; (9) Achievement of a maintenance user-friendly environment; and (10) Adaptability for different functional requirement.

The above-listed criteria and standards for sustainable building indicate that a sustainable building is a building that takes into consideration: the health and wellbeing of occupants, availability to social services, community life, the flexibility of use and minimal impact on the environment. Viewing a sustainable building from set standard seems to make it easy to define; however, with reference to Berardi (2013) sustainable building is difficult to define due to the time, scale, domains and social constraints, which increases the uncertainties in identifying what it is.

For time constraints, Berardi (2013) explained that SD is a time-dependent concept which depends on the knowledge available at the time of the evaluation. Consequently, what is considered sustainable in a building at one moment can be assessed as unsustainable in another moment. The scale constraint involves using cross-scales to evaluate sustainable building. He stated that the scale used for evaluating a building to be sustainable in a particular environment cannot be used to ascertain whether another building is sustainable in another environment due to different climatic conditions. For the domain constraint, he states that the assessment of an economically viable sustainable building in any domain is subject to time and individual preferences. Concerning the social constraint he is of the opinion that people perceive a building, its impact, and effects, in different ways. An example of this is found in a survey carried out by Baird (2010). The respondents' perspective of what constitutes a sustainable building, ranged from acoustic comfort to thermal control, air circulation and storage space.

Despite the view of Berardi (2013) on how difficult it is to define a sustainable building, few authors have expressed their view of what a sustainable building is. Gibberd (2002) suggested that a sustainable building is a building that maximises beneficial social and economic impacts while minimising negative environmental impacts. However, his definition raises the question of what are a building's beneficial social and economic impacts. The economic impacts according to Braganca *et al.,* (2010) involves the building's life-cycle costs and includes comparative cost assessments made over a specified period of time, taking into account all relevant economic factors both in terms of initial costs and future operational costs. The economic impacts also involve providing financial rewards for building owners, operators, and occupants. For sustainable buildings typically have lower annual costs for energy, water, maintenance/repair, reconfiguring space because of changing needs, and other operating expenses (Roaf *et al.*, 2004).

Beneficial social impacts include building users' health and comfort, which is as a result of indoor air quality, thermal control, air ventilation, natural lighting, and noise control (Cole *et al.*, 2008; Baird, 2010). According to Parr and Zaretsky (2010) the beneficial social impacts also include: Adhering to ethical standards, thereby providing safe and healthy work environments for occupants; providing a place that meets needs with a mix of tenure types and ensuring flexibility wherever possible; conserving local heritage and culture; and accessibility to local infrastructure and services for occupants. It can be deduced from the above that a sustainable building can be said to be generally linked to the three legs of sustainability (environmental, social, and economic dimensions).

This is evident in OECD (2003) definition of sustainable building. OECD (2003) defines it as a building that involves building practices, which strive for integral quality and which includes economic, social and environmental performance in a broad way. Thereby, leading to the rational use of natural resources and appropriate management of the building stock, and contributing to saving scarce resources, reducing energy consumption, and improving environmental quality (OECD, 2003). Some recent definitions of sustainable building also support the aforementioned sustainable building definition. These definitions include Kibert (2016) who defines sustainable building as a building that provides a healthy environment for users, based on consideration for the ecological environment and resource efficiency. Balaban and Puppim de Oliveira (2016) refers to sustainable building as the incorporation of sustainability principles in building design, construction and management in order to gradually and progressively reduce environmental footprints of the building industry. With reference to Balaban and Puppim de Oliveira (2016), the concept of sustainable building is a new approach to proffering solution to the environmental and health problems.

Few authors (Cassidy, 2003; Lowe, 2007; EPA, 2008) have also considered a sustainable building to be one that has high efficiency in the use of energy, water and materials, and also reduced impacts on health and the environment in terms of reduced greenhouse gas emissions throughout its life-cycle. This view is supported by Palanivelraja and Manirathinem (2010) who state that sustainable buildings are buildings that use resources such as energy, water, materials, and land more efficiently, with more natural light and better air quality so that these buildings contribute to improved health, comfort and productivity. It can be seen again from the descriptions above that a sustainable building is related to the SD agenda in terms of the environmental, social and economic aspect.

According to Rekola *et al.*, (2012) sustainable buildings do not only aim at the minimising adverse effect on the environment but with required performance encourage maximum improvements in economic, social and cultural circumstances. However, in order for building professionals to meet this goal, they require (a) an introduction of new methods and tools for the assessment of buildings, whole building approach and better understanding of the interaction of components and the general performance of sustainable buildings; (b) use of new materials and new technical solutions; (c) integration of new actors (new manufacturers of new products, new services, integrative planning processes); (d) better mutual adjustment and interaction of developers, designers and construction companies; (e) new competencies and new understanding of sustainable construction by actors involved; and (f) new procedures such as new ways of certification and quality control (Rekola *et al.*, 2012). Tarja and Belloni (2011) also support the need for the adoption of new technologies and assessment methods to achieve sustainable building. However, according to them, new technologies are often resisted because they require process changes which are usually accompanied by risks and unforeseen costs.

From the various definitions of sustainable building as described above a sustainable building can be defined as a building designed and built with the health and wellbeing of occupants in mind, using materials that are environmentally friendly in its construction. It is a building designed with features that aid reduction of negative impacts on the environment and high efficiency use of resources such as energy, water, and building materials throughout the building's life-cycle and promoting heritage and culture (authors' own definition). This definition offers a simple and detailed description of a sustainable building. It encompasses the main aspects of sustainable building.

From the above it is clear that sustainable buildings are buildings that relate not only to the social and economic aspects of SD but also the environmental aspect. This, therefore, leads to the similarity between sustainable buildings and green buildings; for green buildings are also buildings that aim at reducing environmental impacts and maximising resources until there is a return on investment (Ding, 2008). However, there are few that argue that green buildings are different from sustainable buildings and this is discussed in the Section 3.2.1.

3.2.1 Sustainable Buildings versus Green Buildings

The words '*green*' and '*sustainable*' are often used interchangeably. With reference to Yanarella *et al.*, (2009), *green* stands on either the environmental leg of sustainability or the economic leg while *sustainable* rests securely on all three pillars of the *triple bottom line*, that is, all environmental, social and economic aspects. There is also an argument in relation to the similarities and differences between a green building and a sustainable building. Berardi (2013) in Table 3.1 highlights the differences between both.

Table 3.1: Sustainable Buildings versus Green Buildings

Differences	Green Building	Sustainable Building
Consumption of non-renewable resources	x	x
Water consumption	x	x
Materials consumption	x	x
Land use	x	x
Impacts on site ecology	x	x
Urban and planning issues	x	x
Greenhouse gas emissions	x	x
Solid waste and liquid effluents	x	x
Indoor well-being: air quality, lighting, acoustics	x	x
Longevity, adaptability, flexibility		x
Operations and maintenance		x
Facilities management		x
Social issues (access, education, inclusion, cohesion)		x
Economic considerations		x
Cultural perception and inspiration		x

Source: Berardi (2013)

With reference to Berardi (2013), a sustainable building is a green building that goes further in making the best adaptive use of the building and at the same time maintaining an effective level of operations and maintenance. It is a building that gives a sense of community, and increases social equity, cultural and heritage, human health, as well as safe and healthy environments. According to him, sustainable buildings consider the impact of the building on the physical and mental health of the occupiers while green building only focuses on the environmentally friendly nature of a building. He states that for example, psychological and social functions of a residential building shift the meaning of the building from that of a physical living place to that of a home.

This view is supported by Baird (2010) who presented the view of building users from a survey conducted over a set of 30 buildings spread over 11 countries in different continents and under different climatic conditions. According to the survey, the building users perceived a sustainable building to a building that incorporates all or either of the following features:

- Reducing noise to the bare minimum;
- Suitable arrangement for storage;
- Embedding natural light from the sun into the design of the building;
- Providing adequate thermal control to adjust with the seasons, so that summer overheating and air-conditioning in the cold side in summer can be managed; and
- Providing natural ventilation systems to enhance the flow of full fresh air.

The building users perceived themselves to be healthier in these buildings and their level of productivity to have increased as a result of the environmental friendly conditions of the building. Sustainable building's positive impact on the wellbeing of the building user is also confirmed by a study carried out by Lo *et al.*, (2014) on the occupants of 12 of the 40 sustainable office buildings in China. Building users stated that they felt healthier in these buildings than the conventional office buildings and testified to increased productivity. There are studies to show that the design of sustainable buildings embraces the holistic concept of well-being which is a combination of physical, intellectual and emotional comfort and includes thermal and humidity comfort, air quality, light quality, acoustic comfort, interior and exterior design of a building, personal controls for comfort and engagement with nature (Kahneman *et al*., 1999; Storey and Pedersen, 2006; Bluyssen *et al*., 2011; Sarbu, and Sebarchievici, 2013). Studies have also been conducted to highlight that there is a correlation between well-being and conducive working environment (Roelofsen 2002; McCartney and Humphreys 2002; Huizenga *et al*., 2006; Tsutsumi *et al*., 2007; Akimoto *et al*., 2010; Hirning *et al*., 2014). A conducive working environment has been observed to aid workplace satisfaction and which enhances productivity (Raziqa and Maulabakhsh, 2015).

Visual comfort helps to improve psychological health and is inclusive in sustainable building design (Boubekri *et al*., 2014). Achieving acoustic comfort similarly ensures the well-being of building users which is vital for a satisfactory and productive working environment (Vellenga-Persoon and Höngens 2015). Sustainable building designs include the use of natural and artificial means of ventilation, though the study conducted by Park and Kim (2012) show that building users frequently use windows for ventilation more than the mechanical systems. According to Fisk and Rosenfeld (1997), Loftness *et al*., (2009), and Boubekri *et al*., (2014), ventilation method; whether natural or artificial means, help to improve physical health by reducing respiratory illness. This may be attributed to an adequate supply of clean and fresh air that is usually associated with good ventilation.

Adequate ventilation according to Billie (2012) helps to reduce stale and foul air and increases the chances of fresh air. Siew (2011) proposes that this aids the health of occupants and enhances good indoor air quality which is another criterion for sustainable building practice. The sustainable building design also includes thermal comfort of the building user. Thermal comfort according to ASHRAE Standard 55 is the state of the mind in relation to satisfaction with the thermal environment. According to Clements-Croome and Baizhan (2000) thermal comfort is one of the major factors that affect workplace satisfaction and a survey carried out by Nasrollahi *et al.*, (2008) shows that there is a strong relationship between thermal comfort and workplace satisfaction.

Therefore, since thermal comfort does not exist alone but is associated to other comforts of sustainable building, then it can be inferred that sustainable buildings can help achieve healthy workplaces and which aids workplace satisfaction leading to increased productivity due to the good health of occupants (Wells 2000; Ornetzeder *et al*., 2016). This view is supported by Smith and Pitt (2011), who suggest that occupants of sustainable buildings feel better psychologically. They also suggest that the sick building syndrome and poor indoor air of unsustainable buildings are contributory factors to ill health and reduced productivity. Drawing from the discussions above, sustainable buildings have a vital role to play in the comfort and well-being of building users and are also advantageous to the environment and economy.

Sustainable buildings should, therefore, reduce environmental impacts; improve human well-being, occupants' satisfaction, and stakeholders' rights; increase social equity; preserve cultural values and increase demand for safe building, flexibility, market and economic value (Berardi, 2013; Feige *et al.*, 2013). With reference to Billie (2012), a sustainable building should encourage low energy consumption, minimal water use, low material use and sustainable selection of building material, indoor air quality, and innovation.

According to the Brundtland report, sustainable building features can be categorised under three main themes and which are the environmental, social and economic aspects of SD. This is supported by Kang (2015), who also stated that the integration of these three themes helps to achieve sustainable buildings. These themes have been used as the basis for categorising sustainable building constituents for this research as shown in Table 3.2. However, the research added the management aspect. It is observed that certain processes related to the environmental, social and economic aspects need to be managed in order to achieve SD; and if SD, then these processes can be used in ensuring that sustainable buildings are achieved. The processes are directly related to the operations stage of the building in which the facilities manager is actively involved. One of the processes is the administration of Building Management Systems which controls and maximises the effectiveness of building services at the operation stage but need to be incorporated into the design of the building. These systems help to reduce the negative environmental impact of the building and at the same time, help to provide comfort to the building user.

3.3 Sustainable Building Constituents

The definition of sustainable building has been well elaborated in Section 3.2; however, this research goes beyond giving a definition to sustainable building. The research is interested in identifying the constituents that make up a sustainable building. Oxford Advanced Learner's Dictionary defines a '*constituent' as 'one of the parts of something that combine to form the whole*'. In relation to this research, constituents are referred to as processes that contribute to a building's sustainable performance and as earlier stated have been categorised under the environmental, social, economic, and management aspects of SD.

In relations to the environmental aspect, buildings are responsible for the emission of gases that have a negative impact on the environment. This is as a result of the combustion of energy used when extracting raw materials for building, transportation, construction, the operations, and maintenance and demolition phase (Rwelamila *et al.*, 2000; Sorrell, 2003); hence, the need for buildings that have a lower impact on the environment. The social aspect relates to improvements in the quality of life, health, and well-being. In relation to buildings, the social aspect aims to achieve health, comfort, and satisfaction of occupants. Buildings can have both negative and positive impacts on the occupants. Negative impacts include illness, fatigue, discomfort, and stress, and these are usually caused by poor indoor air quality, thermal conditioning, lighting, and harmful building materials (EERE, 2003).

These negative impacts on health affects productivity, however, sustainable buildings contribute to the health, comfort and productivity of building users. In terms of the economic aspect, sustainable buildings provide financial rewards for building owners and users. Sustainable buildings have being proofed to have lower annual costs for energy, water, maintenance and repair, and other operating costs (Kats, 2003). Also through the processes of construction, operation, and demolition or reuse, they provide a chain of economic activities that provide the goods and services necessary for human existence and for social development.

The management aspects relate to some processes that are part of ensuring the effective performance of buildings at the operations stage. Processes such as, post-occupancy evaluation, development of building user's guide, commissioning and handover initiatives, and 6-12 month defect liability period and management of air leakage in buildings to reduce energy use. Though these processes are carried out as standard procedures in conventional buildings, they are highlighted by BREEAM-NC (2012), LEED-NC (2009) and ISO 15392 as processes involved in a buildings' sustainability. Others directly related to sustainability issues include development of a waste recycling management plan, innovation of technology in terms of improving the sustainability performance of a building, establishment of legal and contractual environmental management initiatives and so on.

The environmental, social, economic, and management aspects of SD were used in categorising the sustainable building constituents into the environmental, social, economic, and management aspects. This was done based on the premises that the sustainable building concept is drawn from the SD platform. However, some constituents occurred in more than one aspect. For example, energy under the environmental aspect also occurred under the economic aspect as energy efficiency. This is because the effective use of energy saves cost for the building user and at the same time reduces the negative impact on the environment. These negative impacts include emissions of greenhouse gas emission. As an economic constituent, energy relates to energy efficiency in terms of reducing cost. This involves the use of low energy lightings and fittings to reduce energy consumption and thereby, reducing the cost for the building user.

Another example is in the efficient use of water in the building which relates to both the environmental and the economic aspect. It is usually categorised under the environmental aspect, however, in this research, it is categorised under the economic aspect. This is due to the research's particular focus on buildings and the building users. With reference to Rodrigues *et al*., (2012), the efficient use of water in buildings leads to cost reduction for occupants which is most likely as a result of more efficient processes of water distribution in buildings. The application of water efficient processes involves the use of hydric efficient equipment which substantially reduces water consumption and saves utility cost for the building user and is of economic benefit. According to Rodrigues *et al*., (2012) the reduction in water consumption in buildings reduces the volume of water extracted from natural sources, treated and pumped in the public systems of water supply and reduces the volume of effluents pumped and treated in public systems of drainage, and invariably increases energy efficiency.

This view is supported by Silva-Afonso and Pimentel-Rodrigues (2011) who state that water savings in buildings can enhance economic benefit and at the same time minimise the use one of earth's most treasured resource in the face of climate change. Though, the efficient use of water is categorised under the economic aspect in this research, it is also discussed in relation to the environmental aspect as stated in Section 3.3.18. Another constituent is material efficiency and of which Ruuska and Häkkinen (2014) view it in relation to the scarce use of materials, land use, and environmental impacts and related to the manufacturing of materials. This research views it from the perspective of the environmental and economic impact. Therefore, it is categorised under the environmental aspect as the use of sustainable material and under the economic aspect as material efficiency.

Table 3.2: Sustainable Building Constituents

	CONSTITUENTS OF SUSTAINABLE BUILDING	Hensen 1991	Grimwood 1993	Kibert 1994	Anink et al, 1996	Hill and Bowen 1997	Leaman & Bordass, 1997	Goulding and Owen, 1997	DETR 2000	Shriberg 2000	Esen 2000	Sjostrom 2001	Catto 2001	EC 2002	El-Haram and Agapiou, 2002	OECD 2003	Cheng 2003	Odey 2003	DTI 2004	Iqbal 2004	Esen 2004	Roaf et al, 2004	Venters et al, 2005	Hodges 2005	Esen & Esen 2005	Milani 2005	Puettman *et al*, 2005	Paola 2006	Dair and Williams 2006	Spiegel and Meadows 2006	Lowe 2007	Shah 2007	Alnaser et al, 2008	Halliday 2008	Wargocki *et al*, 2008	Brown and Vergragt 2008	Bolattürk 2008	Zhu 2009	UNEP-SBCI, 2009	Wadel 2009	Kurra 2009	Keeler & Burke 2009	Joelsson & Gustavsson 2009	Holton *et al*, 2010	Parr and Zaretsky 2010	Steskens and Loomans 2010	Rasmussen 2010	Braganca *et al*, 2010	Lavy *et al*, 2010	Mwasha 2011	Lund 2011	Tiwari *et al*, 2011	Siew *et al*, 2011	Bribian *et al*, 2011	Gething 2011	Fakhrudin et al, 2011	Alyamia and Kezgui, 2012	Wang *et al*, 2012	Kibert 2012	Zin and Ibrahim 2012	Akadiri and Olomolaiye 2012	Sharma and Tiwari, 2012	Billie 2012	Cetiner and Ceylan 2013	Berardi 2013	Feige *et al*, 2013	Coimbra & Almeida 2013	Charde and Gupta 2013	Baird and Field 2013	Cobîrzan *et al*, 2013	Roufechaei *et al*, 2014	Kooa *et al*, 2014	Cheng *et al*, 2015	Baird 2015	Chaussinand *et al*, 2015	No. constituents in literature	BREEAM-NC	LEED-NC	ISO-NC	No. of documents mentioning constituent
	ENVIRONMENTAL ASPECT																																																																																
1	**Waste management** which involves an effective and appropriate waste management system both at construction and during the operational life of the building (1)																		•																																															•											2	•	•	•	3
	Pollution																																																																																
2	Provides minimum car parking capacity in order to help reduce transport related pollution																																																																												•	•		2
3	Use of systems that reduce carbon (2)	•																				•	•					•	•		•			•	•		•		•																										•											•			12	•	•	•	3
4	To recognise and encourage construction sites managed in an environmentally sound manner in terms of pollution.																																																																												•	•	•	3
5	Reduction of light pollution (3)																						•																																										•											2	•	•	•	3
6	Developments that minimise rainwater run-off to reduce pollution of natural watercourses (4)	•																				•	•					•	•		•								•																										•											8	•	•	•	3
7	Developments that minimise pollution in terms of discharge to the municipal sewage system																																																																												•			
	Land Use																																																																																
8	Use of previously developed sites and/or contaminated land, and Non-use of virgin land (5)			•	•	•			•							•			•									•																																				•	•	•											10	•	•	•	3
9	Preserving ecological value of land in terms of protecting the environment surrounding the building site (6)			•	•	•			•							•			•									•																																			•	•	•											10	•	•	•	3
10	Biodiversity in terms of preserving and enhancing plant and animal life surrounding the building (7)			•	•	•			•							•			•									•						•																													•	•	•											11	•	•	•	3
	Energy																																																																																
11	Use of energy for energy efficient equipment																																																																												•			1
12	To recognise and encourage construction sites managed in an environmentally sound manner in terms of energy																																																																												•			1
13	In terms of reducing greenhouse gas emissions from refrigeration systems and hot water production																																																																												•			1
14	Use of solar energy (8)						•	•			•										•				•																											•										•														7	•			1
15	Energy efficient transportation systems in buildings (lifts, elevators, escalators or moving walks)																																																																												•			1
16	Appropriate use of local energy generation from renewable sources (9)						•	•		•	•		•							•	•			•	•								•			•		•						•						•	•	•						•				•									•					19	•	•		2
	Sustainable Material																																																																															
17	Use of responsibly sourced materials																																																																												•	•	•	3
18	Use of construction materials with low environmental impact and which involves LCA tools (10)			•												•							•			•	•	•	•	•	•									•			•												•		•								•										•	15	•	•	•	3
19	Construction of building managed in an environmentally sound manner in terms of resource use																																																																												•	•		2

	SOCIAL ASPECT																																																																																
20	Minimises risk of **water contamination** in building services through design and implementation and the provision of clean and fresh drinking water for building occupant (11)																																										•			•																															2	•			1
21	Gives **visual comfort** which involves provision of adequate daylighting, artificial lighting and lighting controls for occupants' comfort																																																																													•	•	•	3
22	Gives **thermal comfort** levels through design and installation of controls to maintain a thermally comfortable environment for occupants within the building (12)	•																																			•										•							•										•					•	•			•		•		9	•	•	•	3
23	Provides **safe access** to and from the building																																																																													•		•	2
24	**Management of space** for occupant privacy and wellbeing																																																																													•		•	2
25	Provides **indoor air quality** which involves providing a healthy internal environment through the specification and installation of appropriate ventilation equipment and finishes (13)	•																				•	•					•	•		•				•		•			•							•							•										•		•			•	•			•		•		17	•	•	•	3
26	Provides **hazard control** which involves materials that are harmful to the comfort and wellbeing of occupants																																																																													•	•	•	3
27	Conserves **local heritage and culture** which involves a building that contributes to social and cultural attractiveness of the neighbourhood leading to users and neighbours' satisfaction (14)								•			•																	•																	•																				•	•										6			•	1
28	Adheres to **ethical standards** in terms of meeting building standards (15)					•			•			•																	•																	•																															5			•	1
29	**Adaptable for different uses** and which involves providing a place that meets needs with a mix of tenure types and ensuring flexibility wherever possible (16)																																																							•											•										2			•	1
30	(17) Exhibits good **acoustic comfort** including sound insulation and meeting the appropriate standards		•											•														•														•						•																											•		6	•	•	•	3
31	**Accessible to good public transport network** and local infrastructure and services and alternative modes of transportation for occupants to reduce transport related pollution and congestion (18)																																													•																															1	•	•	•	3
	ECONOMIC ASPECT																																																																																
32	**Water efficiency** by use of water efficient components and equipment, installation of water recycling system, water consumption monitoring system, water leak detection and prevention systems to reduce comsumption of potable water for sanitary use to save for the building owner and user (19)															•	•	•																																										•	•							•									6	•	•	•	3
33	**Material efficiency** in terms of building material optimisation and replacement and use of recycled materials to save for the building owner and user (20)		•	•										•									•			•	•	•	•	•	•							•			•	•		•				•	•						•	•		•				•						•			•						22	•	•	•	3
34	Management of **construction waste**																																																																													•			1
35	Provision for **maintenance** of the building and services which ensures the durability and economic value (21)														•																																			•							•																				3	•	•	•	3
36	**Energy efficiency** which involves minimising operational energy consumption, monitoring energy usage, use of energy display devices and use of energy efficient light fittings and equipment to save for the building owner and user (22)							•		•	•		•							•	•			•									•			•			•						•						•	•							•													•					15	•	•	•	3
37	**Building life-cycle cost** which involves provision of economic value overtime and financial affordability for beneficiaries (23)		•	•					•			•		•	•								•				•		•	•																•			•	•					•	•	•					•					•				•						19	•	•	•	3

	MANAGEMENT ASPECT																																																																																	
38	**Post Occupancy Evaluation** and information dissemination which involves designing, planning and delivery of the building in consultation with current and future building users and stakeholders (24)																															•																																														1	•		•	2
39	Management **air leakage** in buildings																																																																												•			1
40	Incorporates **waste recycling management plan**																																																																												•			1
41	Involves **use of innovative technology**, method or process that improves the sustainability performance of a building's design, construction, operation, maintenance or demolition																																																																												•	•	•	3
42	Incorporation of **Building Management Systems** to actively control and maximise the effectiveness of building services (25)																															•																																															1	•	•	•	3
43	Establishment of legal and contractual **environmental management** initiatives embedded within the formal management structures of the development																																																																													•	•	•	3
44	**Engages of sustaibale building experts** to assist with the integration of sustainability assessment shcemes' aims and processes through design and construction																																																																												•	•		2
45	**Engages of independent commissioning agent** with regard to future maintenance (26)																															•																																														1				
46	Involves the development of **initiatives to educate building occupants** on how the sustainability issues in building work																																																																														•	1
47	Encouragement of **environmental activities by occupants** (27)																															•																																														1				
48	**Building user's guide** to enable building users optimise the building's performance (28)																															•																																														1				
49	Involves **commissioning and handover initiatives** that ensure that all building services can operate to optimal design potential																																																																												•			1
50	Involves a **6-12 month defects liability period** after all works have been completed at the construction stage																																																																													•	•		2
51	Involves **building tuning** to ensure optimum occupant comfort and energy efficient services performance																																																																													•	•		2
	Total Number of Constituents identified by each author and document	5	3	6	3	4	3	3	6	2	3	3	2	3	2	5	1	1	4	2	3	4	7	2	2	3	3	10	9	3	6	5		2	4	2	5	2	4	3	3	1	2	2	4	2	3	2	2	2	2	2	2	2	3	2		2	1	1	2	2	2	3	11	6	2	2	2	2	2	2	1	3	1		44	30	31	

Number of Constituents | **Constituents from Literature Review** | **Constituents from Document Analysis** | **Related Constituents**

Table 3.2 shows 51 sustainable building constituents. These constituents were derived from literature review and the content analysis of building sustainability rating tools as described in Section 7.9.2.The constituents comprise of 19 constituents under the *environmental aspect*, 12 constituents under the *social aspect*, 6 constituents under the *economic aspect* and 14 constituents under the *management aspect*.

This research study discusses the 51 constituents under 31 sections as presented in Sections 3.3.1 to 3.3.31 and as already shown in Table 3.3. Some constituents and particularly in the environmental aspect have been discussed under certain sections due to the relative nature of these constituents to one another. Some constituents under the management aspects have also been discussed under various sections. The Sections that consist of the related constituents include:

(1) Section 3.3.2 and which involves *Pollution.* The section has under it six related constituents and these are: minimising car parking capacity; the reduction of carbon emissions by equipment use during the construction of buildings; construction sites managed in an environmentally sound manner in terms of pollution; light pollution; and pollution as a result of rainwater runoff.

(2) Section 3.3.3 and which involves *Land use.* The section has under it three related constituents and these are: use of previously developed sites and non-use of virgin land; preserving ecological value of land during site preparation and construction works; and preservation and enhancement of biodiversity.

(3) Section 3.3.4 and which involves *Energy*. The section has under it six constituents and these include: Use of energy efficient equipment, construction sites managed in an environmentally sound manner in terms of energy consumption; reduces greenhouse gas emissions from refrigeration systems and hot water production; maximises use of solar energy; energy efficient transportation systems in buildings (lifts, elevators, escalators or moving walks); and appropriate use of local energy generation from renewable sources.

(4) Section 3.3.5 and which involves *Sustainable materials*. The section has under it three constituents and these are: Use of responsibly sourced materials; use of construction materials with low environmental impact and which involves LCA tools; and construction of building managed in an environmentally sound manner in terms of resource use.

(5) Section 3.3.19 and which involves *Material efficiency*. The section includes efficient use of material and management of construction waste.

Table 3.3 Sustainable Building Constituents according to the Different Sections in Literature

	SUSTAINABLE BUILDING CONSTITUENTS	SECTIONS
	ENVIRONMENTAL ASPECT	
1	**Waste management** which involves an effective and appropriate waste management system both at construction and during the operational life of the building	3.3.1
	Pollution	3.3.2
2	Provides minimum car parking capacity in order to help reduce transport related pollution	
3	Use of systems that reduce carbon	
4	To recognise and encourage construction sites managed in an environmentally sound manner in terms of pollution.	
5	Reduction of light pollution	
6	Developments that minimise rainwater run-off to reduce pollution of natural watercourses	
7	Developments that minimise pollution in terms of discharge to the municipal sewage system	
	Land Use	3.3.3
8	Use of previously developed sites and/or contaminated land, and Non-use of virgin land	
9	Preserving ecological value of land in terms of protecting the environment surrounding the building site	
10	Biodiversity in terms of preserving and enhancing plant and animal life surrounding the building	
	Energy	3.3.4
11	Use of energy for energy efficient equipment	
12	To recognise and encourage construction sites managed in an environmentally sound manner in terms of energy	
13	In terms of reducing greenhouse gas emissions from refrigeration systems and hot water production	
14	Use of solar energy	
15	Energy efficient transportation systems in buildings (lifts, elevators, escalators or moving walks)	
16	Appropriate use of local energy generation from renewable sources	
	Sustainable Material	3.3.5
17	Use of responsibly sourced materials	
18	Use of construction materials with low environmental impact and which involves LCA tools	
19	Construction of building managed in an environmentally sound manner in terms of resource use	
	SOCIAL ASPECT	
20	Minimises risk of **water contamination** in building services through design and implementation and the provision of clean and fresh drinking water for building occupant	3.3.6
21	Gives **visual comfort** which involves provision of adequate daylighting, artificial lighting and lighting controls for occupants' comfort	3.3.7
22	Gives **thermal comfort** levels through design and installation of controls to maintain a thermally comfortable environment for occupants within the building	3.3.8
23	Provides **safe access** to and from the building	3.3.9
24	**Management of space** for occupant privacy and wellbeing	3.3.10
25	Provides **indoor air quality** which involves providing a healthy internal environment through the specification and installation of appropriate ventilation equipment and finishes	3.3.11
26	Provides **hazard control** which involves materials that are harmful to the comfort and wellbeing of occupants	3.3.12
27	Conserves **local heritage and culture** which involves a building that contributes to social and cultural attractiveness of the neighbourhood leading to users and neighbours' satisfaction	3.3.13

28	Adheres to **ethical standards** in terms of meeting building standards	3.3.14
29	**Adaptable for different uses** and which involves providing a place that meets needs with a mix of tenure types and ensuring flexibility wherever possible	3.3.15
30	Exhibits good **acoustic comfort** including sound insulation and meeting the appropriate standards	3.3.16
31	**Accessible to good public transport network** and local infrastructure and services and alternative modes of transportation for occupants to reduce transport related pollution and congestion	3.3.17
	ECONOMIC ASPECT	
32	**Efficient use of water** by use of water efficient components and equipment, installation of water recycling system, water consumption monitoring system, water leak detection and prevention systems to	3.3.18
	Material Efficiency	3.3.19
33	**Efficient use of material** in terms of building material optimisation and replacement and use of recycled materials to save for the building owner and user	
34	Management of **construction waste**	
35	Provision for **maintenance** of the building and services which ensures the durability and economic value	3.3.20
36	**Efficient use of energy** which involves minimising operational energy consumption, monitoring energy usage, use of energy display devices and use of energy efficient light fittings and equipment to save for the building	3.3.21
37	**Building life-cycle cost** which involves provision of economic value overtime and financial affordability for beneficiaries	3.3.22
	MANAGEMENT ASPECT	
38	**Post Occupancy Evaluation** and information dissemination which involves designing, planning and delivery of the building in consultation with current and future building users and stakeholders	3.3.23
39	Management **air leakage** in buildings	3.3.31
40	Incorporates **waste recycling management plan**	3.3.1
41	Involves **use of innovative technology**, method or process that improves the sustainability performance of a building's design, construction, operation, maintenance or demolition	3.3.24
42	Incorporation of **Building Management Systems** to actively control and maximise the effectiveness of building services	3.3.25
43	Establishment of **legal and contractual environmental management** initiatives embedded within the formal management structures of the development	3.3.26
44	**Engages of sustainable building experts** to assist with the integration of sustainability assessment shcemes' aims and processes through design and construction	3.3.27
45	**Engages of independent commissioning agent** with regard to future maintenance	3.3.20
46	Involves the development of **initiatives to educate building occupants** on how the sustainability issues in building work	3.3.26
47	Encouragement of **environmental activities by occupants**	3.3.26
48	**Building user's guide** to enable building users optimise the building's performance	3.3.28
49	Involves **commissioning and handover initiatives** that ensure that all building services can operate to optimal design potential	3.3.29
50	Involves a **6-12 month defects liability period** after all works have been completed at the construction stage	3.3.30
51	Involves **building tuning** to ensure optimum occupant comfort and energy efficient services performance	3.3.31

3.3.1 Waste management

Waste includes extracting, processing, using and discarding of raw materials in order to meet human needs. However, after man has made use of what seems to be beneficial to him, the remaining is discarded as waste. In relation to the SD agenda, the world can no longer afford to lose more resources to waste and particularly in the light of the depleting non-renewable resources (Mavropoulos, 2015). Therefore, in order for the construction industry to meet up with SD, waste management is introduced as criteria for the development of sustainable buildings. Waste occurs both at construction stage, operations and the demolition stages of the build life-cycle and is a major contributor to environmental pollution (Dania *et al.*, 2015). Therefore, there is need to manage construction materials during construction, in order to reuse materials that are left over, instead of discarding them as waste. According to Hendriks and Pietersen (2000), the solution to waste during construction is to reduce waste as much as possible and then to reuse materials which can be in the form of recycling.

With reference to Malina (2012), there are two forms of waste in the building industry: waste from the construction process itself and waste within the lifecycle of the building. In relation to sustainable buildings, ISO 15392, LEED (2009) and BREEAM (2012) relate to waste management during the construction stage as the effective and appropriate management of construction waste in order to reduce demand for new materials. It also involves the use of recycled materials in order to reduce demand for virgin materials. This reduces impacts associated with the extraction and processing of virgin materials (BREEAM, 2014). At the operations stage, waste management includes the provision of dedicated storage facilities for a building's operational-related household and recyclable waste streams, to avoid waste being sent to landfill or incineration (DTI, 2004). It is therefore, safe to say that waste management as sustainable building constituent can be achieved by planning and estimating the right quantity of materials needed to develop a building at the design stage in order to avoid excess use of materials at the construction stage. At the operations waste management involves more of managing waste in order to reduce environmental pollution. This usually includes the development of a waste recycling management plan which is often developed by the facilities manager.

3.3.2 Pollution

Pollution as a sustainable building constituent involves six related constituents and these are minimising car parking capacity, the reduction of carbon emissions in buildings, pollution in terms of the construction site, light pollution, and pollution as a result of rainwater runoff and discharge to the municipal sewage system. Minimum car parking capacity as sustainable building constituent involves providing building occupants with limited car parking in order to reduce transport-related pollution.

With reference to Roaf *et al.*, (2004) transportation is a key to economic growth by granting access to jobs, places of business, education, markets, leisure and other services; yet, it has a significant environmental impact and poses a threat to peoples' health and wellbeing. According to BRE (2003), transportation has a large impact on the environment as it is a major source of carbon emissions. When there is limited car parking for buildings, occupants will have no choice but to limit the number of cars they have and which then will potentially lead to the reduction of cars on the road and reduction in environmental pollution. These issues are important to consider and include transport related environmental pollution such as carbon dioxide (CO_2), nitrogen oxide (NO_2) and ozone (O_3) (Dora and Phillips, 2000).

The reduction of carbon emissions in buildings is related to greenhouse gas emissions which are the result of burning fossil for energy availability. Significant greenhouse gas emissions are also generated at the construction stage through construction materials, and in particular insulation materials, refrigeration and cooling systems (Vanags and Mote, 2011). The use of equipment that makes use of diesel and oil and chemicals such as paint, solvents and cleaners is major source of carbon emission. The infiltration of these substances into the soil and water disturbs plant and aquatic life (Vanags and Mote, 2011). With reference to UNEP (2009), electricity use in buildings is a major source of carbon emissions. Most of these emissions come from the combustion of fossil fuels to provide heating, cooling and lighting, and to power appliances and electrical equipment. The development of sustainable buildings is a way to produce buildings that are more energy-efficient and climate-friendly, thereby allowing the building industry to play a major role in reducing the threat of climate change.

Efficient use of energy reduces greenhouse gas emissions from refrigeration systems and hot water production during the operations stage. At the construction stage, energy is usually provided by gasoline and diesel fuel, electricity, and natural gas. Of these four energy sources, diesel fuel and electricity are responsible for the greatest total air emissions (UNEP-SBCI, 2009). Hence, (Hayter and Kandt, (2011) suggests the use of renewable energy for provision of energy on site. According to BREEAM-NC, LEED-NC, and ISO 15392, encourages the use of systems that reduce emissions such as greenhouse gases, ozone depleting gases, and NOx.

It also involves the use of rainwater collection systems to reduce water pollution and land pollution; and reduction of night light and interior light pollution. In order to prevent or reduce pollution relating to emissions, materials such as refrigerants for Heating, Ventilating, and Air-conditioning Refrigeration (HVAC&R) systems and other compounds that have high global warming potential should be prevented and systems that minimise NOx emissions should be installed (ISO 15392). BREEAM (2013) and LEED (2009) also require that these refrigerants should not be used in buildings for the operations of HVAC&R.

Gustavsson *et al.*, (2010) and You *et al.*, (2011) also affirm that buildings are one of the main sources of energy consumption and GHG emissions; hence, its reduction is of great importance in regards to environmental protection and SD. Global climate is being affected by these GHG emissions, of which the most substantial is CO_2. Therefore, according to Sartori, (2007) buildings should be designed to reduce their CO_2 emissions from the earliest design. CO_2 emissions can be reduced in the early stages by using low-carbon building materials, and by recycling. In the bid towards sustainable buildings, various studies to reduce CO_2 emissions have been actively conducted since the 2000s. These studies include the development of the LCA model (Zhang *et al.*, 2006); the development of environmentally friendly facilities and materials, and sustainable building design (Yang *et al.*, 2008; Radhi, 2010; Gartner, 2004).

Most of these studies have focused on the CO_2 emissions generated during building operation because the largest amount of CO_2 is generated at this stage (Sartori and Hestnes, 2007). On construction sites, Fernández-Sánchez and Rodríguez-López (2012) argue that the use of construction equipment that uses diesel engines is a major contributor to environmental pollution. Marshall *et al.*, (2012) also confirm that emissions from diesel engines are a key air-related contributor to the environmental impact associated with building construction. Constructions of all types depend heavily on the use of diesel powered engines. Engine emissions are a significant source of CO_2, NOx, total hydrocarbons (THC), carbon monoxide (CO), particulate matter (PM), and sulphur dioxide (SO_2). The construction industry should, therefore, improve equipment efficiencies in relation to reduction in fuel use which will directly reduce both building project costs and emissions (ISO, 2014).

In relation to sustainable buildings, pollution caused by rainwater collection systems adds to water pollution and land pollution. Necessary steps to minimise surface water runoff in buildings and prevent contamination of the local environment should be taken (ISO, 2014). According to LEED-NC (2009) in order to reduce or eliminate pollution from storm water runoff, the following must be in place: a stormwater management plan that incorporates the design of the building site to maintain natural stormwater flows by promoting infiltration thereby reducing pollutant loadings; vegetated roofs, pervious paving; designs that reuses storm water the purposes of landscape irrigation, toilet and urinal flushing and custodial uses; and use of systems that treat stormwater runoff. Venters *et al.*, (2005) encourage designs that minimise the risk of localised flooding, water course pollution and other environmental damage; the discharge of rainfall to public sewers and watercourses must be reduced or avoided. With references to BREEAM-NC (2012), this can be done by carrying out a flood risk assessment.

With reference to Kuechly *et al.*, (2012) and Lyytimaki (2015), light pollution and especially night pollution it a source of ill health. When there is excessive light around buildings, it causes lack of sleep and which in turns causes ill health. In order to reduce the effects of light pollution, BREEAM-NC (2012) requires external lighting to be concentrated only in necessary areas and it specifies that the lighting face upward. These measures will lessen discomfort, reduce energy consumption and will not be a nuisance to neighbouring properties. According to LEED-NC (2009) in order to reduce or eliminate night light pollution, only areas that require safety and comfort should be lighted. When building designs incorporate minimum car parking, energy systems with low greenhouse gas emissions, rainwater collection systems, minimum lights at night and equipment that emit low carbon during construction, then buildings can help mitigate negative impacts on the environment.

3.3.3 Land Use

Land use as a sustainable building constituent involves three related constituents which are use of previously developed sites and non-use of virgin land; preserving the ecological value of land during site preparation and construction works; and preservation and enhancement of biodiversity. Land is one of the most vital components that supports human life as well as animal and plant and therefore, has to be handled with great care. Land use involves protection and enhancement of biodiversity. This involves a biodiversity plan which includes incorporating features at the design stage to encourage wildlife and habitat development; protecting local habitat during construction; and landscape planning and management to protect and enhance future biodiversity (ISO, 2014). According to LEED-NC (2009), it also includes conserving existing natural vegetation to provide greenery and promote biodiversity. The provision of trees and plants around a building has been known to provide physiological and psychological balance to building users (Heerwagen, 2012). BREEAM-NC (2012) encourages development of buildings on land that does not affect wildlife and existing ecological features during site preparation and completion of construction works.

For effective use of land, there is need to make use of previously used land which conserves the environment's ecosystem. Previous uses can include any type of built structure, including industrial uses associated with contamination (Paola, 2006). According to Zin and Ibrahim (2012), this method reduces development on undeveloped land and Greenfield sites. It also makes use of previously built design elements such as main building structure and previously used building materials which can be reused or recycled for a new building, enhancing the site and its surrounding.

Using previously used sites and conserving the ecological value of land, are conditions for meeting the sustainable building criteria as specified by BREEAM-NC (2012) and ISO 15392. These documents state that efficient land use entails the use of previously developed sites and or contaminated land in order to avoid using virgin land to preserve ecology. Efficient use of land also involves a site protection plan, in order to ensure that disturbances to the site ecology and soils are minimised. A site protection plan includes erosion and sedimentation control for reducing soil losses, pollution control to reduce contaminating adjoining sites and water bodies, reduced site disturbance, and on-site construction management operations (Cetiner and Ceylan, 2013).

Even though human activities have great impediment on the flora and fauna of land, Zin and Ibrahim (2012) argue that a sustainable building can make responsible and effective use of site and land by protecting the ecology and can enhance biodiversity during site preparation and at project completion stages. If this can be achieved, a building will be contributing to the sustainability of the environment.

3.3.4 Energy

Energy as a sustainable building constituent in this research, refers to efficient use of for equipment, construction sites managed in an environmentally sound manner in terms of energy, reduction of greenhouse gas emissions from refrigeration systems and hot water production, maximum use renewable energy such as solar energy, energy for efficient transportation systems in buildings (lifts, elevators, escalators or moving walks), and appropriate use of local energy generation from renewable sources. (Hayter and Kandt, 2011) describes renewable energy as energy that occurs naturally and continuously in the environment, examples of which are energy from the wind, the sun, and water. In contrast to non-renewable energy (energy from fossil fuels), renewable energy sources are effectively inexhaustible and they do not produce carbon dioxide emissions which ultimately cause climate change (Catto, 2001).

The efficient use of renewable energy for equipment often takes place during the operational life of the building. At this stage, a building is designed to make use of renewable energy from the sun to energise heating, light and power systems. The power systems involve small powered equipment such as microwave ovens and cookers and big powered equipment such as lifts. Therefore, in relation to sustainable buildings, use of renewable energy involves the incorporation of designs that allow for small power plug-in equipment such as microwave ovens and cookers, freezers and fridges, washing machines, dishwashers, swimming pool and so on (Cooke *et al.*, 2007). It also involves the incorporation of designs that allows for renewable energy for the efficient running of lifts, elevators, escalators and moving walks (Hayter and Kandt, 2011). Construction sites being managed in an environmentally sound manner in terms of renewable energy involves the use of renewable energy in site for purposes of lighting and powering of equipment (BREEAM-NC, 2012).

Countries develop economically, socially and environmentally by the use of renewable energy. Renewable energy cannot be depleted because are constantly being replenished from natural sources, unlike fossil fuels, which are negotiated on the international market and subject to international economics (Bilgen *et al.*, 2008). It has the following advantages: the rate of use does not affect their availability in the future; thus, it is inexhaustible; all regions of the world are endowed with one or more forms of renewable energy and have reasonable access to its supply; renewable energy sources are clean and pollution-free and are therefore a sustainable natural form of energy; renewable energy sources involves very little cost in terms of extraction and processing and are, therefore, sustainable (Hui, 1997).

Nowadays, to achieve SD, there is a requirement for sustainable supply of clean and affordable renewable energy sources, which do not cause negative societal impacts. Therefore, reduction of greenhouse gas emissions from refrigeration systems and hot water production as a sustainable building constituent aims at incorporating renewable energy that encourages a less harmful source of energy (Panoutsou *et al.*, 2009). Renewable energy sources include solar, winds, and geothermal. LEED-NC (2009) encourages the use of renewable energy in order to reduce environmental impact and increase economic benefits associated with fossil fuel energy use. Fossil energy is sustainable energy and the sources include waste-to-energy such as biomass fuels and are highly influential in the enhancement of SD (Kothari *et al.*, 2010; Zin and Ibrahim 2012; Panoutsou *et al.*, 2009).

Maximum use of solar energy as a constituent of sustainable building involves passive solar building design, which optimises the use of the site, the building design, and orientation of the building to achieve maximum use of solar energy in the built environment. It also involves landscaping to provide natural shade, natural use of day lighting and natural use of heating and ventilation (Billie, 2012). According to Silverman and Mydin (2014), passive solar building design involves windows, walls, and floors being made to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. Passive solar design is sometimes called climatic design because, unlike active solar heating systems, it does not involve the use of mechanical and electrical devices.

Solar energy also involves the photovoltaic system and has always been a key factor towards the development of sustainable buildings (Esen, 2000; Esen, 2004; Esen and Esen, 2005). The photovoltaic system, which includes photovoltaic cells is used to convert energy from the sun directly into electricity without noise or pollution and with little visual impact; promoting true sustainability and is one of the most promising renewable energy technologies in achieving SD (Goulding and Owen, 1997; Sharma and Tiwari, 2012; Tiwari *et al.*, 2011). This, according to Boyle (2004), can be incorporated into the roof and walls.

Energy is consumed during the following activities: manufacturing of building materials; transport of these materials from production plants to building sites; construction of the building; operation of the building; and demolition of the building (and recycling of their parts, where this occurs) (Abdallah *et al.*, 2015). Energy plays a major role in the economic growth, progress, and development, it also helps to eradicate poverty and aid the security of any nation. For it supports the provision of basic needs such as cooked food, a comfortable living temperature, lighting, the use of appliances, piped water or sewerage, essential health care products, educational aids, communication aids and transport. Energy also fuels productive activities including agriculture, commerce, manufacturing, industry, and mining. Conversely, a lack of access to energy contributes to poverty and deprivation and can contribute to the economic decline (Ramchandra and Boucar, 2011).

Therefore, a continuous supply of energy is necessary for economic growth and which significantly depends on the long-term accessibility to energy from sources that are affordable, accessible, and environmentally friendly. To achieve SD in relation to buildings, there must be an appreciable supply of renewable energy (Ramchandra and Boucar, 2011); Hence, the justification for the efficient use of renewable energy as a sustainable building constituent.

3.3.5 Sustainable Material

Sustainable material as a sustainable building constituent involves responsibly sourced materials, construction materials with low environmental impact and constructed in an environmentally sound manner in terms of resource use. The building industry is a major contributor to the global economy; however as earlier mentioned it is one of the main contributors in resource consumption and waste production, playing a fundamental role in SD. This pushes the industry to design buildings built with minimum consumption of materials (Cobîrzan *et al*, 2013). Approximately, 60% of the materials mined out of earth's crust are used up in the built environment (Wadel, 2009; Bribian *et al.*, 2011). They have a life-cycle related to the building life-cycle, especially in the operational phase. ISO 15392 encourages the establishment of responsible sourcing strategy for building materials, products and related services. Responsible sourcing includes sourcing for building materials that are available locally. This has proven to cost less than materials imported for the same purpose.

BREEAM-NC (2012) encourages specification of building materials with low environmental impact over the life-cycle of the building and this includes using a life-cycle assessment tool to measure the life-cycle environmental impact of the building elements. It also stipulates that building materials should be responsibly sourced and used. The ISO 15392 also encourages the specification and use of renewable building materials. This has led to the development of sustainable materials. Sustainable materials have a huge impact on a building starting from the aesthetic value to its cost and built ability (John *et al.*, 2005). Sustainable materials can be identified by the source of the material, manufacturing process, transport requirements and final disposal. They also include energy efficient or high-performance materials for thermal insulation, roofing and glazing, lighting and heating and ventilation and air conditioning systems (Billie, 2012).

A major step to be taken in terms of sustainable material as a sustainable building constituent is in the careful selection of sustainable materials and which has been identified as the easiest and earliest way for designers to begin integrating sustainable principles in building projects (John *et al.*, 2005). The selection of materials takes place largely in the detail design phase where important decisions are made that determine building performance (Gething, 2011). However, a major challenge is in the identification of the selection criteria for the materials. Akadiri and Olomolaiye (2012) derived six factors that can be used in the selection criteria of building materials, namely; environmental impacts, resource efficiency, waste minimisation, life cycle cost, socio benefit, and performance capability.

These criteria were derived from survey through expert opinion, and therefore, the sustainability of building projects is guaranteed. The result of their survey revealed "aesthetics", "maintainability" and "energy saving" as the three top criteria considered for building materials selection. However, according to Milani (2005) and Spiegel and Meadows (2006), the most general criteria for selection of building materials are resource management, pollution or indoor air quality, and performance. Pollution, according to Milani (2005), consists of all the emissions of the mines and factories used in the production of building materials, as well as emissions from the use of formaldehyde and products used to clean and maintain the material. Pollution also occurs as a result final incineration of the material. Performance refers to how well the material is able to meet its intended purpose because materials with low durability, cannot qualify as sustainable.

It can be inferred from John *et al.*, (2005), that sustainable building materials help to protect building occupants from indoor air pollution. Indoor air pollution includes particulate matter from wood and coal smoke, carbon monoxide and other unburnt hydrocarbons from wood, coal, and paraffin. However, wood, when not burnt, is a renewable building material causing fewer emissions of CO_2 and generates less waste compared to alternative building materials (Petersen and Solberg, 2005). Wood with reference to Sinha *et al.*, (2013), is the most vital renewable building material. Life-cycle assessment analysis has also shown that wood has less embodied energy than concrete and steel because of its biological renewable ability (Puettman *et al.*, 2005). Therefore, Sinha *et al.*, (2013) promote the use of life-cycle assessment analysis towards the development of new wood products.

Life-cycle Assessment (LCA) is the assessment of the impacts associated with materials from their resourcing and manufacturing to their disposal (Paola, 2011; Thiel *et al.*, 2013). The use of kenaf-fibres insulation boards is also highly recommended for application in sustainable buildings. Kenaf can absorb a high percentage of produced CO_2 and can be widely used for thermal insulations (Ardente *et al.*, 2008). It can, therefore, be categorised as a sustainable material. Existing building materials can also be categorised as sustainable materials and contributes to sustainable buildings.

By reusing existing building materials, building components and waste materials, it reduces the negative impacts associated with waste disposal (Paola 2006). Reuse of existing building materials with reference to Sinha *et al.*, (2013) is among the objectives of SD and includes the minimisation of material consumption. It is important to minimise material consumption, because while a material is consumed, its chances for future use are lessened (Roberts, 1994). However, another aspect of minimising consumption is either reusing the same material or recycling the material to mould into a different or similar building product.

Therefore, the selection of sustainable building materials represents a strategic decision in the design and construction of buildings, especially when having to contend with the level of human satisfaction which changes with time and is interrelated with various factors, such as, costs, human comfort, safety and enriching the human spirit (Day, 1990; Billie 2012). Human satisfaction level is also driven by the sustainability goal that in turn dictates the material selection process. Another important aspect that is considered in material selection with reference to Sinha *et al.*, (2013) is its cost to the environment.

3.3.6 Minimisation of Risk of Water Contamination

Minimisation of water contamination as a sustainable building constituent involves water quality which has to do with the availability of decent water for human consumption. Access to clean drinking water is a fundamental necessity of life (Raof *et al.*, 2004). According to LEED (2009), water quality can be ensured by implementing a stormwater management plan. This reduces impervious cover, promotes infiltration, and captures and treats the stormwater runoff using acceptable best management practices. These practices include incorporation of the following into the design of the building: vegetated roofs, pavements that can absorb rainwater, rain gardens, and rainwater recycling system. BREEAM-NC (2012) also adds that a sustainable building must aim to minimise water contamination and ensure that there is provision for clean from fresh water sources for building users. This can be done by ensuring that all water systems in the building are designed to meet standards for health and safety.

However, with reference to Keeler and Burke (2009) water quality in a building can be majorly affected by storm water runoff which pollutes the water; nevertheless, careful site design can minimise the impacts of water runoff from the onset. According to Keeler and Burke (2009) site design should include: preservation and protection of creeks, wetlands and existing vegetation to drain, collect, and filter runoff water; preservation of natural drainage patterns and topography; minimise and disconnect impervious surfaces such as land hardened by houses, patios, driveways and transportation infrastructure; strategically channelling storm water flow path from the first contact to discharge point; and collection and treatment of stormwater.

3.3.7 Visual Comfort

With reference to BREEAM-NC (2012), visual comfort includes daylighting, artificial lighting, lighting and glare control, view out, and internal and external lighting. As a sustainable building constituent, it is discovered that visual comfort entails designing a building to maximise daylighting in relation to building orientation and perimeter. It involves incorporating shading devices, high-performance glazing and automatic photocell-based controls in the building design. It also includes internal lighting controls (LEED, 2009). ISO 15392 adds that good visual comfort should involve providing an indoor visual environment corresponding to the intended visual activities in the building, which promotes engineering and architectural designs for users' satisfaction and well-being.

Adequate lighting and especially natural lighting has been seen as a necessary element for sustainable design. Skylight is necessary for integration into the building for the provision of natural lighting and should be considered when designing the building. It will encourage sunlight to penetrate into the building (Brown and Dekay, 2001). Daylight provision is an important element in illuminating the interior of a building, and especially in low-energy buildings. It allows for vision into the outside surroundings of the building. Provision of daylight into a building has been shown by researchers to be an important influence in determining occupant satisfaction (Leaman and Bordass, 1997). The Chartered Institution of Building Services Engineers (CIBSE) (2005) suggests that most people opt for working in an environment with daylight to one without it. According to CIBSE (2005) people also like having a view through a window, even if the view is not that pleasant. With reference to Brown and Dekay, (2001), a view provides contact with the outside world and also allows the eyes to relax, particularly if the work requires looking into details.

CIBSE (2005) also suggest that the admission of daylight into a building tends to make the interior space feel brighter and more pleasant. They state that there is much documented evidence that confirms the exclusion of daylight leading to increases in discomfort in the working environment, and may have potentially adverse effects on productivity. Even though daylight is the major source of natural lighting, it can also be a source of variation in indoor light levels and may cause discomfort and overheat, particularly among occupants seated close to the window. As a result, most buildings in addition to allowing for artificial lighting, provide for some means of controlling daylight (blinds or curtains); especially on fronts of the building that regularly receive direct sunlight (Nicol*et al.*, 2006). Therefore, GSSA (2014) encourages designs that provide artificial lighting but with minimal energy consumption.

3.3.8 Thermal Comfort

According to Hensen (1991), thermal comfort is a state in which there is no compulsion to correct the environment in which an individual finds himself. This is supported by ASHRAE

(2004), which states that thermal comfort as the condition of mind that expresses satisfaction with the internal environment of a building. It is seen as a constituent of sustainable building in almost all building sustainability evaluation methods and tools; describing the synthesized feeling about the body's thermal state (Steskens and Loomans, 2010). ISO 21929-1 also lists thermal comfort as one of the core indicators of sustainable building. Due to different climates and seasons, thermal comfort in buildings is a major goal of creating a comfortable indoor environment (Bolattürk, 2008).

BREEAM-NC (2012) states that appropriate thermal comfort levels should be achieved through design, and controls should be in place to maintain a thermally comfortable environment for occupants within the building. LEED-NC (2009) requires that individual comfort controls for at least 50% of occupants of a building should be provided, in order to achieve individual comfort levels. ISO (2014) states that the main parameters influencing thermal comfort such as air temperature, radiant temperature, air humidity, air velocity, user's characteristics and activities, taking account of outdoor climate and activity devices should be taken into consideration when designing.

According to a study carried out by Baird and Field (2013), a good degree of satisfaction with internal thermal comfort conditions was found to be more in sustainable buildings than the conventional ones. The temperatures and air quality factors of sustainable buildings in the study proved to be better, on average, than a set of conventional buildings. Charde and Gupta (2013) also carried out a study on building design elements for thermal comfort including static sunshade, cavity wall, and hollow roof. Their study showed that ventilated brick cavity walls with brick projections are better than solid brick walls; walls combined with designed sunshade lower temperature for the hotter part of the day; and walls combined with hollow roof reduce swings in temperature. Their study also shows that a combination of these elements gives best thermal load levelling and thermal comfort indoors, especially during summer.

Though the study by Charde and Gupta (2013) revealed that the type of walls incorporated in a building greatly affects the thermal comfort it provides, Bolattürk (2008) state that the general reduction of heat loss or retaining of heat through building components is not enough for thermal comfort. Bolattürk (2008) suggest that thermal comfort can be achieved by ensuring that the inner and outer envelope of the building is constructed to reduce heat during the cold seasons and release heat in the hot seasons. Building envelope design is considered one of the typical energy-saving techniques and serves as a physical separator between building's interior and the exterior environment, so as to maintain indoor thermal comfort (Kooa *et al.*, 2014). Siew *et al.*, (2011) propose that an early study during the design phase should be done to create a building design which is suitable for the local temperature, for buildings may need different types of walls due to local climates and seasons.

3.3.9 Safe Access

BREEAM-NC (2012) discusses the need for a sustainable building to possess features that promote effective measures for low risk and safe access to and from the building. This includes well lighted dedicated cycle and pedestrian lanes and footpaths that are easily accessible and safe, too and from the building and which easily connects to the public cycle and pedestrian lanes and public transport. BREEAM-NC (2012) also encourages sustainable building designs that have dedicated delivery access and drop-off areas. ISO 15392 encourages designs that consider safe access to and from the building site for workers during construction works and for occupants during the operational life. It also encourages the provision of safe and ease access for occupants into different spaces for all kinds of needs. Therefore, safe access as a sustainable building constituent involves designs that ensure the safety of building users.

3.3.10 Effective Use of Space

According to Becker (1990), space management is the coordination of all efforts related to the planning, designing, and management of a building to help an organisation meets its goals. It is the coordination of the physical workplace (Nutt, 1993) and involves structuring of the building and contents (Park, 1998). In summary, space management is all about the effective use of space and coordinating the physical workspace with people and the work itself in an organisation. According to Archibus (1987), effective use of space optimises and reduces unwanted space and which helps with space efficiency and can lead to increased occupancy of space and reduce costs. Effective use of space as sustainable building constituent involves the allocation of space, equipment, and furnishings to enable people to have the power to express and communicate with themselves. It gives building users an air of well-being which leads to improved productivity (Ihfasuziella *et al.*, 2011). According to Xia (2004), better coordination and communication among people in an organisation improves productivity.

BREEAM-NC (2012) discusses space in sustainable buildings in terms of provision for outdoor spaces such as private garden, balconies, terraces, and patios. It states the need to provide an external space which gives occupants privacy and a sense of wellbeing. GSSA (2014) also encourages designs that make provision for private outdoor space which improves the health and wellbeing of the occupants. However, there is a need for individual indoor space in order to maximise occupant health, comfort, and performance (Green, 2012). ISO 15392 addresses space in terms of serviceability that is, assessing each space in the building in order to see if it meets the required purpose. The Facilities Society (2013) argues that space can be sustainable in terms of functionality and the operational requirements of occupants, users and other stakeholders balancing it with affordability and taking into consideration environmental impact, energy use, and long-term operational costs. Steiner (2005) also confirms the positive influence of space on the productivity of occupants. When space is well planned during design, it leads to effective use of space which in turn can positively influence the wellbeing of the building user.

3.3.11 Indoor Air Quality

With reference to Billie (2012), the indoor environment is where people spend most of their time and it is widely accepted that it is important for health and wellbeing. The indoor environment provides a high level of protection against adverse health effects caused by extreme weather. A conducive indoor environment is a human right as stated by the World Health Organisation Constitution (WHO, 1985). This right includes the right to breathe clean air, the right to thermal comfort, and the right to visual health and comfort (WHO, 2000). Indoor air quality as a sustainable building constituent refers to the quality of a building's internal environment in relation to the health and wellbeing of occupants. BREEAM-NC relates to it as minimising sources of air pollution and increasing the potential for natural ventilation in a building.

LEED (2009) specifies that an additional ventilation system that brings in the outdoor air should be specified in the building design, in order to improve indoor air quality for enhancement of occupant comfort, well-being and productivity. It specifies that in addition to windows, designs should include grates or grills and high-level filtration systems in air handling units, so there may be an effective exchange of indoor and outdoor air. This is confirmed by Siew (2011) who states that the introduction of air cavity in walls, depending on seasonal requirement improves ventilation and which in turn prevents excess moisture indoors. ISO 15392 confirms that good design for ventilation prevents excess moisture in the internal of a building. Ventilation also reduces chances of ill health caused by Sick Building Syndrome (Paola, 2011).

Siew (2011) also proposes that proper ventilation, consisting of natural and mechanical elements, can prevent occupants from diseases that affect their daily life. According to him, some passive strategies can be implemented in the building design such as air well, blockage, and partition, ventilation opening, building facade, corridor and shading also help ventilation and the eventual comfort of building users. This is supported by Billie (2012) who also states that to enhance indoor air quality the following building design strategies need to be implemented: adequate ventilation, usage of low-emitting building products, preparation of indoor air quality management plan for construction and early occupancy, designation of indoor spaces as smoke free and implementation of tobacco smoke controls and installation of control systems to enhance indoor air.

The control of indoor air temperature also helps to provide indoor air quality. This can be achieved by ventilation designs that include ventilated air cavities and shaded area on walls due to brick projections to help regulate indoor environment (Charde and Gupta 2013). Studies have shown that a good indoor environment leads to greater productivity and is a requirement for sustainable buildings (Paola 2011; Feige *et al.*, 2013). Wargocki *et al.*, (2008) developed a model establishing that a better work environment with enhanced indoor air quality leads to higher user satisfaction and thus, increases financial returns. This, therefore, proves that a sustainable building with good indoor air quality increases productivity and leads to financial benefits, thereby increasing the value of the building.

3.3.12 Hazard Control

Hazard control as a sustainable building constituent is related to indoor air quality. LEED-NC (2009) refers to hazard control under making allowance for good indoor air. It states that indoor air contaminants aid odorous that are irritating and harmful to the comfort and well-being of installers and occupants. These contaminants include adhesives for carpets, wood flooring, rubber flooring, ceramic tiles, paints, and coatings. It also discusses making provision for minimising exposure of building occupants to potentially hazardous particulates and chemical pollutants from areas such as the garage, laundry, copying and printing rooms. GSSA (2014) also encourages measures to reduce health risks to occupants from the presence of hazardous materials, as its effect on human health can be irreversible. It encourages the correct disposal of such materials because it can save lives. It encourages precautionary measures at both the construction of the building and during occupancy.

BREEAM-NC (2012) discusses hazard control under Health and Well-being and states that to reduce or negate the impact of natural hazards in buildings a risk assessment should be carried out at outline proposal or concept design stage. This should be done by an appropriate person or persons to identify any potential natural hazards in the region of the development and where a potential hazard is identified, the appropriate measure should be taken to mitigate it effects. ISO 15392 encourages measures to identify health risks associated with contaminated soil, asbestos, electromagnetic fields, carbon dioxide intoxication, fumes, foul odour, noise, in relation to in the choices of design and construction principles. It discusses that measures should be taken to avoid occupants being exposed to these hazards.

3.3.13 Local Heritage and Culture

With reference to ISO 15392 a sustainable building should aim for achieving quality in cultural life and can involve the extent to which construction work can preserve and restore existing cultural heritage and local traditions; facilitate cultural life, exchanges and diversity; and provide easy access for people to social and cultural information networks. According to Parr and Zaretsky (2010) conserving cultural heritage is a beneficial social impact. Beneficial social impact involves giving occupants a sense of community, social equity, cultural and heritage belonging, and a healthy environment (Berardi, 2013). Berardi (2013) argues that beneficial social impact considers the impact of the building on the physical and mental health of the occupiers. This according to UNEP (2003), turns a building from green to sustainable.

3.3.14 Ethical Standards

Adhering to ethical standards in sustainable buildings with reference to Berardi (2013), involves the use of ethics by the building design team, the construction team and the building operations team which leads to a providing safe and healthy building. It addresses the relationship between people and buildings, by providing rules of conduct that generally govern good conduct towards building design, construction and operation. It involves providing technological developments that are safe both for people and the environment (Kibert, 2016). Standards such as the British Standards, BREEAM and LEED are recognised as ethical standards used in meeting a building's sustainable criteria. BREEAM for example is affiliated to the 'BRE Global Code for a Sustainable Built Environment'. The code is a set of strategic principles and requirements that define an integrated approach to designing, managing, evaluating, and certifying the environmental, social and economic impacts of the built environment (BREEAM, 2013). LEED has helped improve the sustainable qualities of buildings and their impact on the environment. The British Standards are sets to encourage the application of general principles of SD by all building stakeholders at each stage of the building project. These standards aim towards a healthy built environment that can last from one generation to another. When incorporated in constituents in buildings, they help achieve sustainable buildings.

3.3.15 Adaptability for Different Uses

Adaptability for different uses relates to a building meeting achieving a mix of tenure types and ensuring flexibility wherever possible in order to satisfy occupant needs. With reference to WGBC (2013), these needs include the ease of conversion of space in order to meet the ever-changing market requirements that are adaptable to new energy sources, new systems that help to give better comfort and climate change. It also includes all efforts that ensure that a building will continue to be a relevant asset. According to ISO 15392, adaptability for different uses as a sustainable building constituent entails specifying to what extent the building should be adaptable to alternative uses on the long term. It involves incorporating construction systems that allow building elements to modified, relocated or removed.

It also involves designing to allow parts of the building to be removed or upgraded without adversely affecting the performance of other parts of the building. Raised floors and movable partitions, with reference to WGBC (2013), enable the occupant reasonable freedom to reconfigure without excessive disruption, downtime, or cost. According to CIB (2010), a sustainable building must be adaptable throughout its service life and with an end-of-life strategy. The building has to allow for adaptation by changing performance and functionality requirements, in accordance with new constraints. In the process of designing a building for possible adaptation for different uses, it is necessary to select building materials that are well suited for this purpose (Gething, 2011). Designing a building in such a way that encourages little or no need to change the load bearing columns and beams makes the building adaptable for different uses. Building adaptability involves putting into consideration specific adaptability principles of versatility, convertibility, and expandability (ISO 15392). This consideration as a sustainable building constituent helps to achieve sustainable building.

3.3.16 Acoustic Comfort

Acoustics comfort as a sustainable building constituent influences occupant's comfort and its unavailability can lead to a disturbance of wellbeing. The World Health Organisation identifies a significant number of specific adverse health effects caused by environmental noise infiltration. These include medical conditions, sleep disturbance, psychophysiological stress or negative effects and have negatives effects on the health of adults and the learning abilities of children (WHO, 1948). Research have also shown the severity of noise impact caused by all types of noise sources; such as transportation systems, i.e. motorways, railways and aircraft, industrial premises, mechanical services, amplified music as well as various indoor noise sources (Berglund and Lindvall, 1995).

According to BREEAM-NC (2012), a building's acoustic performance which includes sound insulation should meet the appropriate standards for its purposes. It stipulates that a suitably qualified acoustician should be employed to provide early design advice on probable external sources around the proposed building. The acoustic consultant can advise on the zoning of the building for good acoustics, acoustics requirements for special hearing and communication needs, and acoustic treatment of different zones and facades of the building. ISO 15392 states that in order to achieve acoustic comfort, sound conditions adapted to the intended activities in the building should be provided and these include sound attenuation and noise reduction for users' satisfaction and well-being and consideration should be made for outdoor and indoor sources of noise.

According to Rasmussen (2010), in order to create a healthy indoor environment in terms of sound, good material insulation should be considered for acoustic control. In the early 20th century it was realised that insufficient sound insulation can give rise to conflicts between neighbours and consequently reduce the well-being of the occupants. According to EC (2002) acoustic comfort can be achieved by sound insulation designs in buildings and is an important task in environmental noise control. Buildings can, therefore, be protected from excessive noise by means of technical solutions, planning, and regulations, within the general concept of "environmental noise management" (EC, 2002; Kurra, 2009).

According to Rasmussen (2010), to ensure acoustical comfort in buildings, building regulations specifying requirements for new housing concerning impact sound insulation and noise levels from traffic and technical installations are now in place. To meet specific sound insulation requirements efficiently and effectively, appropriate design tools are important, and there should be a high correlation between the designed sound insulation, the measured sound insulation in the finished building and the occupants' evaluation of sound (Rasmussen, 2010). The study by Grimwood (1993) confirms that there is a place for acoustical comfort, which is characterised by the absence of unwanted sound, presence of desired sounds with the right level and quality and opportunities for activities without being heard by other people or annoying them.

3.3.17 Accessibility to Good Transport Network

In relation to accessibility to good transport network, a sustainable building should have access to public transport. Transport accessibility involves giving occupants more convenient options to public transport and developing the building where there is easy access to public transport. This has the potential to reduce the number of cars on the roads and will invariably lead to less air pollution (Roaf *et al.*, 2004). According to Parr and Zaretsky (2010), a sustainable building needs to be integrated into the plan and layout of the city or town where it is situated and this includes the transportation system. This is supported by BREEAM-NC (2012), LEED-NC (2009), and ISO 15392 which discuss that a sustainable building should be in proximity to good public transport and local infrastructure and services. It should have access to alternative modes of transportation for occupants, thereby helping to reduce transport-related pollution and congestion. BREEAM-NC and LEED-NC advocate that the building design should incorporate accessibility to cycle paths and provision should be made for storage and parking for bicycles to encourage bicycle use as a means of transportation as it is an energy efficient means of conveyance.

3.3.18 Efficient Use of Water

Water is one of the important constituents that contribute towards sustainable buildings and involves the management of water to achieve reduced cost. With reference to Read (2005), water is a vital resource for both the economy and the environment and according to Silva-Afonso and Pimentel-Rodrigues (2011) efficient use of water has economic benefit and similarly environmental benefit. Water use in homes and industry is vital to any economy and quality of life, yet if not managed carefully, can lead to increased cost and have negative impacts on wetland environments and biodiversity. Building users need to be educated about water facilities in their building and approaches to minimise water usage and wastage as a result of accidental leaks (Pahl-Wolst *et al.*, 2007). Therefore, there is a need to promote strategies for conserving water. This according to Billie (2012) and Pahl-Wolst *et al.*, (2007) involves indoor and outdoor water management, wastewater management plan, and usage of biological treatment.

Water has now become a limited resource and especially as the world population rises, causing the need for more water consumption (Griggs and Burns, 2009). The introduction of innovation in water appliances such as power showers, whirlpool baths, and hot tubs have also increased the demand for water in buildings. This increase in water use has led the need to supply more water and at the same time manage its usage due to its limited supply (Griggs and Burns, 2009). This process is termed water efficiency and can be achieved by decreasing the flush volume of

WCs thereby reducing water waste; by promoting the use of showers instead of baths; by use of water efficient fittings such as taps, baths and showers; water efficient appliances such as dishwashers and washing machines; and water recycling systems such as rainwater harvesting and greywater recycling (Griggs and Burns, 2009).

The above mentioned measures are in line with the guidelines developed and as presented in BREEAM-NC (2012), LEED-NC (2009) and ISO 15392 in relation to reducing the consumption of potable water for sanitary use in buildings from all sources through the use of water efficient components and water recycling systems and the reduction of water for waste. BREEAM-NC (2012) aims to reduce the consumption of potable water for sanitary use in buildings from all sources through the use of water efficient components and water recycling systems. LEED-NC (2009) advocates designs that encourage 50% reduction in the use of potable water and an increase in recycled waste and grey water for landscape irrigation. According to ISO 15392, basis should be established for improving water efficiency and minimising water consumption by incorporating designs that optimise performance through low or zero water use, sanitary fittings and rainwater and grey water recycling or reuse.

Odey (2003) suggested ways by which water can be efficiently managed in buildings to achieve sustainability. These ways include reducing the amount of water used by various types of water facilities such as toilets, urinals, taps, landscaping, laundry and dishwashing contributing to creating sustainable water usage. According to Kibert (2016) and Billie (2012), reduction in water usage can be achieved by installing waterless toilets, saving up to 50% of domestic water use, installing dual flush WCs consisting of a full and half flush, and urinals with detector which activates water flush reducing the amount of wastewater and taps that turn on and off automatically.

Odey (2003) and Kibert (2016) suggest that reuse of wastewater and grey water conserve domestic water usage of water for flushing in toilets and gardening purposes. Greywater is the waste water collected separately from clothes washers, bathtubs, showers, and sinks, however, does not include wastewater from kitchen sinks, dishwashers, or toilets. Zin and Ibrahim (2012) also suggest the automatic irrigation systems of grey water for greener environment to achieve water conservation in the built environment. According to them, high-performance buildings can reduce the consumption of potable water by 50% by opting for water efficient fixtures such as high-efficiency toilets and high-efficiency urinals. By also using alternative sources of water such as rainwater and grey water, potable water consumption can be further reduced by another 50% to one-fourth of the conventionally designed building water system (Zin and Ibrahim, 2012).

Cheng (2003) supports the concept of rainwater harvesting as shown in Figure 3.1 for domestic purposes as a method of water use efficiency. This system collects rainwater from the roofs and is kept within a storage tank; it is then passed through a filter to remove leaves and other debris. According to Cheng (2003), the system can be equipped with pumps for effective distribution. Billie (2012) also supports the use of rainwater collection systems, sustainable landscaping techniques, and high-efficiency irrigation systems, for water efficiency in sustainable buildings.

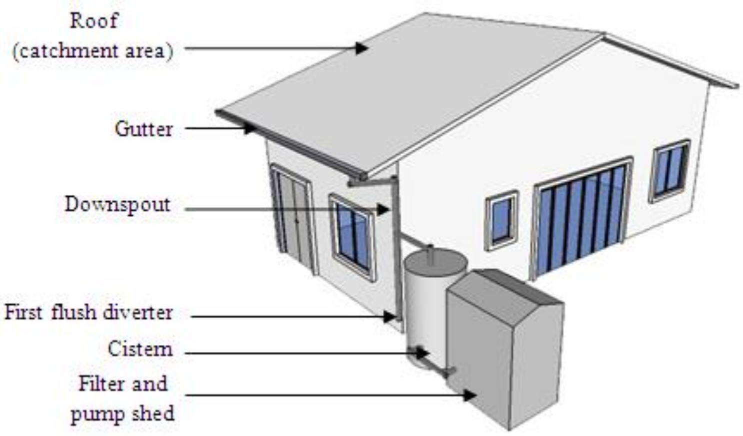

Figure 3.1: Rain Water Harvesting
Source: Zin and Ibrahim (2012)

3.3.19 Material Efficiency

Material efficiency with reference to Allwood *et al.*, (2011) means providing material services with less material production and processing, thereby achieving savings in the cost of manufacturing. This in the bigger picture reduces the cost incurred in constructing a building and reduces the cost for the occupant who is to either own or pay rent. Material efficiency also involves the reduction of loss of materials and has a direct impact on construction costs. When building materials are not used efficiently, it leads to more production of materials and that has to be replaced from the already limited resources (Ruuska and Häkkinen, 2014). The increase in production of materials, results in more extraction of materials, which leads to more production and cost of labour, leading to higher construction costs. Material costs take as much as 15% to 40% of the project cost and this includes labour costs, site overheads, taxes and the contractor's profits (Salmi *et al.*, 2013). Therefore, it is necessary to minimise the loss of materials during and maximise material use during the construction of a building.

Allwood *et al.*, (2011) are of the opinion that there is a need for material efficiency due to the depletion of building resources. In relation to sustainable buildings, material efficiency is the sparing use of building material resources, reduction of waste, recycling and effective management of materials (Ruuska and Häkkinen, 2014). LEED-NC (2009) encourages the reuse of building materials and products in order to reduce the demand for virgin materials and to reduce waste, thereby reducing impacts associated with the extraction and processing of virgin resources. It also encourages the use of building materials that have been extracted and manufactured within 500 miles of the project site for a minimum 10% cost on total materials value reducing environmental impacts resulting from transportation. BREEAM-NC (2012) also encourages minimising the frequency of replacement so as to prevent excessive material use and promote materials optimisation.

In relation to the construction stage, material efficiency includes the use of local materials that are extracted and manufactured within the region of the building project, thereby reducing the cost of production and delivery. Use of local materials also supports the use of indigenous resources and reduces the environmental impacts resulting from transportation (Salmi *et al.*, 2013). Material efficiency involves management of construction waste which Llatas (2011) states represents over one-third of the total solid waste in the world. This, therefore, calls for choosing adequate materials at the design stage in order to reduce waste and future environmental impact. The selection of adequate material is a major feature for reducing the environmental impact of a building (Carpio *et al.*, 2016).

3.3.20 Maintenance

There are many definitions of maintenance, however, BS 3811 (1984, pp.1) defines it as '*the combination of all technical and administrative work including supervision, intended to retain an item, or restore it, to a state in which it can perform a required function*'. In relating maintenance to buildings, the CIOB (2004) describes building maintenance as the work carried out to preserve, renovate or improve every part of a building, its services and surroundings to a particular standard, determined by the balance between the need presented and available resources. BREEAM-NC (2012) states that maintenance of a building involves life-cycle costing and service life planning in order to inform decisions relating to design, specification and through-life maintenance and operation. Shah (2007) encourages the engagement of an independent commissioning agent in relation to the maintenance of the building. In the view of the management aspect of sustainable buildings, maintenance is a management role performed by the facilities manager. Though, the facilities manager does not carry out the technical aspect, he coordinates maintenance works to ensure that periodical maintenance and repairs of the building takes place.

3.3.21 Efficient Use of Energy

According to Rosen (2009), efficient use of energy means using less energy to provide the same service. Wang *et al.*, (2012) describes it as using less energy without reducing the performance of a building and is a strategy for decreasing the use of energy and its negative impacts on the environment (Joelsson and Gustavsson, 2009). Energy efficiency in relation to equipment and fittings significantly helps to do more work with less energy. Its advantages include the efficient exploitation of natural resources, and reduced energy consumption, thereby leading to lower spending by building users on energy related matters. All activities occurring during the life-cycle of buildings use energy. However, the design stage is the stage at which minimum energy consumption can be determined (Mwasha *et al.*, 2011).

Roufechaei *et al.*, (2014) as shown in Table 3.3, made a summary of all energy efficiency parameters along architectural, mechanical and electrical designs, at the design stage in the housing industry for sustainable housing development. It can be seen that energy efficiency as a sustainable building constituent, largely relates to the services aspect of a building. These parameters are crucial in sustainable building design and are significantly related to the design and construction stages (Holton *et al.*, 2010; Cobîrzan *et al.*, 2013). Therefore, energy efficiency can play an important role in improving energy consumption and better sustainability in the environmental and economic aspect can be achieved (Roufechaei *et al.*, 2014).

The construction of a building is accompanied by an initial additional cost; however, it is justified at the operations stage in the reduced operation and maintenance costs; and also in the productivity and health of building users. The reduced operation and maintenance costs relate to energy costs from heating, cooling, lighting and ventilation, and reduced water consumption (WGBC, 2013). Energy efficiency significantly reduces the overall cost of running a building and is a driver for the building user's demand for a building or reason to continue with tenancy or owning the building (Shriberg, 2000). Studies by Kats (2003) shows that the more sustainable a building is, the greater are the chances for reduced cost in energy. The use of renewable energy is a way to achieve energy efficiency in buildings

Table 3.4: Energy Efficiency Parameters

Design base	Energy efficiency parameters	References
Architectural	Application of passive solar (take advantage of climate conditions)	Zimmermann et al, 2005
	Use energy efficiency and renewable energy sources	Seyfang, 2010
	Use wooden logs to provide structure and insulation	Maliene and Malys, 2009
	Optimization building orientation and configuration	Zhang et al., 2011
	Application of green roof technology	Cukovic and Ignjatovic, 2006
	Optimization building envelope thermal performance	Zhang et al., 2011
	Insulation (roofs, windows, floors, walls and exterior doors)	Ding, 2008
	Application of natural ventilation	Menzies and Wherret, 2005
	Ample ventilation for pollutant and thermal control	Gill et al., 2010
Mechanical	Cooling and heating system (environmental friendly materials for HVAC system)	Monahan and Powell, 2010
	Application of ground source heat pump	Knudstrup et al, 2009
	Application of efficient water heating	Knudstrup et al, 2009
	Application of solar water heater	Milton and Kaufman, 2005
	Insulation tank and pipes	Bilgen et al, 2008
	Demand tank less water heater	Bilgen et al, 2008
	Application of thermostats, ducts and metres	Whittington, 2002
Electrical	Making clean electricity (application of solar system technology)	Bahaj and James, 2007
	Application of lighting choices to save energy	Monahan and Powell, 2010
	Application of lighting product	Monahan and Powell, 2010
	Application of artificial lighting	Harvey, 2006
	Use of efficient type of lighting (lighting output and colour)	Tenorio, 2007
	Integrative use of natural lighting (day lighting) with electric lighting system	Fontoynont, 1999

Source: Roufechaei *et al.*, (2014)

According to Zhu (2009), energy efficiency should be achieved through the good design of minimum operational energy consumption. This supported by BREEAM (2012) which encourages monitoring of major consuming systems such as domestic hot water, cooling, fans, lighting, humidification, space heating; and energy efficient light fittings. Others include local energy generation from renewable sources; installation of energy efficient refrigeration systems, therefore reducing operational GHG emissions resulting from the system's energy use; and the specification and installation of energy efficient transportation systems. According to LEED (2009), minimum level of energy efficiency requirement should be established when considering energy consumption in a building and the use of on-site renewable energy systems to offset building energy cost. Refrigerants and HVAC&R that minimise or eliminate the emissions of compounds that contribute to the ozone depletion and global warming should be specified and used.

BSI (2014) advocates for improving energy efficiency and all available options to minimise energy consumption. This includes possible passive design strategies to optimise thermal performance, insulation, air tightness and ventilation. The improvement of energy efficiency also includes the use of natural ventilation and energy efficiency options relating to heating and cooling, hot water systems, lighting systems, daylighting and internal transportation such as lifts, escalators and so on; all which is part of the services of the building. Building services include heating, ventilation, air handling, light, and power. It is safe to say that a building may not fulfil the purpose for which it has been design without these services. These services are an integral and vital part of the building. They are also central to its energy-efficient operation (Malina, 2012). According to Malina (2012), for there to be energy efficient operations in a building, there should be an energy management plan as illustrated in Figure 3.2. Energy has to be measured to produce readable data which can be analysed by an energy manager to provide the necessary information to the building owner and in doing so, the building user can make cost savings.

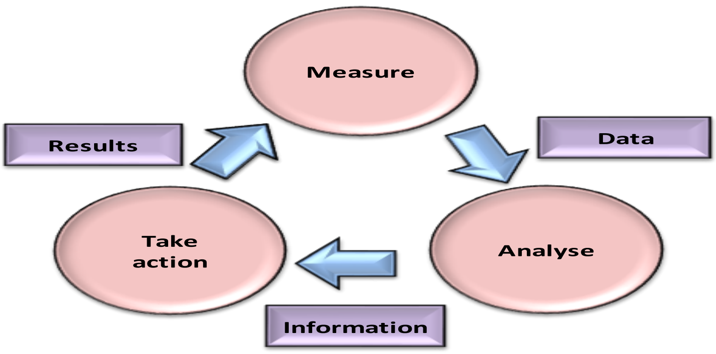

Figure 3.2: The Energy Management Cycle
Source: Malina, (2012)

Various studies (Catto, 2001; Iqbal, 2004; Brown and Vergragt, 2008; Zhu, 2009; Lund, 2011) reveal that buildings characterised with energy efficient designs including low energy, ultra-low energy, and zero energy, are sustainable buildings. With reference to Zin and Ibrahim (2012), achieving a zero energy building is far from realisable. However, Zin and Ibrahim (2012) states that a low energy building design would be a possible target to achieve in sustainable building and suggests that a zero-co_2 energy building as a way to contribute to sustainable building. An energy-efficient building balances all aspects of energy use in a building and these include lighting (artificial and natural), space-conditioning, and ventilation, passive solar design strategies and energy-efficient transportation systems (lifts, elevators, escalators) (Mwasha, 2011). It also includes the use of equipment that consumes less energy (BREEAM, 2014; LEED, 2009). Energy efficient equipment is equipment that consumes less energy than the standard equipment. BREEAM-NC (2012) also states the need for construction sites to be managed in an environmentally sound manner in terms of energy consumption. Ways to reduce energy consumption on site include use of energy efficient plant and equipment and ensuring that it is well maintained and operated; monitoring energy consumption; use of electricity from main where available in order to reduce use generators which add to carbon emissions; and use of low watt light fittings (BREEAM-NC, 2012).

3.3.22 Building Life-Cycle Cost

Building life-cycle cost (BLCC) can be defined as a process that enables long-term costs of operating and maintaining a building to be considered during the building's design stage (Bull, 1992). The standard ISO15686-5 explains 'life-cycle cost' (LCC) as a technique which enables comparative cost assessments to be made over a specified period of time, taking into consideration all relevant economic factors both in terms of initial costs and future operational costs. The concept of LCC emerged in the 1930s when people started to realise that the cost of operating a building was far more than the construction cost and since then LCC has been used to show construction clients how a small additional upfront cost can generate a significant saving in the long term (Roaf *et al.*, 2004).

The principle of LCC in buildings is that when comparing cost alternatives of a proposed building project, the cheapest option should not be selected but the one that is most economical over the long-term, taking account of both the initial construction cost and the future costs and benefits during the service life of the building (Zabalza *et al.*, 2013; Khasreen, 2009). According to Emblemsvag (2003), LCC serves three main purposes namely: an effective engineering tool for use in design and procurement; a cost accounting and management tool; a design and engineering tool for environmental purposes. However, what is common to these three purposes is that LCC is used to provide insight into all future matters regarding cost.

According to Bribian (2011) and BREEAM-NC (2012), LCC analysis should be used at the design stage to inform decisions relating to design specification and maintenance and operation. It states that the LCC analysis should be conducted in accordance with ISO15686-5:2008 with a study period of 40 – 60 years and real and discounted cash flows which include construction costs (capital costs), operation costs and maintenance costs. Fakhrudin *et al.*, (2011) encourages the use of LCC when a decision is to be made at the design stage of the economic implication of such decisions throughout the phases of the building life-cycle. Lower operating costs are a key benefit of sustainable buildings and LCC helps to demonstrate what can be incorporated at the design stage to lower operating costs.

3.3.23 Post Occupancy Evaluation and Information Dissemination

Post Occupancy Evaluation (POE) is a process of systematically evaluating the performance of buildings after they have been built and occupied for some time (Preiser, 2002). Friedman *et al.*, (1978) describe it as an appraisal of the degree to which a building satisfies and supports the occupants' needs. In relation to Post Occupancy Evaluation (POE) as sustainable building constituent, BREEAM-NC (2012) focuses on using information obtained from POE in order to effectively evaluate the opinion of building users about the buildings they presently occupy. The POE assesses how well buildings meet users' needs and also identifies ways to improve the design, performance, and purpose of the building. The information obtained from the POE is then used in the development of the brief which is a documentation of the client's requirements for the development a building. ISO 15392 refers to POE as users' feedback and lessons learnt from past experience for continuous improvement of both the performance of the building and users' satisfaction. ISO 15392 encourages the documentation of the POE for the establishment of transparent decision making and appropriate information dissemination based on best available data. The information received is incorporated into the design in order to help with future maintenance and operation of the building. The incorporation of the POE and the brief helps to ensure delivery of functional and sustainable buildings designed and built in accordance with performance expectations as stated by BREEAM-NC (2012).

3.3.24 Use of Innovative Technology

With reference to Altwiesa and Nemet (2013), innovation is a new idea or more effective process in carrying out a procedure. Innovation can occur in products, processes, services, technologies, business or construction. In buildings, innovation will define some useful changes in technology in relation to energy and water efficiency, building information systems, building developing less harmful building material, and so on (Gerlach, 2000). BREEAM-NC (2012) supports innovation in the construction of buildings through the recognition of sustainability-related benefits which is not rewarded by the earlier versions of BREEAM. It also refers to any technology, method or process that can be shown to improve the sustainability performance of a building's design, construction, operation, maintenance or demolition. LEED-NC (2009) makes allowance for design and projects to be awarded points for exceptional performance above the requirements of any other sustainability rating system in constituents such as energy performance and water efficiency. ISO 15392 encourages the investigation of innovative solutions and approaches in order to provide more sustainable solutions in building development. Therefore, use of innovative technology in sustainable buildings can be said to involve innovative technology that does not have adverse effect on the environment, instead helps to improve the sustainability of the building.

3.3.25 Building Management Systems

Building Management System (BMS) is a computer-based control system installed in buildings that control and monitors the building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems (Pinho, 2015). The benefits are control of internal comfort conditions, individual room control, increased staff productivity, effective monitoring, and targeting of energy consumption, improved plant reliability and life, effective response to HVAC-related complaints, save time and money during the maintenance (Pinho, 2015). BREEAM-NC (2012) encourages the use of BMS for energy management for space heating, domestic hot water, humidification, cooling, fans, lighting, swimming or hydrotherapy pools, kitchen plants, cold storage plant, sterile services equipment, and transportation systems (e.g. lifts and escalators). LEED-NC (2009) also encourages the incorporation of BMS in the design of the building envelope and systems in order to maximize and assess the building's energy performance and identify the most cost-effective energy efficiency measures. According to GSSA (2014) the use of BMS helps to actively control and maximise the effectiveness of building services. However, ISO 15392 recommends the review of BMS in order to check the effectiveness of existing management system and consider improvement as necessary.

3.3.26 Legal and Contractual Environmental Management Initiatives and Occupants' Participation

Legal and contractual environmental management initiatives as a sustainable building constituent involve the incorporation of Environmental Management Systems (EMS) which is a set of procedures that helps the construction team to reduce its environmental impacts and increase environmental performance (EPA, 2016). Figure 3.3 shows a framework for environmental management developed by the International Organisation for Standardisation (ISO) for the ISO 14001 standard. The framework involves five major steps namely: establishment of a policy for environmental management; planning some sort of management system to reduce the impact of construction on the environment; implementation of the plan; evaluation of the system; and review to ensure it fulfils its purpose. The major advantage of an EMS is the consistent review and evaluation of systems which identifies opportunities for improving environmental performance (EPA, 2016).

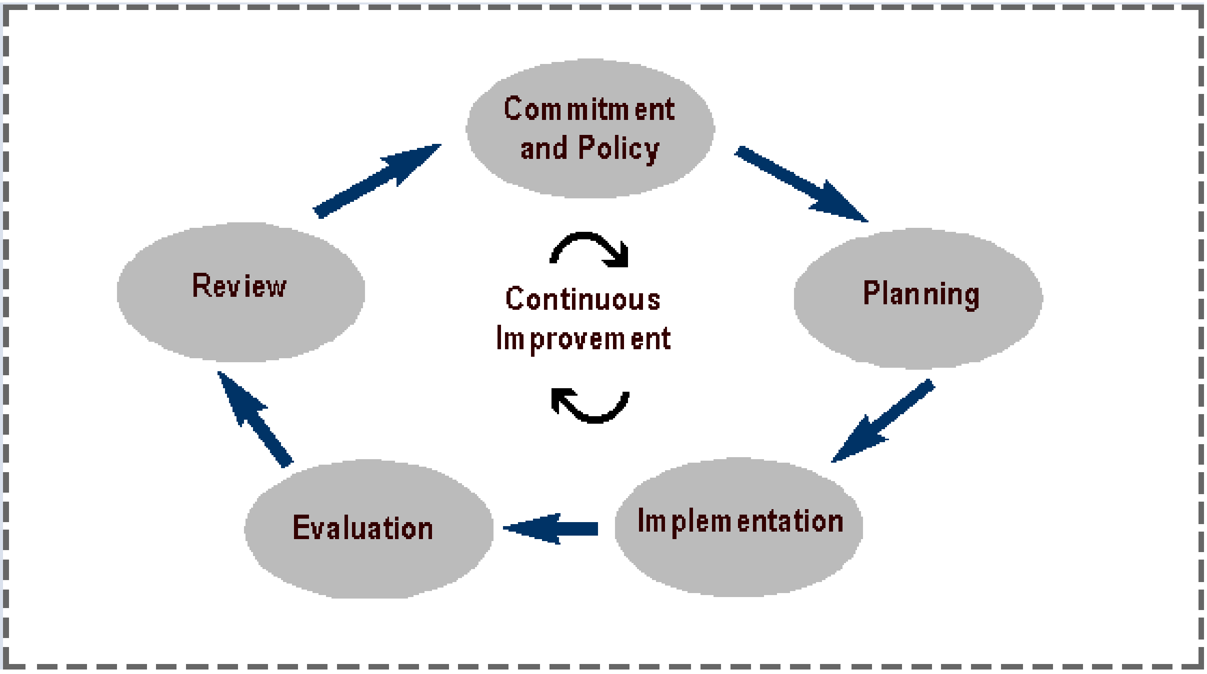

Figure 3.3: Framework for Implementing an Environmental Management System
Source: EPA (2016)

BREEAM-NC (2012) states that the principal contractor for a building project is in a good position to implement EMS. This is necessary in order to monitor energy consumption from the use of construction plant, equipment (mobile and fixed) and site accommodation necessary for completion of all construction processes for environmental management purposes. There is also need to monitor water consumption, transport resulting from delivery of the majority of construction materials to site and construction waste from the site is also included. Legal and contractual environmental management initiatives also involve the development of sustainability policies which ISO 15392 encourages.

According to ISO 15392 the development of a sustainability policy where key elements of sustainability are addressed by the client in conjunction with the design and construction team is needed in achieving a building's sustainability. This policy is communicated to all stakeholders at the design and construction stages. The development of this policy is implemented and reviewed as suggested by EPA (2016). The policy is communicated to occupants at the operations stages and initiatives are developed to educate them about how sustainability issues in buildings work. . According to WGBC (2013), effective communication of such a policy can help aid better user behaviour and improve the longevity of the building. This will encourage environmental activities by occupants which are also a sustainable building constituent under the management aspect.

3.3.27 Engagement of sustainable Building Experts for the Integration of Sustainability Assessment Schemes

LEED-NC (2009) requires that at the design and construction stage a LEED professional is employed on building projects to streamline the application and certification process. It requires that at least one principal participant of the project team is a LEED Accredited Professional and whose duty is to educate the project team members about sustainable building design and construction. BREEAM-NC (2012) also requires that a BREEAM Assessor is engaged to determine a buildings' sustainability rating using the appropriate assessment tools and calculators at the design and post construction stages. However, ISO 15392 and GSSA (2014) encourage an integrated multidisciplinary approach in relation to the engagement of professionals who can assist the project team with the integration of their respective sustainability goals and processes throughout design and construction phases. They also emphasise that it is important that project members understand the eligibility criteria and credit criteria of their rating tools and process.

3.3.28 Building Users Guide

With reference to BREEAM (2013), a Building Users Guide is a non-technical manual with information to provide the safe operation in buildings. They provide information for building users about the principles behind the design of the building and how these affect its operation; the building's standard of performance; energy efficiency measures; water-saving measures; means of operating heating, lighting and cooling systems, and the consequences of incorrect operation; access, security and safety systems; methods for reporting problems; car parking and cycling provision, local public transport, car sharing schemes and waste management. It may also include guidance for facilities managers and for maintenance and other contractors. With reference to GSSA (2014) the building users guide provides rich information for building users to familiarise themselves with systems incorporated within the building and how to use the building in order for it to function efficiently. Informing the users on how the building should function is an important aspect of making sure that the building performs to its optimum. GSSA (2014) refers to it as a constituent necessary for sustainable buildings. Building users' guide as sustainable building constituents is usually encouraged even in conventional buildings; however, it is a necessary also in sustainable buildings in order that building users may have a set of instructions that guides them in the operations of systems in the building.

3.3.29 Commissioning and Handover Initiatives

Commissioning and handover initiatives are processes put in place to ensure that all building services can operate to optimal design level. Commissioning can be described as taking an installation from the completion stage to the level when it works order in accordance with specified requirements by the designer (CIBSE, 2005). It involves building services such as ventilation systems and lighting and power supply Griggs and Grave (2004). Although this process is normally carried out at the end of construction works in conventional buildings, it is nonetheless a process that needs to be carried out even for sustainable buildings. With reference to WGBC (2013) commissioning of sustainable buildings results in reduced operating, maintenance and repair costs. However, is dependent on thorough design and full implementation of designs during installation at the construction stage (Armstrong and Saville, 2005). CIBSE (2004) states that good commissioning is essential for energy efficiency.

GSSA (2014) encourages adherence to guidelines for commissioning of building services developed by Chartered Institute of Building Services Engineers (CIBSE) an international professional engineering association for building services. It also encourages the use of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) for mechanical systems commissioning. CIBSE and ASHRAE are internationally-recognised bodies for the development of standards for the commissioning of building services systems. According to Kibert (2016), when buildings are commissioned it reduces operating costs due to an increased energy efficiency of about 5% to 10%. It leads to better comfort for building users thereby, increasing productivity. It reduces building services failure and aids a fully functioning building from the first day of operation.

3.3.30 Defects Liability Period

Defects liability period is a period of time usually 6 – 12 months within which the contractor is contractually obliged to return to the building and remedy any defective work which has appeared in the contractor's works (Chappell, 2014). With reference to Eggleston (2001) the defect liability period has the advantage of obliging and entitling the contractor to make good all defective works at less cost than he would have to pay for damages to the client or building owner and the building owner has the advantage of the contractor making good all defective work so that the building can perform optimally. GSSA (2014) encourages the incorporation of this period into the building contract and refers to it as a sustainable building constituent. During this period, consultants and contractors warrant the performance of the building and return to rectify any issues with performance. Although, the adherence to the defects liability period is carried out in conventional buildings, it is a necessary period that should be observed in sustainable buildings.

3.3.31 Building Tuning

Building tuning is the process whereby a building is continuously maintained to give optimum performance and it commences after a building has been commissioned. Building tuning is usually carried out after a building has been commissioned and is usually done about a year after commissioning. This is to ensure that the building has gone through seasonal changes all through the year and this also allows the occupant to have used the building a reasonable period of time (CIBSE, 2009; WGBC, 2013). With reference to GBCA (2014) though a building is commissioned well, the quality is adversely affected by construction program pressures and lack of understanding of the different systems involved in the building operations. Building tuning provides a way to ensure to make up for shortfalls in the commissioning process and that building services work to ensure energy saving, safe operations, and comfort of the building user. One of such shortfalls is air leakage in buildings. Building tuning helps to manage any air leakage in a building.

In relation to achieving sustainable buildings, GSSA (2014) encourages tuning to be carried out throughout the life of the building. According to Tymkow *et al.*, (2013) this is necessary because buildings and their services wear due to occupancy. Therefore, in order to ensure maximum occupant comfort and energy efficient services performance for occupants throughout their stay, building tuning is encouraged. Building tuning also has few advantages and these include: allowing building operators understand a building better, ensuring that optimum building performance is maintained, and reduces a building's capacity to emit harmful gases. Building tuning affords a building to adjust to seasons and different occupant usage (Kos and Cooper, 2014).

3.4 Sustainable Building Constituents at Different Stages of the Building Life-cycle

Sustainable building constituents have been described in Section 3.3 according to environmental, social, economic, and management aspects. However, there is need to consider these constituents according to the different stages of the building life-cycle. The building life-cycle stages needs to be highlighted in this research study due to consideration for the building in its entirety to achieve sustainability. For a building cannot attain sustainable status unless designed and constructed with sustainability features in place. The RIBA Plan of Work 2013 provides an adequate representation of the different life-cycle stages of a building which include the processes of briefing, designing, constructing, maintaining and operating a building. The RIBA Plan of Work is an internationally recognised standard for building design and construction processes and is developed by the Royal Institute of British Architects. It is used in a multitude of building contractual and appointment documents and best practice guidance. Since its inception in 1963, there have been 5 updates of the document; the 2013 edition is the sixth and latest of the editions. The document has been amended and updated over time to reflect developments in design team organisation and changes in building procurement arrangements (RIBA, 2013a).

The RIBA Plan of Work 2013 represents the most comprehensive review of the building life-cycle stages to be undertaken since its inception (RIBA 2013a). It reflects change in focus from the traditional procurement method to more innovative procurement methods used in the delivery of building projects and unlike its predecessors it shifts focus from the design team to the project team (client, design team and the building contractor). It encourages team work between project team members which helps the project meet the needs of the client. The document also places greater emphasis on the brief being properly developed and comprehensive development of the design stage with the help of the design team. This enables an adequate check of design issues before implementation at the construction stage (RIBA 2013b). The document incorporates the Building Information Modelling processes and emphasises sustainability checks from design to the operations in-use stage.

The RIBA Plan of Work 2013 consists of eight main stages and these are the strategic definition stage, preparation and brief stage, concept design, developed design, technical design, construction, handover and close out and in-use stage. With reference to RIBA (2013a) and RIBA (2013b), the strategic definition stage is a stage in which a project is assessed with the aim of determining the viability and defining the project before a detailed brief is developed. This helps to project the building team needed for the project and sustainability review of client needs. The preparation and brief stage is the stage in which the initial project brief is developed and any related feasibility studies. The initial project brief is the most important task of this stage and which sets the stage for developing project objectives. The stage similarly includes bringing together the project team and defining each team member's roles and responsibilities. It is at this stage the checks for the building's sustainability starts.

The concept design stage is the stage in which the initial concept design is produced in line with the requirements of the initial project brief. The concept design includes outline proposals for architectural design, structural design, building services, outline specifications and preliminary cost information and other relevant information in line with the design programme. Prepare Developed Design, including coordinated and updated proposals for structural design, building services systems, outline specifications, Cost Information and Project Strategies in accordance with Design Programme. The developed design stage is the stage in which the concept design is further developed and updated. During this stage, strategies that complement the design are prepared and these strategies consider post-occupancy and operational issues along with the consideration of buildability.

At the technical design stage designers aim at defining the technicality and functionality of their designers in order to provide technical definition to the project. Each designer can now independently develop their technical designs and the design work of specialist subcontractors can be developed and concluded at this stage. It is expected that by the end of this stage, all aspects of the design will be completed and minor errors that are discovered during the construction stage will be examined and resolved. During the construction stage, the process of constructing the building is initiated and implemented on site in accordance with the construction programme. The handover stage involves the building handover to the client and the administrative conclusion of the building contract. The project team focusses on successfully handing over the building at the time planned according to the project programme. The stage also includes the inspection and making good of defects. The in-use stage is the last stage in the building life-cycle according to the RIBA Plan of Work 2013. The stage includes post-occupancy evaluation, review of the project performance, project outcomes and updating of project information till the building's end of life.

The stages mentioned above are an adequate representation of the different life-cycle stages of a building. This research, however, place emphasis on three main stages and which are the design, construction and operations stages; the Plan of Work 2013 revolves around these three stages. The design stage includes the strategic definition, preparation and brief, concept design, developed design, and technical design stage. The construction stage includes handover and close out stage (commissioning) and the operations stage includes the in-use stage. In this research, the strategic and definition stage has been excluded because sustainability consideration does not start until the preparation and brief stage and the research revolves around achieving sustainability in buildings. The preparation and the brief stage are just before the briefing stage which is usually chaired by the architect and concrete steps are taken to pencil down the client's desires. Detailed design is not implemented until the briefing stage is completed. For a building to be truly sustainable, the SD concept needs to be considered over the entire stages of the building life-cycle, which is from the planning process, through the construction, operation and renovation phases, and up to the eventual demolishing and recycling processes (Hodges, 2005). A sustainable building needs to serve across these stages as shown in Figure 3.4 and at the same time ensure that the economic, environmental and social criteria are beneficial and are not harmful to current and future generations (Feige *et al.*, 2013).

Through a self-study of the constituents of sustainable building using the 'Sustainability in Buildings and Civil Engineering Works — Guidelines on the Application of the General Principles in ISO 15392' as a guide, sustainable building constituents are discovered to start from the design right through to the construction and the operations stages (see Table 3.9). This supports studies as carried out by Hoseini (2009); Basbagill (2013); Crawford *et al.*, (2011); Li (2011); Ellis *et al.*, (2008); Buvik and Hestnes, (2008); and Andresen and Hestnes (2008). With reference to Tsai and Chang (2012), to integrate sustainability in the life-cycle process of a building, the design stage is the key phase. It is during this stage that designers can create a sustainable building by incorporating sustainable components (Hodges, 2005).

RIBA

RIBA Plan of Work 2013 — Stages / Tasks	0 Strategic Definition	1 Preparation and Brief	2 Concept Design	3 Developed Design	4 Technical Design	5 Construction	6 Handover and Close Out	7 In Use
Core Objectives	Identify client's Business Case and Strategic Brief and other core project requirements.	Develop Project Objectives, including Quality Objectives and Project Outcomes, Sustainability Aspirations, Project Budget, other parameters or constraints and develop Initial Project Brief. Undertake Feasibility Studies and review of Site Information.	Prepare Concept Design, including outline proposals for structural design, building services systems, outline specifications and preliminary Cost Information along with relevant Project Strategies in accordance with Design Programme. Agree alterations to brief and issue Final Project Brief.	Prepare Developed Design, including coordinated and updated proposals for structural design, building services systems, outline specifications, Cost Information and Project Strategies in accordance with Design Programme.	Prepare Technical Design in accordance with Design Responsibility Matrix and Project Strategies to include all architectural, structural and building services information, specialist subcontractor design and specifications, in accordance with Design Programme.	Offsite manufacturing and onsite Construction in accordance with Construction Programme and resolution of Design Queries from site as they arise.	Handover of building and conclusion of Building Contract.	Undertake In Use services in accordance with Schedule of Services.
Procurement *Variable task bar	Initial considerations for assembling the project team.	Prepare Project Roles Table and Contractual Tree and continue assembling the project team.	<----- The procurement strategy does not fundamentally alter the progression of the design or the level of detail prepared at a given stage. However, Information Exchanges will vary depending on the selected procurement route and Building Contract. A bespoke RIBA Plan of Work 2013 will set out the specific tendering and procurement activities that will occur at each stage in relation to the chosen procurement route. ----->			Administration of Building Contract, including regular site inspections and review of progress.	Conclude administration of Building Contract.	
Programme *Variable task bar	Establish Project Programme.	Review Project Programme.	Review Project Programme.	<-- The procurement route may dictate the Project Programme and may result in certain stages overlapping or being undertaken concurrently. A bespoke RIBA Plan of Work 2013 will clarify the stage overlaps. The Project Programme will set out the specific stage dates and detailed programme durations. -->				
(Town) Planning *Variable task bar	Pre-application discussions.	Pre-application discussions.	<------ Planning applications are typically made using the Stage 3 output. A bespoke RIBA Plan of Work 2013 will identify when the planning application is to be made. ------>					
Suggested Key Support Tasks	Review Feedback from previous projects.	Prepare Handover Strategy and Risk Assessments. Agree Schedule of Services, Design Responsibility Matrix and Information Exchanges and prepare Project Execution Plan including Technology and Communication Strategies and consideration of Common Standards to be used.	Prepare Sustainability Strategy, Maintenance and Operational Strategy and review Handover Strategy and Risk Assessments. Undertake third party consultations as required and any Research and Development aspects. Review and update Project Execution Plan. Consider Construction Strategy, including offsite fabrication, and develop Health and Safety Strategy.	Review and update Sustainability, Maintenance and Operational and Handover Strategies and Risk Assessments. Undertake third party consultations as required and conclude Research and Development aspects. Review and update Project Execution Plan, including Change Control Procedures. Review and update Construction and Health and Safety Strategies.	Review and update Sustainability, Maintenance and Operational and Handover Strategies and Risk Assessments. Prepare and submit Building Regulations submission and any other third party submissions requiring consent. Review and update Project Execution Plan. Review Construction Strategy, including sequencing, and update Health and Safety Strategy.	Review and update Sustainability Strategy and implement Handover Strategy, including agreement of information required for commissioning, training, handover, asset management, future monitoring and maintenance and ongoing compilation of 'As-constructed' Information. Update Construction and Health and Safety Strategies.	Carry out activities listed in Handover Strategy including Feedback for use during the future life of the building or on future projects. Updating of Project Information as required.	Conclude activities listed in Handover Strategy including Post-occupancy Evaluation, review of Project Performance, Project Outcomes and Research and Development aspects. Updating of Project Information, as required, in response to ongoing client Feedback until the end of the building's life.
Sustainability Checkpoints	Sustainability Checkpoint – 0	Sustainability Checkpoint – 1	Sustainability Checkpoint – 2	Sustainability Checkpoint – 3	Sustainability Checkpoint – 4	Sustainability Checkpoint – 5	Sustainability Checkpoint – 6	Sustainability Checkpoint – 7
Information Exchanges (at stage completion)	Strategic Brief.	Initial Project Brief.	Concept Design including outline structural and building services design, associated Project Strategies, preliminary Cost Information and Final Project Brief.	Developed Design, including the coordinated architectural, structural and building services design and updated Cost Information.	Completed Technical Design of the project.	'As-constructed' Information.	Updated 'As-constructed' Information.	'As-constructed' Information updated in response to ongoing client Feedback and maintenance or operational developments.
UK Government Information Exchanges	Not required.	Required.	Required.	Required.	Not required.	Not required.	Required.	As required.

Figure 3.4: RIBA Plan of Work (2013)

Source: RIBA (2013)

Table 3.5: Sustainable Building Constituents through Design, to Construction and Operation

SUSTAINABLE BUILDING CONSTITUENTS	Design	Construction	Operation & Maintenance
ENVIRONMENTAL ASPECT			
Waste management which involves an effective and appropriate waste management system both at construction and during the operational life of the building	•	•	
Provides minimum car parking capacity in order to help reducing transport related pollution	•		•
Use of systems that reduce carbon	•	•	•
To recognise and encourage construction sites managed in an environmentally sound manner in terms of pollution.	•	•	
Reduction of night light pollution	•	•	
Developments that minimise rainwater run-off to reduce pollution of natural watercourses	•	•	
Developments that minimise pollution in terms of discharge to the municipal sewage system	•	•	•
Use of previously developed sites and or contaminated land, and Non-use of virgin land	•	•	
Preserving ecological value of land in terms of protecting the environment surrounding the building site	•	•	
Biodiversity in terms of preserving and enhancing plant and animal life surrounding the building	•	•	
Use of energy efficient equipment	•	•	•
To recognise and encourage construction sites managed in an environmentally sound manner in terms of energy consumption	•	•	
Reduces greenhouse gas emissions from refrigeration systems, hot water production	•		•
Maximises use of solar energy	•	•	•
Energy efficient transportation systems in buildings (lifts, elevators, escalators or moving walks)	•	•	•
Appropriate use of local energy generation from renewable sources	•	•	•
Use of responsibly sourced materials	•	•	•
Use of construction materials with low environmental impact and which involves LCA tools	•	•	
Construction of building managed in an environmentally sound manner in terms of resource use	•	•	
SOCIAL ASPECT			
Minimises risk of water contamination in building services through design and implementation and the provision of clean and fresh drinking water for building occupant	•	•	•
Visual comfort which involves provision of adequate daylighting, artificial lighting and lighting controls for occupants' comfort	•	•	•
Thermal control levels through design and installation of controls to maintain a thermally comfortable environment for occupants within the building	•	•	•
Provides safe access to and from the building	•	•	•
Management of space for occupant privacy and wellbeing	•		•
Provides indoor environmental quality which involves providing a healthy internal environment through the specification and installation of appropriate ventilation	•	•	•
Provides hazard control which involves materials that are harmful to the comfort and wellbeing of occupants	•	•	•
Conserves local heritage and culture which involves a building that contributes to social and cultural attractiveness of the neighbourhood leading to users and	•		•
Adheres to ethical standards in terms of meeting building standards	•	•	•
Adaptable for different uses and which involves providing a place that meets needs with a mix of tenure types and ensuring flexibility wherever possible	•		
Provides acoustic control which involves the building's acoustic performance including sound insulation meeting the appropriate standards	•	•	•
Accessible to good public transport network and local infrastructure and services and alternative modes of transportation for occupants to reduce transport related	•		•

ECONOMIC ASPECT			
Water efficiency by use of water efficient components and equipment, installation of water recycling system, water consumption monitoring system,	•	•	•
Material efficiency in terms of building material optimisation and replacement and use of recycled materials	•	•	•
Management of construction waste during construction	•	•	
Provision for maintenance of the building and services which ensures the durability and economic value	•		•
Energy efficiency which involves minimising operational energy consumption, monitoring energy usage, use of energy display devices and use of energy	•	•	•
Building life-cycle cost which involves provision of economic value overtime and financial affordability for beneficiaries	•	•	•
MANAGEMENT ASPECT			
Post Occupancy Evaluation (POE) and information dissemination which involves designing, planning and delivery of the building in consultation with current and future building users and stakeholders	•		•
Reduces air leakage in buildings	•		
Incorporates waste recycling management plan	•		•
Involves innovation of technology, method or process that improves the sustainability performance of a building's design, construction, operation,	•	•	•
Incorporation of Building Management Systems to actively control and maximise the effectiveness of building services	•	•	•
Establishes of legal and contractual environmental management initiatives embedded within the formal management structures of the development	•		•
Engages of professional to assist with the integration of sustainability assessment shcemes' aims and processes through design and construction	•	•	
Engages of independent commissioning agent with regard to future maintenance	•	•	•
Involves the development of initiatives to educate building occupants on how the sustainability issues in building work	•		•
Encouragement of environmental activities by occupants	•		•
Building user's guide to enable building users optimise the building's performance	•		•
Involves commissioning and handover initiatives that ensure that all building services can operate to optimal design potential	•		•
Involves a 6-12 month defects liability period after all works have been completed at the construction stage	•		•
Involves yearly building tuning initiatives to ensure optimum occupant comfort and energy efficient services performance	•		•

Source: Self Study

With reference to Gervásio (2014), the performance of a building through its lifetime is as a result of the decisions made at the design stage. This affects the level of energy consumption, visual comfort, thermal comfort and acoustic comfort. Researchers and practitioners have acknowledged the significance of early design decisions when reducing a buildings' life-cycle environmental impact. According to the research carried out by Cofaigh *et al.*, (1999), early and well thought decisions made in the design process lead to fewer changes at the construction stage and thereby lead to greater potential for reducing the building's environmental impact. Cofaigh *et al.*, (1999) argue that an environmentally preferred building shape and orientation during the early design stages reduces a building's environmental impact by 40%.

With reference to Ellis *et al.*, (2008) when decisions are not made early enough, it leads to also massive changes at construction stage and has considerable environmental and economic cost consequences. Gervásio (2014) further explains that early decisions taken in relation to a building's environmental impact and energy consumption reduces the potential of the building to negatively affect the environment. However, the assessment of a building's sustainability in the early stages of building design faces barriers such as the unavailability of information in the initial stages of design, and lack of insight by the building design consultants into the most critical decisions that will have a significant impact. As a result, designers often defer decisions to later stages of the design process (UNEP 2003; Basbagill 2013; Crawford *et al.*, 2011).

Schlueter and Thesseling (2009) demonstrate that by providing designers with early stage environmental impact performance feedback, concrete decisions resulting in less energy buildings can be made and this creates awareness of ways to reduce energy consumption. According to Samer (2013), the energy consumption in the buildings can be reduced up to 70% by using three major design strategies: selection of a low air conditioning load location, using high energy efficient appliances, and application of energy-conserving habits. It is essential to consider high energy efficiency at the start of the design process and to establish key targets (Buvik and Hestnes, 2008; Andresen and Hestnes, 2008).

Molin *et al.,* (2011) confirm that low energy buildings decrease the level of energy consumption in buildings. Schmidt and Ala-Juusela (2004) propose the application of low energy systems for cooling and heating into the design of a building as an effective tool in achieving sustainable buildings. According to their study users are likely to be highly satisfied with the indoor air quality, while living in houses with low heating systems. Simultaneously, other studies confirm that low energy cooling systems provide adequate thermal comfort to building users (Makaremi *et al.*, 2012).

The construction stage is also not left out in the bid towards sustainable buildings. This is the stage at which the designs generated at the design stage are implemented. It is the stage where construction materials are procured; materials and energy are used, resulting in emissions of greenhouse gases, and leading to depletion of the ozone layer (Zhang *et al*, 2006; Roaf *et al.*, 2004). In the United Kingdom the construction stage is where building works produce about 50% of CO_2 emission, consume 50% of the total amount of water used in economic activity and produce 30% of solid waste. The building industry takes up 25% of the raw materials used up in the UK economy. Vanags and Mote (2011) in Figure 3.4 identify some criteria involved in the construction process to achieve SD and these are: security of technical conformity, high resource use effectiveness, security of work environment safety, ecological development of construction material and construction work technology, minimisation of construction waste, minimal impact on the environment, and customer satisfaction and variable requirement.

As earlier indicated a building cannot be sustainable unless the decisions made at the design stage and implemented at the construction are executed at the operations stage. This confirms Basbagill (2013), who states that though sustainable building constituents start from the design stage, they are operated and used at the operations stages. The operations stage is where the greatest impact on the environment is witnessed in terms of energy usage and carbon emissions as a result of electricity consumption, water consumption and waste management (Shah 2007; Zhang *et al.*, 2006; Abigo *et al.*, 2012). Therefore, once designs and installed components to achieve sustainability have been implemented, it is easy to achieve sustainability at the operations stage.

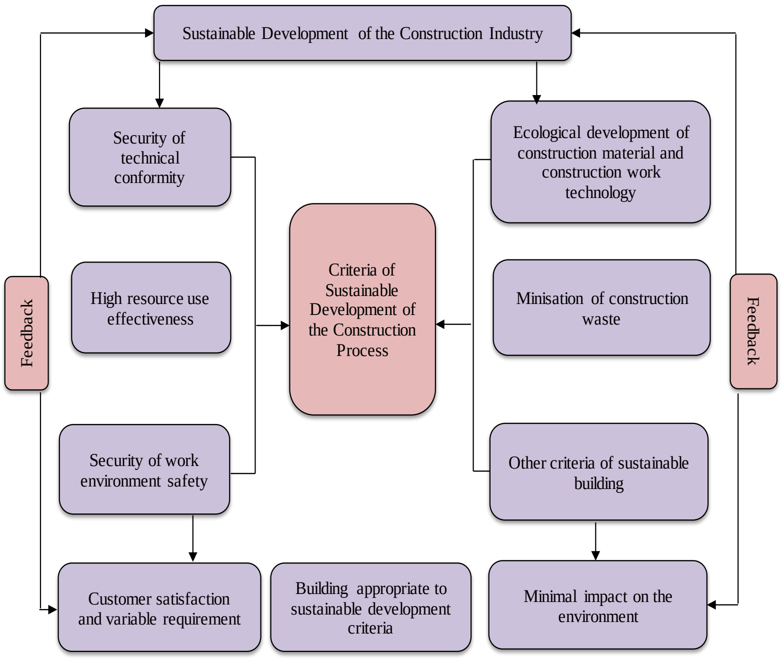

Figure 3.5: Criteria Involved in the Construction Process to Achieve SD
Source: Vanags and Mote (2011)

Section 3.2 to 3.3 explains sustainable building and its constituents with reference to international standards such as BREEAM-NC, LEED-NC, and ISO 15392 and literature review. It has also discussed the effect of sustainable building constituents on the design, construction and operations stages of the building life-cycle. The sections have revealed what a sustainable building is and developing sustainable buildings from the design stage in order to achieve sustainable buildings at the operations stage. The findings at this stage of the research have been majorly based on initiatives created for developed countries such as the United Kingdom, United States, Australia, and Germany and so on. These countries have been concerned about the earth's sustainability due to resource scarcity and energy shortages as the world's population rises (Baker, 2006). There is evidenced-based literature that this concern is linked to the building industry and is a major deterrent in the goal towards sustainability. That is why sustainable building initiatives such as the United Nations Environment Programme-

Sustainable Buildings and Climate Initiative (UNEP-SBCI), Building Research Establishment (BRE), Green Building Initiative (GBI) etc. are been developed.

3.5 The Nigerian Building Industry

The building industry of any nation is a significant sector, as it contributes to the Gross Domestic Product (GDP) and employs a sizeable fraction of the population. For example in the UK in 2014, the building industry contributed £103 billion to the economic and in 2015, 6.2% of the UK population were employed in the building industry (Rhodes, 2015). Likewise in Nigeria, the building industry is responsible for 16% of the GDP and employs up to 20.00% of the labour force (Ayangbade *et al*., 2009). From 2008 to the third quarter of 2013, the building industry in Nigeria accounted for an average of 1.8 % of the country's GDP (Adeagbo, 2014). The country maintained a GDP of an average of N550720.61 Million from 2010 until the second quarter of 2015 where it recorded N740204.22 Million. It however, dropped to N623349.23 Million in the fourth quarter of 2016 (Trading Economics, 2017).

The Nigerian building industry as an organised sector can be said to have started from the 1930s. This was a period when construction activities and major building projects were handled by the Public Works Department (PWD) and the Nigerian Army Engineers. As at this time, direct labour method was the mode of project procurement in Nigeria. Organised construction such as construction contracting did not begin until the 1940s. Construction contracting was introduced by foreign companies from the UK and Italy (Olowo-Okere 1985). This method of project procurement was especially utilised during the 1960s and 1970s when Nigeria's economy experienced an overwhelming boost due to the oil boom. Ever since then, project procurement has developed into more organised ways.

In Nigeria, building projects are usually executed in two separate phases (the design and construction phase) by two separate teams which are the design and the construction team respectively. The design team is made up of consultants such as the architect, quantity surveyor, structural engineer and building services engineer (M&E). The construction team, on the other hand, is mainly made up of the building contractor and a number of sub-contractors who enter into a contract with the building owner on the basis of lump sum competitive tender (Idoro, 2009). This procurement method has affected the delivery of building projects, as it does not allow for integration of construction experience and practicality into the building design. However, other procurement methods such as management contracting, construction management, and design and build have been employed over the years (Mbamali and Okotie, 2012). These methods offer a better integration of the design and construction experience, and provide a better guarantee for overall project success.

Ogunsanmi (2013) confirms the use of different procurement methods used in the building industry in Nigeria. These include the Traditional method, Design and Build, Project

Management, Construction Management, Labour only, Direct Labour, Alliancing, Partnering and Joint Ventures. According to Idiake et al., (2015), the traditional method which is also known as 'Design-Bid-Build method' is the most widely used in Nigeria, however, Babatunde et al., (2010), claims that the variance of the traditional method is mostly adopted in building projects in Nigeria. Despite the use of these various procurement methods, building projects usually suffer delays, cost overruns and poor quality. Babatunde *et al*., (2010) claim that clients are mostly dissatisfied because they expect delivery of buildings that are well built in terms of quality, cost and time. The Nigerian building industry contributes significantly to the development process in the country; however, it is mast by underperformance due to several challenges as discussed in the following section.

3.5.1 Challenges facing the Nigerian Building Industry

The Nigerian building industry is faced with problems such as inadequate project financing, inadequate technical expertise, corrupt government practices and poor implementation of policies and programmes, shortage of skilled manual labour, the relatively high cost of hiring staff at managerial level, the shortage of building materials and the dominance of the industry by foreign construction companies (Oseni, 2015; Oladinrin *et al*., 2012). With reference to Idoro (2009), the dominance of foreign companies in the building industry is a major challenge to the growth of local companies. Companies such as Julius Berger, Setraco Nigeria, Cappa & D'Alberto and China Civil Engineering Construction Corporation are examples of such companies and control almost 95% of the market.

Although there are hundreds of local construction companies, few have the capacity to cope with really large projects. They often partner with these foreign companies to have access to high technological equipment (Idoro, 2009). This situation has led to the local companies struggling with inadequate technical and managerial know-how, insufficient funds, material and equipment capital base (Oladinrin *et al*., 2012). It has also forced the country's local companies to low level of human resources development required for; planning, designing, constructing and maintaining the magnitude (in size and number) of projects conceived by the government (Oseni, 2015).

Despite this obvious challenge, Mbamali and Okotie, (2012) argue that collaborations between local and foreign entrepreneurs, improved training institutions, engagement of expatriates, political stability, and improved government policies are factors that will help reduce the apparent resources gap between local companies and their foreign counterparts. According to Ofori (2001), the development and participation of the various building professional associations will help in mitigating the aforementioned challenges faced by the industry. These associations include the Nigerian Institute of Architects (NIA), Nigerian Institute of Building (NIOB), the Nigerian Institute of Quantity Surveyors (NIQS), Urban and Regional Planners of

Nigeria (URPON), the Institute of Surveyors, the Council for the Regulation of Engineering in Nigeria (COREN), the Nigerian Institute of Estate Surveyors and Valuers (NIESV) and the Nigeria Chapter of the International Facility Management Association and so on.

Other participants in the Nigerian building industry include building owners, operators, users of the constructed facilities, building finance and insurance agencies, land developers, real estate brokers, and material and equipment suppliers and manufacturers and the government. The government usually relates to the industry as purchaser, financier, regulator, and adjudicator (Oladinrin *et al*., 2012). Government participation with the industry is as a result of the minimal participation of the private sector in construction and infrastructure development (Frontier Market Intelligence, 2012). Mbamali and Okotie (2012) state that the government is likely to remain the major client for the sector due to their responsibility in the infrastructural development and the huge finance needed for such projects. However, there is growing interest in the private sector which includes oil companies, banks, hotels, international bodies such as the UN and non-governmental organisations in infrastructural development and the building industry.

3.5.2 Sustainable Building Practices in Nigeria

Few efforts have been made towards achieving sustainable buildings in Nigeria. Adegbile (2013) revealed a sustainable building in the Nigerian context, as a building that promotes health and encourages users to give their best at work. A building that is cost effective in its construction promotes efficient use of resources and promotes the appointment of contractors that are environmental conscious. According to Adegbile (2013), sustainable building practices in Nigeria include the use of locally produced and renewable building materials; efficient waste management system; designs that promotes flexibility, durability, adaptability and quality in design and observes all relevant legislation and regulations. It also includes practices that promote acoustic, visual, and thermal comforts, site suitability at construction; and incorporates Environmental Impact Assessment and Environmental Management Systems.

It is worth noting that buildings proven to satisfy thermal comfort, greenery, aesthetics, environmental friendliness and economic value have always been a major part of the daily life of Nigeria. Materials such as earth, timber, straw, and stone were used in time past to build simple, livable and affordable houses (Iwuagwu and Iwuagwu, 2015). These building materials have now been proven to be sustainable in nature as against modern building materials such as cement and concrete (Dayaratne, 2011). They are generally locally found, affordable, and environmentally friendly. However, over the years, the Nigerian building industry has replaced these comfortable, low-cost and sustainable buildings with modern ones which are in fashion and a show aesthetics and prestige in the society (Iwuagwu and Iwuagwu, 2015). Nevertheless, the building industry is now again reverting back with the rest of the world towards sustainable practices in buildings.

The search towards sustainable buildings in Nigeria has unveiled very scarce literature in relation to it and has also revealed the use of sustainable buildings and green buildings as two terms used interchangeably. This is probably as a result of the LEED rating system that has gained ground in the Nigerian building industry (Dahiru *et al*., 2014). The search revealed that while efforts are being made towards achieving sustainable buildings, Nigeria is struggling with providing habitable accommodation and buildings for its populace (Jiboye, 2012). However, few efforts have been made towards achieving sustainable buildings and one of such is the Green Building Retrofit of Energy Commission of Nigeria Headquarters Abuja, an initiative of the United Nations Development Programme and the Global Environment Facility.

The project is more of an energy retrofit and it accounts as an initiative taken by the government towards sustainable building. The project was undertaken by Julius Berger of Nigeria and has ongoing projects, like the Rose of Sharon Building and Nestoil Towers in Lagos State, and the Akwa Ibom Stadium Complex in Akwa Ibom State; all in Nigeria (NESP, 2014). The Nestoil Tower is a fifteen floor mixed-use development consisting of 7500 m2 of office space, 3500 m2 of residential space, a multi-story parking and recreational facilities. It is strategically located at the intersection of Akin Adesola and Saka Tinubu streets in the business district of Victoria island in Lagos state. The project is aimed at attaining a LEED certificate (ACCL, 2014). With reference to NESP (2014) Julius Berger Nigeria has the specialised knowledge and training needed to construct buildings that meet LEED standards for certification. These projects are new developments and have high capital cost and cannot be regarded as common practice in the Nigerian building industry.

Another initiative of the government is the development of the ‘National Building Code’ through the ‘National Council on Housing and Urban Development’. The Green Building Council Nigeria in conjunction with the Green Star South Africa has also developed the ‘Green Star SA for Use in Nigeria’. These efforts have been made with a view to proffering a lasting solution to the unsustainable practices in the building industry (National Building Code, 2006). The ‘Green Star SA for Use in Nigeria’ (GSSAN) is a building sustainability assessment tool for certification of sustainable buildings in Nigeria. The “National Building Code” is a document developed for buildings in Nigeria at the pre-design, design, construction and operations stages to provide solution to the harmful practices in the building industry. By this, Nigeria joins the rest of the world in tenacity to towards reducing unsustainable practices in the industry. The research at this stage looks briefly into the two aforementioned documents.

3.5.3 The National Building Code

Nigeria did not have standards or even guidelines for the design, construction, and operations or maintenance of buildings until the development of the 'National Building Code' in 2006. The development of the 'National Building Code' started in 1987 under the directive of the then 'National Council of Works and Housing'. It involved the participation of professionals from the six professional bodies in the Nigerian building industry namely: NIA, NIOB, COREN, NIQS, NIEWS and URPON. These professionals were contacted for input and few national workshops were conducted between the period of 1987 and 2005, which led to the eventual approval of the document by the Federal Executive Council of Nigeria for use in the Country in 2006 (National Building Code, 2006).

With reference to Mbamali and Okotie (2012), the basis for the development of the 'National Building Code' can be closely linked to the problems that pointed out the need for SD in the Nigerian built environment. Problems such as the scattered nature of buildings in city and town without proper planning layout, the frequent collapse of buildings, burning buildings, built environment abuse, use of unsustainable building materials, lack of maintenance culture and lack of design standards for professionals and the use of non-professionals. It was developed with the aim of setting minimum standards for buildings at the design, construction and operations stages with a view to ensuring quality, safety, and expertise in the building Industry. However, the document is short in meeting the provision for these standards.

Unlike the ISO 15392, the 'National Building Code' does not address issues such as land use efficiency, pollution, energy and particularly in relation to renewable energy and energy efficient transportation and equipment, accessibility to public transport, proximity to amenities and alternative modes of transport, maximum car parking capacity in order to help reduce transport-related pollution under the environmental aspects; and so there is no consideration for issues such as building life-cycle cost, energy, material and water efficiency, maintenance and management of construction waste under the economic aspect. In the area of the social aspect, the document covers most of the issues addressed by BREEAM-NC (2012), LEED-NC (2009), and ISO 15392.

3.5.4 The 'Green Star SA for Use in Nigeria'

The establishment of the Green Building Council Nigeria (GBCN) is one of the efforts made by building professionals in Nigeria towards sustainability in buildings. The Council is registered with the 'World Green Building Council' as of January 2014 on the prospective membership level. The council is made up of a robust group of building professionals as earlier stated and is a private sector initiative for environmental development and sustainability. Membership is structured in such a way that it is companies or organisations that hold membership and not individuals unless the company itself is a one person operation (GBCN, 2014).

The objectives of the 'Green Building Council Nigeria' are (GBCN, 2014):

- To raise awareness among building professionals in relation to the built environment;
- To encourage and promote training of building professionals in the practice of the design, construction, and operations of sustainable or green buildings;
- To develop an appropriate rating tool for green building development and application of such to both existing and new buildings;
- To promote research in the development of green buildings;
- To build a relationship with organisations within and outside Nigeria, in relation to sustainable or green building objectives.

One of the major achievements of the council is the development of the "Green Star SA for Use in Nigeria" (GSSAN) in conjunction with the Green Building Council South Africa. The building sustainability assessment tool was developed for the Nigerian built environment in relation to the legislation, policies and market practices in building sustainability specific to the Nigerian context. A study of the GSSAN shows that it is developed based on the framework of the GSSA which itself is built on existing systems and tools in the Green Star Australia. The green star Australia is a tool adopted from BREEAM. GSSAN (2014) is nearly as comprehensive as the BREEAM-NC (2012) because it based on the BREEAM framework, though slightly different particularly in the management section. GSSAN (2014) in particular deals with the management criterion that clearly states the involvement of the facilities manager in sustainable buildings, while the 'National Building Code' only addresses the building standards under the design, construction, and operations stages and makes no reference to the facilities manager's role.

GSSAN (2014) is the only attempt towards a building sustainability assessment tool for the Nigerian built environment and there is little evidence to show its use. The assessment tool encourages and recognises building design that facilitates maintenance throughout a building's life-cycle while minimally impacting the occupants. It, therefore, encourages that the design of buildings should reflect the need for maintenance by providing suitable access to facilities managers. According to GSSAN (2014), maintenance in buildings has not received much attention, as the emphasis has always been on the development of new properties. This confirms the finding by Ahmed (2000) and Kunya *et al*., (2007) who observed that there is a poor maintenance culture in Nigeria and that existing buildings are many often neglected for new ones.

In terms of energy, the GSSAN (2014) encourages designs that incorporate renewable and low emission energy sources, as the use of energy from sustainable energy sources in Nigeria is low. With reference to Edomah (2016), this is due to the high initial capital cost for new energy infrastructure; environmental considerations such as (a) visual and noise amenity (in the case of solar Photo-Voltaic and wind power generation) (b) height restrictions (in the case of wind power generation) and (c) birds/bats concerns (in the case of wind power generation) (d) reflection/flicker issues (in the case of solar Photo-Voltaic and wind power generation) (e) drilling operational issues (in the case of geothermal) and (f) heritage restrictions; and inadequate government policies (Edomah, 2016).

There is no energy efficiency requirements legislated by the current Nigerian building code standards; therefore, GSSAN encourages initiatives that reduce energy consumption associated with major appliances. Tajudeen (2015) also argues for policies that can influence consumers' lifestyles, preferences and behaviours and of the need to conserve the environment. Energy consumption, which is largely fossil fuel, is often accompanied by a significant increase in CO2 emissions, contributing to the environmental problem of climate change. To address this problem the Nigerian government has developed few regulations such the Petroleum Drilling and Production Regulation, Gas Reinjection Regulation, and the Environmental and Impact Assessment Act.

GSSAN (2014) confirms the use of low impact environmental and locally sourced materials in constructing buildings in Nigeria. This confirms the claim by Olotuah (2015) that in Nigeria there has been the use of low carbon materials and low carbon construction techniques in the building industry for quite some time. The low carbon materials include ‘compressed earth blocks’ for walling and ‘environmentally friendly mortar’ (Corinaldesi, 2012; Akadiri, 2015). These materials offer low carbon solutions. Stabilised earth bricks, especially when used for houses are suited for passive solar heating and cooling. They are suitable for the different climates in Nigeria as they are warm in cold seasons and cool in hot seasons (Akadiri, 2015). Building earth and stabilised earth brick houses involve considerably less fossil fuel-derived energy to build, than the conventional sandcrete buildings commonly found in many urban centers in Nigeria. The continuous use of these low carbon materials will reduce energy consumption and provide reductions in greenhouse gas emissions (Olotuah, 2015).

Earth as earlier stated is a locally sourced building material and can be in the form of clay, loam or silt. Minke (2012) affirms the use of loam as an excellent building material stating that loam has the characteristics to absorb and desorb humidity faster and to a greater extent than any other building material, enabling it to balance indoor climate. It can also be produced in the form of ‘Compressed Earth Blocks’. It is enhanced in very small amounts with either cement or lime component to achieve a thorough blend of earth, cement or lime mix. After aeration, the

‘Compressed Earth Blocks’ gain a high compressive strength appropriate generally for three floors constructions and even has higher potentials of up to five floors. These blocks can be left unplastered. It offers a cooler temperature which is popularly desired in warm countries like Nigeria than cement block houses (Ugochukwu and Ugochukwu, 2015). Developed countries are coming to the realisation that earth, as a natural building material, is superior to industrial building materials such as concrete, brick, and lime-sandstone. They also realise that careless exploitation of resources combined with energy-intensive production is not only wasteful; it also pollutes the environment and increases unemployment. In these countries, earth is being revived as a sustainable building material (Minke, 2012).

Ede and Okundaye (2014) and Atanda (2015) encourage the use of bamboo for the construction of buildings and confirm that it is a locally sourced material that can be utilised in Nigeria as a substitute for steel reinforcement. Studies have demonstrated that natural fiber (bamboo) reinforcement concrete is stronger, stiffer and more pliable than the conventional concrete or a steel reinforced concrete when subjected to irregular cyclic loads (Lakshmipathy and Sanathakumar, 1980). The constructional utilisation of bamboo in Nigeria includes fencing and scaffolding which is the major use of bamboo (RMRDC, 2004). Bamboo also reduces the use of timber consumption in construction and it is a high-yield renewable resource that can be harvested within 3–5 years, unlike most softwood having 10–20 years, and also they have a biomass of 2–5% unlike wood 10–30% (Atanda, 2015).

Akadiri, (2015) argues the above-mentioned building materials as sustainable materials and that it is a way to reduce the impact that buildings have on the environment. Akadiri and Olomolaiye (2012) describe the selection of sustainable building materials as the use of renewable and recycled sources in order to close the life-cycle loop of materials and select materials with the least environmental impact throughout their entire lifetime. In spite of Nigeria being naturally endowed with building materials such as the mentioned above, it cannot yet achieve enough for production for housing development in Nigeria. Developers also insist on the use of conventional building materials, in the bid to achieve some form of aesthetic value, thereby preventing the use of these readily available local building materials (Iwuagwu and Eme-anele, 2012).

GSSAN (2014), however, encourages the use of locally sourced materials as it stimulates the growth of the building industry in Nigeria and even West Africa, and fosters the environmental advantages gained by using materials and products that are sourced within close proximity to the site. The sourcing of products manufactured intra-regionally is viewed as both an environmental and socio-economic driver of sustainable market transformation. The large proportion of building components, materials, and finishes imported into the country is indicated as a barrier to sustainable building practice in Nigeria.

According to Nwigwe (2008), basic waste management plans and processes are followed on some building projects in Nigeria, however, is challenged by waste disposal habit of the people, attitude to work, lack of adequate equipment, plant and tools necessary for waste disposal and collection, corruption, overlap of function of the state enforcement and waste management agency, and population effect. GSSAN (2014) encourages management practices that minimise the amount of construction waste going to disposal and during the operations stage of a building.

There is evidence of sustainable building practices in the Nigeria building industry as seen in the discussion above and significant efforts have been made in developing standards that can be implemented to achieve sustainability in buildings. However, to achieve the level of building sustainability required by international standards, a lot still needs to be done.

3.6 Chapter Summary

The chapter examined the various definitions of sustainable building and defined sustainable building in the context of the research as a healthy building facility, designed and built in a beginning of life to the end of life resource-efficient manner, using environmental principles, social equity, and life-cycle quality value, and which promotes a sense of community. The chapter identified 51 sustainable building constituents as highlighted by internationally recognised standards namely; BREEAM-NC (2012), LEED-NC (2009), and ISO 15392, and researchers on the subject matter. These include 19 under the environmental aspect, 12 under the social aspect, 6 under the economic aspect, and 14 under the management aspect of SD.

The chapter identified sustainable building constituents in relation to the different stages of the building life-cycle as highlighted by the RIBA Plan of Work 2013. The identification of the 51 constituents has helped with the achievement of Objective 1 for this research study and forms a basis for identifying sustainable building constituents in the Nigerian context and which is discussed in Chapter 7. The identification of the sustainable building constituents was based on the environmental, social, economic, and management aspects of SD as identified in Chapter 2. When these constituents are incorporated into the design stage of the building life-cycle, there is greater chance of achieving sustainable building. The identification of the sustainable building constituents will be used as a basis for identifying the facilities manager’s roles in achieving sustainable buildings in Chapter 4. This chapter, therefore, sets the background for identifying the facilities manager’s role in sustainable building.

CHAPTER 4: ROLE OF FM IN SUSTAINABLE BUILDING

4.0 Introduction

In the previous chapter, the constituents that make up a sustainable building were identified in literature and documents relating to sustainability in buildings. Since the aim of this research study is to develop a framework for facilities managers in achieving sustainable buildings in Nigeria, there is need to now examine roles of the facilities manager that relate to the identified sustainable building constituents in Chapter 3. This chapter therefore, focuses on the facilities manager's roles in sustainable buildings. The chapter is made up of Section 4.1 to Section 4.7. Section 4.1 starts with discussion on various definitions of facilities management from previous studies and Section 4.2 discusses the development of FM. Section 4.3 and 4.4 examines the development of sustainable buildings and FM role in the Nigerian context and this followed by Section 4.5 which discusses on the facilities manager's role at the design, construction and operations stages of the building. Section 4.6 identifies and evaluates the facilities manager's role in relation to sustainable building. The Chapter ends with the chapter summary in Section 4.7. This chapter fulfils Objective 2 of this research, which is to evaluate the role of FM in relation to sustainable building at the design, the construction and operations phases of the building life-cycle.

4.1 Facilities Management Definition

According to the South Africa Facilities Management Association (SAFMA), FM is defined as a process that enables of sustainable enterprise in relation to the whole life management of workplaces in order to achieve productivity and support business effectively (SAFMA, 2012). Facilities Management Association of Australia (FMAA) describes it as a practice that ensures effective operational management of buildings, in both public and private organisations, comprising of a broad range of activities from strategic operational planning to daily physical maintenance, cleaning and the management of environmental performance issues (FMAA, 2014). The European Facility Management Network (EuroFM) view FM as the integration of various processes within an organisation in order to maintain and develop services which support and improve the effectiveness of the organisations primary activities. This definition was formed and adopted by European FM professionals (EuroFM, 2014).

However, the International Facility Management Association (IFMA) and the British Institute of Facilities Management (BIFM) in their own definition of FM include the integration of people in the workplace and other processes as shown in the FM model developed by IFMA in Figure 4.1. They define it as '*the incorporation of multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology*' (IFMA, 2014) and '*the integration of processes within an organisation in the built environment to maintain and develop the agreed services which support and improve the effectiveness of the organisation's primary activities and management of the impact of these processes upon people and the* *workplace*' (BIFM, 2014). FM can be said to a profession that seeks to help others achieve their goals and it is predominantly a people oriented and customer-focused industry and profession.

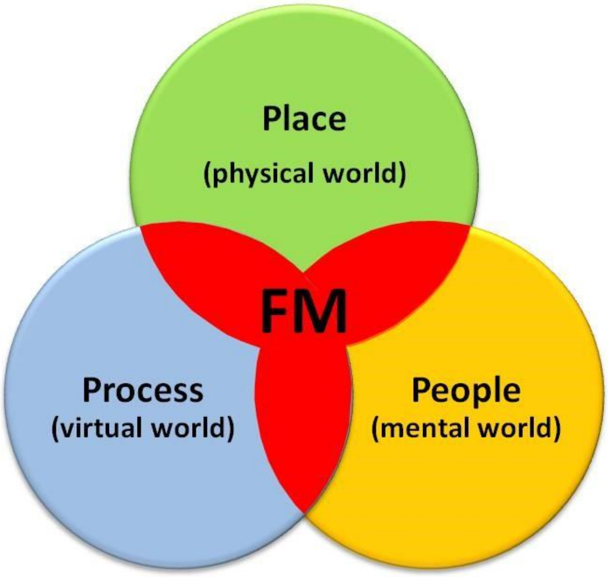

Figure 4.1: People, Process and Place FM Model
Source: EuroFM (2014)

Table 4.1 shows several definitions of FM and including the ones stated above, showing the diversified views of FM due to various opinions of what FM practice should cover. All these definitions agree that FM is a practice and process that cuts across and integrates diverse disciplines, processes, people, physical assets, and technology in order to maintain and develop services which will promote an organisation's core objectives. The definitions of FM stated by the International Facility Management Association (IFMA), the British Institute of Facilities Management (BIFM), the Royal Institute of Chartered Surveyors (RICS), the Facilities Management Association of Australia (FMAA), the Hong Kong Institute of Facilities Management (HKIFM), the Japan Facility Management Association (JFMA) and the South African Facilities Management Association (SAFMA) is an evidence to the fact that FM incorporates all activities to enable an organisation to meet its primary target. These associations according to Awang *et al.*, (2013) are rated leading FM associations in the world and their FM definitions are quite comprehensive.

Table 4.1 Facilities Management Definitions

Source	FM Definitions
BIFM (2014)	FM is the integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities.
IFMA (2014)	FM is a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology.
RICS (2014)	FM is the total management of all services that support the core business of an organisation using best business practice to reduce a company's operating costs and at the same time increasing productivity.
FMA Australia (2014)	FM is responsible for the effective operational management of the buildings, crossing all public and private organisations, covering a broad spectrum of activities from strategic operational planning to daily physical maintenance, cleaning and the management of environmental performance issues.
HKIFM (2014)	FM is the process by which an organisation integrates its people, work process and physical assets to serve its strategic objectives.
SAFMA (2012)	FM is an enabler of sustainable enterprise performance through the whole life management of productive workplaces and effective business support services.
JFMA (2006)	FM is a comprehensive management approach for the optimization of the ownership, utilization, operation, and maintenance of the business real properties (land, buildings, structures, equipment, etc.) and maintaining it in optimal conditions (minimum costs & maximum effects), so that it can contribute to the overall management of the
Atkin and Brooks (2009)	FM is the creation of an environment that is conducive for carrying out an organisation's primary operations, an integrated view of the services infrastructure and using this to deliver customer satifaction and best value through support for and enhancement of the core business.
Pathirage et al., (2008)	FM is the management of company assets and non-core activities to support and increase the efficiency of the core business of any organisation.
Barrett and Baldry (2003)	FM is an integration approach to maintaining, improving and adapting the buildings of an organisation in order to create an environment that strongly supports the primary objectives of that organisation".
Bruijn et al. , (2001)	FM is a set of practices concerned with the management (integration and co-ordination) of buildings and building services by embracing skills required at the inception of building design and subsequently throughout the whole construction process and operational cycle.
Teicholz (2001)	FM is a multidisciplinary profession drawing on theories and principles of engineering, architecture, design, accounting, finance, management and behavioural science.
Price (2000)	FM is an integrated approach to operating, maintaining, improving and adapting the buildings and infrastructure of an organisation in order to create an environment that strongly supports the primary objectives of that organisation.
Then (1999)	FM is the practice of co-ordinating people and the work of an organisation into the physical workplace.
Alan (1998)	FM is the structuring of a building and its content to enhance the creation of an organisation that meets its objectives
Alexander (1996)	FM is the process by which an organisation ensures that its buildings, systems and services support core operations and processes as well as contribute to achieving its strategic objectives in changing conditions.
Cotts and Lee 1992	The practice of co-ordinating the physical workplace with the people and work of the organization; it integrates the principles of business administration, architecture and the behavioural and engineering sciences
Thomson (1990)	FM is the management of an organisation's accomodation and assets through time in the most cost effective way to meet agreed business objectives.
Becker (1987)	The practice responsible for co-ordinating all efforts related to planning, design and managing buildings and their systems, equipment and furniture to enhance the organization's ability to compete successfully in a rapid changing

Source: Self Study

According to Armstrong (2002), the activities in an organisation includes business administration, architecture, behavioural, and engineering sciences and is viewed by HKIFM (2010) as an art and science that promotes the synergy of effective people with their building and assets enhancing an organisation's competitiveness. This is viewed by Alexander (2003) as the key to an organisation meeting up with changing conditions. JFMA (2006) adds that FM also manages information technology, property portfolio that could contribute to the overall management of the business, conditions of facilities, and day to day operations such as cleaning, maintenance, and repairs; to improve an organisation's business.

FM utilises the principles of multiple disciplines to manage the functions of people, processes, and technology through time in the most cost effective way (Alexander, 1996; Atkin and Brooks, 2005). This shows the new view towards FM as a strategically integrated approach to maintaining, improving and adapting buildings and supporting services of an organisation in order to create an environment that strongly supports the primary objectives of that organisation (Barret and Baldry, 2003; Nutt, 2004). It also involves using best business practices to reduce a company's operating costs and at the same time increase productivity (RICS, 2014). This is supported by Alexander (1996) and Atkin and Brooks (2005) who states that FM coordinates the operation of the built environment, maintains, improves and adapts buildings and its assets. It can be said that FM is involved with the running of the building in order to meet an organisations' agreed business objectives and deliver customer satisfaction and best value, supporting and enhancing the core business.

However, according to Spedding and Holmes (1994), the aim of FM should be not just to optimise running costs of buildings, but to raise the efficiency of the management of space and related assets for people and processes. This is done in order that the mission and goals of the organisation may be achieved at the best combination of efficiency and cost. To carry out this role, FM applies quality techniques to improve the quality of the building, add value to the building and reduce the risks involved in occupying a building and delivering reliable support services. This approach provides an operational environment to meet the strategic needs of an organisation (Barret and Baldry, 2003).

In regards to the context of this research, the role of FM in sustainable buildings is evaluated in order to determine its functions in sustainable buildings. Therefore, the research takes forward Pearson (2003) description of FM as a profession that utilises useful information to help building owners and operators, designers and building contractors to develop and fit buildings to meet users' needs, develop more business, aid competitiveness and improve environmental performance by the reduction of energy and material waste at the operational phase. This particular definition of FM has been selected because the research focuses on FM functions from the design phase, through the construction phase to the operations phase of a building and the influence of FM in reducing the negative impact made by buildings on the environment.

4.2 The Development of Facilities management

Up until forty years ago, organisations maintained, serviced and cleaned their buildings using in-house staff. The concept of FM had not yet evolved (Atkin and Brooks, 2005). FM started in the United States and owes its origin to the growth of office administration, especially in the areas of bringing together large groups of people and computers to fit into office spaces in buildings. In the 1960s, Ross Perot in the United States in his efforts to fit computers into the workplace invented the term ‘facilities management’ (FM). However, the scope of FM has widened since then to include systems, furniture and office design (Wiggins, 2010).

The move toward using systems furniture known as cubicles and the introduction of computer terminals into the workplace, and managers of workplaces needing guidance on how to manage these and people, helped in starting the course of FM. This guidance was later provided by the Facility Management Institute (FMI) was founded in 1979. Before this time, no organisation focused on providing information to manage the office environment (IFMA, 2014). In 1980 the National Facility Management Association (NFMA) was formed and in that same year, gave birth to the International Facility Management Association (IFMA) to accommodate a growing Canadian membership. IFMA is the world's largest and most widely recognized international association for FM professionals, supporting more than 24,000 members in 94 countries (IFMA, 2014).

Since then, FM has developed as a vocation, handling complex and challenging roles and it has helped contribute to the business performance of organisations around the world (Alexander, 2003). The FM market spread across to Europe with the establishment of EuroFM in 1990 and the British Institute of Facilities Management (BIFM) in 1993 (Shah, 2007). The BIFM is a merger of the Association of Facilities Managers (AFM) launched in 1986 and the Institute of Facilities Management (IFM) launched in 1990. These institutions provide information on the state-of-the-art developments of FM, which helps members to make more informed business decisions through effective management (Wiggins, 2010).

In other developed countries such as Japan, New Zealand, Hong Kong, Singapore Australia and South Africa, FM has been successfully developed and established. It is recognised in these countries as an activity that can achieve more effective management of buildings, its services, and associated workforce, in support of the strategic objectives of an organisation (Kamaruzzaman and Zawawi, 2010). According to Shah (2007) FM in Australia is one of the fast growing industries with an annual turnover of more than AUD$60 billion. Germany and France are also significant FM markets.

In developing countries such as Malaysia, Uganda and Nigeria, FM is still developing. Malaysia for instance, is now putting great focus and emphasis on FM, particularly in the public sector (Kamaruzzaman and Zawawi, 2010). In Uganda, the FM industry, though not officially recognised, exists in a capacity to grow steadily in line with the economy (Natukunda, 2013). This is the conclusion of a study carried out in order to project the growth of FM in Uganda. In Nigeria, FM is relatively new and the growth of the profession has been slow. It is practiced in government agencies, corporations and non-profit institutions that have realised the benefits of FM (Adewunmi *et al.*, 2012). There is also the presence of the International Facility Management Association (IFMA) Nigerian Chapter and limited research has been conducted in relation to FM in corporate organisations, outsourcing in FM, FM in relations to higher institutions of learning and sustainable FM.

FM have in time past was viewed as merely playing a co-ordination role; integrating the work of specialists such as property and estates, construction and refurbishment, space management, IT, support services, and maintenance (Bell, 1992). It took a quiet role in business organisations, however, with rising energy costs, indoor air quality concerns and the greening of the workplace, companies are realising the effect of FM on their businesses and the well-being of their employees. FM now combines environmental commitment with its role of managing buildings and its associated services and also manages the building users themselves to promote productivity (Noor and Pitt, 2009). This affords the FM department an opportunity to have a larger role in helping organisations achieve their goals (Putnam and Price, 2004). Many organisations are now associating everyday business performance to their method of managing their facilities and workplace assets (Edum-Fotwe *et al.*, 2003).

Nowadays as shown in Figure 4.2, FM covers real estate management, financial management, change management, space management, human resources management, health and safety, contract management, in additional to building and engineering services maintenance, domestic services, and utilities supplies (Kamaruzzaman and Zawawi, 2010). These services are all part of resource management as confirmed by Edum-Fotwe *et al.*, (2003) and Nit-Mat *et al.*, (2011). Resource management helps to reduce costs and improve work flexibility which enables an organisation to competitive advantage (Alexander, 2003).

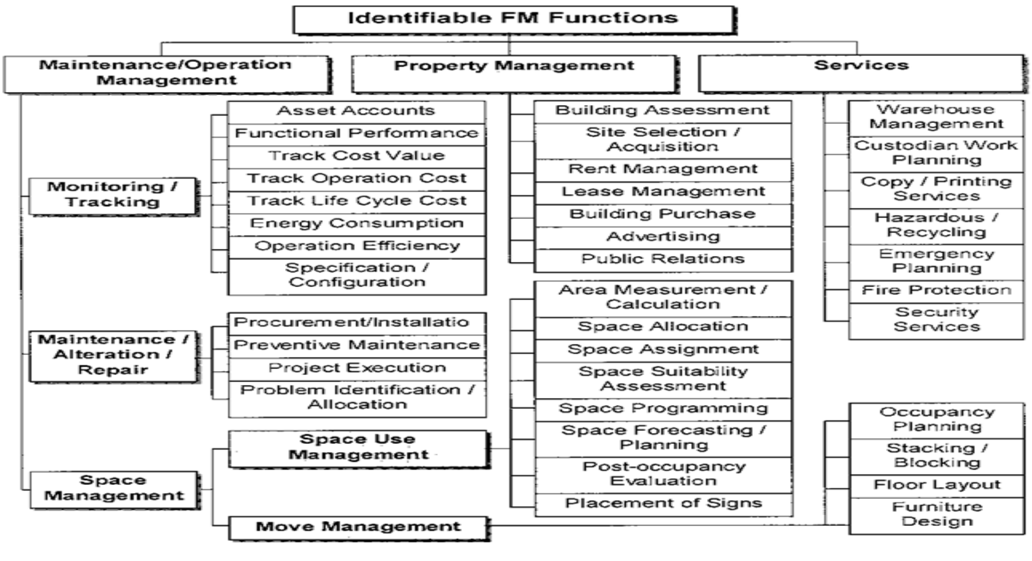

Figure 4.2: Identifiable FM functions
Source: Yu *et al.*, (2000)

FM concentrates on management issues over technical matters. This is seen in a study carried out by Barrett and Baldry (2003). The study focusses on FM department in different establishments ranging from a small manufacturing company to public sector organisation. The table shows different FM organisations. It reveals that despite the different organisational size and structure, they all work towards supporting their organisation to meet core business objectives and manage services and processes that help to achieve this. Their study showed FM as part of the strategic planning of any organisation and FM not only as a department dealing with cleaning and maintenance but also helping to meet the core business objectives of their organisations (Alexander, 1996).

The application of FM techniques enables organisations to provide the right environment for conducting their business on a cost-effective and best value basis. If buildings and other facilities are not managed, they can begin to impact upon an organisation's performance. FM has the potential to enhance performance by contributing towards the provision of the optimum working and business environment (Atkin and Brooks, 2005). In order for FM to develop in the strategic delivery of its services Nutt (2004) proposes a more developed view of FM. Meaning that FM should be run based on an organisation's business plan. FM should reflect an organisation's business objectives, needs, and policies. Atkin and Brooks (2005) also propose that FM should strategically handle even non-core business services, in order to empower an organisation to function in the most effective way to produce the best value for money while still supporting core operations. Hodges (2005) promotes the strategic delivery of FM services in order to contribute to SD in buildings and this involves the facilities manager:

- Appreciation of the organisation's philosophy and strategy towards handling finances.
- Encouraging the strategic planning process for the organisation.
- Developing a strategic plan for achieving sustainability.
- Executing the strategy and
- Supporting the achievement of long-lasting facilities.

To improve strategic delivery, FM also needs to develop in knowledge management (KM) of the various fields it manages. KM is the management of information, knowledge and experience available to an organisation in order that organisational activities build on what is already known and extend further on the knowledge (Mayo, 1998). According to Manasco (1996) and Bassie (1997), KM encompasses the strategies and processes of identifying, capturing, creating and using knowledge to enhance organisational performance, thereby, creating business value and competitiveness (Pathirage *et al.*, 2008). It is about encouraging individuals to communicate their knowledge by creating environments and systems for capturing, organising, and sharing knowledge throughout the company (Martinez, 1998).

The London Times as cited in Nutt and McLennan (2000) reviewed KM as the “fifth discipline” after business strategy, accounting, marketing, and human resources. Yet, KM in FM has been given little attention despite documented evidence of its benefits in business (Puddy *et al.*, 2001). Many FM firms are limited in identifying and understanding what knowledge is important to enhance their function as facilities managers, to capture this knowledge and promote its use throughout their organisations, and their project teams (Nutt and McLennan, 2000). Dettwiler (2009) highlights the benefits that KM can have on FM delivery. He argues that FM as a profession needs to manage effectively the different information underlying the multidisciplinary facets it incorporates. Some of the information to be managed by the facilities manager is the Corporate Responsibility (CR) report. The FM industry has a major role to play in the provision of accurate and transparent information in CR reporting. CR reports according to Shah (2007) are public reports by companies, providing internal and external stakeholders with a picture of corporate positioning and activities on economic, environmental and social dimensions. According to him, such reports attempt to describe a company’s contribution to SD.

FM is a web of knowledge that combines management concepts and technical expertise. This knowledge is applied systematically to provide an optimum sustainable working environment (McLennan, 2000). According to Nutt (1999), FM has three main sources, inter alia, which it derives its knowledge base from and these are: knowledge of property and construction; FM knowledge; and knowledge of facilities design and use. Bell (1992) argues that facilities managers need to possess a broad knowledge base in construction and property management, and business administration. This, however, puts the FM profession at a disadvantage because there remains an absence of educational pathways at all levels of FM career development that aids this knowledge in the aforementioned fields (Best *et al.*, 2003).

Another major goal of FM is the use of life-cycle assessment (LCA) tool in reducing overall environmental impact. This is a comparative analysis tool and a necessary part of the design process especially when promoting sustainability as a primary objective (Brown and Pitt, 2001). It is a tool for systematically analysing the environmental performance of products over their entire life-cycle, including raw material extraction, manufacturing, use, and end-of-life disposal and recycling. Hence, LCA is often considered a “cradle to grave” approach to the evaluation of environmental impacts and can be used for buildings (Joshi, 1999). LCA tools are also considered to be of importance for FM seeking to improve environmental efficiency (Brown and Pitt, 2001). Environmental efficiency has been defined as “the achievement of the maximum benefit for each unit of resources and waste produced" (EU, 1996). According to Brown and Pitt (2001), the key areas to look into when assessing environmental efficiency is energy consumption, pollution, and natural resource usage. Achieving environmental efficiency in the built environment involves the reduction of unhealthy gases into the atmosphere such as CO_2, NOX, and SO_2 emissions.

It can be inferred from the above, that FM has grown from a small maintenance unit to a corporate profession that deals with board room management, decisions and strategic planning, knowledge management and environmental impact management in order to assist organisations achieve their objectives and minimise harm to the environment. FM is now seen as a profession that is critical to monitoring of the building's negative impact on the environment, ensuring that the building is comfortable and healthy for building users at the most economic cost.

Since this research study focusses on achieving sustainable buildings in Nigeria through the facilities manager's role, there is need to determine a sustainable building in the Nigerian context; few efforts have been made towards meeting this need. Adegbile (2013) revealed a sustainable building in the Nigerian context, as a building that promotes health and encourages users to give their best at work. It is also a building that is cost effective in its construction and promotes the efficient use of resources and appointment of contractors who are environmentally conscious. According to Adegbile (2013), sustainable building practices in Nigeria include the use of locally produced and renewable building materials; efficient waste management system; designs that promotes flexibility, durability, adaptability and quality in design and observes all relevant legislation and regulations. It also includes practices that promote acoustic, visual, and thermal comforts, site suitability at construction; and incorporates Environmental Impact Assessment and Environmental Management Systems.

It is worth noting that buildings proven to satisfy thermal comfort, greenery, aesthetics, environmental friendliness and economic value have always been a major part of the daily life of Nigeria. Materials such as earth, timber, straw, and stone were used in time past to build simple, liveable and affordable houses (Iwuagwu and Iwuagwu, 2015). These building materials have now been proven to be sustainable in nature as against modern building materials such as cement and concrete (Dayaratne, 2011). They are generally locally found, affordable, and environmentally friendly. However, over the years, the Nigerian building industry has replaced these comfortable, low-cost and sustainable buildings with modern ones which are in fashion and a show aesthetics and prestige in the society (Iwuagwu and Iwuagwu, 2015). Nevertheless, the building industry is now again reverting back with the rest of the world towards sustainable practices in buildings.

4.3 Sustainable Building Practices in Nigeria

The search towards sustainable buildings in Nigeria has unveiled very scarce literature in relation to it and has also revealed the use of sustainable buildings and green buildings as two terms used interchangeably in the country. This is probably as a result of the LEED rating system that has gained ground in the Nigerian building industry (Dahiru *et al*., 2014). The search also revealed that while efforts are being made towards achieving sustainable buildings, Nigeria is struggling with providing habitable accommodation and buildings for its populace

(Jiboye, 2012). However, few efforts have been made towards sustainable buildings and one of such is the Green Building Retrofit of Energy Commission of Nigeria Headquarters Abuja, an initiative of the United Nations Development Programme and the Global Environment Facility.

The project is more of an energy retrofit and can account as an initiative taken by the government towards sustainable building. The project was undertaken by Julius Berger of Nigeria and has ongoing projects, like the Rose of Sharon Building and Nestoil Towers in Lagos State, and the Akwa Ibom Stadium Complex in Akwa Ibom State; all in Nigeria (NESP, 2014). The Nestoil Tower is a fifteen floor mixed-use development consisting of 7500 m2 of office space, 3500 m2 of residential space, a multi-story parking and recreational facilities. It is strategically located at the intersection of Akin Adesola and Saka Tinubu streets in the business district of Victoria island in Lagos state. The project is aimed at attaining a LEED certificate (ACCL, 2014). With reference to NESP (2014) Julius Berger Nigeria has the specialised knowledge and training needed to construct buildings that meet LEED standards for certification. These projects are new developments and have high capital cost and cannot be regarded as common practice in the Nigerian building industry.

Another initiative of the government is the development of the 'National Building Code' through the 'National Council on Housing and Urban Development'. The Green Building Council Nigeria in conjunction with the Green Star South Africa has also developed the 'Green Star SA for Use in Nigeria'. These efforts have been made with a view to proffering a lasting solution to the unsustainable practices in the building industry (National Building Code, 2006). The 'Green Star SA for Use in Nigeria' (GSSAN) is a building sustainability assessment tool for certification of sustainable buildings in Nigeria. The "National Building Code" is a document developed for buildings in Nigeria at the pre-design, design, construction and operations stages to provide solution to the harmful practices in the building industry. By this, Nigeria joins the rest of the world in tenacity to towards reducing unsustainable practices in the industry. The research at this stage looks briefly into the two aforementioned documents.

4.3.1 The National Building Code

Nigeria did not have standards or even guidelines for the design, construction, and operations or maintenance of buildings until the development of the 'National Building Code' in 2006. The development of the 'National Building Code' started in 1987 under the directive of the then 'National Council of Works and Housing'. It involved the participation of professionals from the six professional bodies in the Nigerian building industry namely: NIA, NIOB, COREN, NIQS, NIEWS and URPON. These professionals were contacted for input and few national workshops were conducted between the period of 1987 and 2005, which led to the eventual approval of the document by the Federal Executive Council of Nigeria for use in the Country in 2006 (National Building Code, 2006).

With reference to Mbamali and Okotie (2012), the basis for the development of the 'National Building Code' can be closely linked to the problems that pointed out the need for SD in the Nigerian built environment. Problems such as the scattered nature of buildings in city and town without proper planning layout, the frequent collapse of buildings, burning buildings, built environment abuse, use of unsustainable building materials, lack of maintenance culture and lack of design standards for professionals and the use of non-professionals. It was developed with the aim of setting minimum standards for buildings at the design, construction and operations stages with a view to ensuring quality, safety, and expertise in the building Industry. However, the document is short in meeting the provision for these standards.

Unlike the ISO 15392, the 'National Building Code' does not address issues such as land use efficiency, pollution, energy and particularly in relation to renewable energy and energy efficient transportation and equipment, accessibility to public transport, proximity to amenities and alternative modes of transport, maximum car parking capacity in order to help reduce transport-related pollution under the environmental aspects; and so there is no consideration for issues such as building life-cycle cost, energy, material and water efficiency, maintenance and management of construction waste under the economic aspect. In the area of the social aspect, the document covers most of the issues addressed by BREEAM-NC (2012), LEED-NC (2009), and ISO 15392. The National Building Code seemly does not address some environmental issues as stated above and does not address the economic and social aspects. This and moving towards a more sustainable built environment may be what encouraged the development of the "Green Star SA for use in Nigeria".

4.3.2 The 'Green Star SA for Use in Nigeria'

The establishment of the Green Building Council Nigeria (GBCN) is one of the efforts made by building professionals in Nigeria towards sustainability in buildings. The Council is registered with the 'World Green Building Council' as of January 2014 on the prospective membership level. The council is made up of a robust group of building professionals as earlier stated and is a private sector initiative for environmental development and sustainability. Membership is structured in such a way that it is companies or organisations that hold membership and not individuals unless the company itself is a one person operation (GBCN, 2014).

The objectives of the 'Green Building Council Nigeria' are (GBCN, 2014):

• To raise awareness among building professionals in relation to the built environment;

• To encourage and promote training of building professionals in the practice of the design, construction, and operations of sustainable or green buildings;

• To develop an appropriate rating tool for green building development and application of such to both existing and new buildings;

• To promote research in the development of green buildings;

• To build a relationship with organisations within and outside Nigeria, in relation to sustainable or green building objectives.

One of the major achievements of the council is the development of the "Green Star SA for Use in Nigeria" (GSSAN) in conjunction with the Green Building Council South Africa. The building sustainability assessment tool was developed for the Nigerian built environment in relation to the legislation, policies and market practices in building sustainability specific to the Nigerian context. A study of the GSSAN shows that it is developed based on the framework of the GSSA which itself is built on existing systems and tools in the Green Star Australia. The green star Australia is a tool adopted from BREEAM. GSSAN (2014) is nearly as comprehensive as the BREEAM-NC (2012) because it based on the BREEAM framework, though slightly different particularly in the management section. GSSAN (2014) in particular deals with the management criterion that clearly states the involvement of the facilities manager in sustainable buildings; while the 'National Building Code' only addresses the building standards under the design, construction, and operations stages and makes no reference to the facilities manager's role.

GSSAN (2014) is the only attempt towards a building sustainability assessment tool for the Nigerian built environment and there is little evidence to show its use. The assessment tool encourages and recognises building design that facilitates maintenance throughout a building's life-cycle while minimally impacting the occupants. It, therefore, encourages that the design of buildings should reflect the need for maintenance by providing suitable access to facilities managers. According to GSSAN (2014), maintenance in buildings has not received much attention, as the emphasis has always been on the development of new properties. This confirms the finding by Ahmed (2000) and Kunya *et al*., (2007) who observed that there is a poor maintenance culture in Nigeria and that existing buildings are many often neglected for new ones.

In terms of energy, the GSSAN (2014) encourages designs that incorporate renewable and low emission energy sources, as the use of energy from sustainable energy sources in Nigeria is low. With reference to Edomah (2016), this is due to the high initial capital cost for new energy infrastructure; environmental considerations such as (a) visual and noise amenity (in the case of solar Photo-Voltaic and wind power generation) (b) height restrictions (in the case of wind power generation) and (c) birds/bats concerns (in the case of wind power generation) (d) reflection/flicker issues (in the case of solar Photo-Voltaic and wind power generation) (e) drilling operational issues (in the case of geothermal) and (f) heritage restrictions; and inadequate government policies (Edomah, 2016).

There is no energy efficiency requirements legislated by the current Nigerian building code standards; therefore, GSSAN encourages initiatives that reduce energy consumption associated with major appliances. Tajudeen (2015) also argues for policies that can influence consumers' lifestyles, preferences and behaviours and of the need to conserve the environment. Energy consumption, which is largely fossil fuel, is often accompanied by a significant increase in CO2 emissions, contributing to the environmental problem of climate change. To address this problem the Nigerian government has developed few regulations such the Petroleum Drilling and Production Regulation, Gas Reinjection Regulation, and the Environmental and Impact Assessment Act.

GSSAN (2014) confirms the use of low impact environmental and locally sourced materials in constructing buildings in Nigeria. This confirms the claim by Olotuah (2015) that in Nigeria there has been the use of low carbon materials and low carbon construction techniques in the building industry for quite some time. The low carbon materials include ‘compressed earth blocks’ for walling and ‘environmentally friendly mortar’ (Corinaldesi, 2012; Akadiri, 2015). These materials offer low carbon solutions. Stabilised earth bricks, especially when used for houses are suited for passive solar heating and cooling. They are suitable for the different climates in Nigeria as they are warm in cold seasons and cool in hot seasons (Akadiri, 2015). Building earth and stabilised earth brick houses involve considerably less fossil fuel-derived energy to build, than the conventional sandcrete buildings commonly found in many urban centers in Nigeria. The continuous use of these low carbon materials will reduce energy consumption and provide reductions in greenhouse gas emissions (Olotuah, 2015).

Earth as earlier stated is a locally sourced building material and can be in the form of clay, loam or silt. Minke (2012) affirms the use of loam as an excellent building material stating that loam has the characteristics to absorb and desorb humidity faster and to a greater extent than any other building material, enabling it to balance indoor climate. It can also be produced in the form of ‘Compressed Earth Blocks’. It is enhanced in very small amounts with either cement or lime component to achieve a thorough blend of earth, cement or lime mix. After aeration, the ‘Compressed Earth Blocks’ gain a high compressive strength appropriate generally for three floors constructions and even has higher potentials of up to five floors. These blocks can be left unplastered. It offers a cooler temperature which is popularly desired in warm countries like Nigeria than cement block houses (Ugochukwu and Ugochukwu, 2015). Developed countries are coming to the realisation that earth, as a natural building material, is superior to industrial building materials such as concrete, brick, and lime-sandstone. They also realise that careless exploitation of resources combined with energy-intensive production is not only wasteful; it also pollutes the environment and increases unemployment. In these countries, earth is being revived as a sustainable building material (Minke, 2012).

Ede and Okundaye (2014) and Atanda (2015) encourage the use of bamboo for the construction of buildings and affirm that it is a locally sourced material that can be utilised in Nigeria as a substitute for steel reinforcement. Studies have demonstrated that natural fiber (bamboo) reinforcement concrete is stronger, stiffer and more pliable than the conventional concrete or a steel reinforced concrete when subjected to irregular cyclic loads (Lakshmipathy and Sanathakumar, 1980). The constructional utilisation of bamboo in Nigeria includes fencing and scaffolding which is the major use of bamboo (RMRDC, 2004). Bamboo also reduces the use of timber consumption in construction and it is a high-yield renewable resource that can be harvested within 3–5 years, unlike most softwood having 10–20 years, and also they have a biomass of 2–5% unlike wood 10–30% (Atanda, 2015).

Akadiri, (2015) argues the above-mentioned building materials as sustainable materials and that it is a way to reduce the impact that buildings have on the environment. Akadiri and Olomolaiye (2012) describe the selection of sustainable building materials as the use of renewable and recycled sources in order to close the life-cycle loop of materials and select materials with the least environmental impact throughout their entire lifetime. In spite of Nigeria being naturally endowed with building materials such as the mentioned above, it cannot yet achieve enough for production for housing development in Nigeria. Developers also insist on the use of conventional building materials, in the bid to achieve some form of aesthetic value, thereby preventing the use of these readily available local building materials (Iwuagwu and Eme-anele, 2012).

GSSAN (2014), however, encourages the use of locally sourced materials as it stimulates the growth of the building industry in Nigeria and even West Africa, and fosters the environmental advantages gained by using materials and products that are sourced within close proximity to the site. The sourcing of products manufactured intra-regionally is viewed as both an environmental and socio-economic driver of sustainable market transformation. The large proportion of building components, materials, and finishes imported into the country is indicated as a barrier to sustainable building practice in Nigeria.

According to Nwigwe, (2008) basic waste management plans and processes are followed on some building projects in Nigeria, however, is challenged by waste disposal habit of the people, attitude to work, lack of adequate equipment, plant and tools necessary for waste disposal and collection, corruption, overlap of function of the state enforcement and waste management agency, and population effect. GSSAN (2014) encourages management practices that minimise the amount of construction waste going to disposal and during the operations stage of a building. Therefore, the above discussion confirms a sustainable building in the Nigerian context to be a building that mainly encourages reduced energy consumption, use of low impact environmentally and locally sourced materials and a building with adequate waste management system. It is also a building that manages cost and resources effectively during construction and encourages the involvement of participants who are environmental conscious as inferred by Adegbile (2013).

4.4 FM in Relation to Sustainable Building Practice in Nigeria

FM in Nigeria, like any other developing country is relatively new, though there are claims that the profession has been in existence since the 1980s (Adewunmi *et al*., 2009). It is practiced in government agencies, corporations and non-profit institutions that have realised that management of corporate assets using traditional organisational structures is inadequate. There is also the presence of the International Facility Management Association (IFMA) Nigerian Chapter which started in 1997 and offers guidance and opportunities to acquire expertise to its members in Nigeria (Ikediashi, 2012; Adewunmi *et al*., 2012).

Though the practice of FM in Nigeria is only gradually being integrated into the private and public sectors; there is limited research conducted in previous studies in relation to sustainable buildings. These include Adewunmi *et al*., (2009) who examined the extent of the estate surveyor's role in FM practice in Nigeria and conclude that estate surveyors are lacking in the core competencies of FM practice. The study did not investigate competencies that aid the facilities manager's role in achieving sustainable buildings. Oladokun (2011) examines FM practice in Nigeria and the findings reveal that, though various professionals in the building industry are involved in the practice of FM, the practice is still in its infancy as their major focus is on the management of buildings at the operation stage. The study revealed that facilities managers are not yet involved in the design and construction stages. The study did not examine FM role in sustainable buildings.

Adegoke and Adegoke (2013) and Gbadegesin and Babatunde (2015) investigates the use of FM in Nigerian higher institutions of learning. Their study focuses on utilising FM as a means to creating a more conducive environment for learning. Their studies both revealed FM outsourcing as a more efficient way of having an environment that is well structured and comfortable for learning. Odediran *et al*., (2015) also carried out a study on FM practices in the Nigerian public universities and also conclude that FM outsourcing is essential for improving facilities. Though, their study revealed FM as a sustainable tool for better performance of existing facilities in the universities, it did not consider sustainable FM practices that relate to creating sustainable buildings.

Some other studies have examined sustainable practices in relation to FM in organisations. These include Ikediashi *et al*., (2014) on the investigation on policy direction and drivers for sustainable FM practice in Nigeria and Adewunmi et al., (2012) on developing a sustainable approach to corporate FM in Nigeria. Ikediashi *et al*., (2014) reveal health and safety management, waste management, creating flexible working environment, and energy management as sustainable practices in FM. Adewunmi *et al*., (2012) reveal achieving energy efficiency as a very vital environmental practice within organisations. These studies also did not examine FM as a tool for sustainable buildings.

The study by Abigo *et al*., (2012), however, addresses the need for sustainable practices in the management of public buildings in Nigeria. Their study reveal the absence of legislations, sustainable policies, awareness, training of maintenance personnel, knowledge and senior management commitment as barriers to the management of public buildings by facilities managers. The study identifies some sustainable practices in the management of buildings, yet did not relate any of these practices to developing sustainable buildings.

Though, FM profession has been in existence in Nigeria for quite some time, the aforementioned studies indicate that research in FM in sustainable buildings is only just progressively increasing; for much effort towards sustainable practices in buildings need to be encouraged. To achieve sustainable buildings in Nigeria, GSSAN can be used to identify roles which the facilities manager can carry out in order to contribute towards sustainable building. IFMA Nigeria has not yet developed a document that discusses FM competencies in the Nigerian context. However, the facilities manager's role in sustainable buildings as identified in Section 4.3 can be used in discussing FM role in relation to GSSAN (2014) in the achievement of sustainable buildings in Nigeria.

Waste management: GSSAN (2014) encourages the management of practices that minimise the amount of construction waste going to disposal. The facilities manager can on advise recycling of construction waste which can be a source of an income for contractors and the environment can benefit from it as well. The facilities manager can also develop waste management strategies at the construction stage. According to Booty (2009), facilities managers are stewards of the built environment and waste management is a major part of their job description. The facilities manager in Nigeria is therefore, able to advise and encourage practices that will ensure waste during construction and the operational phase is managed appropriately.

Pollution: GSSAN (2014) encourages building designs with minimal car parking in order to facilitate the use of alternative modes of transportation for commuting and use of construction materials with low environmental impact. The facilities manager can advise on minimum car parking space and low-emission construction materials and finishes (Shah, 2007).

Environmental management: GSSAN identifies the adoption of a formal environmental management system in line with established guidelines during construction. This role relates to the facilities manager developing, advising and implementing policies that help to protect the environment (IFMA, 2009).

Renewable energy: GSSAN encourages designs that minimise energy use in order to reduce greenhouse gas emissions associated with operational phase. The facilities manager can advise on renewable energy sources in order to reduce the negative effects of energy combustion and to minimise the consumption of non-renewable energy sources (Wiggins, 2014)

Visual comfort: GSSAN encourages building designs that maximise day lighting, however, controlled by shading devices in order to control glare and adequate artificial lighting. The role of the facilities manager in relation to this constituent is to ensure that visual comfort is achieved. Booty (2009) argues that one of the functions of the facilities manager is to ensure that building users are visually comfortable.

Acoustic comfort: GSSAN encourages buildings that are designed to maintain internal noise levels at an appropriate level. The role of the facilities manager is to advice and ensures that the building is designed and constructed to minimise noise as much as possible. According to Booty (2009) the facilities manager can ensure that there is general acoustic comfort in the building.

Thermal comfort: GSSAN encourages building designs that provide a high level of thermal comfort. The facilities manager can advise on designs that will ensure thermal comfort such as individual thermal comfort control. With reference to Akande (2015) individual control is necessary as climate in Nigeria is characterised with high temperature and humidity all year round and the rate at which individuals react to heat is different. Therefore, cooling at different levels may be required for different occupants in a building.

Indoor Air quality: GSSAN encourages building designs that provide adequate amounts of outside air to neutralise build-up of indoor pollutants. It states that the effective distribution of air in a space is an important element in providing a good indoor environment. Armstrong (2005) states that the facilities manager can advise on building designs and systems that encourage effective air ventilation.

Water efficiency: GSSAN encourages designs that reduce potable water consumption by building occupants. The facilities manager can advise on effective measures to reduce wastage of potable water. According to Taylor (2014) at the design phase gives his recommendation on fixtures that can help manage water.

Material efficiency: GSSAN encourages designs that prolong the useful life of existing products and materials. This role in particular, with reference to Hodges (2005) shows the relevance of the facilities manager in the design team. He is required to advise on building materials that have the potential for recycling and reuse. This the facilities manager does in order to save cost in the long term and to meet the requirements of sustainability.

Maintenance: At the operation stage, GSSAN in particular recognises the role of the facilities manager and encourages building designs that facilitates on-going maintenance, and minimises the need for on-going building maintenance throughout a building's lifecycle. The facilities manager can assesses the building to determine if there is a need for repairs. He manages and monitors maintenance schedules to ensure that maintenance of the entire is carried out (IFMA, 2014).

Energy efficiency: GSSAN encourages the installation of energy sub-metering to facilitate on-going management of energy consumption. The facilities manager according to Taylor (2013), can help monitor energy consumption and advice the project team during the design stage on main energy uses.

Building life-cycle costing: In order to ensure environmentally sustainable attributes in the design, maintenance and operations stage of the building, GSSAN encourages the development of a life cycle-cost (LCC) analysis. The facilities manager carries out this role from the design stage through to the operations phase of the building life-cycle. The facilities manager uses life-cycle costing to estimate the cost of facilities, equipment or furniture with a plan to either replace or repair, and at the same time seeking the decision that is most beneficial to the organisation in terms of cost. He uses the life-cycle costing to secure funds for maintenance of existing building and for the development of new projects (Spedding, 1994; Park, 1998; Wiggins, 2010).

This section has been able to identify few authors' view of what constitutes a sustainable building in Nigeria and the facilities manager's role in attaining sustainable buildings with regards to the GSSAN; yet, there is need to identify this role in accordance with internationally recognised FM standards. Therefore, Section 4.6 examines FM standards in order to identify which roles relate to achieving sustainable buildings. However, in recognition that a building is a product of different life-cycle stages, it is necessary to examine the role of the facilities manager at the building life-cycle stages according to literature.

4.5 Facilities Manager's Role in the Building life-cycle

A building can be referred to as any structure used or proposed primarily for shelter from weather. It denotes a place of comfort and safety and can be referred to as general living space, to provide privacy, store belongings and live and work comfortably (Brackett, 2012). Nowadays, buildings provide more than shelter; they also provide convenience, life-support and a feel of community. These buildings provide most of the immediate necessities for human comfort such as clean air for breathing, and clean water for drinking, thermal comfort, and privacy (Edward, 2005). However, in order for a building to fulfil the aforementioned roles, adequate consideration for comfort, health and sustainability will have to be incorporated into the different stages of its life-cycle. The RIBA Plan of Work 2013 shows the different building life-cycle stages as shown in Figure 3.4 and these stages have been briefly described in Section 3.4.

One of the objectives of this research study is to identify the facilities manager's role in sustainable buildings and in order to achieve this, the various functions of the facilities manager over the entire life of the building needs to be examined. In this view, the BIFM in conjunction with FM professionals recently developed a document called the 'BIFM Operational Readiness'. This document was published in 2016 and is based upon the building life-cycle stages identified by RIBA Plan of Work 2013. The document identifies the facilities manager's role at the different stages and provides a checklist of FM activities to support design, construction, operations, and post occupancy evaluation (POE). As stated in Section 3.4, the RIBA Plan of Work 2013 consists of eight stages and which are: Strategic definition stage, preparation and brief stage, concept design stage, developed design stage, technical design stage, construction stage, handover and close out stage, and in-use stage.

With reference to the document, the facilities manager at the strategic definition stage is expected to ensure compliance with the client's brief as this can be used as a standard against which the building's performance can measured. The client is expected to establish an FM project team to ensure that the Building Information Modelling (BIM) is implemented. The facilities manager is also expected to set up a communication plan that sets out how and when information is to be exchanged and with whom within the project team. The communication clearly explains what is critical for accurate information to be given in timely fashion to those who need to know.

The facilities manager at the preparation and brief stage has the competence to prepare a project brief. The project brief consists of what the client wants in terms of the building function and quality and targets defining the project's objectives in relation to sustainability, budget and building quality. Therefore, the facilities manager aims at merging the client's expectations with the project budget, sustainability and building quality and functionality. This stage involves the facilities manager ensuring that there are parameters in place to measure use of energy, water, waste, and other environmental aspects and future comfort of the building user in order to meet up with sustainability criteria. The facilities manager can also provide background information concerning environmental operational targets for the project. When involved at this stage, the facilities manager can develop an initial operating budget based on the estimated management and service delivery costs. This cost takes into account FM organisational costs, sinking fund costs/life cycle replacement, and estimated utilities costs. The facilities manager also has the opportunity to request that adequate space be provided for FM service operations.

At the concept design stage, the facilities manager with reference to the BIFM Operational Readiness, the facilities manager should further develop the service delivery strategy initially developed at the strategic definition stage into operational plans for all FM services that will be required. The facilities manager is expected to ensure that all FM-related activities and associated timescales have been incorporated into the final Project Brief; activities such as fire safety, security, catering, cleaning, M&E services, energy, waste management and landscaping. The facilities manager works with the design and construction team to agree targets for the building's performance in the view of post-occupancy evaluation.

At the developed design stage, facilities manager should be involved in reviewing drawings and specifications produced by the design and construction team in order to ensure that appropriate consideration for the client's/end user's operational and occupational requirements for the building and premises have been incorporated into the developing proposed design. During the technical design stage which is the fourth stage, the architectural, structural, building services and specialist designs are finalised. Therefore, the role of the facilities manager at this stage is to continue to ensure that the client and end user requirements are incorporated into the technical design. The facilities manager together with the design and construction team work on the scope and content of operating and maintenance manuals, drawings and building user guides and in the process develop plans for the handover of the project.

The construction stage is the fifth stage and the overall aim of the facilities manager at this stage is to ensure the operational impact of all construction activities are considered in order to ensure the smooth running of the buildings' operations. He, therefore, monitors modifications made to the design to ensure that these are approved by the client and checks the impact that the changes can have on FM operations. The facilities manager is also responsible for ensuring that all plant and equipment incorporated into the building are safely maintained according to current legislation. He therefore, has the informational background of the services and equipment installed to develop a comprehensive manual of FM procedures instructing the FM team on their specific roles and responsibilities as they will be in charge of the building.

At the handover and close out stage (sixth stage), the facilities manager finalises the end-user guide for simple operational processes and minor change requirements. He examines the 'as built' documents for certain information in order to ensure the completeness and accuracy of the 'as built' documents. These information relate to asset data required for the computer-aided FM; requirements and attendance at all testing and commissioning of services; staffing, plant, tools and IT requirements; issues of ongoing maintenance; the servicing contracts of installers; and including all warranty. The facilities manager should organise training about the use of the building services to his team and the building users. The in-use stage is the seventh and the final stage in which the facilities manager coordinates operations after the building has been handed over. During this period, the facilities manager holds regular meetings with building users in order to review its operations and determine if the needs of the users are being met. This can be achieved by also carrying out a post occupancy evaluation.

Though, the BIFM Operational Readiness (2016) has explicitly described the facilities manager's role in the building life-cycle stages, there are few authors that have also identified FM roles in these stages. With reference to Gervásio (2014) the design stage is the most critical stage in the building life-cycle; for the most fundamental decisions influencing the life-cycle performance of a building are taken in the very beginning of the design process. The design process of any building usually consists of drawings and specifications, prepared by a design team which includes:

- The client or real estate developer who secures funding for the project; the client according to British Property Federation, (1983) is defined as the person or firm responsible for commissioning and paying for the design and construction of a facility;
- The land surveyor who performs land and construction surveys throughout the project;
- Project managers who coordinate the effort of different groups of project participants;
- Architects;
- Mechanical, electrical and structural engineers who provide building design and prepare construction documents;
- Interior designers;
- Contractors who provide construction services and install building systems such as climate control, electrical, plumbing, Decoration, fire protection, security and telecommunications;
- Estate managers; and
- Facility managers who are responsible for operating the building.

The listed professionals show that the practice of designing, constructing, and operating buildings is a collective effort of different groups of professionals who come together right from the design stage with aim of meeting a building's sustainable requirements. According to Evins (2013), it is this joint effort that helps to create a sustainable building. Shah (2007) and Mohammed and Hassanain (2010), however, argue that it is the facilities manager that plays a more significant role in achieving sustainable buildings. This is because his role starts from the design stage and continues to the operations stage, unlike the other professions who conclude their work with the building soon after it has been completed. The facilities manager is able to influence sustainable measures from the design stage because checks for sustainability start from there. This is confirmed by the RIBA Plan of Work (2013) where it shows sustainability checks starting from the preparation and brief stage. However, in order to totally achieve the requirement for sustainable building, consideration for sustainability needs to be given to a building over its life-cycle, that is, from the design stage, through the construction, operation and renovation stages, and to demolishing and recycling (Feige *et al.*, 2013).

The facilities manager makes his contribution at the design stage and then plays a monitoring role at the construction stage in order to ensure implemented of agreed designs as stated by Shah (2007). According to Kubicki *et al.*, (2005) the building construction stage is where the building moves progressively from a virtual state to an actualised state. However, various challenges are discovered at this stage leading to complexity and of which Hodges (2005) argue the facilities manager is well equipped to handle. Numerous aspects have to be faced and which are: respecting deadlines (anticipating problems and solving conflicts), managing the design team, costs management, and quality of execution of the different building elements and conformity with the original drawings.

At the construction stage, the facade of the building which forms a barrier to heat, cold, light and air, must be carefully assembled, in order to achieve high performance (Evins, 2013). The performance of the building can only be tested and proven at the operations stage. The involvement of the facilities manager from the design stage will help in achieving the proposed high performance of the building. According to Zhang *et al.*, *(*2006) the effectiveness of this stage is dependent on the design of both the structure and services of the building. It is also dependent on the construction stage and the skilled installation of building services, namely; electricity supply and consumption, water supply and consumption, lifts, air-conditioning and waste management. According to Shah (2007) the operations stage of the building life-cycle is the longest phase and carries with the greatest impact upon the environment, society and the economy.

As earlier stated a building's life does not start at the building handover from a facilities manager's view but from the initial briefing stage (Shah, 2007). This is supported by Tucker (2012) who is of the view that the involvement of the facilities manager from the onset prolongs the life of the building. However, Hodges (2005) argues that the facilities manager has specialised knowledge not just for the design stage but for the other stages as well. This supported by Shiem-Shin and Hee (2013) who argue that the facilities manager manages the different stages carrying out various roles as shown in Figure 4.3 in order to derive optimum value of the building at the most economical cost over its life-cycle. The facility manager has the potential to contribute to the design stage by providing useful feedback from the knowledge acquired when carrying out the various roles during the operational phase of the building (Mohammed and Hassanain, 2010).

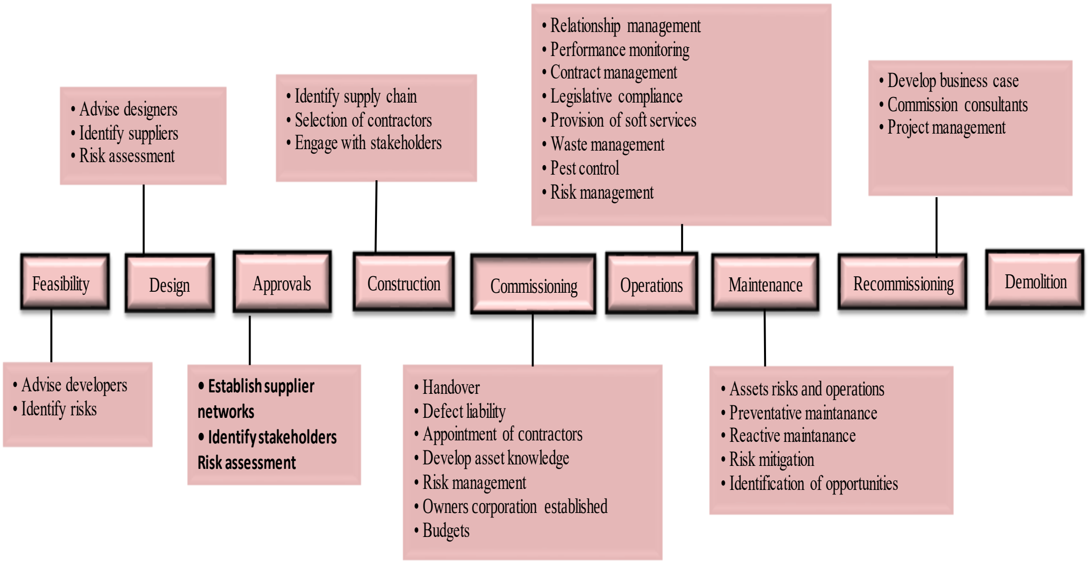

Figure 4.3: FM Role and the Building Life-Cycle
Source: Shiem-Shin and Hee (2013)

4.5.1 Facilities Manager at the Design stage

In the context of this research, the design stage includes the strategic definition and the preparation and briefing stage. Briefing in construction is the activity of taking a clear, unambiguous and explicit performance specification of a project from a client (Kamara *et al.*, 2001). Yet, a common occurrence in most briefing exercises is that there is no facilities manager on the team contributing to the brief before design starts, and which later results in operational issues in the latter stages of the project. A major function of the facilities manager according to RICS (2014), is to help in establishing the client brief. According to Nutt (1993) a briefing team should consist of the client, the facilities designer, the facilities manager and a representative of facilities users.

The briefing team should work together to ensure a successful building. The range of issues to be taken into account during the briefing stage by the facilities manager include; an organisation meeting corporate strategy and objectives; providing the building user with comfort, safety, and healthy and clean environment; providing functional space, structure, services, and maintenance; providing initial cost, development value and costs in use; advice on site and location; and finally operational issues involving post-occupancy management of the building and support services (Nutt, 1993).

Preiser (1995) states that facility managers are the custodians of valuable information that is needed for the operations of different building types and, therefore, recommends that facilities managers be involved in the briefing process. McLennan (2000) also states that the facilities manager plays an important role in the brief preparation. The Assessment of Professional Competence RICS (2015) states that one of the roles of the competent facilities manager is to meet the client's requirements, consequently to perform this role, the facilities manager needs to develop the client's detailed brief. However, Eley (2001) recommends the involvement of facilities managers with a wealth of experience and knowledge to contribute to the briefing process before actual design starts.

The design stage also consists of the concept design, developed design, and technical design stages as identified by the RIBA Plan of Work 2013. The facilities manager has a major role to play in these stages because it is the FM department that is burdened with the effective performance of the building during its operational life states (Shah, 2007). However, this is not usually the case as facilities managers are involved too late into the design process and are not integrated thoroughly enough (Cousins *et al.*, 2005). Even when the facilities manager is involved early in the design stage his involvement is often hampered by difficulties with co-ordinating the requirements of both the client and various professionals (Pitt *et al.*, 2005). For they argue that facilities manager's role in the design phase is not just one of understanding simple designs, instead it comprises of understanding complex designs for the purpose of interrelated user functional efficiency.

Despite the challenge highlighted by Pitt *et al.*, (2005), the Assessment of Professional Competence RICS (2015) recommends that the facilities manager is in a good position to co-ordinate and manage the design and specification process on building projects. The document highlights that the facilities manager has the competence to assist in the preparation of the outline proposals to completion of the design and specification process, in consultation with other members of the design team. Table 4.2 illustrates the involvement of the facilities manager with other members of the team at the design stage. This, therefore, makes a fundamental difference to the way buildings are designed, built, commissioned, maintained, and refurbished. Thus, the facilities manager is becoming increasingly involved in whole life cost analysis, projecting facility plans, and reviewing project proposals in the context of the operation and core business requirements as stated by El-Haram and Agapiou (2002).

Table 4.2: FM's Contribution to the Design Team

Members of the Design team	FM Involvement
Architect	The facilities manager provides the architect with organisational plans which includes the purpose of the facility and future requirements for space which includes working space, storage space for equipment, loading and off-loading space, escape routes and so on. This aids the architectural design.
Structural Engineer	The facilities manager provides related information on nature size and weights of various machines and equipment to be accommodated in the facility and future load expectation for consideration by the structural engineer in the design process, this will reduce or totally eradicate the issue of deflections and buckling as a result of overloading load bearing strucral elements.
Mechanical Engineer	The facilities manager recommends on efficient systems in terms of maintainability by providing imformation that pertains to procurement and transportation of materials and equipment including quantity and transportation of these materials vertically or horizontal and frequency of their transportation.
Electrical Engineer	The facilities manager provides information that will inform the electrical engineer on the type of wiring system to adopt, the sizes of cables to install, and the number of electrical switches and sockets to install.

Source: Mohammed and Hassanain (2010)

Figure 4.4 shows the role of the facilities manager at the design stage, as every member of the team submits their proposals for maintainability checks. The facilities manager incorporates and adopts lessons learnt from previous design, construction and occupancy periods to avoid repetitive mistakes by design consultants (Hassanain, 2006). This creates opportunity for the facilities manager to be involved not only in the briefing process but also at the concept design, developed design, and technical design stages of the building and this will definitely reduce facility maintenance cost and time (Mohammed and Hassanain, 2010). According to Jensen (2008) the most important FM specific task at the design stage is the transfer of experiences from existing building, for consideration of the operations and sustainability of the new building.

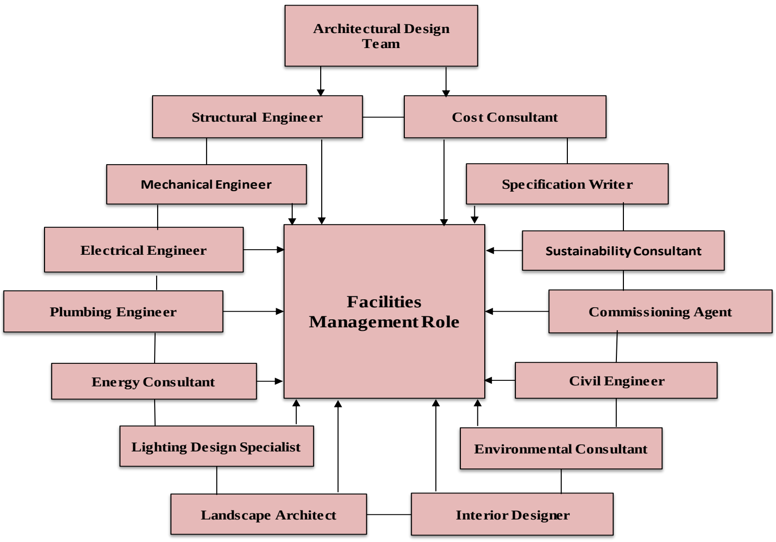

Figure 4.4: The Role of the Facilities Management Team within the Integrated Design Team
Source: Mohammed and Hassanain (2010)

El-Haram and Agapiou (2002) argue that the facilities manager has a major role to fulfil in the building design process. According to them, the facilities manager's responsibility varies from reviewing and assessing the building design for maintainability, operability and serviceability, to liaising with the design team to select the most cost-effective design option which will optimise whole life costing. At the design stage and in relation to sustainable buildings, the facilities manager under the environmental aspect has the ability to give advises on effective waste management system, minimum car parking, systems that minimise carbon emissions, policies that help to protect the environment, and encourages the use of renewable energy. In relation to the social aspect, facilities manager can advise on visual, acoustic, and thermal comfort, indoor air quality, safe access, space management, and building adaptability for different uses. The facilities manager can also advise on energy, water and material efficiency. His responsibility also includes identifying and selecting the optimum maintenance and replacement strategies for the facility. The facilities manager also carries out building life-cycle cost exercises (BIFM, 2014; IFMA, 2009; FMAA, 2012; and RICS, 2014).

Though, the facilities manager has the competence to give advice as stated above, this role is usually limited by the involvement of a project manager as shown in Figure 4.5. For the traditional role of the facilities manager is predominantly through the project manager, limiting the facilities manager ability to influence design and establish end-user requirement. However, Shah (2007) proposes that the facilities manager should work directly with the client, the architect and the project manager in order to communicate the end-user requirement in order to achieve true satisfaction of the building user.

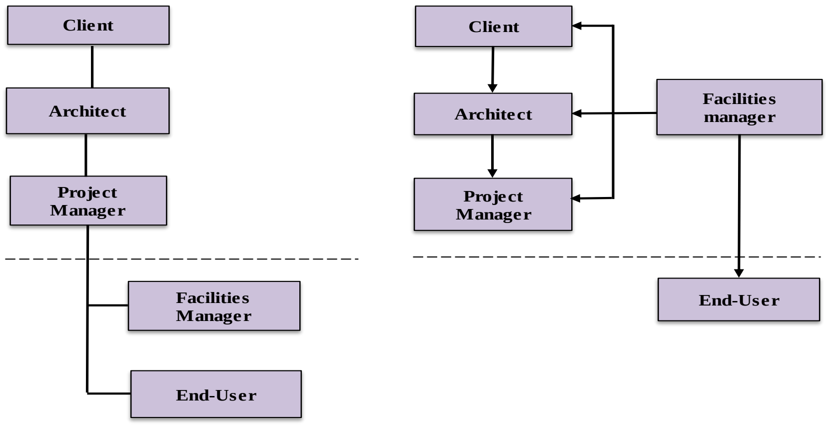

Figure 4.5: Current Role of FM (left) and Proposed Role of FM with Involvement in Design (right)
Source: Shah (2007)

4.5.2 Facilities Manager at the Construction Stage

Latham (2001) firmly states that the facilities manager is the eyes and ears of the clients particularly at the construction stage and seemly plays a monitoring role, although, shared by other consultants at this stage. This is supported by Shah (2007) who states that FM role at construction is to provide an on-going monitoring role to ensure all building components that can affect operations at the occupancy stage are successfully installed. At the handover stage of the building, the monitoring role continues for the facilities manager, while it ends for the other consultants and the building contractor.

Shah (2007) is of the opinion that the last two decades have seen significant growth in FM, as a result of this emerging role. Hodges (2005) view of FM at construction supports that the facilities manager's involvement at the construction stage will help in preserving the building and reduces environmental impacts. In relation to achieving sustainable buildings, FMAA (2012) states that facilities managers have the ability to identify and advice on suppliers of electrical and mechanical systems with low energy consumption and low CO_2 emissions during installation works in preparation for the operations phase of the building. It can, therefore, be deduced that the facilities manager plays a monitoring role at the construction stage especially with constituents that deal with the social aspect. Though, the facilities manager does not have the technical expertise to check if installations have be done correctly, he can, however, play the monitoring role by liaising with the building services consultants. Määttänen *et al.*, (2014) argues that there is need for the facilities manager to train in the technical aspects of the building, as this will facilitate the FM monitoring role.

The facilities manager in conjunction with building services engineers can monitor installations in relation to visual, thermal, and acoustic comfort and indoor air quality. It can be deduced that the facilities manager is mainly concerned with installations that is related to the comfort of the building user. However, he is also concerned with other aspects of the building to ensure effective performance and maintainability. Shah (2007) states the facilities manager plays a minor role at the construction stage.

4.5.3 Facilities Manager at the Operations Stage

With reference to Lavy *et al.,* (2010), FM deals with the management of built assets and incorporates services necessary for successful business operations of an organisation and for the ultimate satisfaction of the building users. These built assets start to age from the moment they are installed and put in use. They need maintenance throughout their life time in order to achieve effective and economical usage (Fakhrudin *et al.*, 2011). When buildings are put in use, the facility manager's responsibilities includes: management of maintenance strategies and costs; management of operating activities and costs; collection and analysis of FM data for improvement; ensuring that the required level of service is met; and ensuring the availability of every facility in the building (El-Haram and Agapiou, 2002).

At the operations stage, the facilities manager is grossly engaged with the maintenance of the building. According to Shah (2007), building maintenance operations is a complex mixture of reactive task management by the facilities manager to meet customer demands and proactive maintenance to achieve a clean and healthy work and living environment. In order for the facilities manager and his team to fulfil the role of ensuring that maintenance works are carried out, work-order systems are developed to deal with requests for rectification a problem or to execute a particular work. These work-order systems include corrective maintenance, project work, preventive maintenance, predictive maintenance and lean maintenance (Fennimore, 2014).

Facilities managers' tasks during the operations stage also range from performance monitoring and improvement in the delivery of building services, to monitoring government regulations on environmental, and health and security standards (Bernard Williams Associates, 1999). The operations stage has by far the greatest impact on the environment, the society and the economy as rightly stated by Aaltonen *et al.*, (2013). The majority of CO_2 emissions caused by buildings are created during the operations stage of buildings. In other words, the way a building is managed and maintained has a major impact on the environmental performance of the building; this therefore, demonstrates the need for a facilities manager.

The facilities manager's role at the operations stage is growing to be more critical than before as building users are becoming well aware of the quality of their living and working environments. The role of the facilities manager in ensuring that a safe and comfortable indoor environment is provided to the building user is becoming an increasingly tedious responsibility (CIBSE, 2005). The facilities manager is required to have a good knowledge of building services, sometimes called engineering services operations. Building services are primarily used to create a comfortable and safe working environment for people and processes by providing warmth, cooling, light, electrical power, water, sanitation, drainage, transport, communication, noise control, security and fire protection. When working properly they often tend to be ignored or taken for granted, whilst poor performance can cause discomfort and occupant dissatisfaction and contribute to reduced productivity (Armstrong and Saville, 2005).

Though, the facilities manager's role has been proofed to be vital at the operational stage of the building's life-cycle; he plays an important role in the other stages as highlighted by the BIFM Operational Readiness and the discussion above. Kelly *et al.*, (2005); Kamara *et al*., (2001); Preiser, (1995); and Nutt (1993) all argue that the facilities manager's role starts at the briefing stage. Cotts *et al.*, (2010); El-Haram and Agapiou (2002); and Shah (2007) argue further that the facilities manager's role even continues through to the detailed design, construction, and operations stages. However, they emphasise the operations stage as the longest phase in the building life-cycle, where FM functions are mostly significant. It is at this stage the facilities manager carries out roles under the management aspect as identified in this research study. Roles such as monitoring the technological trends and innovation in the buildings, assessing the application of technology within building operations and incorporating and managing building management systems as shown in Table 4.3. The focus of this research study is to achieve sustainability for a building thorough the facilities manager's role and in order to achieve this, the facilities manager's role at the different stages of the building life-cycle is identified in this section. Moving forward, to attain sustainability in a building through the facilities manager's role, the contribution that the facilities manager can make towards a building's sustainability needs to be identified. The

4.6 Facilities Manager's Role in Relation to Sustainable Buildings

According to Shah (2007) the efforts towards a sustainable built environment, is making facilities managers align their practice with the SD agenda. This is evidenced by how facilities managers play a key role in the environmental performance of buildings by supporting their organisations in efforts to minimise environmental impact (Aaltonen *et al.*, 2013). Their practice influences an organisation's carbon footprint (BIFM, 2014). The facilities manager implements green management data and gathers, analyses and reports on environmental issues (Shah 2007). Shah (2007) highlighted 14 areas where FM has impact on environmental sustainability issues and these include management of sustainable framework tools, minimisation of sources of air pollution, management on issues relating to land contamination, noise control involving workforce occupants, contribution to local environment and infrastructure, inclusion of environmental issues throughout the building life-cycle, energy management, emissions to water, use of resources, waste management, marketplace, human rights, biodiversity and transport.

According to Wood (2006), FM professionals have the best chance to add value to their organisations and customers through efficient management of sustainability issues and practices. According to him, FM professionals are tasked with implementing and managing sustainability as a core business strategy. Shah (2007) adds that facilities managers are at the forefront of implementing their organisation's vision and commitment towards the SD agenda by implementing legislative requirements. Hence, the need for knowledge of the key sustainability issues and drivers that motivate facilities managers to adopt sustainability practices both theoretically and practically.

In efforts to achieve sustainability, facilities managers make use of a range of legislations such as Clean Air Act 1970/1977, Clean Air Act Amendments of 1990, Clean Water Act (CWA) (original title: Federal Water Pollution Control Amendments of 1972) and so on. Applying these legislations and regulations helps to achieve sustainability by the efficient use of energy, management and removal of waste and the subsequent reduction of carbon emissions which is often the responsibility of facilities managers in any organisation (Shah, 2007). Facilities managers develop, implement and review SD policies that protect the environment and comply with relevant legislation BIFM (2014).

An SD policy is a document which contains all the processes, targets, reporting and feedback on matters relating to energy reduction, water treatment and waste minimisation in which the organisation is engaged in (BIFM, 2008). It is crucial that there is collaboration during the formulation stage between individuals who have knowledge of SD issues, so as to ensure the policy will meet the organisation's potential and objectives. According to Massa and Rydin (1997), a policy is created from deliberation, so as not to end up being an established statement. According to them, this deliberation makes it a policy, and the subsequent views of the organisation, openness to change and improvement, make it a higher value document.

SD policies and drivers directly influence facilities managers' activities, thereby positioning them at the forefront of implementing their organisation's vision and commitment towards the SD agenda (Elmualim *et al.*, 2012). This is supported by the IFMA report (2007) which emphasises the importance of facilities managers developing and implementing programs to reduce, reuse and recycle waste; work closely with building users to conserve energy, monitor the amount of energy used by the facilities they are managing; adopt energy efficiency measures like switching to efficient lighting equipment, match heating and cooling and ventilation equipment to facility loads to reduce energy consumption. Elmualim *et al*., (2010) and Shah (2007) state that FM has a significant influence over how buildings and facilities are used and therefore, are tasked to promote and implement SD policies in buildings. However, current research on SD policies and drivers influencing the activities of facilities managers is limited.

Development of SD policies enables facilities managers assess their organisation's view on environmental issues and which in turn helps them determine what environmental issues need to be focussed on (Alexander, 1996). According to Price *et al*., (2011), FM achieving sustainability thrives on the development of SD policies. The formulation and implementation of SD policies in organisations are necessary in order to achieve positive environmental impact in areas such as building disposal, sustainable products and services, biodiversity, health and safety, energy management and waste management and recycling as stated by Elmualim *et al*., (2010). However, it appears that facilities managers are lacking in understanding of these basic information necessary to implement SD policies in their organisations and therefore do not rate SD policy as a high priority. In the study carried out by Elmualim *et al*., (2010), sixty-nine per cent (69%) of 251 facilities managers reported that they had an SD policy in place while the other thirty-one per cent (31%) did not have due to a lack of focus by senior management on implementing sustainable practice. Even when organisations go ahead to form a sustainable policy, it may not necessarily be acted upon. This is shown in another study carried out by Carpenter and Meehan, (2002) of ten institutions which had sustainable policies in place, and the main findings of their study are as follows:

- Conservation, waste management and sustainability formed key parts of the environmental management policy in these institutions;
- Six out of the ten institutions had formally established an environmental management committee overseeing the policy, four indicated that they had no committee structure, and of those four one institution indicated that a previously running committee had now ceased to meet;
- Five institutions indicated that executive management was involved in the management of the environmental programme;
- Only one institution indicated that there was direct funding for the implementation of the environmental management plan while in the other institutions, there no direct funding for the implementation of the environmental management plans, for priority was given to projects with the potential return on investment.

It can be deduced from the above case study that lack of senior management commitment to the SD agenda is a major barrier to implementing a company's sustainable policy. This is supported by Elmualim *et al*., (2010) who stated that lack of senior management commitment, time constraints, financial constraints and lack of knowledge are major barriers to the SD agenda; while legislations, corporate image, and organisation ethos are the main drivers. However, corporate image and organisation ethos according to him are often influenced by client demands and competitiveness in the industry.

Apart from the environmental aspect, facilities managers also help in achieving the economic and social aspects of sustainability. This they do by determining profitability, productivity, and employee well-being of an organisation (Ortiz *et al.*, 2009). Priess (2010) supports this opinion stating that when employees are well, they produce good services having a positive impact on an organisation's profitability. According to Alexandra (2003) FM has the ability to reduce costs and improve flexibility in an economic climate which can sequentially lead to quality improvement and competitive advantage in favour of the organisation.

According to Alexander and Brown (2006), FM provides a platform by which all the stakeholders in a community work together, to plan, deliver and maintain an enabling environment. The local economy can prosper, quality services can be delivered and natural resources protected, in order that citizens can enjoy a quality of life. According to them, FM also has the ability to provide a better understanding of the social value of facilities and is in a position to align facilities to positive social outcomes such as community identity, respect for people, public and civic life, sociability and so on. By managing buildings and the processes that take place in them, FM contributes to the environmental, social and economic aspects of sustainability.

The facilities manager's role in achieving sustainable buildings has been met to some degree as part of their daily functions itself. These roles include: building maintenance, mechanical and electrical systems management and maintenance, financial management, space management, energy and water management, waste management, environmental management and so on (Wiggins, 2014). However, to identify their specific roles in sustainable buildings, this research looks into the facilities managers roles as highlighted in FM competencies' documents namely: the Facilities Management Professional Standards Handbook developed by British Institute of Facilities Management (BIFM); the IFMA Complete List of Competencies as defined in the Global Job Task Analysis (GJTA) developed by International Facilities Management Association (IFMA); Skills in Facilities Management Investigation into Industry Education developed by Facilities Management Association Australia (FMAA); and the RICS Assessment of Professional Competence Facilities Management Pathway Guide developed by Royal Institute of Chartered Surveyors (RICS) FM group. The research sets out to identify which of their competencies relate to FM roles in sustainable building constituents.

According to FMAA (2012), competencies are standards that describe the knowledge, skills and attitudes required for a professional in a given field to meet the standards expected of their position. Holmes and Joyce (1993) describe it as an action, behaviour or outcome which a person demonstrates, or the ability to transfer skills and knowledge to new situations within the occupational area. The BIFM Facilities Management Professional Standards Handbook (2014) states that to be competent is to have the skill or ability to perform a task, function or a role; Consequently for this research, the competencies stated in the documents are viewed as roles for facilities managers in relation to sustainable building constituents.

Associations such as the German Facility Management Association (GEFMA) founded in 1989 with more than 600 members; the Hong Kong Institute of Facility Management (HKIFM) established in 2000 and formed by a group of professional people who were actively involved in the field of FM; the Japan Facility Management Association (JFMA) established in 1987 as an organisation for the promotion and establishment of FM practice in Japan, and the skill development of the facility managers; and the South African Facilities Management Association (SAFMA); are FM associations that have been established and promote the FM profession in their various countries. The FM competencies documents used in this research are developed by BIFM, IFMA, FMAA, and RICS FM group.

According to Awang *et al.,* (2011) these FM associations are globally accepted as bodies that deal with the FM profession and are leading FM associations in the world. They have their own competencies and countries have adopted their competency frameworks as a basis for professional accreditation in the field of FM (Awang *et al.*, 2012). They define FM, explicate the scope of FM and elucidate the knowledge, skills, abilities and behaviours needed to perform FM tasks. These competencies include 71 competencies under 10 functional areas sub-divided into 24 functional area components (BIFM); 92 sub-competencies under 11 core competencies (IFMA); 90 competencies under 7 categories (FMAA); and 22 competencies (RICS).

The BIFM Facilities Management Professional Standards Handbook has been developed to support the use and implementation of FM standards and it clearly defines the competencies that are necessary to be a competent facilities manager (BIFM, 2014). It is developed in consultation with industry experts to reflect the requirement and standards of the profession and can be used as a benchmarking tool to develop a skilled FM workforce. The FM Professional Standards form the underlying framework with which BIFM is able to develop new products and services to ensure that BIFM provides high-quality services.

The IFMA Complete List of Competencies is developed according to the Global Job Task Analysis (GJTA) 2009 which defines 11 core FM competencies and which has been refined by responses from facility managers in 62 countries. It ensures that the FM body of knowledge incorporates current knowledge, best practices and trends in FM (IFMA, 2014). The Skills in Facilities Management Investigation into Industry Education was developed by FMAA as a result of lack of standards to benchmark FM professionals, compare roles and responsibilities. It defines FM knowledge, skills and attitudes that are required to be an effective facilities manager in Australia (FMAA, 2012). The RICS Assessment of Professional Competence Facilities Management Pathway Guide (2014) is designed to help interpret FM competencies as stated in the RICS Assessment of Professional Competence Facilities Management document. As earlier stated these associations have produced documents that describe FM roles.

The research carried out a content analysis of the 4 aforementioned documents using the NVivo software to find common themes that relate to the facilities manager's role in sustainable buildings. Table 4.3 show findings of the content analysis. The content analysis in relation to the sustainable building constituents revealed the facilities manager's roles in 17 categories. The 17 categories have been adopted from the identified sustainable building constituents and are as shown in Table 3.2. Due to the facilities manager's role at the design, construction and operations stages as identified in the literature, the 17 categories comprised of 44 FM roles and are related to the environmental, social, economic and management aspects of SD.

The results show 21 out of the 44 roles common to the four documents. The 21 roles have been found to be related to sustainable building constituents that are common to BREEAM-NC (2012), LEED-NC (2009) and ISO 15392. This indicates that these constituents are key constituents that are vital to a buildings' sustainability and may be the reason why it is common to the 4 FM documents. The results revealed IFMA to be the most comprehensive of the four documents with 42 roles, followed by BIFM with 34 roles. The results revealed RICS to have 31 and FMAA 24 roles.

Table 4.3: The Facilities Manager's Role in Sustainable Building

	FM Role in Sustianable Buildings	BIFM	IFMA	FMAA	RICS	No. of documents mentioning constituent
	Environmental Aspect					
	Waste management 1					
1	Advises on an effective waste management system.	√	√	√	√	4
2	Coordinates waste management during the operational life of the building.	√	√	√	√	4
	Pollution 2					
3	Advises on minimum car parking capacity in order to help reduce transport related pollution.		√			1
4	Advises the use of systems that reduce carbon emissions.	√	√	√	√	4
5	Influences and installs refrigeration systems that minimise carbon emissions.	√	√	√	√	4
6	Maintains systems that minimise carbon emissions.	√	√	√	√	4
	Biodiversity 3					
7	Develops, advises and implements policies that help to protect the environment surrounding the building site.	√	√			2
8	Educates the design team on measures to preserve and enhance the plant and animal life surrounding the building site.	√	√			2
	Energy 4					
9	Encourages on the use of **renewable energy**.	√				1
	Social Aspect					
	Visual comfort 5					
10	Advises on visual comfort in terms of daylighting and artificial lighting and lighting controls for the comfort of building occupants.	√	√	√	√	4
11	Ensures installation of fittings that will give visual comfort to building occupant.	√	√	√	√	4
12	Maintains all installations that give visual comfort.	√	√	√	√	4
	Acoustic performance 6					
13	Advises on the building's acoustic performance including sound insulation meeting the appropriate standards.	√	√	√	√	4
14	Monitors installation of systems that provide acoustic comfort.	√	√	√	√	4
15	Maintains systems that provide acoustic comfort.	√	√	√	√	4
	Thermal comfort 7					
16	Advises and specifies system that provide thermal control (air-conditioning) at design.	√	√	√	√	4
17	Ensures installation of thermal controls such as air-conditioning units.	√	√	√	√	4
18	Maintains a thermally comfortable environment for occupants within the building.	√	√	√	√	4
	Safe access 8					
19	Advises on safe access and security to and from the building at design stage.		√		√	2
20	Maintains systems that provide safe access and security in the building.		√		√	2
	Space management 9					
21	Advises on apportioning of space for occupant privacy and wellbeing.		√			1
22	Executes space management plan.		√			1
	Indoor air quality 10					
23	Helps to provide a healthy indoor environment through advice and specification of designs that encourage ventilation.	√	√	√	√	4
24	Monitors installation of appropriate ventilation equipment to provide good indoor environment.	√	√	√	√	4
25	Maintenance of ventilation equipment and outlets.	√	√	√	√	4
	Adaptability for different uses					
26	Advises on building design that is adaptable for different tenure types and ensuring flexibility wherever possible. 11	√	√			2

	Economic Aspect					
	Efficient use of water (12)					
27	Advises and specifies water efficient fittings.	√	√	√		3
28	Ensures installation of water efficient fittings.	√	√	√		3
29	Monitors water consumption and carries out activities that reduce waste of water.	√	√	√		3
	Material efficiency (13)					
30	Advises on minimising the frequency of material replacement at design.	√	√		√	3
31	Ensures use of recycled materials at construction.	√	√		√	3
	Building maintenance (14)					
32	Carries out **maintenance of the building and services** which ensures the durability and economic value.	√	√	√	√	4
	Efficient use of energy (15)					
33	Advises on design that ensures energy efficiency.	√	√	√	√	4
34	Monitors installation of energy efficient lighting fittings and equipment.	√	√	√	√	4
35	Monitors energy consumption to reduce energy usage.	√	√	√	√	4
	Building life-cycle costing (16)					
36	Carries out building life-cycle cost exercises for building material selection.	√	√		√	3
	Management Aspect (17)					
37	Post occupancy evaluation that ensures delivery of functional buildings in consultation with current and future building users and other stakeholders.		√		√	2
38	Monitors and evaluates technology trends and innovation in the building.	√	√			2
39	Assesses the application of technology within building operations.	√	√			2
40	Incorporates building management systems that actively control and maximise the effectiveness of building services.	√	√		√	3
41	Establishes legal and contractual environmental management initiatives.				√	1
42	Develops initiatives that educate building occupants on how the sustainability issues in building work.	√	√			2
43	Develops a building users guide to enable building users to optimise the building's performance.		√			1
44	Executes yearly building tuning initiatives that ensure optimum occupant comfort and energy efficient performance.		√			1
	Total number of FM roles indentified in documents	34	42	24	31	

Source: Self-study

Table 4.3 shows 9 FM roles under the environmental aspect. These roles show the facilities manager’s contribution to reducing the impact that buildings have on the environment. This supports Aaltonen *et al.*, (2013) view that facilities managers support their organisations in minimising environmental impact caused by buildings. Table 4.3 shows 17 roles under the social aspect. The Table shows that the facilities manager carries out the most roles in the social aspect when compared to the environmental, economic and management aspects. This indicates that the facilities manager is majorly concerned with the comfort and well-being of the building user. The social aspect of SD has been revealed to relate to the wellbeing of the building user (Cole *et al.*, 2008; Baird, 2010; Parr and Zaretsky, 2010). Therefore, the facilities manager is a vital instrument in the achievement of the social aspect of SD in relations to buildings.

Table 4.3 shows 10 roles under the economic aspect. In the economic aspect the facilities manager has the potential for cost savings for the building owner and the building user.

According to Ellis *et al.*, (2008), when the economic aspect of a building is achieved, it encourages financial savings. With reference to El-Haram and Agapiou (2002), the facilities manager is able to influence savings in cost by adopting building life-cycle costing at the design stage. 8 roles are shown under the management aspect. As explained in Section 3.3, the management aspect is viewed as an aspect that manages the environmental, social and economic aspects. There is a need to manage the 3 aforementioned aspects in relation to buildings, in order to maintain at the operations stage, sustainable measures initiated at the design stage. These 8 FM roles are discovered to be roles carried out by the facilities manager mostly at the operations stage of the building life-cycle.

The following sections discuss the 44 FM roles under the 17 categories highlighted in Table 4.3 by which the facilities manager can contribute to achieving sustainable buildings.

4.6.1 Waste Management

With reference to Wiggins (2014), waste is any substance or object which the producer or owner intends to recover, recycle or discard. Facilities managers are stewards of the built environment and waste management is a major part of their job description states Booty (2009). Waste management is defined as the unwanted residue of an organisation's activities, and can include anything from toxic liquids and solids, pallets and packaging, expired light bulbs and printer cartridges, to the contents of the wastepaper basket (Mavropoulos, 2015).

According to BIFM (2014) the facilities manager collects and analyses information on environmental performance and waste management issues. However, this cannot be achieved without some sort of plan states Wiggins (2010). There is a need for a waste management structure where waste data collection and management co-ordination are carried out. The structure involves processes that deal with the strict reduction of waste generation through adjustment and redesigning of processes and cooperation with suppliers. It also involves internal and responsible recycling of waste materials to provide new or different products; and contracting waste management companies to dispose of the waste (Booty, 2009). According to Shah (2007), the facilities managers is equipped to manage waste with its associated cost and is knowledgeable in all waste processes and management policies. Therefore, the facilities manager can advise and implement waste management processes that enables buildings comply with the environmental aspect of SD and this role can be carried out at the design and the operations stages.

4.6.2 Pollution

Pollution has been described as the presence of harmful substances into the environment. The pollution could be of the air, water or land (Zhang *et al.*, 2015). Pollution in relations to the FM role relates to the facilities manager advising on minimum car parking in order to reduce vehicle-related emissions (BIFM, 2014). Minimum car parking in buildings helps to reduce carbon emissions released into the air. Air pollution is often caused by emissions from petrol, diesel, and alternative-fuel engines and of which vehicles are a major contributor. These air pollutants include carbon monoxide, oxides of nitrogen, un-burnt hydrocarbons and particulate matter (Benbrahim-Tallaa *et al.*, 2012). One of the downsides of economic growth and development is pollution. It is now been connected to various environmental damages and frowned upon by many as awareness for SD increases states Tian *et al.*, (2013).

These greenhouse gases and carbon emissions have been linked to various acute and chronic health effects. In particular, a number of studies have confirmed positive relations between cancers, heart attacks and asthma and exposure to nitrogen dioxide NO_2, an accepted marker of traffic-related air pollution (Shekarrizfard *et al.*, 2016). There is also the issue of water pollution which is often caused by construction site works. Water pollution can be caused by flooding and clogging of the drainage system. It reduces groundwater recharge and leads to the destruction of natural aquatic life (Belayutham *et al.*, 2016). The facilities manager with reference to Shah (2007) advices on minimising sources of air pollution at the design stage, advice on uses of low emission finishes, construction material, carpets, and furnishings. Due past experience the facilities manager can determine potential sources of water pollution and see whether suitable processes are in place to minimise the risk of water pollution.

4.6.3 Environmental Management

Environmental management involves measures to prevent pollution in the environment and includes developing, implementing and assessing policies which influence an organisation towards protection of the environment (Feng et *al.*, 2014). IFMA (2009) requires the facilities manager to develop environmental management programs, provide data to support facilities evaluation and support an organisation's commitment to protecting the environment. RICS (2014), however, states that the facilities manager can only develop environmental management concepts if he understands what environmental management is all about. It requires the facilities manager to report and maintain the environmental management system.

With reference to Shah (2007), there are four main types of environmental management systems that the facilities manager can help an organisation to implement, these include: an internal 'home-grown' environmental management system without certification; step-by-step systems to develop an environmental management system; certification to BS EN ISO 14001:2004; and certification to eco-management audit scheme (EMAS). In relation to buildings, the facilities manager is expected to ensure that the design team complies with existing environmental management policies in order to achieve sustainable buildings. The facilities manager also develops new environmental management policies as deemed necessary, maintains existing ones and ensures that these policies are implemented (Shah, 2007).

4.6.4 Renewable Energy

Renewable energy is energy that is collected from resources which are naturally replenished by sunlight, the wind, and water. Utilisation of renewable energy is a central measure in achieving reduction of greenhouse gas emissions and mitigation of climate change states Newsom (2012). Conventional energy derived from oil, coal and natural gas are the most used in the world. However, due to the rapid industrial development and the sharp increase in population, these conventional energy sources have been gradually depleted and hence, the need for renewable energy (Li *et al.*, 2016). Renewable energy is needed to achieve energy efficiency in buildings and the facilities manager is required to have adequate knowledge in alternative supply and management of energy. Due to training and experience, the facilities manager is expected to advice the project team that a building can be installed with solar photovoltaic cells when exposed to high radiant energy from the sun (Low *et al.*, 2010).

Tin *et al.*, (2009) state that facilities managers should be generally aware of different technologies and systems to enhance energy efficiency and renewable energy. This is supported by BIFM (2014) which requires that the facilities manager be aware of renewable energy sources and should be able to advise the design team on renewable energy sources. Wiggins (2014) encourages the facilities manager should engage the services of providers of renewable energy.

4.6.5 Visual Comfort

Visual comfort is important for well-being and has been proven to have an effect on occupant work performance, productivity, comfort, and satisfaction and it involves access to natural light (Veitch, 2001). It also involves access to artificial lighting which in the right proportion is essential for well-being particularly, in parts of the building where natural lighting is missing or at evening when natural lighting dwindles (Aries *et al.*, 2010). According to Booty (2009), adequate lighting is responsible for visual comfort, employee safety, acceptable job performance, good workplace atmosphere, comfort and appearance for both workplace and living. The facilities manager ensures visual comfort by making use of natural lighting and maximising low screens and glazed partitions to allow clear sightlines to windows.

Yun *et al.*, (2014) proved daylight to be an important source of visual comfort and energy savings. However, a building's proximity to daylight does bring with it the problem of glare. The facilities manager deals with glare by introducing adjustable blinds to provide shade and to allow local control. Due to natural light never being enough for most of the time, it is supplemented with artificial lighting. The recommended minimum ratio of artificial light to natural light at any long-term work setting is 1:5 (Race, 2006). With reference to Wiggins (2010), the facilities manager is usually aware of lighting requirements for different building types and space and manages lighting efficiency and controls. According to Race (2006), the facilities manager ensures that lamp and luminaire cleaning schedules are in place. When replacing items, the facilities manager ensures the use of efficient lamps and ballasts. The facilities manager also checks that controls are effective and match user requirements, and switched off when not required. In order to achieve sustainable buildings, the facilities manager carries out this role at the design, construction and the operations stages.

4.6.6 Acoustics Comfort

The facilities manager advises, monitors, and maintains all installations, fittings, and equipment related to acoustic comfort. According to Al horr *et al.,* (2016), the acoustic comfort of buildings is the state of well-being where building occupants are protected from noise. With reference to Landstro¨m *et al.*, (1995) there is a direct relationship between acoustic comfort and occupant productivity in buildings. With growth in open plan offices and new technological development in building fabric, issues of acoustic comfort and privacy have been identified as significant issues impacting on occupant productivity states Sundstrom *et al.*, (1994).

However, in spite of acoustic comfort being recognised as an important parameter in sustainable buildings, research indicates that it is not considered high priority in building design leading to several post occupancy productivity related issues (Al horr *et al.,* 2016). With reference to Booty (2009), it is up to facilities managers to ensure as much as possible that the partitions are well fitted (special packing materials can help to seal gaps where panels meet uneven floor plates) in order to noise control. The facilities manager is able to ensure that designs that allow sound to travel through the ceiling and walls are avoided. The facilities manager is able to fulfil this role due to his training and also feedback from building occupants.

4.6.7 Thermal Comfort

According to ASHRAE (2010), thermal comfort is the ability to determine satisfaction with the thermal environment in which a person finds him or herself. Thermal comfort is a basic parameter for indoor air quality; however, it is based on thermal adaptation of the individual occupant which is associated with climate, time of year, gender, race, and age (Quang *et al.*, 2014). Thermal comfort has a direct effect on energy consumption of any building as any sense of discomfort of occupants leads to changing of controls to undesirable levels (Corgnati *et al.*, 2009). ASHRAE (2010) guidelines recommend that since people spend about 80%–90% of their time indoors, designs that ensure thermal comfort should be encouraged. People’s health is affected either positively or negatively by their indoor environments.

Thermal comfort can be achieved by incorporating designs that encourage thermal comfort in buildings. An example is the use of building materials that facilitate warmth or cool in buildings. The facilities manager according to BIFM (2014) should be knowledgeable enough to advise the design team on building materials that aid thermal comfort and also controls to ensure individual control. Van der Linden *et al.,* (2007) suggests that the facilities manager who deals with building occupants during the operations stage should be able to advise on designs that will ensure thermal comfort. This is suggested because the facilities manager has information based on post occupancy evaluation of individual experiences with indoor climate. The facilities manager also monitors installation of fittings and equipment to ensure compliance with thermal comfort measures at the construction stage. At the operations stage, the facilities manager maintains systems that ensure thermal comfort.

4.6.8 Safe Access

In order to achieve safe access in sustainable buildings, Wiggins (2014) encourages the facilities manager to be familiar with safety policies that have been developed to safeguard movement into buildings. These policies include the Workplace (Health, Safety, and Welfare) Regulations 1992 amended 2002. IFMA (2009) requires that in order for facilities managers to be competent in the role of achieving safe access in sustainable buildings, they should develop and implement practices that provide security that meets the user needs in term of access controls and safety in the building. The facilities manager executes this role by being part of the design team as he can influence the building design to ensure safe access into and from the building. Hassanain (2008) encourages the competence of facilities managers in terms of safety processes such as illumination of egress, access to marked exit access doors, and fire safety concepts. The facilities manager is involved in the day-to-day operation of facilities to ensure continued safety of life through the building’s life-cycle.

4.6.9 Space Management

Space management involves the management of space spaces within buildings. Spaces provide an enabling environment for work tasks to be accomplished in an organisation. They also have the potential to improve productivity states Atkin and Brooks (2009). With reference to RICS (2014), the role of the facilities manager in space management involves taking an overall strategic view of a building’s space suitability for business operations. Space management in relation to sustainable buildings involves the maximum use of every available space for the sake of economy and at the same time, ensuring that space is impartially distributed to provide adequate room for building users, creating an atmosphere of well-being (Hassanain, 2010). According to Langston and Lauge-Kristensen (2002), it is an essential skill of the facilities manager to maximise existing space and minimise the need for new space. The facilities manager ensures that space is assigned appropriately and projects for future space requirements, identifying deficiencies within the assigned space and help users solve space problems (Brauer, 1992).

According to BIFM (2014), the facilities manager contributes to achieving sustainable buildings, by developing and implementing a strategy for space, optimising its use and at the same time taking into account environmental issues. The facilities manager contributes to the brief of the designer on space layout (BIFM, 2014). The facilities manager can implement changes to use of spaces and develop strategies for introducing alternative ways of working and the need to change the use of accommodation. According to Booty (2009), the way an organisation's workspace is laid out and maintained gives an important message to visiting customers, potential recruits and existing employees. Workspace layout is the function of the facilities manager and is the most conspicuous part of the job (Hassanain, 2010). The facilities manager can contribute to the wellbeing of building users by allocating adequate individual space that can ensure wellbeing. The facilities manager adds value to an organisation by making good use of available space.

4.6.10 Indoor Air Quality

Indoor air quality refers to the quality of a building's internal environment and relates to the health and well-being of occupants within it. There are two common strategies for building design that is employed to deal with the indoor air quality in a building. The first one is to increase the ventilation rate, which in turn reduces air pollutants. The second is to reduce the source of pollution within and outside the building (Daisey *et al.*, 2003). According to Armstrong (2005), the facilities manager ensures that a safe and comfortable indoor environment is provided for building occupants. Managing the heating, ventilating and air-conditioning (HVAC) systems is a vital part of this responsibility. This role is carried out by the facilities manager at the design, construction, and the operations stages.

The facilities manager advises the design team on HVAC systems according to the post-occupancy evaluations and his experiences in managing such systems (Wiggins, 2010). At construction, the facilities manager monitors that HVAC systems are installed in compliance with laid down policies and then maintains these systems when the building is in full operations. According to Bas (2004), building users are becoming more conscious and critical of the quality of their living and working environments, therefore, the facilities manager needs to be knowledgeable in some causes of indoor environment problems such as poor air quality, defective air infiltration, and inadequate maintenance of air infiltration systems. HVAC systems help in providing and maintaining internal air quality which aids the comfort of occupants (Bas, 2004).

According to ASHRAE (2010) HVAC systems are building services which determine the internal environmental conditions that affect building occupants and business processes. In the process of installing and managing HVAC systems the facilities manager considers the following as stated by Wiggins (2010):

- Acoustics – Because fans and air extraction equipment generate noise in enclosed spaces.
- Thermal comfort – Because each building occupant has different personal preferences due to metabolism and clothing. Therefore, thermal comfort has to be achieved by

balancing statutory requirements, climatic conditions, thermal control and energy conservation.

- Adequate natural and mechanical ventilation – In order to ensure that the conditions in a building are conducive for safe working and living, comfort and efficiency adequate ventilation needs to be provided.

It is estimated that the average person spends 90 percent of their time inside a building and maintaining air quality is important to ensure health and well-being, as well as maximum productivity in the workplace (Armstrong, 2005). Health problems (such as asthma, eye irritations, and nausea) are known symptoms of poor air which impacts productivity in the workplace. Ensuring that the right HVAC equipment is installed in the appropriate space and maintained properly is the responsibility of the facilities manager (Armstrong, 2005). However, whatever type of air conditioning system is used, the key objective is temperature control. The facilities manager ensures that all necessary controls are installed and maintained to guaranty temperature control (Bas, 2004).

4.6.11 Adaptability for Different Uses

Due to the increasing rate of technological progress, occupants' expectations in relation to buildings are rising. For example, offices are required to have flexible partitions that can change with the new developments of modern office configurations. Secondly, IT systems are now installed in accessible floors and ceiling systems facilitating their replacements. Even homes, now require some level of flexibility in meeting up with new trends in home design (Slaughter, 2001). Adaptability for different uses involves giving adequate thought to the design, construction and maintenance of a building in a way that it can be easily altered in order to prolong its life (Addis and Shouten, 2004). Due to experience in the management of buildings, the facilities manager can share knowledge about designs specifications that can ease change in the purpose of building.

At the design stage, it is the role of the facilities manager to have studied market trends in relation to the current developments in building adaptability and advise the project team on how to help occupants fit out their precise requirement for future needs. The facilities manager is required to give useful suggestions that will make a building be a place that has a mix of tenure types and spaces that can be easily adapted for different purposes (Wiggins, 2014). Spedding (1994) suggests that the facilities manager must be capable of handling a building's adaptation for different functionality requirements in order to meet different tenure needs.

4.6.12 Efficient Use of Water

According to Taylor (2014), delivering water efficiency is majorly the responsibility of the facilities manager. However, while often seen as secondary to energy efficiency, its importance cannot be underestimated, particularly with water shortages due to climate change and the growing demand for fresh water supplies. According to Taylor (2014), the facilities manager takes the first step to water efficiency by understanding existing water use and establishing overall consumption and identifying any areas or equipment with significant demand. This process is called water consumption monitoring.

Having established the water consumption for the overall building and, ideally, any areas or equipment with particularly high water use, the facilities manager then compares actual consumption with industry benchmarks or predicted consumption figures to establish the current level of performance. Checking actual consumption against industry benchmarks and predicting consumption makes it possible for the facilities manager to identify both potential opportunities for making savings through improved operation and opportunities for reducing water consumption through investing in more efficient equipment, controls, and appliances. The facilities manager then sets targets for water savings and identifies priority areas for making improvements that save water and costs (Taylor, 2014).

Water efficiency is a criterion for sustainable building and consequently is considered one of the major categories in most building sustainability rating systems. According to Lau *et al.*, (2012) efficient use of water resources helps to reduce the fossil fuel energy and the associated carbon dioxide emission in water processing for domestic use. They made reference to the Environmental Protection Department (EPD) and the Electrical and Mechanical Services Department (EMSD), stating that the greenhouse gas emissions due to fresh water and sewage processing are indirectly related to building operation. Imteaz *et al.*, (2012) suggested a rainwater harvesting system as a way for facilities managers to carry out their water management function. They suggest that the facilities manager should request for a rainwater harvesting system in the design of the building and that even the facilities manager himself can introduce rainwater tanks; for this has proven to provide significant water savings.

The substantial water savings that the facilities manager can achieve is also confirmed by Lau *et al.*, (2012) who argue that the facilities manager plays a critical role in achieving significant water savings. They were able to create a water management efficiency strategy as illustrated in Figure 4.6. This involves developing a plan for water management, organising meetings with all stakeholders which are the building users, the facilities management team and the contractors (cleaning, gardening and the repair and maintenance), setting a target to reduce water consumption by a certain amount discussing strategies, executing the plan and reviewing the progress, and identifying areas for improvement.

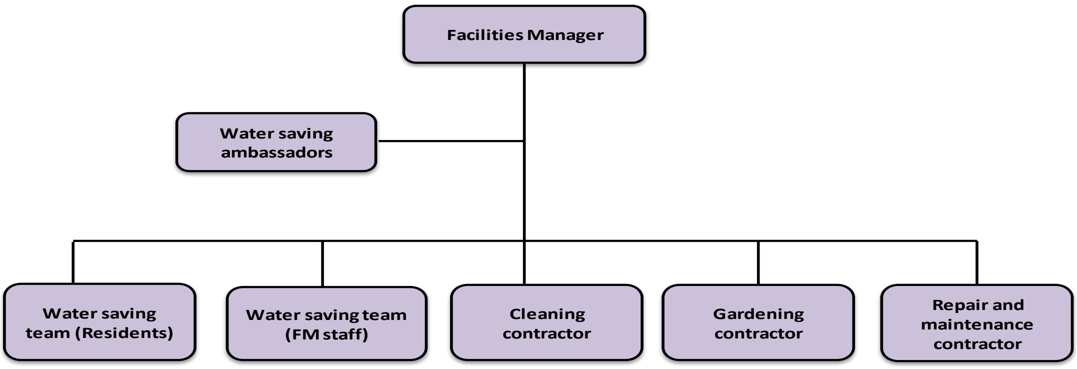

Figure 4.6: Water Management Efficiency Strategy
Source: Lau *et al.*, (2012)

With reference to Taylor (2014), water demand can be reduced by limiting areas of water-intensive grass and turf and, where possible, using permeable surfaces to reduce rainwater run-off. Regular maintenance of planted areas can reduce water consumption by removing weeds and applying mulch or bark to flower beds to reduce evaporation. The facilities manager ensures that water efficiency distribution systems such as low-flow water fittings and equipment (taps, showers, WCs, urinals) are installed; and also ensures that rainwater or greywater harvesting systems are installed to make further savings in overall water consumption. The facilities manager's competence in this role will help in achieving sustainable buildings.

4.6.13 Material Efficiency

According to Allwood *et al.,* (2011), material efficiency is the construction industry's process of reducing the environmental impact caused by buildings. It involves avoiding significant volumes of building material waste, reducing the extraction and consumption of more resources and to decrease energy demand and carbon emissions. However, the area of material efficiency in manufacturing of building materials has been under-researched and related knowledge is limited. As described in Section 3.3.19 material efficiency is the sparing use of building material resources, reduction of waste, recycling and effective management materials (Ruuska and Häkkinen, 2014). RICS (2015) requires the facilities manager to be competent enough to advice on sustainable material selection and encourages the reuse of building materials in order to reduce the demand for new materials and to reduce waste. Facilities managers are required to have knowledge of material resource efficiency so as to save cost in the long term and to fulfil the laws of sustainability (BIFM, 2014). This is also a necessary area of competence for the facilities manager to show his relevance in the design team as inferred by Hodges (2005).

4.6.14 Building Operation Maintenance Task

Maintenance has been described in Section 3.3.20 as all efforts to restore and maintain a building to meet ethical standards and the purpose for which it has been developed. According to Wiggins (2010), the prime goal of building maintenance is to preserve a building in its original state as far as practicable, in order for it to serve purpose. According to IFMA (2014) building maintenance, task involves the facilities manager assessing the building structure, the interiors and exteriors of the building and grounds of the building; and managing and overseeing occupant services such as parking, janitorial, food, concierge, facilities helpdesk, security and safety services. According to BIFM (2014) the facilities manager analyses the maintenance implications associated with an organisation's building structure and assets; develops, implements, and reviews the strategies for building use, services and control systems; manages and monitors maintenance programmes, and evaluates and uses different management systems and technology available in the process. According to FMAA (2012) building maintenance tasks also involves managing minor works and repairs; cleaning services; and natural and artificial lighting to ensure visual comfort.

Wiggins (2010) adds that the role of the facilities manager in building maintenance task includes to devise and implement maintenance policies, programmes, activities and schedules for building services such as electrical, mechanical and plumbing services; and heating, ventilation, and air-conditioning systems. The FM department develops these in collaboration with specialists in the services engineering field. The role of the facilities manager also includes identifying problems at their earliest stages and evaluating a building's future maintenance and repair needs through a systematic approach that assesses the condition of a variety of building components and systems. These may include building structure, building envelope, mechanical systems, electrical systems, interior finishes and lift safety (Booty, 2009).

According to Taylor (2013), if the building fabric and the building services deteriorate due to a lack of maintenance, the heating and cooling energy demand is likely to increase and so will energy consumption. Regular maintenance of the building fabric is required to ensure that energy demand is kept to a minimum, and regular maintenance of the building services is required to ensure that any remaining demand can be met as efficiently as possible. Maintenance of buildings is a major role for the facilities manager and is at the core of FM role (Booty, 2009). The facilities manager starts this role at the design stage by checking designs for ease of maintenance at the operations stage.

4.6.15 Energy Efficiency

Energy efficiency is a way of managing and decreasing energy consumption (Arik, 2014). A building is, therefore, energy efficient if it delivers more services for the same amount of energy input, or the same services for less amount of energy. According to Ashford (1993) good design, good execution, good management and appropriate technology are the key ingredients of energy efficiency in buildings. The facilities manager must be well aware of what he is managing, for a broad knowledge of buildings day-to-day operations is essential for energy efficiency (Aune *et al*, 2009). Energy efficiency involves energy consumption management and includes the process of monitoring, controlling, and conserving energy in a building or organization. The main energy consuming activities in buildings are heating, lighting and cooling, which can be controlled by building automation systems (Wu *et al.*, 2010).

It is acknowledged, that improper operation and maintenance of building services systems can lead to unnecessary energy consumption, tenant complaints, poor indoor air quality and even environmental damage (Määttänen *et al.*, 2014). According to Taylor (2013), the facilities manager carries out energy efficient task by identifying the main energy uses and undertaking a preliminary energy audit. BS EN 16247-1:2012 (Energy audits – General requirements) defines an energy audit as '*systematic inspection and analysis of energy use and energy consumption of a site, building, system or Organisation with the objective of identifying energy flows and the potential for energy efficiency improvements and reporting them*'. Having established the energy consumption for different zones and end uses by an energy audit, the facilities manager compares this information against industry benchmarks to see which areas are performing well and, more importantly, where there could be scope for improvement. The facilities manager then implements measures to improve energy efficiency and identify any specific causes of poor energy efficiency. Generally, according to Taylor (2013), the causes of poor energy efficiency are original design and installation of the building services; poor condition of the building fabric or building services resulting from a lack of maintenance; and inefficient operation of the building and its services.

Once a building has been handed over, the FM team has limited scope to change anything about the original design and installation of the building services without major investment. According to BIFM (2014), the facilities manager helps in reducing energy consumption by influencing a reduction in the consumption of electricity and measuring and monitoring energy consumption against targets. The facilities manager implements improvement programmes for building users and optimises asset operation thereby reducing cost and increasing efficiency. The facilities manager develops, implements, and reviews an organisation's energy and utilities management policy and ensures compliance with relevant legislation. Concerning energy and heating, the condition of both the building fabric and the building heating system will affect the energy consumption associated with space heating. The facilities manager does a simple visual check of the building exterior in order to identify the most obvious causes of unnecessary heat loss. Then measures are taken to prevent heat loss in order to increase energy efficiency (Taylor, 2013).

As with heating energy consumption, the facility manager takes steps to reduce lighting energy consumption by implementing measures to reduce demand. General light levels are checked to ensure that they are appropriate for space and activity being carried out. BS EN 12464-1:2011 (Light and lighting – Lighting of work places – Indoor work places) gives recommended light levels for different spaces and activities. The facilities manager ensures that windows and internal surfaces are clean and blinds are operational and used properly to help maximise daylighting potential and reduce the need for artificial lighting. However, the benefits of natural daylight can only be realised if the lighting controls are effective and if lights are not turned on unnecessarily during daylight hours. Having reduced the lighting energy demand through maximising daylighting and optimising controls, it is important to ensure that the remaining demand is met efficiently states Taylor (2013).

4.6.16 Building Life-cycle cost

Building life-cycle costing has been identified as one of the processes under financial management in relations buildings in FM. According to BIFM (2014) financial management usually involves the facilities manager identifying how income is generated within FM, identifying the legal obligations and evaluating financial performance. It also involves the facilities manager understanding the principles of management accounting, balance sheets, and use of capital and revenue budgets. The facilities manager identifies trends and variances and prepares financial cases, develops and manages budgets, understands the impact of depreciating asset values, whole-life costing and discounted cash flow. According to Wiggins (2010) the facilities manager is usually in charge of budgets, also known as a financial plan, to develop financial information to help in order trend and benchmark information; inform decisions; prepare future budgets and request for investment via business cases; allocate funding to give appropriate services; make allowances for the depreciation of assets; and repair or renew decision points.

Financial management according to Booty (2009) is a core part of any business, supporting the achievement of the organisation’s short, medium and long-term goals. Booty (2009) states that facilities managers view financial management as the efficient use of available finance through the use of planning and control mechanisms. This, ideally, is a proactive process which ensures that the right level of financial resource is available at the right times, enabling the required level of service quality to be delivered by a contractor.

According to Spedding (1994), financial management for the facilities manager involves capturing operation and running costs data and the use of life-cycle cost appraisal which according to Wiggins (2010) is carried out from design through to the operations phase of the building life-cycle. The facilities manager uses the life-cycle costing to secure funds for maintenance of existing building and for the development of new projects (Wiggins, 2010). With reference to Park (1998), the facilities manager uses life-cycle costing to estimate the cost of facilities, equipment or furniture with a plan to either replace or repair and at the same time seeking the decision that is most beneficial to the organisation in terms of cost. The facilities manager, therefore, has the ability to carry out cost appraisals to present the project team with the most cost effective option in terms of new building developments and for maintenance works.

4.6.17 FM Role and the Management Aspect

As earlier mentioned, the facilities manager's roles under the management aspect relate to existing processes in conventional buildings. However, these processes are relevant in making a building sustainable and are therefore, recognised as sustainable building constituents. One of them is the facilities manager's role in post occupancy evaluation (POE). POE ensures that functional buildings are delivered in consultation with current and future building users, and other stakeholders. It involves assessing and reviewing the feedback from occupants of a building about the building's performance in order to make good. The facilities manager is suited to carry out POE as he has access to all aspects of a building once it is in use and is the occupants' first port of call when the building does not perform to expectation. The feedback of the POE helps him to functional issues such as air leakage in buildings. He employs experts that help to confirm air leakage and suggest ways of remedy. This is done to reduce energy consumption to the barest minimum. Though, POE has it obvious advantages, the facilities manager is faced with inadequate financial support and the right channels for effect beneficial change (Eley, 2001).

The facilities manager monitors and assesses technology trends and innovation and considers their application within the building operations. Since todays buildings are hinging towards new technology developments, the facilities manager is required to monitor new innovations in building systems. The facilities manager needs to have adequate knowledge of these systems so as to enable deliver FM duties more effectively. This creates room for continuous improvement in the due to his long term relationship with the building's operations (Atkin and Leiringer, 2006).

The facilities manager is usually involved with building tuning procedures to ensure optimum occupant comfort and energy efficient performance. However, before building tuning can commence, the building needs to be commissioned. It is the duty of the designers to monitor the commissioning process, however, the facilities manager is needed to observe the processes involved in order to have a better understanding of the building operations. The facilities manager is needed to ensure that all commissioning records are complete and his team have been appropriately trained with regard to the related building operations (Griggs and Grave, 2004).

The facilities manager incorporates building management systems that actively control and maximise the effectiveness of building services. He also manages building management systems to provide feedback on the building's performance. It is suggested by Wang *et al.*, (2013) that building management systems can provide the facilities manager with a database of information to support the building life-cycle. The early involvement of facilities manager will contribute to reducing the needs for major repairs and alternations that will otherwise occur at the operational phase.

The facilities manager has the ability to develop a building user's guide that can enable building users optimise the building's performance. The guide helps building users to understand the sustainability components involved in the building and how to operate and maintain them. The facilities manager is also required to organise yearly building tuning initiatives that ensure optimum occupant comfort and energy efficient performance. The facilities manager develops a waste recycling management plan to help with reducing the environmental impact of the building and establishes legal and contractual environmental management initiatives. One of such is the development of initiatives that educate building occupants on how the sustainability issues in building work as stated by Shah (2007).

In summary the facilities manager in relation to a building's sustainability carries out the following roles:

- Incorporates practices involving waste management.
- Incorporates specification of materials with low environmental impact,
- Incorporates life-cycle costing to minimise frequency of material replacement and maximise material optimisation.
- Incorporates environmental management and stewardship involving reduction of pollution from storm water.
- Promotes healthy, secure, and good working environment, good indoor air quality, thermal comfort, visual comfort and noise control; contributing to the wellbeing of building users.
- Incorporates energy management in compliance with relevant legislation, energy efficiency of building services equipment, including their maintenance and operations, and reduction of energy consumption and energy monitoring.
- Incorporates the reduction of water usage, water efficiency equipment installation, operations and maintenance and water monitoring measures.

The facilities manager is able to contribute to the achievement of sustainable buildings by carrying out the aforementioned roles at the different life-cycle stages as discussed in Section 4.4.1 to 4.4.3. However, the contribution that the facilities manager makes at the different stages of a building's life-cycle in relation to the building's sustainability needs to be identified. Therefore, Table 4.4 was developed based the facilities manager's roles as presented in Table 4.3. Table 4.3 has been developed based on the content analysis of the four FM documents stated earlier; these documents have been described and the basis for their selection in Section 4.3 (pp 128) and Section 6.9.1 (pp 181-182). The content analysis was based on the initial findings of the sustainable building constituents and involved identifying the facilities manager's roles that relate to the environmental, social, economic, and management aspects of sustainable building constituents as shown in Table 4.3. After identifying the facilities manager's roles that relate to sustainable building constituents, the roles were then examined and categorised according to the design, construction, and operations stages of the building life-cycle as shown in Table 4.4 in order to show specific roles of the facilities manager in sustainable buildings.

An examination of Table 4.4 shows that the facilities manager plays a crucial role at the design stage in terms of the environmental aspect. This is probably due to the emerging role of the facilities manager as the building professional that majorly helps in reducing the negative impact of the building on the environment and particularly at the operations stage. As seen in Table 4.4, the facilities manager plays a major role in reducing carbon emissions. The facilities manager's role starts from the design stage as particularly seen in the social and economic aspects. In the management aspect, the facilities manager's role is majorly at the operations stage.

Table 4.4: FM Role in relation to Sustainable Building at Building Life-cycle Stages

Facilities Manager's Role at Design	Facilities Manager's Role at Construction	Facilities Manager's Role at Operations
Environmental		
	Advises on an effective waste management system at construction.	Coordinates waste management during the operational life of the building.
Advises on minimum car parking capacity in order to help reduce transport related pollution.		
Advises the use of systems that reduce carbon emissions.	Influences and installs refrigeration systems that minimise carbon emissions.	Maintains systems that minimise carbon emissions.
Develops, advises and implements policies that help to protect the environment surrounding the building site.		
Educates the design team on measures to preserve and enhance the plant and animal life surrounding the building site.		
Educates on the use of renewable energy.		
Social		
Advises on visual comfort in terms of daylighting and artificial lighting and lighting controls for the comfort of building occupants.	Ensures installation of fittings that will give visual comfort to building occupant.	Maintains all installations that give visual comfort.
Advises on the building's acoustic performance including sound insulation meeting the appropriate standards.	Monitors installation of systems that provide acoustic comfort.	Maintains systems that provide acoustic comfort.
Advises and specifies system that provide thermal control (air-conditioning) at design.	Ensures installation of thermal controls such as air-conditioning units.	Maintains a thermally comfortable environment for occupants within the building.
Advises on safe access and security to and from the building at design stage.		Maintains systems that provide safe access and security in the building.
Advises on apportioning of space for occupant privacy and wellbeing.		Executes space management plan.
Helps to provide a healthy indoor environment through advice and specification of designs that encourage ventilation.	Monitors installation of appropriate ventilation equipment to provide good indoor environment.	Maintenance of ventilation equipment and outlets.
Advises on building design that is adaptable for different tenure types and ensuring flexibility wherever possible.		
Economic		
Advises and specifies water efficient fittings.	Ensures installation of water efficient fittings.	Monitors water consumption and carries out activities that reduce waste of water.
Advises on minimising the frequency of material replacement at design.	Ensures use of recycled materials at construction.	Carries out maintenance of the building and services which ensures the durability and economic value.
Advises on design that ensures energy efficiency.	Monitors installation of energy efficient lighting fittings and equipment.	Monitors energy consumption to reduce energy usage.
Carries out building life-cycle cost exercises for building material selection.		
Management		
		Delivers functional buildings in consultation with current and future building users and other stakeholders.
		Monitors and evaluates technology trends and innovation in the building.
		Assesses the application of technology within building operations.
		Incorporates building management systems that actively control and maximise the effectiveness of building services.
		Establishes legal and contractual environmental management initiatives.
		Develops initiatives that educate building occupants on how the sustainability issues in building work.
		Develops a building users guide to enable building users to optimise the building's performance.
		Executes yearly building tuning initiatives that ensure optimum occupant comfort and energy efficient performance.

Source: Self-study

4.7 Chapter Summary

This chapter has defined FM as a practice and process that cuts across and integrates diverse disciplines, processes, people, physical assets and technology in order to maintain and develop services which will promote an organisation's core objectives. The chapter considered the development of FM from a cleaning and maintenance department to dealing with environmental issues, developing SD policies, knowledge management and strategic delivery of its services. The chapter identified 44 FM roles in relation to sustainable buildings as found in the BIFM Facilities Management Professional Standards Handbook, the IFMA Complete List of Competencies, the FMAA Skills in Facilities Management Investigation into Industry Education, and the RICS Assessment of Professional Competence Facilities Management Pathway Guide.

The chapter identified the facilities manager roles in the stages of the RIBA Plan of Work 2013, that is the strategic definition stage, preparation and brief stage, concept design, developed design, technical design, construction, handover and close out and in-use stage. These stages are equivalent to the design, construction, and the operations stages highlighted in this research study and as explained in Section 3.4. At the design stage the facilities manager starts with establishing the client brief and in the process highlights problems and provides valuable information on building performance and operating costs. The facilities manager then moves on to review and assess the building design for maintainability, operability and sustainability. The facilities manager also identifies and selects the optimum maintenance and replacement strategies for the building. At construction stage the facilities manager plays a monitoring and supervisory role to ensure all sustainability issues are effectively managed.

At the operations stage, the facilities manager's role includes management and maintenance of the building with its associated costs. His role ranges from performance monitoring and improvement in the delivery of building service to ensure occupant health and wellbeing, good indoor air quality, energy efficiency and compliance with government regulations on environmental issues and security. Though the facilities manager's roles have been categorised into the different life-cycle stages of the building, the roles were identified according to the environmental, social, economic, and management aspects of sustainable building in order to ensure the facilities manager's roles are in relation to the aspects of SD. The chapter revealed that the facilities manager's roles in sustainable buildings will help in providing the end user with a building that meets purpose and provides comfort. The identification of these roles fulfils objective 2 of this research.

CHAPTER 5: Conceptual Framework, Barriers and Drivers for Facilities Managers in Achieving Sustainable Buildings

5.0 Introduction

This research study aims at developing a framework for facilities managers to enable them achieve sustainable buildings through their role. This chapter, therefore, focuses on the development of a conceptual framework for facilities managers in achieving sustainable buildings. The conceptual framework has been developed from the findings of Objective 1 and 2. The findings of Objective 1 provided constituents of a sustainable building while findings of Objective 2 highlighted the facilities manager's roles in sustainable buildings. This chapter addresses Objective 3 of this research study.

5.1 Conceptual Framework for Facilities Manager's Role in Sustainable Buildings

Miles and Huberman (1994) defines a conceptual framework as a visual or written structure that explains, either graphically or in narrative form, the main things or key concepts to be studied in a research. Likewise in this research, the main issue to be studied are the facilities manager's roles that relate to sustainable building constituents. The facilities manager has always been committed to the management of buildings and its associated services. He, even now focuses on the environmental issues caused by buildings (Noor and Pitt, 2009). Yet, the specific roles in ensuring the delivery of buildings that are less harmful to the environment, promote health and wellbeing of building users, and provide economic benefit through the building life-cycle is needed to be identified.

A conceptual framework clearly explains the processes involved in the achievement of a research goal, including significant findings that are relevant to the research and how they relate to address every aspect of the research (Environment and Heritage, 2011). Similarly, in the development of this research's conceptual framework, research objectives were developed, relevant literature was reviewed, and a content analysis of 3 documents (BREEAM-NC, LEED-NC and ISO 15392), was carried out. This was done in order to identify the constituents that make up a sustainable building. A content analysis was also carried out to identify the facilities manager's roles that relate to sustainable building constituents. The identified constituents informed the identification of the facilities manager's role in sustainable buildings. A conceptual framework also outlines concepts, assumptions, expectations, beliefs, and theories that supports and informs research (Maxwell, 2005). It is generally believed that the aforementioned documents set the criteria for sustainable buildings and informs this research.

The conceptual framework according to McGaghie *et al.*, (2001), provides the platform for the presentation of a particular research question that drives the research study being investigated based on the research problem. It aids an understanding of the research problem (Mertens, 2005). The framework represents the first step in addressing what makes up a sustainable building and the facilities manager's role in achieving sustainable buildings in the Nigerian context. For as identified earlier on, a major problem facing the Nigerian built environment is poor design, inadequate construction standards, use of harmful building products and materials, and poor maintenance and management of buildings (Abigo *et al.*, 2012). The framework gives an understanding of the solution to this problem.

With reference to Smyth (2004), a conceptual framework is constructed by the inquirer. Its origin may be adapted from various literature, however, the structure and overall coherence, is built. Figure 5.1 shows three steps in the development of the framework.

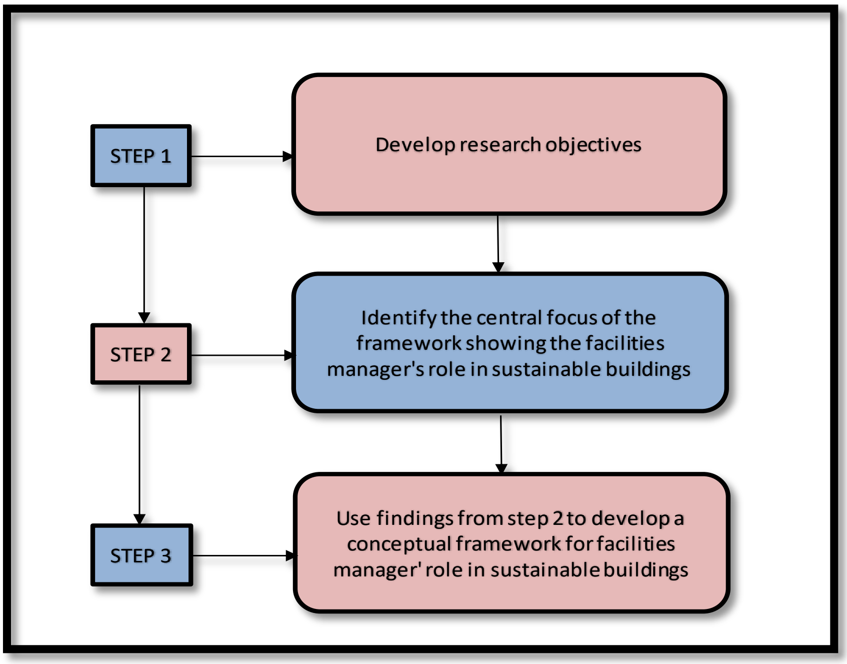

Figure 5.1: Steps Adopted to Develop the Conceptual Framework for Facilities Manager's Role in Sustainable Buildings

STEP 1: Development of research objectives. Step 1 of the conceptual framework involves the development of the research Objectives 1: To identify the constituents of sustainable building with reference to literature and internationally recognised standards and Objective 2: To evaluate the role of FM in relation to the sustainable building at the design, the construction and operations stages of the building life-cycle . The development of research objectives is one of the processes involved in developing a conceptual framework. The identification and development of the objectives of this research study is the basis on which the conceptual framework is developed. The objectives 1 and 2 address the different areas that need to be focused on to achieve the aim of the research. This was deemed necessary in developing the conceptual framework that shows the facilities manager's role in sustainable buildings.

STEP 2: Identification of the central focus of the framework. Step 2 involves developing the central focus of the conceptual framework and which involves identifying the facilities manager's role in the achievement of sustainable buildings. To identify this role, the first step is in the identification of the constituents that make a sustainable building (Objective 1) and then followed by the second step which is the identification of the facilities manager's role in relation to these sustainable building constituents at the design, construction and operations stages (Objective 2). Therefore, the main factors to be investigated are sustainable building constituents and the facilities manager's roles that are related to these constituents. These factors give guidance for the conceptual framework to provide a layout of major issues that need to be addressed in a research (Environment and Heritage, 2011) and guides the research process into achieving its goal (Regoniel, 2015).

Therefore, an investigation of sustainable building constituents is carried out by a review of relevant literature and a content analysis of documents to provide the research with general information on the sustainable features of a building. The content analysis involves the building sustainability assessment tools such as BREEAM-NC, LEED-NC and ISO 15392. The process provided sustainable building constituents and for the purpose of developing a framework that aligns with the criteria for SD, the identified constituents are categorised into the environmental, social, economic, and management aspects as shown in Figure 5.2. This fulfilled the first step in the development of the framework. In order to fulfil the second step in the development of the framework, a content analysis of the Facilities Management Professional Standards Handbook, the IFMA Complete List of Competencies, Skills in Facilities Management Investigation into Industry Education, and the RICS Assessment of Professional Competence Facilities Management Pathway Guide is carried out. The content analysis is necessary to ascertain the facilities manager's competencies that relate to sustainable building constituents. The FM competencies are used to determine FM roles at the design, construction and operations stages of the building life-cycle. This is necessary because a building is created from the design and construction stages, and then occupied and used at the operations stage. The process of how the content analysis was carried out is described in Section 6.9.2.

The aforementioned steps are used in the development of the framework. The conceptual framework shows the facilities manager's roles with regards to sustainable building constituents at the design stage. The design stage is the first stage in the building life-cycle in which steps towards the operational life of the building are considered in order to achieve the purpose for which the building will be built. There is a growing acknowledgement that in order to maximise the sustainability of a building, the facilities manager should be included as early as possible in the design process (FMAA, 2014). According to Erdener (2003), the early engagement of the facilities manager can contribute to reducing the potential negative impact of buildings and major repairs that will otherwise occur at the operations stage. To ensure that buildings achieve a sustainable state from the very beginning, the facilities manager is needed to be involved in the design process (Kelly *et al*, 2005). However, few efforts have been made in the building industry to involve the facilities manager at the design stage (Nutt and McLennan, 2000).

When comparing the facilities manager's role in the design stage of the developed framework, with the facilities manager's role at the design stages in relation to RIBA Plan of Work 2013 and as highlighted by the BIFM Operational Readiness (2016); the facilities manager plays a significant role and proves the relevance of the facilities manager to this stage. The design stage of the RIBA Plan of Work is made up of five of the eight-stage plan and this shows that the design stage forms a significant part of the building life-cycle. The stage comprises of the strategic definition, preparation and brief, concept design, developed design, and technical design stages as highlighted in Section 3.4 and the role of the facilities manager is identified at these various stages. The facilities manager at the strategic definition phase works in collaboration with other building professionals to define the scope of the proposed building project. At the preparation and brief stage, the facilities manager in collaboration with other project team members defines the project objectives in terms of the building functionality and quality, cost and sustainability. The concept, developed and technical design are design stages where the facilities manager has the competence to incorporate the client's and end user's requirements into the design proposals and the construction process. The framework also shows the facilities manager's roles at the construction stage. The construction stage includes handover and close out (commissioning) as stated in the RIBA Plan of Work 2013. At this stage the facilities manager's role is to ensure that the operational impact of design decisions are considered and adjusted where necessary. The facilities manager is also involved in developing the building user guide and ensuring that the mechanical and electrical services in the building are tested to ensure they will they have been properly installed and they are working. Although, the facilities manager's involvement at the construction stage is identified as being minor (Shah, 2007) when compared to the role that the builder plays in terms of constructing the physical structure of the building; his role enables him to at least contribute his expertise as aforementioned at this stage.

At the operations stage and which is the same as the in-use stage in the RIBA Plan of Work; the facilities manager in sustainable buildings performs the various roles shown in Figure 5.2. One of the major roles played by the facilities manager at this stage is the implementation of the post occupancy evaluation (POE). POE involves developing a process for the collection of feedback from end users with regards to a building's performance. The aim of carrying out a POE is to ensure that the building is performing optimally and that users are satisfied. The POE enables the facilities manager to examine ways to improve building performance (Eley, 2001).

The framework shows the initiation and integration of the facilities manager into the design stage. The framework also shows the involvement of the facilities manager at the construction and operations stages. there is clear indication that if the facilities manager is involved right from the design stage, he will be able to monitor, guide and ensure that the building is designed and constructed to meet purpose and sustainability standards. Both he and the end users will enjoy the benefits of a building that functions effectively, safe for the environment and aids the comfort and health.

In relation to the facilities manager's role according to the RIBA Plan of Work (2013) as identified by BIFM Operational Readiness (2016), it can be inferred that the facilities manager performs the general role of a building operations consultant who when introduced early into the building team can make significant contributions on matters of client and end user requirements and operational functionality of the building. In contrast, the conceptual framework for this research study provides a breakdown of the facilities manager's specific role according to the constituents that make a sustainable building. It shows the role of the facilities manager in achieving specific sustainable building constituents. The conceptual framework can lead to a better understanding of constituents that make a building sustainable and the role of FM in the achievement of sustainable buildings.

STEP 3: Development of a conceptual framework that shows the facilities manager's role in sustainable buildings. The findings of step 2 (Objectives 1 and 2) is used to develop a conceptual framework that shows the facilities manager's roles in the achievement of sustainable buildings and this is shown in Figure 5.2. Figure 5.1 shows the step taken in the development of the framework and is as explained in step 2. The framework can be critiqued using the criteria used in Brathwaite (2002) to critically appraise six models of cultural competence for their suitability to guide the development of intervention in a research study. The criteria include: comprehensiveness of content, logical congruence, conceptual clarity, level of abstraction, clinical utility, and perspective of culture (cultural literacy versus experiential-phenomenological perspective). Similarly, these criteria can be used to assess the appropriateness of this research's conceptual framework for facilities manager role in sustainable buildings.

The comprehensiveness of content refers to the depth and breadth of contents of the framework. Depth provides adequate descriptions of constructs, and links the relational propositions of the constructs to one another (Fawcett, 1995). This research's framework provides adequate descriptions of what constitutes a sustainable building and the facilities manager's role that relates to the constituents. Logical congruence refers to the logic of the internal structure of the framework, which is assessed through critical reasoning. Conceptual clarity refers to identification and explicit description of the concepts (Fawcett, 1995). The structure of the developed conceptual framework is based on the environmental, social, economic, and management aspects of sustainable building in order to meet the criteria for SD. The framework similarly includes the facilities manager’s role in sustainable buildings and is chronologically categorised into the aforementioned aspects and according to the design, construction and operations stages of the building life-cycle and in clear language that is easily understood.

The level of abstraction refers to the extent or intensity by which concepts are represented in a conceptual model. The concept of SD in buildings is represented in the conceptual framework as the framework shows sustainable building constituents under each aspect of the SD concept. Similarly, the framework represents the facilities manager’s role in relation to the aspects of SD and in the design, construction and the operations stages of the building life-cycle. Clinical utility refers to the applicability and relevance of the model to the real practice (Sidani, 2000). The framework can lead to a better understanding of the constituents that make a sustainable building and help in the competence of the facilities manager in sustainable buildings. It shows the relevance of the facilities manager to achieving sustainable buildings.

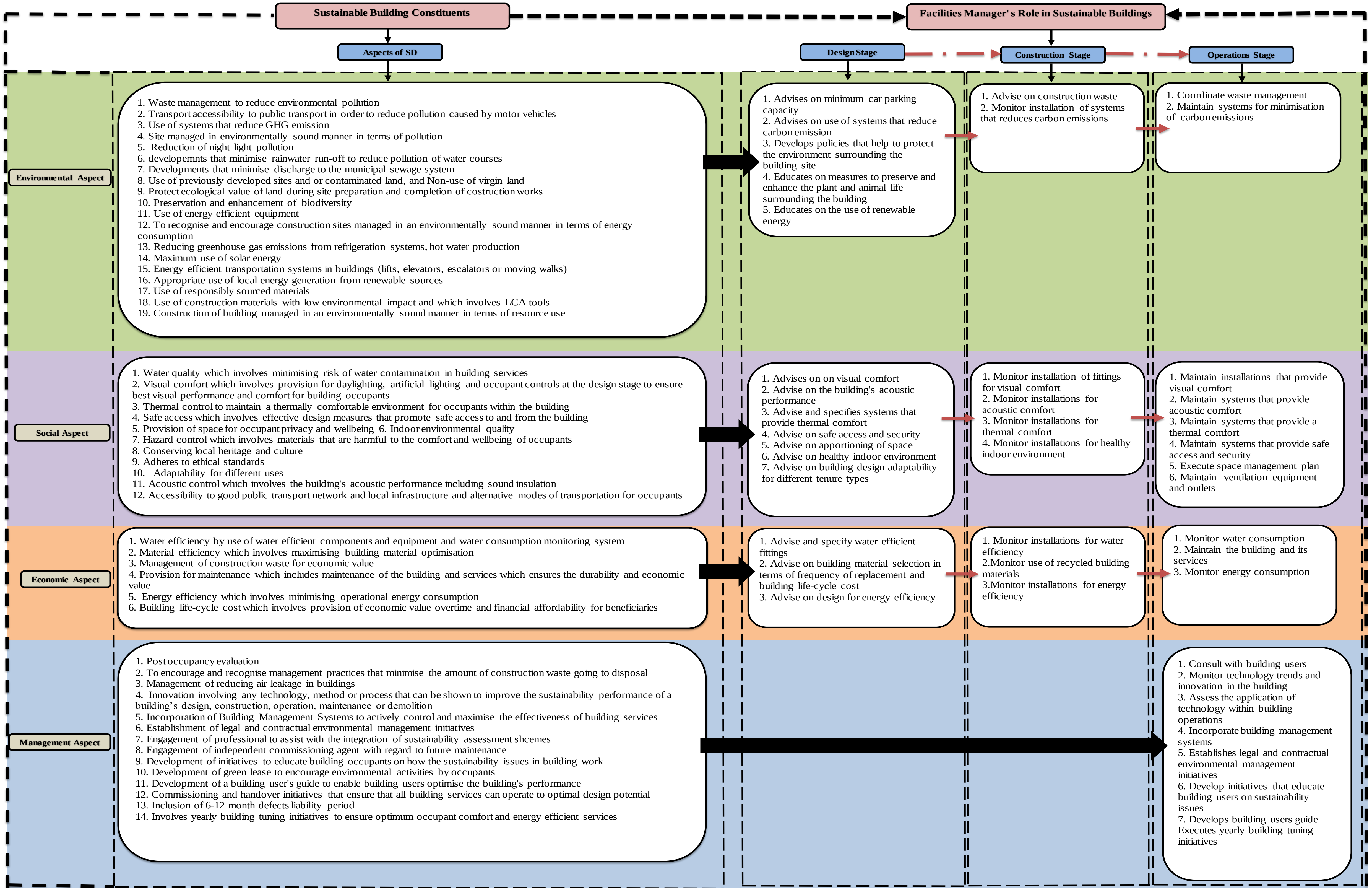

Figure 5.2: Conceptual Framework for Facilities Manager's Role in Sustainable Buildings

5.2 Barriers to FM Practice in Achieving Sustainable Building

Though, the developed conceptual framework can guide facilities managers into developing sustainable buildings, certain factors with regards to sustainable buildings might hinder the realisation of the facilities manager's role in sustainable buildings. These factors can be termed as barriers to FM practice in achieving sustainable buildings and include: inadequate technical knowledge and understanding of intelligent buildings that can foster innovation in technology by facilities managers, lack of awareness, lack of training and tools (Finch and Clements-Croome (1997). This is confirmed by Brown and Pitt (2001), who argue the facilities manager's lack of professional and scientific training is a barrier to current understanding of FM issues generally and will no doubt impact sustainable practice as facilities evolve in new technology. Literature has identified barriers to sustainable building practice itself and these include lack of education, lack of knowledge in sustainable buildings, perceived higher upfront costs when compared to conventional buildings, split incentives, lack of government policies that support sustainable buildings and building services as an afterthought (Smith and Baird, 2007; Gleeson and Thomson, 2012; Murray and Cotgrave, 2007; Häkkinen and Belloni, 2011; Rydin *et al.*, 2006; Djokoto *et al*., 2014).

The building industry has been gradually working towards sustainability in buildings; however other disciplines have started a decade before in embedding sustainability into their practices and within their higher education programmes (Gleeson and Thomson 2012). The building industry is lacking behind in the training of its members in matters of sustainability. Tarja and Belloni (2011) identify with the inadequate training as a barrier to sustainability in buildings. They affirm that building professionals lack the capacity to implement sustainable practices due to their ignorance or a lack of common understanding about sustainability. Rydin *et al.*, (2006) claim that while building professionals demonstrate confidence in the delivery of their ability to access and use knowledge, in general, this confidence level drops when sustainable building issues are addressed.

Gleeson and Thomson (2012) also confirm lack of adequate training of building professionals as a barrier to sustainable buildings. However, professional bodies over the last ten years have been working to adopt sustainable practices within their professional competency frameworks. They have put processes in place to ensure that people seeking membership and new graduates are sufficiently literate in sustainable building practice (Murray and Cotgrave, 2007). Inadequate training of building professionals in sustainable building practices indicates their lack of understanding of sustainability issues.

Even facilities managers seem to lack understanding in sustainability issues. Elmualim *et al.*, (2012) identify lack of understanding of sustainability issues as a barrier to sustainable FM practice. They argue that facilities managers often seem not to understand basic information that is needed to implement sustainability policies and perceive that in many organisations sustainability is not a high priority. The experience of facilities managers surveyed in their research show that substantial segments of the FM industry lack basic sustainability policies and fail to report or communicate their activities to stakeholders and investors. This indicates that facilities managers need to gain adequate knowledge about sustainability issues in general before understanding how to implement it in buildings.

In relation to the lack of knowledge, Williams and Dair (2006) affirm that design and construction teams are not knowledgeable enough with regards to best available information on products and tools in sustainable building practice. In their research, there was evidence that building professionals were not aware of sustainable measures or alternatives that fall within their work descriptions. According to Tarja and Belloni (2009), building professionals are not well-informed in installation and workings of sustainable technologies and materials and which require new forms of competencies. Therefore, they seem to lack the capacity to implement sustainable practices (CIB Report, 1999). This makes it more difficult for facilities managers as they have to work with people who have limited or no knowledge in sustainable building practice.

Perceived higher upfront costs is another barrier to sustainable building practice found in literature. Bond (2010) argues that this barrier is one factor commonly put forward against sustainable building practice. Ang and Wilkinson (2008) and Zhou and Lowe (2003) are of the view that developers and the public believe that sustainable buildings cost more than conventional buildings. However, with reference to Carter (2007), even when sustainable buildings generate higher initial cost, this cost has long-term benefits such as savings in energy and water efficiency, reduction in replacement of materials used in the fabric of the building and reduced volumes of waste. Perceived higher upfront costs could be a result of the cost associated with unfamiliar techniques, the lack of previous experience, additional testing and inspection in construction, a lack of manufacturer and supplier support, and a lack of performance information (Häkkinen and Belloni, 2011).

Perceived higher upfront costs can also be solved by introducing split incentives. With reference to Bond (2010), split incentives is the situation where building owners invest in sustainable buildings and the financial benefit accrues to them through structured payments and the building occupants also benefit through cost savings in reduced energy and water consumption and better health and productivity. The benefits of sustainable buildings, especially in energy savings and occupant productivity, accrue to occupants over the long term and to the building owner. However, the benefit over the long term has created a lack of demand for sustainable buildings by both building owners and occupants (Landman, 1999; Ahn *et al.*, 2013).

Hydes and Creech (2000) perceive that the unfamiliarity of the design and construction team in sustainable building practices also adds to the upfront cost. Design and construction team members being in unfamiliar ground causes an increase in their fees and which is indirectly charged to the cost of the building. To overcome this barrier, Sayce *et al.*, (2007) and Sodagar and Fieldson (2008) suggest that funding should be made available through financing arrangements, so that the extra costs could be absorbed and claimed back later through increased rents. Life-cycle costing (LCC) is seen as another way to overcome the perceived higher upfront costs barrier. The concept of LCC enables the building owner to envisage the operating costs right from the design stage and see the cost benefits of sustainable decisions as compared to the initial upfront cost (Roaf *et al.*, 2004). According to Wiggins (2010), LCC is a tool used in determing the most cost effective option between different alternatives in relation to building, operating and maintaining and final disposal of a building and is an area of expertise for the facilities manager.

The lack of government policies can hinder achieving sustainable buildings (Rydin *et al.,* 2006). Tarja and Belloni (2011) argue that sustainable building practice can be promoted with the help of government regulations. According to Samari (2012), the role of governments in promoting sustainable building cannot be over-emphasised and is effective. Regulations should be developed and continuously updated and enforced. Governments have the power to facilitate sustainable building development by a variety of instruments. Another barrier to sustainable building practice is the incorporation of building services as an afterthought, which often leads to more cost in running the building both financially and environmentally. Building services should be considered at the earliest possible stage in the designing of a building to achieve an efficient and optimally performing building (Malina, 2012).

Elmualim *et al.*, (2008) identified financial constraints, cost of certification, lack of in-house knowledge, customer demands and constraints, physical and historical constraints, and organisational engagements as barriers to sustainable FM. Elmualim *et al.*, (2010) also identified the barriers and commitment of FM profession to the SD agenda and revealed time constraints, lack of senior management commitment, financial constraints, lack of training, lack of awareness and lack of tools as barriers to the SD agenda. Though these barriers have been identified with sustainable FM practice, they can be related to the facilities manager's role in sustainable buildings as their role in sustainable buildings is a function of their sustainable practice.

5.3 Drivers to FM Practice in Achieving Sustainable Building

In order to mitigate the barriers stated above, sustainable practices need to be encouraged in the facilities manager's role. It is believed that an increase in sustainable practices by facilities managers will aid their role in sustainable buildings. Pitt and Hinks (2001) suggest an increase in the perception of FM role as a key to advancing the cause of sustainability by facilities managers. They argue that, though FM was generally considered as a conservative profession, climate change and carbon emission reduction has changed the course of the profession. Pitt and Hinks (2001) advocate for the integration of FM within the strategic management functions. Elmualim *et al.*, (2012) identified drivers for sustainable FM practice and these are: legislation, corporate image, organisational ethos, senior management or directors' leadership, pressure from clients, life-cycle cost reduction, and pressure from employees and shareholders on sustainable practices. These drivers if incorporated can help to achieve sustainable buildings.

A barrier can also be a driver when reasons for it being a barrier have been reversed to offer solutions to the subject matter. Therefore, barriers earlier mentioned such as lack of education, lack of knowledge, perceived higher upfront costs, split incentives, lack of government policies and building services as an afterthought; when reversed can be drivers of sustainable building practices. With reference to Tarja and Belloni (2009), the most important factors in promoting sustainable building practices are increase in the awareness of clients about the benefits of sustainable building, the development and adoption of methods for sustainable building requirement management, the mobilisation of sustainable building tools, the development of designers' competence and team working, and the development of new concepts and services. The aforementioned factors can be achieved by the development and enforcement of government policies.

Globally, government policies are seen as a key driver of sustainable building. According to Taylor-Wessing (2009), quite a number of policy initiatives and measures by the government are used in the United Kingdom to encourage the property sector towards sustainability. This view is reinforced by Ang and Wilkinson (2008), who argue that policies are the tool government uses to steer the building industry towards sustainability. This is evidenced in the UK as the government fosters and encourages policies that promote the building industry to sustainable methods (Zhou and Lowe, 2003). These policies have encouraged many companies to have strong environmental focus and sustainability policy at the core of their business which leads them to occupy sutainable buildings (Shah, 2007).

Malina (2012) also emphasises that the government needs to be actively involved sustainable building practices and initiate standards that will enforce such. Government policies act against the non-use of substandard building materials and encourage the need for openness and accountability in terms of adopting and embracing sustainability standards with comprehensive checklists and overviews for all building professionals to follow. According to Gleeson and Thomson (2012), the promotion of skills development in new technologies among building professionals in buildings is a driver towards sustainable buildings. Government policies can help more skills development in new technologies.

Another driver for sustainable building practice is cooperation among members of the design team and among members of the construction team. A tool that fosters this relationship is the building information modelling (BIM). With reference to Schlueter (2009), BIM is a software tool that is helping to encourage greater collaboration in construction teams. It can also be seen as a tool to encourage and promote a more sustainable and cost-effective way to delivering sustainable buildings. It acts as foundation for collaboration among all project stakeholders including client, architects, consultants, contractors and facilities managers at the design and construction stages, to ensure that they have access to a collective system that includes all the details of the projects design, specification, materials, project plan and costs (Malina, 2012). Due the benefits of BIM, the UK government has identified it as an important part of its construction strategy. The UK government has identified a 20% improvement in efficiency of construction using BIM, and has stated that it intends this method to be phased in for all government contracts by 2016 and upwards (GCS, 2011).

Other drivers to sustainable building practice are the development and adoption of building sustainability assessment systems such as BREEAM, LEED, Green Star, CASBEE and Green Globes (Bond, 2010). These assessment systems have played an important role in helping the building industry achieve sustainability (Carmody *et al.*, 2009; Braganca *et al.*, 2010). Rising energy costs, lower life-cycle costs, client demand, and environmental conditions are also drivers to sustainable building practice (Smith and Baird, 2007). According to Bond (2010), a driver to the sustainable building practice is the awareness of building occupants of the benefits of sustainable building. Increase in sustainable building practices can increase the chances of facilities managers in achieving sustainable buildings.

The facilities manager plays an important role by educating the developer in concerning a building's sustainability and its economic benefits. The developer's knowledge about sustainable buildings can enable the developer play a pivotal role in achieving sustainable buildings. The developer's role can be indirectly related to the fact he is the financier of the building project, and his knowledge and acceptance of sustainable building concept will provide opportunity for the sustainability building measures to be recommended and implemented. Based on his knowledge of sustainable buildings he can insist right from the design stage that a sustainable design be implemented. This supports the research study by Abidin (2010) that developers are the ones that initiate the building projects and have prevailing influence over the overall project direction. Therefore, the developers' knowledge of sustainable buildings is vital to the achievement of sustainable buildings.

The building industry creates the built environment in which FM plays a major role in managing the buildings and facilities produced by it. According to Atkin and Brooks (2009), buildings represent substantial investments for organisations and accommodate and support a range of activities including the core business objectives. FM helps to create an appropriate environment that encourages productivity. If these buildings are not managed, they affect productivity and begin to impact upon an organisation's performance. FM profession like other professions has keyed into the sustainability agenda as a result of an increasing awareness for environmental issues. This has made facilities managers to begin to get involved in the environmental, social and economic aspects of the SD agenda; however they are faced with barriers and challenges that make their journey to achieving sustainability difficult (Elmualim *et al.*, 2012). It is argued by Elmualim *et al.*, (2010) that facilities managers are at the forefront of influencing their organisations in achieving sustainability and this includes the management of existing buildings as well as the development of newly designed ones.

5.4 Chapter Summary

The identification of the constituents that make a sustainable building as identified in Chapter 3 and the facilities manager's role in the identified sustainable building constituents as identified in Chapter 4, has been employed in developing a conceptual framework (see Figure 5.2) that can be used by facilities managers in achieving sustainable buildings. The conceptual framework comprises of two major sections and which are the constituents that make a sustainable building across the environmental, social, economic, and management aspects (Objective 1 Chapter 3); and the facilities manager's role with regard to the identified constituents, however, in relation to the design, construction and operation stages (Objective 2 Chapter 4).

The facilities manager's role at the design, construction and operations stages was compared to the facilities manager's role as identified by BIFM Operational Readiness (best practice guide for facilities managers based on the RIBA Plan of Work 2013). It was discovered that, even though, the document provides the facilities manager's role at the life-cycle stages, the developed framework in this research study highlights his role in achieving the related sustainable building constituents. This has enabled the development of a conceptual framework for the facilities manager's role in achieving sustainable building.

Facilities managers have a significant role to play if the goal of SD in buildings is to be achieved. For successfully buildings have the potential of being a major detriment to the realisation of the environmental, social and economic dimensions of SD. Facilities managers as the custodians of buildings are required to assist in the achievement sustainable buildings. However, facilities managers are faced with challenges such as inadequate technical knowledge, lack of training in sustainable building practices, lack of knowledge in sustainable buildings, perceived higher upfront costs, split incentives, lack of government policies that support sustainable buildings etc. that hinders them from fulfilling their role. If these barriers are overcome, sustainable buildings can be achieved by the facilities manager. This chapter fulfils Objective 3 of this research.

CHAPTER 6: RESEARCH METHODOLOGY

6.0 Introduction

This chapter discusses the research methodology to achieve the aim of the research and also describes the research methods adopted in collecting and analysing data. The chapter discusses the research framework for this study which consists of three main stages. Stage one consists of three steps which are: review of relevant literature on sustainable buildings and FM roles; content analysis of three documents on sustainable building constituents and four documents on FM roles that relate to sustainable buildings; and development of a conceptual framework that shows the facilities manager's role at the design, construction and operations stages in sustainable buildings. Stage two consists of two steps which are: interviews of 20 facilities managers with relevant experience and a questionnaire survey of 139 members of the International Facilities Management Association Nigeria Chapter to further investigate findings of the conducted interviews. Stage three involves the development and validation of the developed framework for facilities managers in the goal towards achieving sustainable buildings in Nigeria. The following sections discuss in detail the above-stated research procedures.

6.1 Research Design

Research is all about learning about a new topic and has been variously defined. It is defined by Fellows and Liu (1997), as a process of enquiry and investigation. Bailey (1997) further defines it as the systematic investigation of a problem, area of issue and is undertaken to increase knowledge. Clough and Nutbrown (2012) support the definition of research given by Bailey (1997) that research is an orderly investigation into an area of activity, leading to the discovery of new ideas and conclusions and of which data collected can be analysed and compared, identify trends, similarities or differences.

Fellows and Liu (2009) describe research as a voyage of discovery involving the three main research questions of 'what', 'why' and 'how'. According to Blaikie (2010), the 'what' questions describe the characteristics of a concept; the 'why' questions explain the relationships between processes or event; while the 'how' questions provide practical outcomes and intervention. Though, some researchers have proposed other types of research questions such as the 'who', 'where', 'how many', how much', and 'when' questions (Yin, 2003 and Blaxter *et al.*, 2002); they acknowledge that these are different forms of the 'what' questions.

This research proposes to answer the "what" questions of "*what are the constituents of a sustainable building in the Nigerian context*?" and "*what is the role of FM in sustainable buildings in Nigeria*?" (This is addressed in Chapter 7 and 8). The "why" question of "*why the development of an FM framework for sustainable buildings in Nigeria*?" and the "how" question of "*how can the developed framework help towards achieving sustainable buildings in*

Nigeria?" (This is addressed in Chapter 9). With reference to Denscombe (2010), a researcher should have answers to the what, why and how questions of his research, for having these answers give a research project focus and direction. According to Kerlinger and Pedhazur (1973) as cited by Blaikie (2010), the development of a research design helps to obtain answers to these research questions.

Denzin and Lincoln (2011) describe research design as a detailed outline of how a research investigation will take place. Bailey (1997) refers to it as the overall strategy that is chosen to integrate the different components of a study in a coherent and logical way, thereby, effectively addressing the research problem and constituting the blueprint for the collection, measurement, and the analysis of data. The chosen strategy can be qualitative, quantitative and mixed methods in approach providing specific direction for procedures in research (Creswell, 2009). According to Denzin and Lincoln (2011), these approaches adopt certain philosophical assumptions, strategies of design, research methods and research practices. The description of a research design is illustrated in Figure 6.1.

The research design adopted for this research shows a plan of how the study has been conducted from the objectives of the research (Section 1.2) to the conclusion of the research in Chapter 10. Creswell (2009) explains further that researchers need to give proper thought to the philosophical assumptions that they adopt in a study, the strategy of inquiry that is related to these assumptions and the specific methods of research that translate the approach into practice.

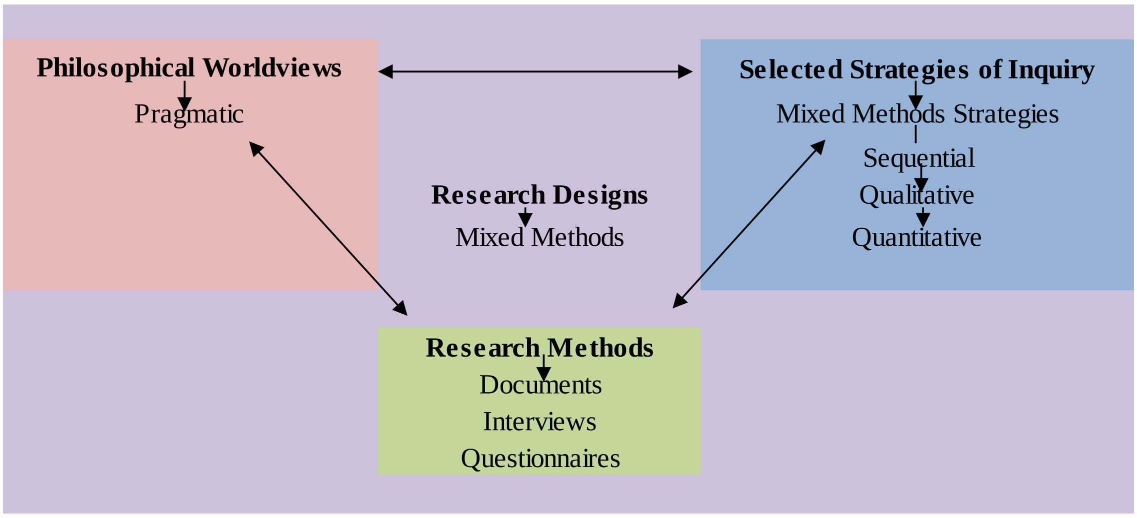

Figure 6.1: A Framework for Research Design
Adapted from: Creswell (2009)

6.2 Philosophical Assumptions of the Research Study

Philosophical assumptions can be defined as general orientation and beliefs about the world and the nature of research that a researcher brings to a research study (Creswell, 2014). It is defined by Guba (1990) as a basic set of beliefs that guide action in research. In research, philosophical assumptions have been referred to by various names such as paradigms (Mertens, 2010; Lincoln *et al.*, 2011), epistemologies and ontologies (Crotty, 1998) and research methodologies (Neuman, 2009). However, this research study will maintain the term "philosophical assumptions" because the term philosophy can be easily associated with 'viewpoint'. Every research is made up of certain viewpoints that guide and direct thinking and action. These philosophical assumptions are often based on the researcher's discipline orientations, the researcher's supervisors' inclinations and past research experiences (Denzin and Lincoln, 2011).

Whether a researcher is aware of it or not, he usually brings certain beliefs and philosophical assumptions to a research study. However, there are those that do not agree as to the need to acknowledge an underlying assumption, nor do they agree on the role that such assumptions serve in the research process (Mertens, 2015). According to Patton (2002) philosophical assumptions are unnecessary and are not a prerequisite for fieldwork. He is of the opinion that, in qualitative research, one can learn to be a good interviewer or observer, and learn to make sense of the resulting data, without first engaging in deep epistemological reflection and philosophical study. Though, Schwandt (2000) supports this view, he is of the opinion that philosophical assumptions are inevitable. According to Lincoln *et al.*, (2011), philosophical assumptions are not always stated; however, the interpretive frameworks do convey them.

Philosophical assumptions include ontology, epistemology, axiology and methodology (Denzin and Lincoln, 2011); and Creswell (2014) adds rhetoric as another philosophical assumption. Figure 6.2 shows these philosophical assumptions with a focus on certain questions such as what is the process of research? What is the relationship between the researcher and the researched? What is the role of values in the research? What is the state of reality in the research? And what is the language of the research?

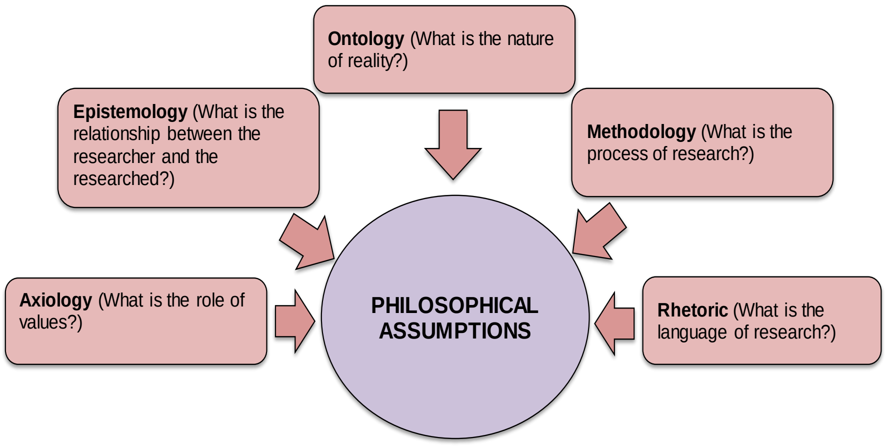

Figure 6.2: Philosophical Assumptions
Source: Gunatilake (2013)

Ontology is a philosophical assumption about the nature of reality, in it, researchers embrace multiple realities of their participants and this is shown by the use of multiple themes using actual words of different individuals and presenting different perspectives (Moustakas, 1994). The aim of this research study is to obtain multiple perspectives on the sustainable building practice in the Nigerian building industry, the FM role in sustainable building and the barriers and drivers to FM practice in achieving sustainable buildings. Therefore, the research presents different views of FM professionals from various building industry professional backgrounds such as architecture, estate management, building maintenance, building services engineering and so on; who have different opinions of FM role in the built environment and particularly in buildings (Ojo, 2002; Alaofin, 2003; Durodola, 2009; Ikediashi *et al.*, 2012).

Epistemology is a philosophical assumption about the relationship between the inquirer and the known and how the researcher acquires the knowledge needed for the research. The second stage of the research study involved interviews which were conducted in the participant's setting. This was done in order to be in settings where participants are most comfortable in order to obtain as much information as possible. With reference to Guba and Lincoln (1998), this produces rich information from participants through their subjective experiences.

Axiology is a philosophical assumption about the role of values in research. In it, the researcher reports his own view in terms of value and biases about the subject matter and positions himself in the research (Denzin, 1989). In relation to this research study, the researcher's view in relation to the facilities managers' role in sustainable buildings is presented. Methodology is a philosophical assumption about the process and procedure of research, which is characterised as inductive, emerging and shaped by the researcher's experience in collecting and analysing data. A fifth assumption included in this research is the rhetorical assumption. Rhetoric is the study of the art of language; it is the art of persuasion claiming validity for a particular audience (Gusfield, 1981; Creswell, 2007). It involves the language used to report the findings of a study. The language of this research is in the third person form, which has been encouraged for research reports (Denscombe, 2007).

The major philosophical assumptions that structure and organise research include postpositivism, constructivism, transformative, and pragmatism, just to mention a few in the ever expanding list (Ritchie *et al.*, 2013). These philosophical assumptions are embedded within social science theories used in framing the researcher's theoretical base in studies and are key grounds that researchers use when conducting a research study (Creswell, 2013). Their features are described in the following paragraphs below.

Table 6.1: Features of Philosophical Assumptions

Pragmatism	
• Consequences of actions	It involves the study of an area in which a real life problem has been identified and there is limited knowledge about the problem.
• Problem-centered	It focuses on the research problem and therefore involves an in-depth study in order to proffer a best solution.
• Pluralistic	Makes use of diverse approaches to obtain knowledge about the research problem and which can be a combination of both quantitative and qualitative approaches because they provide the best understanding of a research problem.
• Real-world practice oriented	Involves the 'what' and 'how' of a research problem with the intension of providing a solution that will work in practice.

Source: Creswell (2013).

The postpositivist philosophical assumption usually represents the traditional form of research and is closely related to the quantitative research. It is also called positivist/postpositivist research, empirical science, and postpositivism. The characteristics of this type of research include formal propositions, quantifiable measures of variables, hypothesis testing, and the direct drawing of conclusions about a phenomenon from the sample to a stated population (Orlikowski and Baroudi, 1991). The Constructivist philosophical assumption also called social constructivism is often combined with interpretivism and is usually related to qualitative research (Creswell, 2014). This philosophy is involved in understanding the meanings that people give to their experiences on a subject matter. It is largely inductive and the researcher generates meaning from the data collected in the field (Crotty, 1998).

The transformative philosophical assumption was developed as a result of individuals who were not satisfied with the postpositivist assumptions and also felt that even the constructivist viewpoint did not advocate enough for an action agenda to help people marginalised in the society as a result of gender, race, ethnicity, disability, sexual orientation and socioeconomic class (Mertens, 2010). The assumption behind this framework is based on the works of Fay (1987); Heron and Reason (1997); Kemmis and Wilkinson (1998); and Kemmis and McTaggart (2000). Mertens (2010) has also added to this school of knowledge, that the transformative philosophy focuses on the inequalities stated above and links political and social action to it and seeks how best to obtain a solution.

The pragmatic philosophical assumption according to Creswell (2014), relates to the mixed methods research, combining both quantitative and qualitative approaches because they provide the best understanding of a research problem. It is generally regarded as the philosophical partner of the mixed methods approach (Bryman, 2012). It also has a characteristic feature of focusing attention on the research problem and then uses diverse approaches to obtain knowledge about the problem (Patton, 2002; Morgan, 2007; Tashakkori and Teddlie, 2010). According to Rossman and Wilson, (1985), pragmatist researchers take a careful look into the 'what' and 'how' of their research based on where they want to go with it. Instead of paying attention to the research methods, pragmatics focus on the research problem and adopt all available ways to gain an understanding of the problem (Bryman, 2012).

This research study has adopted the mixed methods approach, combining both qualitative and quantitative methods in order to understand and identify the constituents that make a sustainable building and the facilities manager's role. Details of this justification are shown in section 6.5. Therefore, the study is framed within theories that support the pragmatic philosophical assumption. Table 6.1 shows the features of the pragmatic philosophical assumption adopted in this research study. With reference to Johnson and Duberly (2000), it is necessary to take a clear philosophical stance which measures appropriately with the personal style of the researcher, the nature and style of the research, and the possibility for effective learning about the subject matter of the study. At this stage, it is necessary to mention the types of research and this can be viewed from three different perspectives namely: applications of the findings of the research; objectives of the study; and mode of enquiry used in conducting the study.

6.3 Types of Research

A research project may be classified as descriptive, correlational, explanatory or exploratory from the perspective of research objectives. It can be classified as qualitative or quantitative from the perspective of the mode of enquiry employed and as pure or applied research from the perspective of application of the research findings (Kumar, 2011). In summary, the purpose of the research determines the type of research study to be adopted (Neuman, 2011).

In relation to the perspective of research objectives (Kumar, 2011; Neuman, 2011):

- A study is classified as a descriptive study when it attempts to systematically describe a situation, phenomenon, service or programme or even describes attitudes towards certain issues; and in the process outlining the steps to answer the who, when, where and how questions of the research.
- A study is classified correlational if the study lays emphasis on discovering or establishing the existence of a relationship, association or interdependence between two or more aspects of a situation.
- A study is classified as explanatory when the primary purpose is to explain why events occur and to build, elaborate, extend or test the theory. It attempts to clarify 'why' and 'how' there is a relationship between two aspects of a phenomenon.
- A study can be exploratory when a study is undertaken with the objective of either to explore an area where little research has to be carried out or to investigate the

possibilities of undertaking a particular research study, and moving forward to develop preliminary ideas and research questions.

This research is descriptive in nature as it attempts to thoroughly describe the different phenomena surrounding the achievement of sustainable buildings and the role that FM plays towards this goal in Nigeria. The study is also such that very little research has been undertaken previously, and is, therefore, exploratory in nature. In relation to the perspective of the mode of enquiry employed, the study takes on board both the qualitative and the quantitative approaches; for the combination of the two approaches are needed to achieve the aim of the study. In relation to the perspective of application of the research findings, the study falls into the category of applied research, as it involves gathering information that enables understanding of FM as a tool for the achievement of sustainable building.

6.4 Choice of Research methodology

Ryan (2006) states that what should guide a researcher in the choice of a research methodology is the research questions to be answered. Other factors that influence the chosen research methodology include (a) methodology preference, (b) structure of the research project, (c) time constraint for completing the research, and (d) the nature of the data to be collected (Henn *et al.*, 2006). According to Creswell (2014), the research methodology adopted by a study is informed by the philosophical assumptions the researcher brings to the study, the research design and specific research methods of data collection, analysis and interpretation. Although there are different methodologies available to a researcher, a researcher chooses the methodology to use based on the above-stated criteria and no matter what approaches are selected, it should be adequate to meet the aim of the research (Blaikie, 2010).

Research methodology is described as the type of qualitative, quantitative and mixed methods that provide direction for procedures in a research design (Mertens, 2015). Table 6.2 describes these approaches in relation to their philosophical assumptions, strategies of inquiry, research methods, research practices, function, process, data collection and style of report. Research methodologies are also known as strategies of inquiry as indicated in Figure 6.1.

The quantitative method is described as an approach that explains a phenomenon by collecting numerical data analysed using mathematically based methods (Aliaga and Gunderson, 2005). Creswell (2014) describes it as an approach for testing objective theories in relation to variables which can be analysed using statistical procedures. Quantitative research according to Aliaga and Gunderson (2005) is good at providing information in breadth, from a large number of units, but when a problem or concept is to be explored in-depth, quantitative methods can be too shallow.

However, the qualitative method is considered better for an in-depth study of a research problem. It is a method that studies subjects in their natural settings, attempting to make sense of or give an interpretation to a phenomenon in terms of the meanings people bring to them (Flick, 2014). In this type of approach, data is inductively analysed, building from particulars to general themes, and the researcher makes interpretations of the meaning of the data (Creswell, 2014). Qualitative research is an approach for searching and understanding the meaning individuals or groups assign to a social or human problem (Scupola, 2012). According to Flick (2014), qualitative research is inclined towards analysing actual situations in their time-based and local particularity, and thus, includes people's expressions and activities in their local contexts.

Table 6.2: Description of the Qualitative, Quantitative and the mixed Methods Approaches

Description	Quantitative Approaches	Qualitative Approaches	Mixed Mehods Approaches
Use these philosophical assumptions	Postpositivist knowledge claims	Constructivist/transformative knowledge claims	Pragmatic knowledge claims
Employ these strategies of inquiry	Surveys and experiments	Phenomenology, grounded theory, ethnography, case study and narrative	Sequential, concurrent and transformative
Employ these methods	Close-ended questions, predetermined approaches, numeric data.	Open-ended quaestions, emerging approaches, texts or image data	Both open and closed ended questions, both emerging and predetermined approaches, and both quantitative and qualitative data and analysis
Use these practices of research as the researcher	Tests or verifies theories or explanations; identifies variables to study relates variable in questions or hypothesis; uses standards of validity and reliability; observes and measures information numerically uses unbiased approaches Employs statistical procedures	Positions himself or herself; collects participants meanings; focuses on a single concept or phenomenon; brings personal values into the study; studies the context or setting of participants; validates the accuracy of findings; makes interpretations of the data; creates an agenda for change or reform; collaborates with the participants	Collects both quantitative and qualitative data; develops a rationale for mixing; Integrates the data at different stages of inquiry; presents visual pictures of the procedures in the study; employs the practices of both qualitative and quantitative research
Function	Testing objective theories by examining relationship among variables.	Exploring and understanding the meaning individuals or groups ascribe to a social problem.	Combines investigating the meaning individuals or groups ascribe to a social problem and testing objective theories.
Process	It involves gathering of factual data.	It involves the gathering of unstructured data that tend to be detailed and rich in content and scope.	It involves gathering of factual and non-factual data.
Data	Data collected is measured on instruments and analysed using statistical procedures	Data is collected and the researcher makes interpretations of the meaning of the data.	It combines the collection of data that is interpreted by the researcher and data that will be measured on instruments and analysed using statistical procedures.
Report	The final written report has a set of structure consisting of introduction, literature and theory, methods, results and discussion.	The final written report has a flexible structure.	The final report gives a good combination of both the qualitative and the quantitative approaches.

Source: Creswell, (2014)

Mixed methods, on the other hand, offer the advantages of both quantitative and qualitative methods. The choice between quantitative and qualitative approaches has been regarded as crucial to researchers. However, neither of them is better than the other given that they both have unique features and have their individual strengths and weaknesses and can, therefore, be combined to complement each other (Mertens, 2015). The mixed methods involve integrating and merging the qualities of both quantitative and qualitative research within a single project and using distinct designs that may involve philosophical assumptions and theoretical frameworks (Bryman, 2012). The main advantage of this form of inquiry is that it provides a complete understanding of a research problem than either method alone. Mixed methods are useful when either quantitative or qualitative data alone does not give a full understanding of the research problem (Johnson *et al.*, 2007).

However, there has been much debate as to whether quantitative and qualitative approaches can be combined in research. The argument tends to be based on the idea that, the two research methods carry epistemological and ontological commitments that have separate paradigms (Bryman, 2014). However, some authors such as Ritchie and Lewis (2003); Kaplan and Duchon (1988) believe that there is a great benefit in bringing the two methods together. As such quantitative data can be used as supplementary evidence for an interpretive study, while the combination of both the qualitative and quantitative methods can offer a richer contextual basis for interpreting results (Janetzko, 2001).

These have promoted the preference of researchers for mixed methods because it enables them to view problems from multiple perspectives, so as to enhance and enrich the meaning of a particular perspective in their research (Janetzko, 2001). The method enables them to contextualise the information and helps to develop a representation of likely outcomes. It also helps in comparing, validating, and the triangulation of results (Plano-Clark, 2010). Despite the advantages of the mixed methods approach, it requires extensive time and resources to carry out the multiple steps involved in data collection and analysis (Ritchie and Lewis, 2003). The general features of the mixed methods approach are as illustrated in Table 6.3. These features include combining the quantitative and qualitative methods in order to: triangulate findings; offset the weaknesses in each approach; produce a more comprehensive account of enquiry; answer research question; explain findings generated by the other; enhancing the integrity of findings; generate hypotheses and test the hypothesis within a single study; and merge the researchers' and participants' perspective in order uncover relationships between variables capture meanings among research participants (Mertens, 2015). Table 6.2 on the other hand, clearly shows the difference between the quantitative and qualitative approaches and shows how the mixed methods approach differs from the quantitative and the qualitative approaches. These include the physiological assumption of the researcher in mixed methods which has been associated with the pragmatic physiological assumption; and in the strategies of inquiry, which has been associated with combining the quantitative and the qualitative methods either sequentially, concurrently or in a transformative way.

Table 6.3: Features of Mixed Methods

Triangulation	This relates to the traditional view of quantitative and qualitative methods combined to triangulate findings in order that they may be mutually corroborated.
Offset	This relates to the quantitative and qualitative methods having their own strengths and weaknesses so that combining them enables the researcher to offset their weaknesses to draw on their strengths.
Completeness	This relates to the researcher being able to produce a more comprehensive account of the area of enquiry in which he is interested with the combination of both methods.
Process	This relates to the combination of an account of structures in social life (quantitative) and also a sense of process (qualitative).
Research questions	This relates to the fact that quantitative and qualitative methods can each answer different research questions.
Explanation	This relates to when one of the two research methods is used to help explain findings generated by the other.
Unexpected results	This refers to when the reasercher generates surprising results that can be understood by using the quantitative and the qualitative methods.
Instrument development	This relates to the context in whichthe qualitative method is employed to develop questionnaire and scale items.
Sampling	This refers to situations in which one approach is used to facilitate the sampling of respondents or cases.
Credibility	This relates to both approaches enhancing the integrity of findings.
Context	This is when the qualitative method provides contextual understanding coupled with either generalisation, external valid findings or broad relationships among variables uncovered through survey.
Illustration	This refers to the use of qualitative data to illustrate quantitative findings.
Utility	This refers to improving the usefulness of findings to practitioners by combining the two approaches.
Confirm and discover	This relates to using qualitative data to generate hypotheses and using the quantitative method to test them within a single project.
Diversity of views	This relates to combining the researchers' and participants' perspective through the two methods and uncovering relationships between variables through the quantitative method while also revealing meanings among research participants through the qualitative method.
Enhancement	This includes augmenting either of the two methods by gathering data using a qualitative or quantitative approach.

Source: Bryman, (2012)

6.5 Rationale for Choosing a Mixed Method Approach

The mixed methods approach is adopted in this research study because the research seeks an in-depth understanding what constitutes a sustainable building and the facilities manager’s role in achieving sustainable buildings in Nigeria. Sustainable building is regional based and open to a variety of interpretations. It therefore, requires a combination of content analysis, interviews and questionnaire survey to identify constitutes a sustainable building in Nigeria. The same approach is adopted in seeking to identify what FM functions are needed by the facilities manager in the achievement of sustainable buildings.

According to Creswell (2014), if a concept or phenomenon needs to be explored and understood because little research has been carried out on it, then it merits a mixed methods approach. This is the state of FM in Nigeria and particularly in relation to sustainable buildings. FM practice in Nigeria has been in existence since 1984, however, has been limited to very few foreign companies who have established themselves in the country (Adewunmi *et al*, 2014). Local companies, institutions of learning and government offices have only started to incorporate FM into their daily businesses. As a result of this, FM research is limited and few people are just beginning to see the relevance of FM in organisations.

FM studies that have used the mixed methods approach include Nousiainen and Junnila (2008) who incorporated qualitative study and triangulation approach by combining data archives with time series analysis method, semi-structured interviews, case study and a survey. This was done in order to determine the environmental objectives of building end-user organisations in an office environment and to anticipate the environmental management demands this could have on FM. Valen and Olsson (2012) conducted a study where questionnaire survey and in-depth interviews were conducted to determine the extent of how FM profession adds value to the building owner in relation to their building stock being kept in good condition, functional and up-to-date in the long-term. Adewunmi *et al*, (2012) conducted questionnaire survey and structured interviews to examine common environmental practices and strategies for the implementation of sustainable FM among Nigerian FM practitioners.

This research study is similar to Adewunmi *et al.*, (2012) because it also conducted in Nigerian settings, however, seeks to investigate sustainable FM practice, with regards to developing and managing sustainable buildings. The study adopted the sequential approach of the mixed methods strategy, starting with the qualitative method and followed by the quantitative approach. Content analysis of the documents specified in Section 6.9.1 was carried out in order to identify sustainable building constituents and the facilities manager's role in achieving them. The qualitative method was considered first because the research study is exploratory nature due to limited literature in the subject area and needed explanatory studies to confirm results. The quantitative method was then adopted by the application of a questionnaire survey in order to confirm and generalise results to a population and to further explore findings of the qualitative method.

6.6 Selection of Research Methods

Having chosen mixed methods as an appropriate methodology for this research study, this section discusses suitable research methods. Research methods are tools for the collection of empirical data for research and according to Denscombe (2010), these tools or instruments can be grouped into four main categories which are documents, interviews, observation, and questionnaires. The data collection methods used in this research includes documents, interviews, and questionnaires. The research required an exploratory design approach which involves gathering qualitative data at first and then followed by quantitative data. The research started with a collection of qualitative data from relevant documents and literature in order to gather as much information on the sustainable building constituents. This involved the first stage of the research.

Interviews were considered appropriate in gaining insights into sustainable buildings in Nigeria and FM role. This involved the first step in the second stage of the research. The second step in the second stage of the research involved obtaining quantitative data. The findings of the data collected from the documents and the interviews were used to develop a questionnaire that was administered to facilities managers who are members of IFMA Nigeria Chapter. How the tools were used in collecting both qualitative and quantitative data is described in Sections 6.8 and 6.9.

6.7 The Research Framework

The research process adopted in this study can be illustrated using a research framework consisting of three stages as shown in Figure 6.3. Stage 1 includes a review of literature and analysis of documents relevant to sustainable building and its constituents. The literature review and document analysis similarly included relevant literature in relation to the facilities manager's role in sustainable buildings. Stage 1 also included the development of a conceptual framework that shows the facilities manager's role in sustainable buildings.

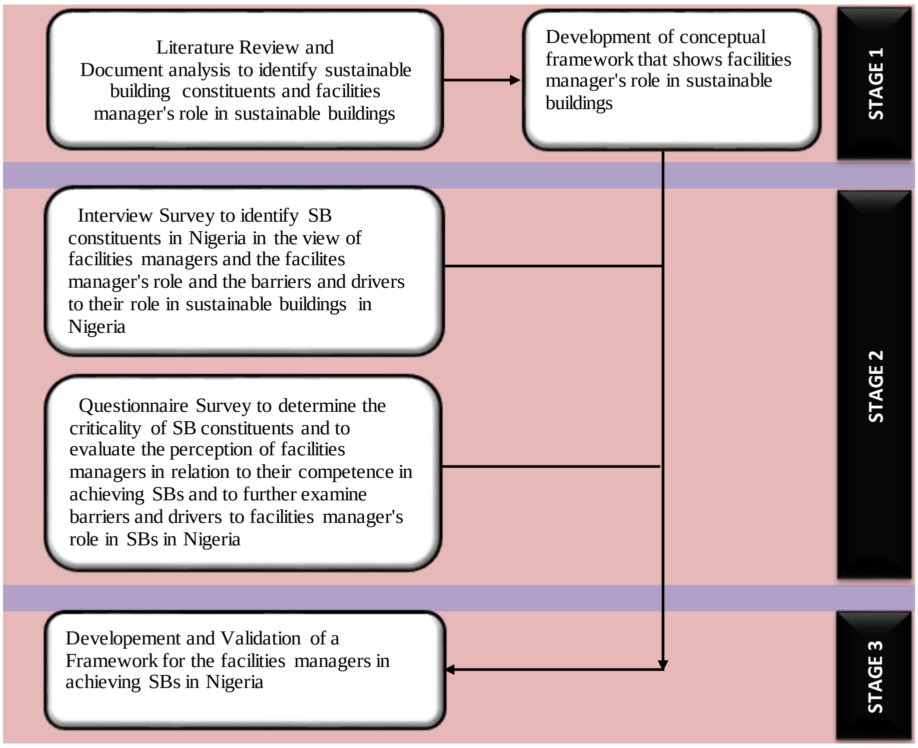

Figure 6.3: Research Framework

Stage 2 consists of carrying out interviews and a questionnaire survey to further establish findings of the document analysis and interviews. Stage 3 consists of development and validation of the framework. In depth discussions of the research process within each of the stages are presented below.

6.8 Stage 1: Step 1-Literature Review

A comprehensive review of literature throughout the study was carried out in order to build up a solid theoretical base for the research area and a foundation for addressing the research aim and objectives. The review of literature continued to the latter stages of the research process when findings began to emerge. A review of related literature positions a research within ongoing study, identifying the gaps in knowledge, providing a framework establishing the importance of the study, thereby providing a rationale for the research problem (Marshall and Rossman, 2011; Creswell, 2014). Figure 6.4 shows the flow of literature in the research as presented in Chapters 1 to 9. The review of the literature provided the research with a theoretical base for sustainable building constituents and FM role in sustainable buildings. This according to Charmaz (2006), strengthens the argument and increases the credibility of the research findings.

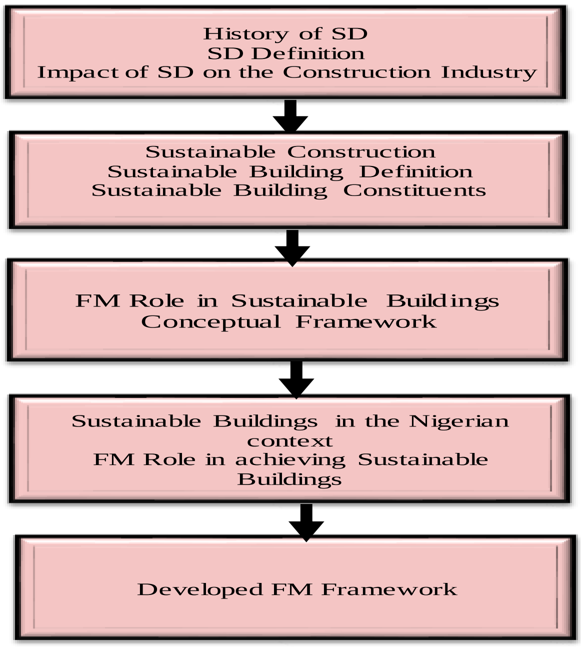

Figure 6.4: Flow of Literature in Research

In relation to the identification of sustainable building constituents in particular, the research study started with a general review of related literature and then adopted a systematic approach of relevant literature in order to fulfil the aim of the research study. This approach was deemed necessary as there was need to identify what constitutes a sustainable building. According to Tranfield *et al*, (2003) a systematic approach to literature review is used in research to reduce the lack of thoroughness and bias of the researcher in a study. Denscombe (2014) argues that this type of approach aims at reaching a conclusion about the state of knowledge on a topic based on a thorough and unbiased overview of research that has been undertaken on the subject matter. A systematic review of literature is popular in the field of medicine due to the need for evidence-based solutions to treat illnesses. However, it is gaining attention in social scientific fields, despite the nature of theoretical approaches used in social research (Bryman, 2014). This approach was useful as numerous papers were found relating to the research topic, however, there was need to focus on papers that would help in identifying sustainable building constituents.

Therefore, a search of relevant literature to the research was carried out in order to capture the essence of the research topic. It involved selection of literature from a variety of sources and which included books, conference proceedings, web sites, and databases such as Science Direct, Elsevier, Discovery, and Ebsco. It also included search in various journals namely; Journal of Building and Environment, Journal of Construction, Engineering and Management, and Journal of Sustainable Development. The basis of literature selection included a keywords search for 'sustainable building'. Literature selection was also based on the literature's relevance to the study, currency of the paper and quality of the content.

The relevance to the study included findings from previous research related to the constituents that make a sustainable building; while the quality of content included consideration for the richness of information available in the literature in relation to the objectives, findings, and recommendations of the research which were usually stated in the abstracts. The currency of the paper included features such as year of publication which spanned with papers covering diverse and extensive research. In the search of the literature for sustainable building, the papers ranged between 1991 and 2015. The search did not reveal relevant literature prior to 1991. This may be due to the call of attention to SD created by the Brundtland report in 1987 which stimulated interest in the impact of buildings on the environment and promoted the start of research in this area. However, proper focus did not commence until 1994 at the proceedings of the first international conference on SC in Tampa, Florida (Kibert, 1994). Table 3.2 reveals more literature from 1994 and one each in 1991 and 1993. The basis of paper selection as stated above reduced the overall number of papers reviewed in relation to sustainable buildings from 85 to 74. Figure 6.5 shows steps taken to identify sustainable building constituents at this stage of the research.

74 literatures were selected from the above named sources on sustainable buildings and a manual search for constituents that make a sustainable building was carried out in the selected literature. A total of 28 constituents were identified in relation to sustainable buildings. Based on literature the 28 constituents were then categorised into the environmental, social, economic, and management aspects. Each of the constituents was refined to match the constituents identified in the content analysis. For example indoor environmental quality was refined to match indoor air quality as found in the content analysis and acoustic performance to match acoustic comfort etc. The 28 constituents were then merged with the constituents identified by the content analysis. However, the 28 constituents were found to be part of the constituents identified in the content analysis.

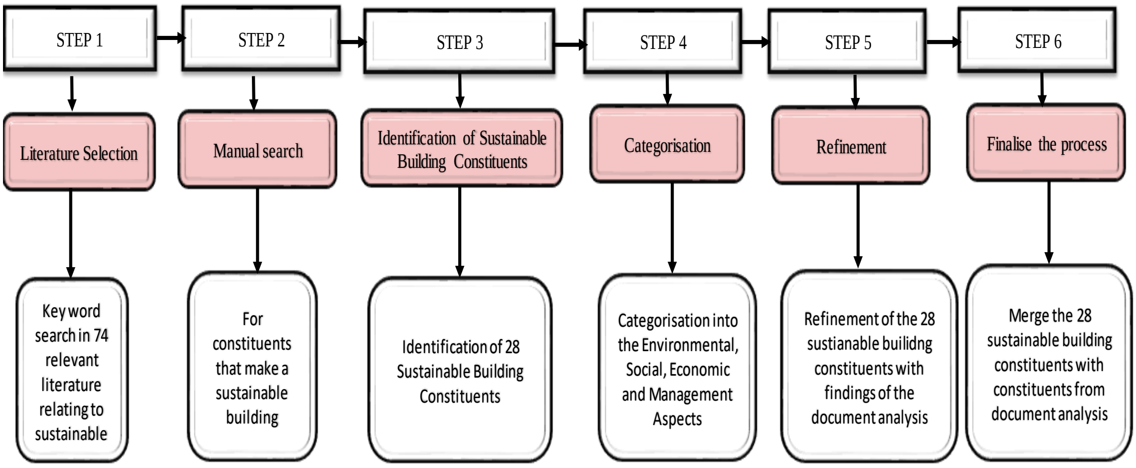

Figure 6.5: Steps in conducting literature Review (Research Design Stage 1: Step 1 of Research)

6.9 Stage 1: Step 2-Document Analysis

Despite the comprehensive level of literature review, a content analysis of documents was conducted in order to investigate if there were more sustainable building constituents that had not been discovered in literature. Figure 6.6 shows the research design for this stage of the research. Content analysis according to Schwandt (2007), involves the analysis of documents and records relevant to a particular study. These documents include newspapers, minutes of meetings, official reports, personal journals and diaries, letters, e-mails, government reports, and political and judicial reports. The main purpose of the content analysis in this study was to identify the constituents that make a building sustainable in accordance with internationally recognised building standards.

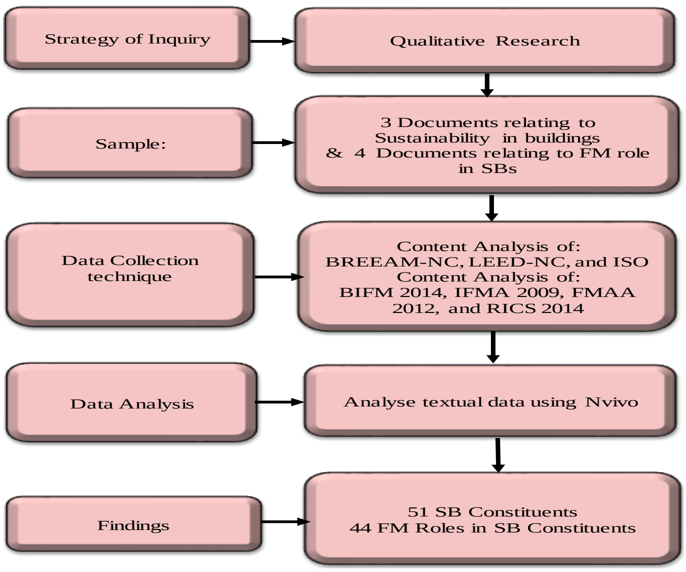

Figure 6.6: Research Design for Stage 1: Step 2

6.9.1 Criteria for Selecting Documents

Documents are visual and textual materials designed as records of action and activity and include state documents, public records, notes, memoranda, and case records, email threads, diaries and letters and so on. The documents were purposely selected for their specific contents of sustainable building constituents and the facilities manager's role. In qualitative research, issues such as; what document to select, what to select in the document and whether such selection is relevant, are factors that determine the purposeful selection of documents (Neuman, 2011). The sampling method selected for this stage of the research involved the purposive sampling method which is usually appropriate in selecting cases that are informative to a research.

Therefore, 3 documents that can be used to identify sustainable building constituents and 4 documents in identifying FM role in sustainable buildings were selected. The documents include the BREEAM-New Construction (BREEAM-NC), LEED-New Construction (LEED-NC) and the 'Sustainability in Buildings and Civil Engineering Works — Guidelines on the Application of the General Principles in ISO 15392'; and also the BIFM Skills in Facilities Management Investigation into Industry Education; the IFMA Complete List of Competencies as defined in the Global Job Task Analysis; the BIFM Facilities Management Professional Standards Handbook; and the RICS Assessment of Professional Competence Facilities Management Pathway Guide. With reference to Patton (2002), this small selection of documents is related to purposive sampling and relies on the judgement of the researcher. The strength of purposive sampling lies in the selection of in-depth information from which one can learn a great deal about issues of central importance to the purpose of the inquiry (Patton, 2002). Neuman (2011) particularly states that purposive sampling is useful when wanting to adopt content analysis to study documents. The criteria used in selecting the documents are presented in the following section.

Documents produced by the Building Research Establishment (BRE), the United States Green Building Council (USGBC), and the International Organization for Standardization (ISO), were specifically selected for this stage. The research found it necessary to examine these documents because they are tools that have been carefully developed by organisations made up of experts in the subject area who have come together to combine their vast experience and knowledge. The documents produced by these organisations are building assessment standards used in assessing a building's sustainable qualities, and these include; the BREEAM-NC, the LEED-NC and ISO 15392 as identified as aforementioned. Below are details of these documents and the criteria considered for their selection.

- BREEAM-NC is a document produced by Building Research Establishment (BRE) Global Ltd, a non-governmental Organisation formally established in the UK in 2006. It has a 90-year track record of expert, impartial research, knowledge, and advice for the built environment. It is an assessment tool that is used to measure and certify the social, environmental and economic sustainability of new buildings. It is an internationally recognised measure and the mark of a building's sustainable qualities. It can be used to assess and rate the environmental impact of newly constructed building developments at the design and post construction stages of the building life-cycle and at the same time improve positive and economic impacts in a cost-effective manner. This provides reliability of the document for identifying constituents of a sustainable building (BRE, 2012).

- LEED-NC is a document produced by United States Green Building Council (USGBC), also a non-governmental Organisation comprising of many collaborators from industry, academia and government. It addresses the whole building and its site and which includes both the design and construction of new buildings and the major renovations of the existing ones. LEED-NC is designed to be used when upgrading a building with the stipulated condition that the upgrade can be done only when, there is assurance that less than 50 percent of the buildings' occupants remain inside it during the upgrading process (Jalaei and Jrade, 2015). The LEED-NC is widely used in several countries. It is a comprehensive initiative for addressing the impacts of buildings within the environmental, social, and economic context of SD and also at the design and post construction stages of the building life-cycle. Thereby, providing a reliability of the document for identifying constituents of a sustainable building (LEED, 2005).

- The 'Sustainability in Buildings and Civil Engineering Works — Guidelines on the Application of the General Principles in ISO 15392' is a document produced by British Standards Institution and is the British Standard UK implementation of PD ISO/TS 12720:2014. It is a guideline on ISO 15392, (Sustainability in Building Construction — General Principles) which is a document that is based on the concept of SD as it applies to the life-cycle of buildings and other construction works, from their inception to the end of life. The objective of this document is to demonstrate how to implement the general principles of sustainability in buildings. The standards contained in the document are set by technical committees in the UK with a 75% vote on its implementation. This provides a reliability of the document for identifying constituents of a sustainable building in this research (BSI, 2014).

These documents address buildings at the design phase, on the basis that a building can only be truly sustainable if sustainable measures were put into consideration at the design stage. Through the years, they have contributed to the increase in awareness about the criteria and objectives of SD in relation to buildings and have become a framework of reference. Though they present their assessment of what a sustainable building is in different ways, they share a common framework.

This study is also focused on the use of FM towards achieving sustainable buildings and, therefore, documents that specify standards for FM practice were selected to determine which of the facilities managers' roles relate to sustainable buildings. The documents included the Facilities Management Professional Standards Handbook, the Skills in Facilities Management Investigation into Industry Education, the IFMA Complete List of Competencies, and the RICS Assessment of Professional Competence Facilities Management Pathway Guide as identified in Section 4.3.

- The 'BIFM Facilities Management Professional Standards Handbook', was developed to support the use and implementation of FM standards as stated in the BIFM Facilities Management Professional Standards, which clearly defines the competencies that are necessary to be a competent facilities manager (BIFM, 2014). It was developed in consultation with industry experts to reflect the requirement and standards of the profession and can be used as a benchmarking tool to develop a skilled FM workforce. Hence the reliability of the use of the document for this study. The FM Professional Standards form the underlying framework with which BIFM is able to develop new products and services to ensure that BIFM provides high-quality services.

- The 'IFMA Complete List of Competencies' was developed by members of IFMA who are from various building industry backgrounds and from over 62 countries. The IFMA Complete List of Competencies is developed according to the Global Job Task Analysis (GJTA) 2009, which defines 11 core FM competencies and ensures that the FM body of knowledge encompasses current knowledge, best practices and trends in FM; hence the reliability for the use of the document for this study (IFMA, 2014).

- The 'Skills in Facilities Management Investigation into Industry Education' was developed by FMAA as a result of lack of national standards of training from which to benchmark FM professionals, compare roles and responsibilities. It defines FM knowledge, skills and attitudes that are required to be an effective facilities manager in Australia. It was developed by FM experts in Australia who have vast knowledge and experience in FM and therefore provides reliability for its selection for this study (FMAA, 2012).

- The RICS Assessment of Professional Competence Facilities Management Pathway Guide (2014) is designed by FM experts to help interpret FM competencies as stated in the RICS Assessment of Professional Competence Facilities Management document.

RICS is a professional body established in the UK by Royal Charter; they are committed to upholding the highest standards of excellence and integrity.

These documents were selected on the basis that; they are produced by the above-named associations and that they are set as standards for facilities managers. With reference to Awang *et al.*, (2012) the professional bodies such as IFMA and BIFM have adopted their competency framework as a basis for professional accreditation in the field of FM. Therefore, the identified FM competencies in relation to sustainable buildings are referred within this study as FM roles in sustainable buildings. The documents were studied and analysed using the NVivo software and the FM roles that relate to sustainable building constituents were identified in the categories of the environmental, social, economic, and management aspect. Details of steps taken to identify the FM roles are described in Section 6.9.2 and shown in Figure 6.8. The identified FM roles were examined in relation to the design, construction and operations phases of the building life-cycle.

6.9.2 Content Analysis using QSR NVivo

To analyse data means to systematically organise, integrate and examine data; it means to connect data to concepts, advance generalisations and identify broad themes. Data analysis helps to improve understanding, expand theory and advance knowledge (Neuman, 2011). Literature has revealed different approaches that can be used to analyse textual data. These include content analysis, semiotics, deconstruction, and hermeneutics (Marshall and Rossman, 2011). Content analysis was chosen for the analysis of the selected documents because it involved analysing textual data from the selected documents for the purpose of identifying the criteria of sustainable building and FM role in sustainable buildings. The content analysis involved identifying themes rather than determining the frequency of words. Word frequency was deemed inadequate to analyse the content of the documents because the sustainable building constituents were described in rich text and with detailed information. Content analysis allows for identifying themes from textual data and it can be achieved using qualitative data analysis software (Bazelay and Jackson, 2013).

Qualitative data analysis software have been developed for easy sorting, structuring, and analysing of large amounts of text or other data and assist in facilitating the management of the resulting interpretations and evaluations (Creswell, 2014). In this study, the QSR NVivo, a qualitative data analysis software developed by '*QSR International'* was used in analysing the content of the documents. QSR NVivo is developed by researchers and continues to be developed with extensive researcher feedback to support researchers in various ways as they work with data (Bazelay and Jackson, 2013). The selected documents for this stage of the research are also referred to as '*reference materials*'. Reference materials, according to Bazelay and Jackson (2013) can be coded, reflected on, and queried like interview materials. The documents were available in portable document format (pdf) which was easily imported into NVivo. Adopting QSR NVivo to analyse pdf materials, regardless of a researchers' approach to literature, adds value to research through sophisticated searching, coding, and querying tools (Bazeley, 2013). Each document was selected one after the other in no particular order and imported into the NVivo software.

Categories were created under the environmental, social, economic, and management aspects as identified in literature. The coding exercise started with the BREEAM-NC, followed by the LEED-NC and the ISO 15293. BREEAM-NC provided the initial set of themes after being guided by the findings of Section 3.3; however, other themes emerged from the other documents. The initial set of themes were stored in nodes and include building life-cycle cost, energy efficiency, material efficiency, water efficiency, land use efficiency, building material use, energy, acoustic control, indoor air quality, building tuning initiatives etc. The documents were in normal text, thereby, making it easy to select contents, drag and drop in appropriate nodes (Bazelay and Jackson, 2013).

Nodes are references to the exact location of the text coded in a document source (Bazeley and Jackson, 2013). Neuman (2011) refers to sorting out text into themes as '*open coding*' (see Figure 6.7). Open coding is coding being performed during the first examination of collected data; themes are located and initial codes are assigned to reduce large data into categories (Neuman, 2011). A code with reference to Bernard and Ryan (2010), is a way of identifying themes in a text and range from being purely descriptive to interpretive or analytic (Richards, 2009). It involves coding which is a way of tagging text with codes in order to organise data for further analysis (Corbin and Strauss, 2008). This represented the first step taken in the coding process of the content analysis of the selected documents.

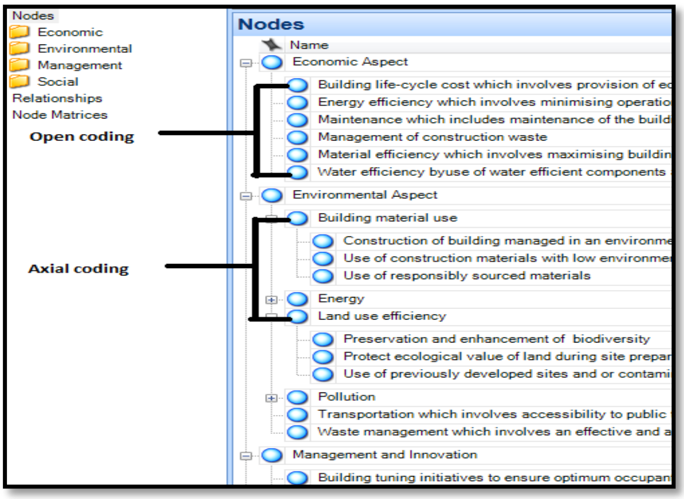

Figure 6.7: Screen Shot of Open Coding of Sustainable Building Constituents Stored in Node

These themes were based on literature as described and categorised into the environmental, social, economic, and management aspects. The coding process produced 51 themes and the 28 sustainable building constituents initially identified in literature were discovered to be part of the 51 themes. The coding process continued by coding the nodes in a structured hierarchical manner, so that the node at the top of the hierarchy describes the contents in general terms of the items below. This was done in order to sort themes into categories to assist with analysis. Neuman (2011) refers to this second level of coding as '*axial coding*' (see Figure 6.7) and represents the second step in the coding process of the content analysis. The 51 themes represent the 51 constituents that make up a sustainable building as shown in Table 3.2. The steps involved in conducting the content analysis of this stage of the research is as shown in Figure 6.8.

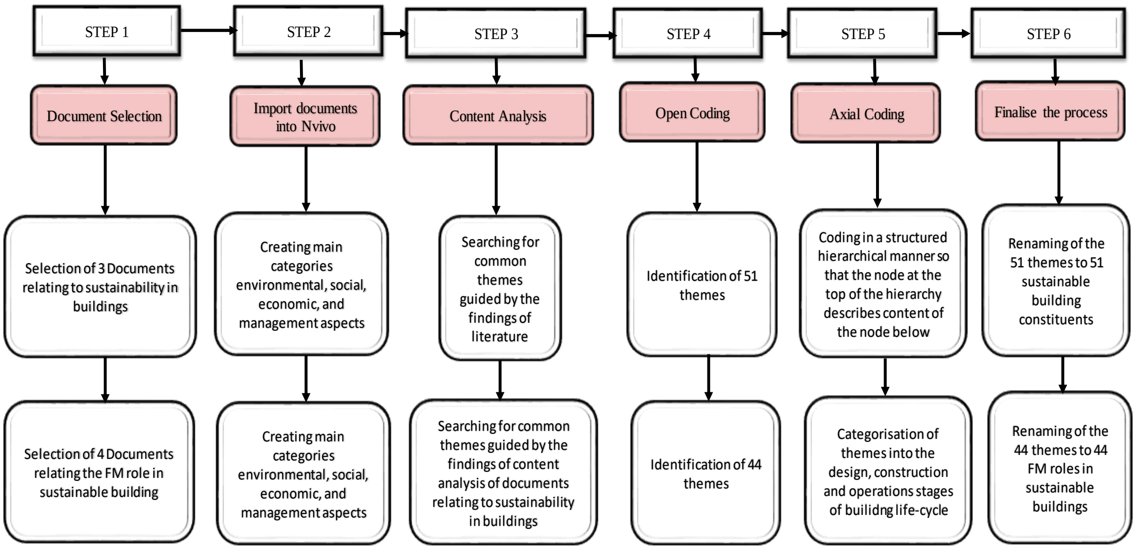

Figure 6.8: Steps adopted in Content Analysis (Research Design Stage 1: Step 2 of Research)

Content analysis was also carried out for the BIFM Facilities Management Professional Standards Handbook, the FMAA Skills in Facilities Management Investigation into Industry Education, the IFMA Complete List of Competencies, and the RICS Assessment of Professional Competence Facilities Management Pathway Guide. The same steps taken in analysing the documents selected in relation to sustainable building constituents were used in analysing the selected aforementioned documents (see Figure 7.8). The purpose of the content analysis was to investigate the facilities manager's roles that relate to sustainable building constituents. Therefore, the nodes created were based on the sustainable building constituents identified in the first content analysis. The themes identified produced 44 FM roles in relation to the sustainable building constituents.

6.10 Stage 2: Step 1-Interviews

This section describes the first step in the second stage of the research as shown in Figure 6.9, and involves steps such as conducting interviews, transcribing of the interviews, and analysis of the interview. The purpose of any interview is to critically examine a topic from another person's perspective and is usually being used as a strategy of inquiry and data collection tool in qualitative research (Patton, 2002). Interviews involve face to face interaction between two or more individuals with a specific purpose in mind. They are usually adopted in collecting information from a small number of respondents (Kumar, 2011). Interviews have the qualities of gathering rich and spontaneous information from participants and have high response rates (Oppenheim, 1992). The following sections describe the sample chosen, the type of interview conducted, characteristics of the interviewees, and the method of data analysis used.

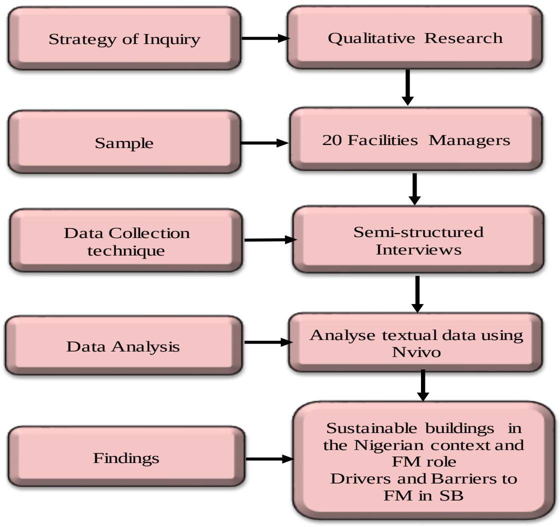

Figure 6.9: Research Design for Stage 2: Step 1

6.10.1 Sample of Study for Interviews

In order to carry out a data collection exercise and gather participant experiences and opinions, it is essential to first decide on the population that this research targets. Population, as defined by Neuman (2011), refers to a large group of many cases from which the researcher draws a sample as it is impossible to approach all members of a population. The sample is a smaller group of the larger population and to which results are generalised and the process termed sampling. Methods of sampling differ depending on the type of research approach, whether quantitative study or qualitative study.

In the qualitative approach, sampling is used primarily for selecting people that are relevant to the research topic and not their representation of the larger population. It is more about shining light on major issues of the social world in order to deepen understanding and provide clarity (Neuman, 2011). This stage of the research adopted a qualitative approach and chose a non-probability sampling method called the purposive sampling method. The research study chose the purposive sampling method due to its characteristic features of research participants being selected on the basis of their relevance to the research questions not seeking to sample participants on a random basis (Patton, 2002). IFMA Nigeria was approached and a request for facilities managers who have worked for a reasonable period of time in international FM companies based in Nigeria or reputable local FM firms and that have interest in the area of sustainability in buildings and are also presently working on such projects was made by the researcher. It is believed that they will be able to give answers to what constitutes a sustainable building in Nigeria and identify the current role that facilities managers play in achieving sustainable buildings and whether they are competent in this role. Using her membership data base, IFMA Nigeria selected members in the aforementioned category and after which participants were approached via email and asked to show their interest in participating in the interviews by responding to the email.

There was poor response to the request for participation in the interviews. After two (2) weeks, only four (4) facilities managers responded to the email that they would like to part of the research. The researcher approached participants for date and time of interview while still waiting for more responses. By the end of another four (4) weeks, five (5) more facilities managers responded favourably to the email and at the end of a total of twelve (12) weeks, twenty (20) facilities managers had responded. The research concluded the wait for responses at the twentieth (20^{th}) response on the premises that there was already an identification of consistency in patterns in the responses of the participants to the interview questions; there was no new concept emerging. According to Patton (2002), when there was no new concept emerging a sample size has reached its saturation point and is good enough reason to determine sample size in qualitative studies. Therefore, a sample size of 20 facilities managers was used for this study and this is deemed adequate for in-depth interviews.

In relation to the interviews conducted, the participants were informed and sent a copy of the interview questions three days prior to the day of intended interview, in order to afford him/her a fore knowledge of the subject matter (details of the interview questions have been described in Section 6.10.2 and a sample shown in Appendix C). The research title, aim, and particularly the objective of the interview were introduced to the participant via an information sheet which was attached to the email sent by IFMA. The 20 facilities managers approached, gave their consent and interviews were not held until consent was given by the participants. They signed a consent form which was collected and stored (sample of the consent form is found in appendix B). The interviews were conducted in the participants' office and they were informed that they could end discussions at any point during the interview. The duration of each interview took an approximate of 90 minutes which gave ample time to ask the set questions and interviews were recorded with digital recorder.

The research calls for an in-depth understanding of the focus of the research from facilities managers that have practiced FM in the country long enough to understand and confirm what constitutes a sustainable in the Nigeria context and the current role and competence of facilities managers in achieving sustainable buildings. For this reason, the research study seeks to examine the facilities manager's role as tool to developing sustainable buildings. It is an area in the Nigerian building industry where little research has been conducted and therefore, requires information from facilities managers with credible years of experience. It is expected that they will be able to identify what a sustainable building is in the Nigerian environment and the role that the facilities manager can play towards its achievement. With reference to Denzin and Lincoln (2011) interviews are usually carried out at the early stages of a research study as a means of shedding light on a research problem that little is known about. FM in sustainable buildings in Nigeria is an area that has been sparsely researched and, therefore, there is need to carry interviews in order to shed some light into the focus of the research. . The type of interviews adopted was the semi-structured interviews which were deemed appropriate at this stage. Semi-structured interviews were chosen to allow for follow up questions as the research is exploratory in nature as mentioned earlier.

The face to face method was adopted which allowed for an in-depth investigation of the subject matter as suggested by (Creswell, 2014). With reference to Leedy and Ormrod (2001), face to face interviews have a distinct advantage of enabling the researcher to establish rapport with potential participants and therefore gain their cooperation. These interviews according to them yield the highest response rates in qualitative research. Face to face interviews also allows the researcher to clarify ambiguous answers and when appropriate and seek more information if need be. However, they conclude that face to face interviews have the disadvantage of being impractical when large samples are involved and are time-consuming.

6.10.2 Interview Questions

Due to understanding from literature of what constitutes a sustainable building (Objective 1) and the facilities manager's role in sustainable buildings (Objective 2), questions were developed by the researcher in conjunction with a highly experienced supervisory team. The supervisory team was made up of two facilities management (FM) experts who provided the much needed guidance in this research and one Public-Private Partnership (PPP) expert with a background in the Nigerian built environment. The questions were based on issues identified in the literature review and document analysis in order to determine if facilities managers understand the concept of sustainable buildings and understand what their roles are in them.

The questions were categorised into two sections A and B (see Appendix B for the interview questions). Section A contained 6 questions (1 - 6) in relation to general information about the participant to help provide credibility of the participant to the research and Section B which contained 18 questions (1 – 18) essentially developed to address objectives 4 and 5 as shown in Appendix 2. The questions were set in clear language in order to obtain as much information as possible in relation to constituents that make a building sustainable and the also the facilities manager's role in sustainable building. Some of the questions were intentionally constructed to reflect similar meaning and probably attract similar answers. This was done in order to determine consistency in the participants' responses to the subject matter. The questions were set to deduce findings that were relevant to the aim of the research.

Section A was developed to provide justification for the credibility of the participants interviewed and to identify the range of functions carried out by these participants; while Section B was structured in such a way as to determine the perceptions of facilities managers with regard to sustainable building and identify the drivers and barriers to FM in relation to sustainable buildings in Nigeria. Due to the semi-structured nature of the questions, open questions were used to allow for flexibility and further probing of answers if need be. However, open questions have the disadvantage of taking significant time in transcription (Bryman, 2012).

6.10.3 Characteristics of Interview Participants

This section focuses on Section A of the interview questions which involves the characteristics of the interview participants in relation to their professional backgrounds and years of experience, job descriptions, the position held, the type of organisation they work for, and the main industry in which they offer their services.

6.10.4 Professional Background

The professional backgrounds of the participants interviewed ranged from architecture to building services mechanical and electrical engineering (M&E), building surveying, estate management and quantity surveying. Codes were assigned to each of their professional backgrounds as shown in Table 6.4 for ease of identification in the subsequent tables. The Table 6.5 shows 60% of the participants interviewed with building services M&E. This is perhaps as a result of the campaign for energy efficient buildings in Nigeria as highlighted by Nwofe (2014) and the call for building services professionals in the bid towards achieving this in the country. The Table also shows 15% of the participants from the estate management background. Estate managers seem to be increasingly focusing their attention on the FM role due to various new developments and particularly in sustainability issues. However, their role is being challenged by the multidisciplinary nature of FM allowing other professions to participate (Fatoki, 1998).

Table 6.4: Interviewee Codes

Interviewees' Professional Background	Code	No of Professionnals
Architect	A	2
Estate surveyor	E	3
Mechanical & Electrical engineers	ME	12
Building surveyor	B	2
Quantity Surveyor	Q	1
Total		**20**

Table 6.5 similarly shows ten per cent (i.e. 10%) of the participants from the architecture and ten per cent (i.e. 10%) from the building surveying profession. The chart also shows five per cent (i.e. 5%) of interview participants from the quantity surveying background. Table 6.5

shows the involvement of the professionals from different backgrounds and indicates the multi-disciplinary nature of the FM profession cutting across various disciplines (BIFM 2008; Awang *et al*, 2012).

Table 6.5: Professional Backgrounds

Interview Participants'Professional Background	A1	E1	ME1	A2	ME2	ME3	B1	ME4	ME5	ME6	ME7	ME8	ME9	B2	ME10	ME11	Q1	E2	E3	ME12	Number of participants	%
Architecture	√			√																	2	10
Building sercvies M&E			√		√	√		√	√	√	√	√	√		√	√				√	12	60
Building surveying							√							√							2	10
Estate management		√																√	√		3	15
Quantity surveying																	√				1	5
Total																					**20**	**100**

6.10.5 Years of Experience

In relation to their years of experience, Table 6.6 shows no interviewee with 0 – 5 years working experience. The least experienced interviewee has 8 years’ experience and is categorised under 0 – 10 years. Table 6.6 shows twenty-five per cent (i.e. 25%) of interviewees between 0 – 10 years working experience. Table 7.6 also shows forty per cent (i.e. 40% of interviewees with 11 – 15 years’ working experience. This produces a total of sixty-five per cent (i.e. 65%) of interviewees having between 0 – 15 years working experience. Studies in FM in Nigeria have categorised respondents with 0 - 15 years’ working experience as participants with reasonable years of experience. These studies include Oladokun (2011); Ikediashi *et al*, (2014); Odediran *et al*, (2015); and Ogungbile and Oke (2015). Therefore, their experience can be relied upon for findings of this research. Table 7.6 shows 15% of interviewees with 16 – 20 years’ working experience and 15% with over 20 years’ working experience.

This result shows 35% of interviewees with over 15 years’ experience indicating a fair percentage of interviewees with high years of experience in FM and can, therefore, be relied upon for information regarding FM in Nigeria. The low result of ‘16 – 20’ and ‘over 20 years’ working experience is evidence to the evolving nature of the FM profession in Nigeria as affirmed by Ikediashi *et al*, (2014). The profession is at a stage where those with medium or reasonable years of working experience outweigh those with high experience. However, as indicated above, each interviewee has reasonable working years of experience and are, therefore, credible in relation to the information given by them.

Table 6.6: Years of Experience

Interview Participants'Professional Background	A1	E1	ME1	A2	ME2	ME3	B1	ME4	ME5	ME6	ME7	ME8	ME9	B2	ME10	ME11	Q1	E2	E3	ME12	Number of participants	%
0 -10 years					√			√	√					√			√				5	25
11 - 15 years						√						√	√		√	√		√	√	√	8	40
16 - 20 years			√				√			√	√										4	20
Above 20 years	√	√		√																	3	15
Total																					**20**	**100**

6.10.6 Job Description

Figure 6.10 shows interviewees description of what their job entails and these were categorised under 10 major descriptions using the NVivo software. They include water management, energy management, management of cleaning services, property and asset management, business management, ensuring the comfort of building user, management of maintenance works, financial management, management and coordination of contractors and suppliers, and space management. The job descriptions majorly varied on management roles. Figure 6.10 shows all of the interviewees involved in the management of cleaning services. This supports the view of Wiggins (2014) that cleaning is one of the most sourced services in FM. Figure 6.10 also shows all participants involved in ensuring the comfort of the building user. The figure shows fourteen (14) out of the twenty interviewees (i.e. 70%) involved in management of maintenance works; it shows twelve (12) of them (i.e. 60%) involved in energy and water management; it shows ten (10) of them (i.e. 50%) involved in financial management; six (6) of them (i.e. 30%) involved in property and asset management, and business management; ten (10) of them (i.e. 50%) involved in management of contractors and space management.

This result indicates the priority that organisations place on maintenance of their facilities and confirms the finding of Adegoke and Adegoke (2013) that many institutions do not want their building to become a liability and also do not want them to be hazardous to people's health which leads to low productivity, excessive labour turnover and increased absenteeism. The results also confirm the involvement of the professionals from the building services M&E background in FM as they perform roles in energy and water management. Management of cleaning services was also indicated from the results as a regular function the participants perform in their day-to-day activities. This supports the claim by Wiggins, (2010) that management of cleaning services is a major activity that facilities managers oversee; however, it is a majorly outsourced aspect of FM practice.

The various roles displayed in their job descriptions confirms the description of FM by FMAA (2014) as the practice responsible for the effective operational management of buildings, covering a broad spectrum of activities from strategic operational planning to daily physical maintenance, cleaning and the management of environmental performance issues. Their job descriptions also fall into the tactical and the operational level of FM function in an organisation as categorised by (Wiggins, 2010).

Figure 6.10: Interview Participants' Job Descriptions

6.10.7 Position Held

Table 6.7 show the position held by the interviewees in their various organisations. Thirty-five per cent (i.e. 35%) of them have no specialised name given to them; their position was labelled by their job description which is the '*facilities manager*'. Thirty per cent (i.e. 30%) of them hold the position of '*Managing Director Facilities*' and at the same time perform FM roles. 20% occupy the position of '*Head Facilities'* while fifteen per cent (i.e. 15%) occupy the '*Senior Facilities Managers*' position. All participants interviewed were either the head of their facilities department or held managerial positions. This indicates that interviewees occupy positions of responsibility and can, therefore, be relied upon for information in relation to the research.

Table 6.7: Positions Held

Positions Held by Interview Participanta	A1	E1	ME1	A2	ME2	ME3	B1	ME4	ME5	ME6	ME7	ME8	ME9	B2	ME10	ME11	Q1	E2	E3	ME12	Number of participants	%
Facilities Manager									√			√	√	√			√	√	√		7	35
Managing Director	√		√				√			√	√				√						6	30
Head Facilities		√		√	√	√															4	20
Senior Facilities Manager								√								√				√	3	15
Total																					**20**	**100**

6.10.8 Type of FM Company

Wiggins (2010) argues that FM aims at balancing the demand for its services which ranges between integrating people, space, and processes and therefore, that an FM company can either offer its services as consultants, in-house facilities managers, out-sourced facilities managers or as specialist facilities managers. Fifty per cent (i.e. 50%) of interviewees work in FM companies that provide outsourced FM services such as cleaning, generator maintenance, air-conditioning maintenance, electrical/power maintenance, plumbing services, and fire safety installation and maintenance etc. Fifty per cent (i.e. 50%) of interviewees work in non-FM companies, providing in-house FM services. Both in-house FM services and the out-sourced are operational services, described as part of FM services involving the day-to-day provision of a safe and efficient working environment for an organisation to thrive in its core business (Nutt, 1999).

These services according to Chitopanich (2004) are the primary functions of FM and involve management of support services to meet the needs of an organisation, its core operations and employees. The results confirm the finding of Ikediashi and Ekanem (2015) that the benefits of out-sourcing of FM services are gradually being recognised by organisations. The results of this stage of the research are, therefore, based on the experience of facilities managers from in-house FM services and outsourced FM services companies. This adds to the credibility of the results. All the participants work in FM companies that service the commercial industry. This confirms the findings of VETIVA (2011) and Oyedepo (2012) that due to the country's rising profile as one of the fastest growing entities in the emerging market economies and a key player in the international oil industry, FM practice is evolving at an exponential rate.

6.10.9 Transcribing of Interview Findings

The interviews were conducted at different times and each interview was recorded with a recording device and then stored on the researchers' university's network in a secure location with restricted access. The recorded interviews were then transcribed manually by the researcher into Microsoft word. Transcribing is usually done by listening patiently to a recording device and then accurately typing out what is been heard according to a preferred format (Gilbert, 2002). Kvaler (1996) describes transcribing as translating an oral language with its own set of rules to a written language with another set of rules. As stated above, the transcription of the recorded interviews was manually done by the researcher in order to build familiarity with the data and to avoid omission of words that are vital to the data analysis.

Transcription was done making use of the font styles features in Microsoft word. Interview questions were formatted in '*Heading 1 font style*' while the responses were formatted in '*Normal font style'*. This was done in order to differentiate between the questions and the response while analysing. The transcribed interviews were individually saved in files in Microsoft word and which was later used as a source from which QSR NVivo imported data.

6.10.10 Use of QSR NVivo for Qualitative Data Analysis

Data analysis is the central step in any research (Gibbs, 2002). This section of the research consists of the qualitative analysis of data collected from the interviews using of QSR NVivo. The particular version used is the NVivo 10 which is the latest version of the QSR NVivo series produced by QSR International. It is a software package for qualitative researchers and provides a range of tools for handling data, ideas, information and theories built up from observations, interviews, document analysis, literature reviews and other qualitative research processes (Jupp, 2006). Salkind (2010) describes QSR NVivo as a software tool that assists a researcher from the time of conceptualization of a project through to its completion. According to him, although QSR NVivo is software that is designed primarily for researchers undertaking an analysis of qualitative (text and multimedia) data, its usefulness extends to researchers engaged in any kind of research.

Four major steps were involved which are importing of data sources, creation of nodes, coding and then the interpretation of the coded data. The analysis of qualitative data derived from interviews is a field that is constantly growing and becoming less structured and has called for the need for computer aided programmes such as MAXQDA, ATLAS.ti and QSR NVivo (Creswell, 2014; Bazeley and Jackson, 2013; Flick, 2014). There is three schools of thoughts in relation to the use of computer aided programmes for qualitative data analysis. Some have criticised the use of these programmes suggesting that users lose closeness to data through poor screen display, segmentation of text and loss of content; some others argue that the combination of transcripts and the computer aided programmes make users too close to data and become caught in the coding trap, overwhelmed with data and unable to see the larger picture (Gilbert, 2002). While some believe that it offers both closeness and distance to data which researchers need to aid data analysis; closeness in terms of understanding the data and distance in terms of reducing data to a set of essential characteristics and for synthesis and the ability to switch between the two. According to Bazeley (2013), these programmes have been developed to increase the effectiveness and efficiency of learning from data. The QSR NVivo assisted the study in:

- Tracking and management of data sources and information about sources
- Tracking and linking ideas associated with or derived from data sources
- Searching for terms or concepts
- Coding text for easy retrieval
- Organizing codes to provide a conceptual framework for a study
- Querying relationships between concepts, themes, or categories

To start the analysis, the researcher imported the individual files saved in Microsoft word as described in Section 6.9.4 into the '*internals*' folder of the software in order to kick start the coding process; the '*internals*' folder is a data source in NVivo. Bazeley and Jackson (2013) identify three sources of data in NVivo and these include:

- Internals of which are text sources such as files in Microsoft word, pdfs, pictures, audio or video files, datasets or web-based materials;
- Memos in which the reflective thoughts of the researcher about a project as a whole are recorded; and
- Externals of which are proxy documents for sources either too large, not available electronically or not needed in detail (minutes of meeting or a set of guidelines).

QSR NVivo makes use of data contained in these sources for processes such as the creation of nodes and coding of data to assist the user in data analysis. Gibbs (2002) refers to coding as a process of identifying and recording one or more discrete passages that demonstrate the same theoretical or descriptive idea and connecting them to a node. A node provides a place for connecting a theoretical concept or idea with passages of text that in some way exemplifies that idea (Gibbs, 2002). Simply put, a node is a place where ideas and coding can be kept or stored (Richards, 1999). Coding has been defined as a way of tagging text with codes in order to organise data for further analysis (Corbin and Strauss, 2008) and with reference to Patton (2002), it is needed to make sense of data.

As earlier stated, the transcribed interview questions were formatted in Heading 1 font style in Microsoft word while the responses were formatted in Normal font style. This reduced the complexity of using NVivo in the analysis of the textual data. With reference to Bazeley and Jackson (2013), heading styles in NVivo are hierarchical as in Microsoft word, segmenting a group of text into parts and sub-parts. A heading style allows NVivo to select all text between where there is another heading style. NVivo recognises three features within a heading style and these are:

- The heading that has been applied;
- The exact string of characters where the heading level has been applied; and
- The associated text that follows the heading.

The heading styles allowed NVivo to differentiate the questions from the responses and group together all responses under a particular question, which facilitated the use of auto coding and querying tools in NVivo. The 20 interview transcripts were each stored in individual nodes; this was done in order to have access to all information or responses given by each participant and to systematically store the information and responses of each participant to each question. Bazeley and Jackson (2013) compare this to designating a hanging file for cut-up photocopies as in a manual coding system. However, NVivo instead of keeping actual segments of data in the nodes, it keeps references to the exact location of the text coded.

The nodes were each labelled and can be identified by the interviewers' questions. The heading style feature in NVivo enabled all responses for each question to be gathered together under their individual question nodes. As earlier inferred the questions were framed in such a way as to aid determining facilities manager's perception in relation to sustainable building and identifying drivers and barriers to FM practice in sustainable building. The questions were used as a means of generating codes, which according to Bazeley and Jackson (2013) aids the development of a conceptual model; each question was opened to view all responses in them and this kick started the coding process.

Coding with reference to Gibbs (2002) is a process of labelling and categorising data by identifying themes and storing them in nodes. The coding process followed a similar procedure as in Section 6.9.2 in relation to using coding to analyse the content of selected documents for this study. However, unlike the document analysis where themes were predetermined in the coding process based on literature review, the themes at this stage of the research were not predetermined. When coding the interview transcripts, the themes were discovered as the researcher went through the data, and nodes were created to store the themes and relevant text that fell into the category of the themes.

The first set of coding was simply done by identifying reoccurring themes in the each of the participants' responses to the questions and this has been termed '*open coding*' by Neuman (2011) as described in section 6.9.2. A second set of coding was carried out and the purpose was to review and re-examine initial codes, which resulted in coding new themes as they emerged. Neuman (2011) refers to this as '*axial coding*' and suggests at this stage that the research moves towards identifying the key concepts in analysis. The opening and axial coding are shown in Figure 6.11.

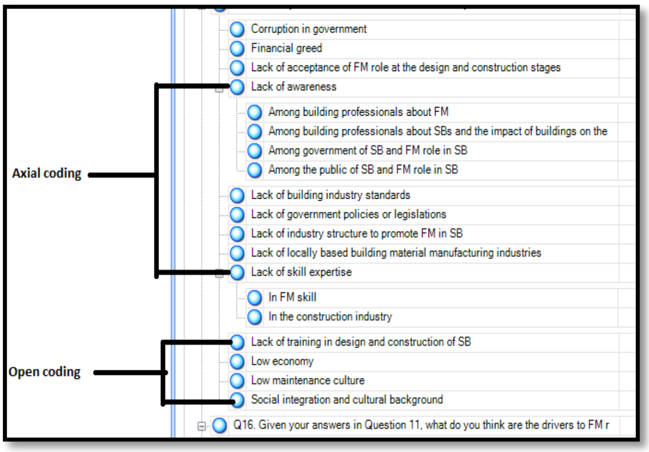

Figure 6.11: Screen Shot of Open and Axial Coding

6.11 Stage 2: Step 2-Questionnaire Survey

A questionnaire survey is developed by researchers to provide a quantitative or numeric description of trends, attitudes or opinions of a population by studying a sample of that population (Creswell, 2014). The research process at this stage is illustrated in Figure 6.12 and addresses the third and fourth objectives of the research study. This section focuses on the development and the process of the questionnaire survey and the analysis of the results of the survey to further establish the findings of the interviews conducted. The questionnaire seeks to empirically determine the constituents that make up a susainable building in Nigeria and the roles of facilities managers in sustainable building. It also seeks to determine the drivers and the barriers to FM role in sustainable buildings in Nigeria.

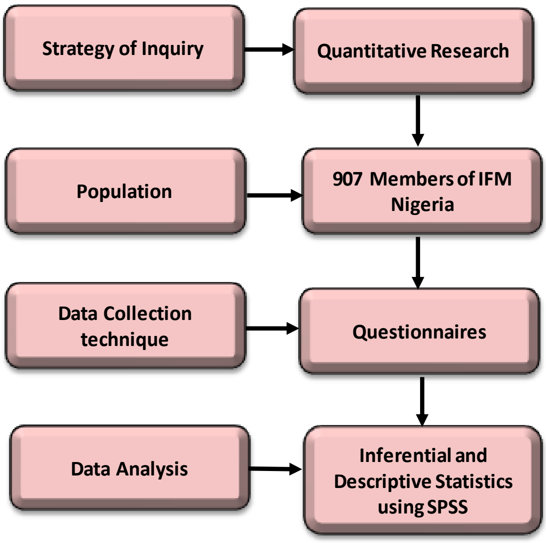

Figure 6.12: Research Design for Stage 2: Step 2

Questionnaires are a written list of questions that have been developed to gather information from people directly and are also designed to collect information that is used for data analysis. They are prepared in such a way that respondents can complete them without any assistance other than built-in or separate written instructions (Hague, 1993). Questionnaires have the disadvantage of having exactly the same questions and pre-coded answers for respondents to choose from. They can be challenging in terms of the respondents not being able to express themselves in their own words, and many times the researcher having little opportunity to check the truthfulness of the answers given. Yet, they are relatively easy to arrange and all respondents are posed with exactly the same questions and chose from pre-coded answers. They are appropriate for quantitative studies (Blaikie, 2010; Denscombe, 2012).

6.11.1 Sample of Study for Questionnaires

Questionnaire survey involves the quantitative approach with the primary use of sampling that selects people that can represent a larger population, that is picking a few to stand in for the many and of which results can be generalised. With reference to Bryman, (2012) how well a sample represents a population depends on the sample size, the specific design of selection procedures and the sample frame. A sample size according to Kumar (2011) is the number of people from a population from which a researcher obtains information; the specific design selection procedure is referred to as the sampling design or sampling strategy; while the sample frame is a list identifying people in a population.

The population for this stage of the research study is taken from the register of IFMA Nigeria. The register is regarded as a very suitable method of choosing sample for any survey, due to the following reasons:

- Up-to-date nature of the registers
- Detailed information made available in the registers
- The time that will be saved in obtaining participants information in terms of email addresses that the questionnaires will be sent to.

The registered facilities managers constitute the population. IFMA Nigeria is the only association in Nigeria that registers building professionals who are involved in FM practice and therefore provides a representation of the population for this research study. An ideal sample is one that provides a perfect representation of a population with all the relevant features of the population included in the sample in the same proportions and Blaikie (2009) argues that this is seldom achieved in any research. However, the IFMA Nigeria register provides a good sample and representation of the population for this research study. Currently, the Nigerian IFMA membership has a significant presence in Lagos and though the majority of its members currently practice in Lagos, there are several of its members located in other major cities of the country. In view of this, it is presumed that the findings of the research can be applicable to other cities in the country.

As shown in Figure 6.12 the questionnaires were targeted at 907 registered members of IFMA Nigeria. Participants were contacted by email addresses obtained from the register of IFMA Nigeria as stated above. Participants were asked to complete the questionnaires attached to their email and send back completed questionnaires via the email address with which they received it. They were given a period of 4 weeks to respond to the questionnaires. However, after the 4 weeks, only 79 questionnaires had been returned. This warranted the need to extend the time for completion by another 4 weeks, after which 60 more questionnaires were returned, making a total of 139 questionnaires.

6.11.2 Questionnaire Design

Questionnaires should be designed to collect information which can be used as data for analysis; it should consist of a list of questions and should request information from people concerning issues relating to the research topic (Denscombe, 2010). With reference to Lavrakas, (2008) when questionnaires are designed, four primary requirements must be met:

- Theoretical knowledge of the research being undertaken and which achieved through the review of relevant literature, in-depth interviews or other qualitative methods of research that may serve as pilot studies.
- The validity of the questions, which is the degree to which the question measures what it was designed to measure and reliability of the questions that is the consistency or replicability of what the question measures.
- Experience in writing a questionnaire, or at least the availability of good ranges of published questionnaires.
- Knowledge of the target population. The target population must be able to answer the questions accurately.

The four above-listed requirements were met while designing the questionnaire. The questionnaire was designed covering the different areas of the research based on an extensive review of literature on sustainable buildings and its constituents (see Chapter 3); the FM role in sustainable buildings (see Chapter 4); and some knowledge of the research area had also been acquired from the interviews. The questionnaire is an eight-page questionnaire that is accompanied by a participant information sheet, which informed the participant of the details of the research, such as the aim and objectives of the research study, and additionally encouraging the participant to take part in the research. The participant information sheet also informed the participant of their anonymity should they consent to take part in the research and that all the information provided would be used strictly for the research purpose. Apendix C contains a sample of the questionnaire.

The questionnaire consists of a set of closed questions, developed to collect information that will help in meeting the research aim and objectives. Closed questions are structured with answers that allow only answers which can fit into categories that have been established in advance by the researcher. They have the advantage of giving clarity to the participant; being easy for the participant because he just places a tick or circles the answers; and being easy for the researcher to process during data analysis; overall saving the time of both the participant and the researcher (Hague, 1993; Bryman, 2012). The questions are categorised as attitudinal questions. Attitudinal questions are questions used to find out what people think about a subject matter. It concerns attitudes, opinions, beliefs, interests and values. The questionnaire for this research consists of attitudinal questions that are opinion based, that is, what facilities managers think of sustainable buildings in Nigeria and their role in sustainable buildings.

The questionnaire also consisted of scales of measurements which are also known as levels of measurements. Scales of measurements with reference to Neuman (2014) is a system for organising information in the measurement of variables into the nominal, ordinal, interval and ratio levels. Within these scales are measures for determining intensity, direction, level, or potency of a variable construct along a continuum in quantitative data and most of these scales are in the ordinal level of measurement (Haughton and Stevens, 2010). The scales include Likert, Thurstone, Borgadus social distance, semantic differential, numerical rating and Guttman scale. They are used by social researchers for high coverage of data, a high degree of accuracy and reliability, comparison between sets of data and for simplifying of collection and analysis of data (Oppenheim, 1992). The scales of measurements used in this research study are the nominal and the ordinal (numerical rating and the Likert) scales of measurement.

It is crucial for a researcher to determine from the outset of a study the scale of measurement to use based on the nature and type of data to be collected. This is necessary in order to determine the kind of numerical analysis that can be carried out on the data generated (Oladapo, 2005). The scale of measurement is, therefore, critical because it relates to the types of statistics that can be used to analyse data (Markham, 2001). For example, the statistics which can be used with nominal scales are in the non-parametric group such as mode and cross tabulation - with chi-square. For ordinal scales, the median and mode, rank order correlation and non-parametric analysis of variance (all in the non-parametric group) can be used. The interval scales and the ratio levels, on the other hand, use parametric statistical techniques such as mean and standard deviation, correlation – r, regression, analysis of variance, factor analysis and a whole range of advanced multivariate and modelling techniques (Markham, 2001).

The nominal scale of measurement is used for questions in Section 1 of the questionnaire, where the respondent is asked to choose which professional discipline he is a member off and a number of years of experience. Section 2 and 3 deals with questions using the ordinal scale of measurement (numerical rating and the Likert scales). The numerical rating scale is used in Section 2, where respondents are required to choose between numbers 1 to 10, representing the extent of criticality of the listed constituents to the practice of sustainable building in Nigeria. Numerical rating scales is also used in part 1 of Section 3, where respondents are required to choose between 1 to 10, representing the extent of the competence level of the facilities management profession in undertaking the identified roles in sustainable buildings. With reference to Dornyei (2010), a numerical rating scale entails assigning one of several numbers to a series of predetermined categories describing an objective of a research. The scale became popular because the rating continuum can refer to a wide range of adjectives on the scale. For this research 1 represents '*Not Critical at all*' and 10 represents '*Extremely Critical'*. This was done to fulfil the general rule of starting the scale with the least desirable, so the respondent has the opportunity to read through the scale before making a choice. The 1-10 scale also allows the respondent to critically evaluate his opinion concerning the subject matter and then make a choice (Sudman and Bradburn, 1982).

The remaining part of Section 3 consists of a 5-point level Likert scale, where respondents are required to indicate to what extent they agree or disagree with the listed barriers and drivers to the facilities manager's role in SBs in Nigeria; where 1 = '*Strongly disagree*'; 2 = '*Disagree*'; 3 = '*Neither agree nor disagree*'; 4 = '*Agree*'; and 5 = '*Strongly Agree*'. The Likert scale is the most commonly used scaling method due to its simplicity, versatility, and reliability (Neuman, 2014); the respondent's attitudes, beliefs or behaviours are measured by requesting them to choose one option that best aligns with their view.

Adequate steps were taken to ensure clarity and unambiguity of the questions contained in the questionnaire and coverage of issues relating to the research study. These steps include:

- Section 2 Question 4 of the questionnaire was purely based on the findings of the document analysis as such the sustainable building constituents identified were developed into questions on the extent of criticality of the listed constituents to the practice of sustainable buildings in Nigeria.
- Section 3 Question 5, was purely based on the findings of the document analysis. However, in this section the facilities manager's function in sustainable buildings as identified were developed into questions on the extent of the competence level of the facilities management profession in undertaking the identified roles in sustainable buildings in Nigeria.
- Section 3 Question 6 and 7 was based on the findings of the interviews. The research study deemed it needful to further investigate the barriers and drivers to the facilities manager's role in sustainable buildings.

- The questionnaire was evaluated and validated by the researcher's supervisors and the questions were modified based on the comments given.
- The questionnaire was also evaluated and validated by three practising professionals who revealed that the questionnaire was clear and was free of ambiguity and could be completed in about 20 minutes.

The major objective of a pilot study is to discover problems prior to the main study, which will enable the researcher to take helpful steps towards improving the research process. The findings of Item 9 in the interview questions helped the researcher in identifying that the answers given were not sufficient to establish factors that can represent sustainable building constituents and, therefore, led to the researcher adopting the use of the identified sustainable building constituents from the findings of the document analysis in the development of Section 2. Researchers also do pilot studies to have a good idea in relation to the time it will take for participants to complete questionnaires and yet address all necessary issues without feeling frustrated. Each of the interviews took approximately 90 minutes, leading to a projected estimated time of 30 minutes in the completion of questionnaires. This according to Oppenheim, (1992) is a good length of time to capture the attention of any participant.

Patton (2002) even argues that pilot studies should be a normal component of good research design because such studies can save researchers both time and money because logistical problems and other design deficiencies can be identified prior to the real study, and corrections and adjustments can be made before the main study is executed. It is helpful in identifying research challenges in advance. Though a pilot study has the above stated benefits, it does not guarantee the success of the main study, it can even lead to its termination. Other problems may be encountered that may not have been revealed by the pilot. Problems such as response rates being much lower than anticipated or adulteration problems may surface if pilot participants are subsequently included in the main study. A more serious concern, however, may be if the research funding is terminated as a result of the pilot indicating that the study may no longer be original or warranted (Bryman, 2012).

6.11.3 Data Collection

In data collection, the response rate is useful in determining the effectiveness of the questionnaires returned in the survey. Self-administered questionnaires usually have a higher response rate than postal surveys or telephone surveys (Cooper and Emory, 1995). Akintoye and Fitzgerald (2000) argue that the norm of response rates within the construction industry is 20% -30%. Table 6.8 shows the questionnaire distribution for the research study. 907 questionnaires were sent out via email, and only 139 usable completed questionnaires were returned through email, thus, achieving 15% response rate. Though, the response rate is lower than 20%, it can still be used for analysis. The low response rate may be due to the low response rate associated with questionnaires sent as an attachment to an email. The low response may also be due to a general lack of knowledge of sustainable buildings. Table 6.9 shows the number of responses according to the different professional backgrounds of the respondents. .

Table 6.8: Response Rate

Questionnaire Distribution	Number
Total Number of questionnaires sent by email	907
Total Number of completed questionnaires returned	139
Percentage response	**15%**

Table 6.9: Questionnaire Distribution

Professional Background	Frequency	Percent
Architecture	15	10.8
Building Services M&E	88	63.3
Building surveying	1	0.7
Quantity surveying	12	8.6
Estate management	9	6.5
Facilities management	4	2.9
Others	10	7.2
Total No of questionnaires returned	**139**	**100**

6.11.4 Data Analysis of Questionnaire Findings

Statistical data analysis is generally used in social science and management research to establish the credibility of a theoretical model and to estimate the extent to which the various explanatory factors are seen to influence the dependent variable (Coorley, 1978). The primary aim of this study is to develop a framework for facilities managers in achieving sustainable buildings. In order to achieve this, the research took initial steps of entering the data collected into the SPSS version 22 software, after which the entered data was proofread and checked for errors. This was a necessary exercise and done to ensure the accuracy of the data entry process, although time consuming. The SPSS version 22 was used to analyse the data from the survey descriptively and inferentially. According to Calkins (2005), descriptive statistics generally characterise or describe a set of data elements, by displaying the information graphically or describing its central tendencies and how it is distributed while inferential statistics try to infer information gathered by sampling. The significant level adopted throughout the analysis was 5% (0.05). The analysis included the percentile method, criticality analysis, Kruskal-Wallis test, Mann-Whitney and the Cronbach's Alpha which was used in the measurement of the reliability of the survey.

6.11.5 Kruskal-Wallis Test

With reference to Field (2013) Kruskal-Wallis test is a non-parametric statistical test that assesses the differences among three or more independent samples on a single, non-normally distributed continuous variable. Pallant (2013) describes the Kruskal-Wallis test as the non-parametric alternative to a one-way between groups analysis of variance. It allows comparism of scores on some continuous variable for three or more groups. It is similar to the Mann-Whitney test. Thus, the Kruskal-Wallis is a more generalised form of the Mann-Whitney U test and is the non-parametric version of the one-way ANOVA. It is used to test the difference between two independent groups on a continuous measure. The Kruskal-Wallis test was used to analyse the statistical variation in the opinion of facilities managers in relation to how critical identified sustainable building constituents are to the achievement of sustainable buildings and across the low, medium and high experience facilities managers. It was also used to analyse the statistical variation in the opinion of low, medium and high experience facilities managers on how competent they are in the carrying out their roles in relation to sustainable building constituents.

6.11.6 Mann-Whitney

Pallant (2013) describes the Mann-Whitney U Test as a test used to test for the differences between two independent groups on a continuous measure. It is the non-parametric alternative to the T-test for independent samples. The Mann-Whitney U Test is similar to the Wilcoxon rank sum test and the Kruskal-Wallis test for grouping variables (Field, 2013). It is one of the most powerful of the non-parametric tests for comparing two populations and it can be used to test the null hypothesis that two populations have identical distribution functions. In this research, Mann-Whitney test was used to identify where the variation lies in opinion in relation to sustainable building constituents and the facilities manager's role in sustainable building among the low and high experience facilities managers, medium and high experience facilities managers and low and medium experience facilities managers.

6.11.7 Criticality Index

Criticality index has been defined as the actual equivalent of the mean item scores of the responses to questions assessing the level of criticality of a factor under consideration (Zhang, 2005). Criticality index was chosen because it expresses meaningful interpretation of the significant importance of issues rather than mean score analysis derived from non-parametric data. The Criticality index for each sustainable building constituent and the facilities manager's role in sustainable building under the environmental, social, economic and management aspect were calculated as follows:

$$Criticality\ index = 10((5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1) / 5(n_5 + n_4 + n_3 + n_2 + n_1))$$

Where n_5 = number of respondents whose answer fall into "very critical"; n_4 = number of respondents whose answer fall into "critical"; n_3 = number of respondents whose answer fall into "medium critical"; n_2 = number of respondents whose answer fall into "less critical"; n_1 = number of respondents whose answer fall into "not critical". In project planning, ratio (between

0 and 1) of the number of times an activity is on the critical path to the total number of simulation trials.

6.11. 8 Relative Importance Index

Relative importance index is used when wanting to determine and rank the relative responses of respondents in terms of a particular view or subject matter. It could be to rank perceived agreement to an issue, relevance of a subject, importance of a factor, risk attached to process etc. (Holt, 2014). The relative importance index generates indexes in an ordinal manner. It has been used in research studies relating to the construction industry; studies such as Fugar and Agyakwah-Baah (2010); Aziz (2013); and Muhwezi *et al*., (2014). In order to determine the relative importance of barriers and drivers affecting the facilities manager in achieving sustainable buildings in Nigeria, the Relative Importance Index (RII) was computed based on the formula provided by Adnan *et al*., (2007) as:

$$RII = (5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1) / 5(n_5 + n_4 + n_3 + n_2 + n_1)$$

Where n_5 = number of participants who answered “strongly agree”; n_4 = number of participants who answered “agree”; n_3 = number of participants who answered “neither agree nor disagree”; n_2 = number of participants who answered “disagree”; n_1 = number of participants who answered “strongly disagree”. The score for each factor is calculated by summing up the scores given to it by the respondents.

6.11.9 Cronbach’s Alpha

Cronbach’s alpha is one of the most popular reliability statistic used for measurement of the reliability of the scale. Cronbach’s alpha (α) is given by the formula:

$$\alpha = \frac{k}{k-1}\left(\frac{\sigma_y^2 - \sum \sigma_i^2}{\sigma_y^2}\right)$$

Formula 1: Cronbach’s Alpha

Source: (Stangor, 1998)

Cronbach’s alpha is a coefficient which ranges in value from 0 to 1. There is, however, no agreement as to the value which gives an acceptable level of reliability (Somekh and Lewin 2005). Rosnow and Rosenthal (1999) stated that the acceptable range depends on the situation in which the instrument is to be used and the purpose or objective of the research. Generally, it is accepted that an increasing sample size leads to a higher reliability estimate (Salkind, 2010). The reliability of the 4-point Likert-type scale, which was the main scale in this study, was subjected to a reliability test using the SPSS statistical software. Cronbach's alpha determines the internal consistency or average correlation of items in a survey instrument to gauge its reliability. It should be noted that Cronbach's alpha is not a statistical test but a coefficient of reliability or consistency (Santos, 1999). Alpha coefficient may be used to describe the reliability or internal consistency of factors extracted from dichotomous (questions with two possible answers) and/or multi-point formatted questionnaires or scales (Santos, 1999). The higher the score, the more reliable the generated scale is. Patton (2002) considers a reliability of less than 0.6 as poor, in the range of 0.6-0.7 as acceptable and over 0.8 to be good.

6.11.10 Re-coding of Data for Analysis

In order to use the SPSS software for data analysis, codes were assigned to the scales 1-10 for the opinion of respondents on the critical level of sustainable building constituents and the competence level of facilities managers in sustainable buildings (see Questions 4 and 5 of questionnaire in Appendix C). The scales 1-10 were collapsed and re-coded as shown in Table 7.10. With reference to Pallant, (2010) re-coding is a technique used in reducing or collapsing categories of variables into fewer and manageable ones and can be used to reverse coding for a particular variable such as a 5-point scale for 1 to become 5, 2 to become 4 and so on. In this research, recoding was used to reduce the 10 point scale to 5 categories.

There are studies that have collapsed and re-coded data when analysing data. Snyder *et al.*, (2008) used a 7-point Likert scale (1 - strongly disagree, 4 - neutral, 7- strongly agree) and collapsed it into 3 categories: Disagree (Likert 1 to 3), Neutral (Likert 4), and Agree (Likert 5 to 7) when analysing the data. Magableh (2011) also used a 6-point Likert scale and analysed data by collapsing the results into dichotomous categories, so as to produce fewer numbers which made the data easier to understand. According to Magableh (2011), collapsing the Likert scale into dichotomous categories helps to identify trends in data, thus, facilitates interpretations, and improves the unambiguousness of the analysis results. This is confirmed by Choice Magazine (2011) in the review of 'Polling the Nations'. The review stated that when data are "collected in 5-point, 7-point or 10-point Likert scale, two options are presented for reporting the data. First, the data can be stated in terms of a Likert scale, and second, the data can be collapsed, to report simply the total percentage opposed in relation to their review on polling data.

Table 6.10: Collapsed and Re-coded Categories of Variables

Initial Variables for Data Collection	Re-coded variable for Data Analysis
Scale for Sustainable Building Constituents	
1 - Not critical at all	
2 - Mostly critical	Not Critical
3 - Not critical	
4 - Hardly critical	Less Critical
5 - Occasionally critical	
6 - Moderately critical	Medium Critical
7 - Critical	
8 - Very critical	Critical
9 - Highly critical	
10 - Extremely critical	Very Critical
Scale for Competence Level of Facilities Managers	
1 - Not competent at all	
2 - Mostly incompetent	Not Competent
3 - In competent	
4 - Low competence	Less Competent
5 - Moderately competent	
6 - Fairly competent	Medium Competent
7 - Competent	
8 - Mostly competent	Competent
9 - Very competent	
10 - Highly competent	Very Competent

6.11.11 Professional Background of Participants of Survey

Figure 6.13 shows the professional background of the different facilities managers who participated in the questionnaire survey. The results show that 63.30% have building services M&E background which carries the highest percentage of facilities managers in the survey. This may be as a result of the campaign for energy efficient buildings in Nigeria as highlighted by Nwofe (2014) and the call for building services professionals in the bid towards achieving this. Goulden and Spence (2015) also argue for facilities managers to be trained in skills relating to energy management and efficiency. As building services management forms a major part of the FM profession particularly at the operations and maintenance stage (Shah, 2007). This result supports the view of Määttänen *et al.*, (2014) in relation to energy and the building services engineer. They claim that a combination of the facilities managers' building management skills and technical knowledge in energy efficiency and management, energy efficiency can be achieved. The results also show that 0.70% is from the building surveying background. The results show an uneven distribution among respondents in relation to professional background and therefore cannot be used as basis for analysis. The result shows 8.60% from the quantity surveying background, 6.5% from the estate management background, 10.80% from the architect background.

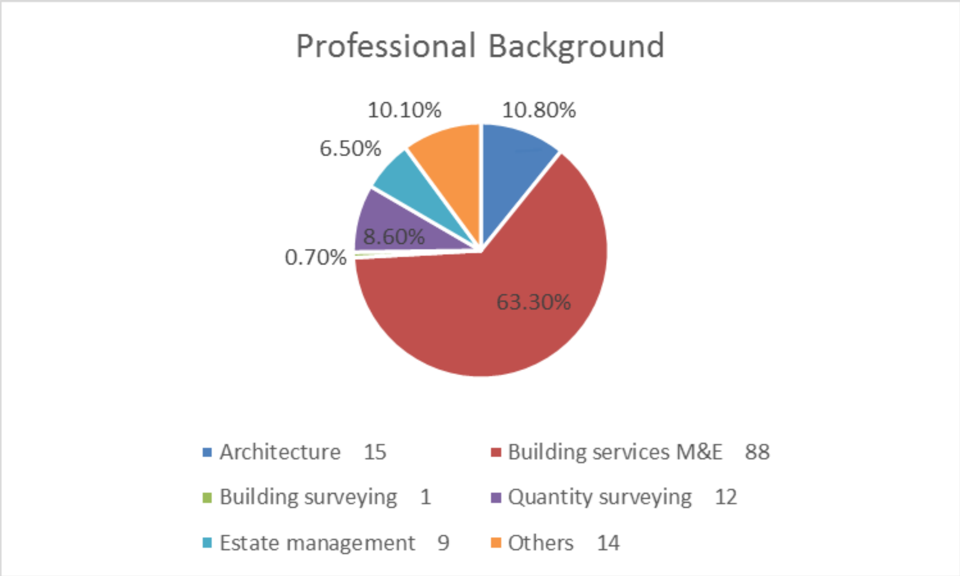

Figure 6.13 Professional Backgrounds

6.11.12 Years of Experience of Participants in Questionnaire Survey

Table 6.11 shows the 43.20% of participants with 0 - 5 years working experience, 25.20% of participants with 6 - 10 years, 13.70% with 11 – 15 years, 16 – 20 years with 6.5% and 11.40% with over 20 years' working experience. This result is consistent with Oladokun (2012) who established that the FM profession in Nigeria is dominated by young professionals in the built environment and indicates that the profession is at its infancy stage. This finding is contrary to the view of Ogungbile and Oke (2015) who argue that there is a worldwide shortage of graduates into the FM profession. A plausible reason for this could be because till now there no higher institution of learning offering FM as a first degree. However, since FM is an interdisciplinary profession, graduates from the other building professions are involved in the practice (Oladokun, 2012).

Table 6.11: Years of Experience

Years of experience	Frequency	Percent
0-5 years	60	43.20
6 to 10 years	35	25.20
11 to 15 years	19	13.70
16 to 20 years	9	6.50
More than 20 years	16	11.40
Total	139	100.00

The result indicates a young generation of building professionals eager to embrace the practice of FM and their interest in helping organisations meet their aims of business. The result also shows the interest of the younger generations in the growth of FM along sustainability issues. For there is now awareness of FM involvement in sustainability matters in Nigeria as established by Ikediashi *et al.*, (2012). The results, therefore, dictate three categories of experience which are low experience (0 - 5 years), medium experience (6 - 15 years), and high experience (16 to 20 years and more) as shown in Figure 6.14. Studies in relation to sustainable buildings in Nigeria have included 0 – 5 years' experience as this viewed as a reasonable number of years of experience. Studies in FM in Nigeria have often included respondents in the medium years of experience (Ikediashi *et al.*, 2014; Odediran *et al*, 2015; Ogungbile and Oke, 2015). The result also shows 16 - 20 years' experience with 6.5%.

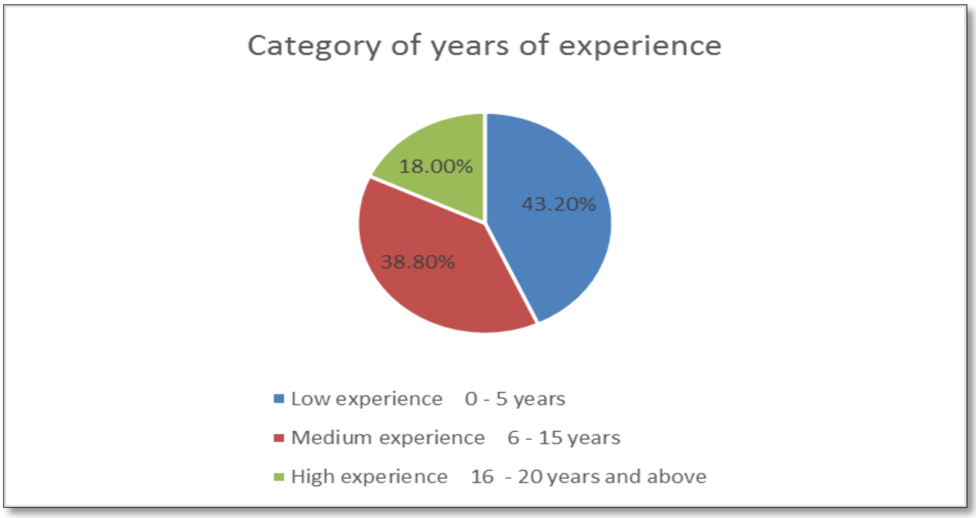

Figure 6.14: Low, Medium, and High Experience

6.12 Stage 3: Development and Validation of Framework to Facilities Managers in achieving Sustainable Buildings

The research aimed at developing a framework for facilities managers to embed their practice to achieving sustainable buildings. The findings of objectives 1, 2, 3, 4, and 5 of the study helped in the development of the framework. The development of the framework involved 3 stages consisting steps 5 as described below.

Stage 1: This stage in the development of the framework involved 2 steps. The first step was a review of literature that provided the theoretical knowledge and the first set of findings on the constituents that make a building sustainable and of which 28 sustainable building constituents were discovered. The second step involved document analysis in order to further investigate and establish the sustainable building constituents. This produced 51 sustainable building constituents and which included the initially discovered 28 sustainable building constituents. The processes involved in this and the findings are as discussed in Chapter 3. Through the review of literature and document analysis, this step revealed the role that facilities managers perform in sustainable buildings. A conceptual framework that shows the facilities manager's role in sustainable buildings was developed. The processes involved are as discussed in Chapter 5.

Stage 2: This stage also involved 2 steps. The first step involved conducting interviews to obtain information on sustainable building and the facilities manager's role in Nigeria. The second step at this stage involved using the findings of the interviews and document analysis to identify sustainable building constituents in the Nigerian context. It was also used to identify barriers and drivers to the facilities manager's role in the achievement of sustainable buildings in Nigeria.

Stage 3: This stage combines stages 1 and 2 for the development of a framework that can be used by facilities managers to achieve sustainable buildings in Nigeria. The findings of the literature review, document analysis, interviews and questionnaire survey were processes that helped in the development of the FM framework for facilities managers in achieving sustainable building in Nigeria. The developed framework was validated by FM professionals who participated in a questionnaire conducted using open-ended questions as shown in Section 9.8. The participants comprise of; 1 FM professional who has worked with a reputable international FM company based in Nigeria and now manages a local FM company, 2 FM professionals who work with respected local FM companies, and 1 FM professional that works with one of the few reputable international FM companies based in Nigeria. Details of their selection criteria is described in Section 9.8.

6.13 Ethical Consideration

The consideration of ethical issues in field research is an important aspect of every research (Creswell, 2014; Denscombe, 2014). This has raised the awareness of the researcher to give priority to ethical issues from the area (topic selection), data collection and analysis to the presentation of the result. The ethical consideration was necessary in order to promote the research quality and guard against inappropriateness and also to protect the participants and their organisations as mentioned by Creswell (2007). After meeting specified conditions, ethical approval was obtained from the University's Ethics Committee prior to contacting the participants and a copy of the ethics approval is as shown in Appendix A. The entire research was undertaken with high respect to the integrity and the confidentiality of the participants. The participants were informed that the information gathered would be treated with high level of confidentiality. This allowed for voluntary participation within the chosen population study.

6.14 Findings, Establishing the Credibility and Limitation of the Research Findings

The initial findings of the first stage of the research revealed 28 constituents of sustainable building as presented in Table 3.2 and produced a definition for sustainable buildings (see Section 3.9). The review of literature in relation to sustainable buildings established credibility and direction in the study. Credibility in terms of demonstration of the researchers' knowledge; and direction in terms of showing the path of prior research on the subject matter, current state of research and the focus for future research. The direction of study was integrative in nature; Neuman (2013) describes integrative literature review as a review in which the researcher presents the current state of knowledge on a topic, highlighting the agreements in relation to the topic and various arguments within it. This in itself adds credibility to the research findings at this stage (Neuman, 2013). The limitation faced at this stage was apparent in the considerable time it took to carry out the initial review of literature on sustainable buildings and FM role in them.

The findings of the content analysis addressed the first objective of the study (which is to identify the constituents of sustainable building with reference to internationally recognised standards) and also the second objective (which is to identify the role of FM in relation to sustainable building at the design, construction and operations phases of the building life-cycle). The content analysis strengthened the reliability and credibility of the research findings obtained from the literature review and mitigated probable lack of thoroughness at that stage. The 28 sustainable building constituents discovered from the literature review were constituents also found in the documents. A total of 51 constituents that make up a sustainable building were found in the findings of the content analysis of the selected documents cutting across the environmental, social, economic, and management aspects. It can be seen that the content analysis revealed more constituents and a new set of constituents under the management aspect. The constituents include: 19 constituents under the environmental aspect, 12 constituents under the social aspect, 6 constituents under the economic aspect and 14 constituents under the management aspect as shown in Table 3.2. The content analysis of Facilities Management Professional Standards Handbook, the Skills in Facilities Management Investigation into Industry Education, the IFMA Complete List of Competencies, and the RICS Assessment of Professional Competence Facilities Management Pathway Guide; revealed 44 FM roles in sustainable buildings and in relation to the design, construction and operations stages of the building life-cycle. Table 6.12 shows the number of sustainable building constituents discovered altogether from the literature review and in each of the documents. Table 6.13 shows identification of FM roles in each FM document.

Table 6.12: Number of Sustainable Building Constituents found in Literature and Documents

Sustainable Building Constituents	Literature Review	BREEAM-NC	LEED-NC	ISO 15392
Environmental Aspect	10	19	13	10
Social Aspect	8	9	6	11
Economic Aspect	5	6	5	5
Management Aspect	5	10	6	5
Total No. of constituents	28	44	30	22

Table 6.13: Identification of Facilities Manager's Roles in Documents

Facilities manager's roles in SB

Identification of FM role in document

No. of document mentioning document

		BIFM	IFMA	FMAA	RICS	
	Environmental Aspect					
	Waste management					
1	Advises on an effective waste management system.	√	√	√	√	4
2	Coordinates waste management during the operational life of the building.	√	√	√	√	4
	Pollution					
3	Advises on minimum car parking capacity in order to help reduce transport related pollution.		√			1
4	Advises the use of systems that reduce carbon emissions.	√	√	√	√	4
	Social Aspect					
	Visual comfort					
10	Advises on visual comfort in terms of daylighting and artificial lighting and lighting controls for the comfort of building occupants.	√	√	√	√	4
11	Ensures installation of fittings that will give visual comfort to building occupant.	√	√	√	√	4
12	Maintains all installations that give visual comfort.	√	√	√	√	4
	Acoustic performance					
13	Advises on the building's acoustic performance including sound insulation meeting the appropriate standards.	√	√	√	√	4
14	Monitors installation of systems that provide acoustic comfort.	√	√	√	√	4
15	Maintains systems that provide acoustic comfort.	√	√	√	√	4
	Thermal comfort					
16	Advises and specifies system that provide thermal control (air-conditioning) at design.	√	√	√	√	4
	Economic Aspect					
	Water efficiency					
27	Advises and specifies water efficient fittings.	√	√	√		3
28	Ensures installation of water efficient fittings.	√	√	√		3
29	Monitors water consumption and carries out activities that reduce waste of water.	√	√	√		3
	Material efficiency					
	Management Aspect					
37	Post occupancy evaluation that ensures delivery of functional buildings in consultation with current and future building users and other stakeholders.		√		√	2
38	Monitors and evaluates technology trends and innovation in the building.	√	√			2
39	Assesses the application of technology within building operations.	√	√			2
40	Incorporates building management systems that actively control and maximise the effectiveness of building services.	√	√		√	3

In relation to the credibility on the selection of the documents for this study, the research took into account the various institutions and professionals that produced the documents; which stands for its authenticity and the purposes for which these documents were developed. The research also considered the clarity of the documents. The sustainable building constituents were described in rich detail and the same applies to the documents on the function of facilities managers. The process of adopting a computer aided data analysis software (NVivo) for content analysis for analysing the selected documents, helped in the systematic structuring of the findings and helped in the validity and transparency of the findings. The general orientation of content analysis towards quantitative methodology which is seen as a limitation was used to identify the constituents of sustainable buildings and the facilities manager's role in the selected documents. The method was seen to be cost effective and yet time consuming. QSR NVivo is developed by researchers and continues to be developed with extensive researcher feedback to support researchers in various ways as they work with data (Bazelay and Jackson, 2013). It assists researchers in understanding what concepts are predominantly discussed in data. Hence, the justification for using it for the content analysis of the aforementioned documents

The use of interviews has been identified as a credible tool for data collection in qualitative studies (Neuman, 2014) and helped with the development of the questionnaire. All participants interviewed held positions of responsibility and can, therefore, be relied on for information in relation to the research. The findings of the interview included 20 FM roles in sustainable building in relation to the Nigeria. The findings also revealed barriers and drivers to the facilities manager's role in sustainable buildings. However, the method is limited by the interviewers' experience which can affect the quality of the information obtained. Thus, generalisation of findings using a questionnaire survey was needed. The use of QSR NVivo helped with the systematic management of information and helped the researcher develop themes, make connections among themes and elaborate on the concepts that the themes represent. It also helped in managing and analysing data in a timely and efficient manner. Furthermore, it helped to code and retrieve data on a particular theme which is not possible when using manual methods (Richards, 1999; Gibbs, 2002). This was useful in making the coding process much more organised and less time consuming.

In relation to the validity and the reliability of the interview questions, the research attempts to demonstrate that the research instrument is fulfilling what it was designed to find out and that it is consistent in its findings when used repeatedly. In qualitative research, validity and reliability of the research instrument are measured by the four indicators of credibility, transferability, dependability and confirmability (Guba and Lincoln, 1994).

6.15 Reliability Analysis of the Questionnaire Variables

With reference to Field (2013) reliability analysis is used to measure the consistency of a scale and the Cronbach's alpha is the most common measure of scale of reliability. Checking the reliability of a scale is related to a scale's internal properties, which is the degree to which the items in a scale hold together Langdridge and Hagger-Johnson (2009). The reliability analysis was carried out to demonstrate the reliability of scales for ranking the extent towards which sustainable building constituents are critical to the practice of sustainable, the competence level of the FM profession in sustainable buildings, barriers to the facilities manager's role in sustainable buildings and drivers to the facilities manager's role in sustainable buildings. The Cronbach's coefficient was used to examine the internal consistency of the scales. With reference to Langdridge and Hagger-Johnson (2009) values of 0.70 or higher are considered to be acceptable. Table 6.14 shows all the values are above the 0.70 value which is an acceptable value for Cronbach's alpha indicating the scales for this study are reliable. Field (2013) states that Cronbach's alpha indicates the overall reliability of a questionnaire.

Table 6.14: Cronbach's Alpha Values of the Survey Data

Variable	Number of Items	Cronbach's Alpha	Cronbach's Alpha based on Standardised Items
SBC	51	0.908	0.945
SBF	44	0.970	0.974
SBB	18	0.779	0.910
SBD	17	0.883	0.884

SBC=Sustainable Building Constituents, SBF=Sustainable Building FM role, SBB=Sustainable Building Barriers, SBD=Sustainable Building Drivers

6.16. Validity and Reliability of Scales of Measurement

With reference to Rosnow and Rosenthal (1999) all forms of measurement, are subject to error which makes it necessary for the assessment of research instruments for reliability and validity. McQueen and Knusson (1999) state that reliability and validity are two essential qualities that a measurement scale must possess and Oppenheim, (1992) confirm reliability and validity as two properties which constitute the essence of measurement or data generation of any kind.

In relation to measurement procedures, validity is the ability of an instrument to measure what it has been designed to measure (Kumar, 2011). Smith (1991) defines it as the degree to which the researcher has measured what he has set out to measure. Babbie (1989) describes it as the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration. These definitions raise two main questions and which are: (1) *'who decides whether an instrument is measuring what it is supposed to measure?'* and (2) *'how can it be established that an instrument is measuring what it is supposed to measure?'* With reference to Kumar (2011) the answer to the first question is the person who designed the study, the readership of the report and experts in the field. With reference to the second question, an instrument can be established as measuring what it is supposed to measure based on either logic that the construction of the research tool is based on or statistical proof that is gathered using information generated through the use of the instrument.

These answers lead to the three types of validity in quantitative research and which include: *face and content validity, concurrent and predictive validity,* and *construct validity*. The face and content validity was used in this research to measure the validity of the questionnaire. The validity measurement is primarily based on the logical link between questions and the objectives of the study and therefore easy to apply. Each question on the questionnaire must have a logical link with the objectives of the research (face validity) and the questions must also cover the full range of the issue or attitude being measured (content validity). Though easy to apply due to the presentation of logical arguments, the face and content validity is based on subjective logic where no definite conclusions can be drawn. The extent to which questions reflect the objectives of a study may differ (Kumar, 2011).

The concept of reliability has to do with how dependable, how consistent, how predictable and how stable a research instrument is; the greater the degree of consistency and stability in an instrument, the greater the reliability (Oppenheim, 1992). However, in social sciences it is impossible to have an instrument which is 100% accurate due to the wording of the questions, the physical setting which can affect the responses given by the respondent, the respondent's mood, the interviewer's, the interaction between the interviewer and the respondent and finally the regression effect of the instrument (Kumar, 2011). The researcher used *'the parallel forms of the same test'* in determining the reliability of the questionnaire. The "the parallel forms of the same test" is an external consistency procedure used in determining the reliability of a research instrument and involves constructing two instruments that are intended to measure the same phenomenon; the two instruments are administered to two similar populations (Kumar, 2011). The interviews and the questionnaire survey conducted for this research study were administered to similar population and they produced similar results.

6.17 Chapter Summary

This section summarised the general research design adopted in this study. The chapter describes the philosophical assumptions brought to the study, the research methodology and specific research methods of data collection, analysis and interpretation. The chapter discussed the pragmatic philosophical assumption underlying the research and involving both qualitative and quantitative methods and therefore, leading to mixed methods research methodology. The chapter also discusses research methods adopted in this study and these include documents selection, interviews, and questionnaires. The chapter discusses research process adopted in the study involving 3 major stages namely; Stage1 – Literature review and document analysis, Stage 2 – Interviews and questionnaire survey, Stage 3 –Validation and Refinement of framework.

CHAPTER 7: FACILITIES MANAGER'S PERSPECTIVE IN RELATION TO SUSTAINABLE BUILDINGS IN NIGERIA

7.0 Introduction

This chapter focuses on the interviews and questionnaire survey carried out to determine constituents that are critical to sustainable building in the Nigerian context in the view of facilities managers. The chapter discusses what facilities managers consider as sustainable building practices and what constitutes a sustainable building in Nigeria. Sustainable building constituents presented in the questionnaire survey are examined in the order of criticality. The chapter addresses Objective 1 by relating the sustainable building constituents identified in BREEAM-NC, LEED-NC and ISO 15392 to sustainable buildings in the Nigerian context and addresses the research question: '*what constitutes a sustainable building in the Nigerian context*?'

7.1 Sustainable Buildings in Nigeria

The concept of sustainable building has been extensively discussed in Section 3.2 and defined in Section 3.2.1. Based on literature review, a sustainable building is a building designed and constructed with low environmental impacts and environmental friendly materials that are not harmful to human health. It is a building designed and operated to use minimum energy and water; provide efficient space and ventilation to aid healthy indoor environment and promotes social integration. The findings of the interviews reveal that this is true of sustainable buildings in the Nigerian environment.

This section discusses the findings of the twenty (20) interviews carried out in relation to sustainable buildings in Nigerian. There was a general consensus that the concept of sustainable building is not widely practiced in Nigeria. One of the interviewees associated this with the fact that Nigeria has no local building manufacturing industry.

'*What I know of a sustainable building is that it is a building home grown, however, in our environment there is very little thought or attention to sustainability but I blame it on the fact that we do not have a local building manufacturing industry. Every material used is imported, so then it becomes more of a game of economics than the game of sustainability. Nigerian builders go to China and Turkey for third grade building materials and even order for Nigerian grade. For example, the poorest quality of tiles ends up in Nigeria. So the few stabs at sustainability are not sustained*'. – A1

However, the interviewees understood the concept of sustainability as they related sustainable buildings to the environmental, social and economic aspects. An example of this is shown in the response of E1 to the question '*what is your opinion of a sustainable building'*?

'*In my own opinion a sustainable building is a building with the fundamentals of sustainability, which is a building that has been economically built, with least environmental impact and* *meeting the needs of occupants. I think it can also be described as a green, a building with less impact on the environment and so on*'. – E1

Their understanding of what a sustainable is in the Nigerian context was related to their general knowledge of sustainable buildings. This is evidenced in the responses of B1 and A1.

'*A sustainable building is a building that is LEED certified. In Nigeria it is a building with windows that are water tight because of the heavy tropical rains that we have in Nigeria, most European designs cannot work here in Nigeria, a building that emits heat because of the warm weather, a building with low energy usage, low water wastage and which has a waste management structure in place. However Nigeria does not have a certification system in place for ascertaining the sustainability of a building in our environment*'. – B1

'*I will say a sustainable building is a building that has been built with locally produced sustainable building materials. The building materials that weather well in the warm tropic region and are easily accessible and available and therefore cheaper to purchase'*. – A1

Seven constituents emerged from their opinion of what a sustainable building is (see Table 7.1). These include reducing use of water, reducing energy use, meeting user needs in terms of comfort, health, security and building performance, encouraging use of construction materials with low environmental impact, ensuring waste management, and building with materials that are locally sourced, and ensuring financial savings. These constituents relate to sustainable building practices. Cassidy (2003) describes sustainable building as the practice of increasing the efficiency with which a building uses energy, water, and materials. It is also described as the practice of reducing building impacts on human health and the environment, through better design, construction, operations, maintenance, and demolition.

There was a general consensus that reducing water use and energy use are sustainable building constituents in Nigeria. This was mentioned by all twenty (20) interviewees. Seventy per cent (70%) of them consider meeting user needs in terms of comfort, health, security and building performance as sustainable building constituents. Encouraging use of materials with low environmental impact was mentioned by sixty-five per cent (65%) of the interviewees. Fifty-five per cent (55%) of them mentioned ensuring waste management. Thirty-five per cent (35%) and twenty-five per cent (25%) are of the opinion that building with materials that are locally sourced and ensuring financial savings respectively are sustainable building constituents in Nigeria. The findings indicate that they understand in general what a sustainable building is, as the constituents mentioned are in line with practices that can be applied to reducing the negative impact of buildings on the environment and also on people (Balaban, 2012).

Table 7.1: Interviewees Opinion on Sustainable Building Practices

Participants opinion of Sustainable Building Practices	A1	E1	ME1	A2	ME2	ME3	B1	ME4	ME5	ME6	ME7	ME8	ME9	B2	ME10	ME11	Q1	E2	E3	ME12	Total No of participants mentioning the role	%
1 Reducing use of water	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	100
2 Reducing energy use	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	100
3 Meeting user needs in temrs of comfort, health, security and building performance	√	√	√	√	√			√	√	√			√		√	√		√	√	√	14	70
4 Encouraging use of construction materials with low environmental impact	√	√		√						√	√	√			√	√	√	√	√	√	13	65
5 Ensuring waste management		√	√			√	√	√	√	√	√	√					√	√			11	55
6 Building with materials that are locally sourced	√	√				√										√	√	√	√		7	35
7 Ensuring financial savings	√	√								√					√					√	5	25
Total	**6**	**7**	**4**	**4**	**3**	**4**	**3**	**3**	**4**	**6**	**4**	**4**	**3**	**2**	**5**	**5**	**5**	**6**	**5**	**5**		

The interviewees were also asked to *state what a sustainable building is in the Nigerian context*. 8 constituents emerged from their opinion of what constitutes a sustainable building. Table 7.2 shows 8 sustainable building constituents in which 6 of the constituents identified in Table 7.1 are included. '*Ensuring financial savings*' was not mentioned a sustainable building constituent, however, '*Ecological value' and 'use of sunlight'* were mentioned as 2 additional sustainable building constituents by the interviewees. It can be seen that the findings of both questions are similar. They were able to relate their understanding of what constitutes a sustainable building in general to such a building in the Nigerian environment. It can, therefore, be inferred that their understanding of a sustainable building influenced their decision.

Table 7.2: Sustainable Building in the Nigerian Context

What constitutes a Sustainable Building in the Nigerian context	A1	E1	ME1	A2	ME2	ME3	B1	ME4	ME5	ME6	ME7	ME8	ME9	B2	ME10	ME11	Q1	E2	E3	ME12	Total No of participants mentioning the role	%
1 Exhibits efficient use of water	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	100
2 Meets user need in terms of comfort and buildng performance	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	100
3 Use of sunlight for energy	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	100
4 Exhibits efficient use of energy		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	19	95
5 Waste management		√	√		√		√	√	√		√	√				√	√	√			11	55
6 Built with materials that are locally sourced	√	√	√						√			√				√	√		√		8	40
7 Minimum impact on environment	√			√						√			√				√			√	6	30
8 Surrounded with vegetation such as plant and trees						√				√		√									3	15
Total	**5**	**6**	**6**	**5**	**5**	**5**	**5**	**5**	**6**	**6**	**5**	**7**	**5**	**4**	**4**	**6**	**7**	**5**	**5**	**5**		

All twenty (20) interviewees are of the opinion that efficient use of water, meeting user needs and use of sunlight for energy are features of sustainable buildings in Nigeria. Though, interviewees agree that efficient use of water is a sustainable building constituent, water is a resource that is in limited supply in Nigeria due to low development of infrastructure for water supply, characterised by poor funding, operations and maintenance (Adelegan and Adelegan, 2001; Alayande, 2005). Therefore, there is need for water efficient systems such as low supply taps to help manage the limited water supply in buildings. The high results for water and energy may be as a result of the emphasis being placed nowadays on water and energy efficiency as environmental and economic aspects of SD. Energy is seen as a vital asset for any country today as future economic growth significantly depends on the long-term accessibility to energy from sources that are affordable, accessible, renewable and environmentally friendly (Ramchandra and Boucar, 2011).

Meeting user needs is considered to embrace visual comfort, thermal comfort, indoor air quality and acoustic performance as identified by BREEAM-NC (2012) and is categorised under the social aspect of SD. Research has clearly established that a building has a direct effect on the comfort, health and productivity of the occupants and is related to thermal, acoustic, and visual comfort and indoor air quality (De Giuli *et al.*, 2012). Ninety five per cent (i.e. 19 of the interviewees) are of the opinion that energy efficiency is a sustainable building feature. Energy efficiency is being encouraged in buildings and involves practices that include use of low energy bulbs instead of incandescent bulbs and monitoring of energy consumption. Despite measures taken to reduce energy use in buildings in the country, there are major barriers militating against the adoption of more energy efficient practices. This include lack of awareness of the potential and importance of energy efficiency, absence of skilled manpower to undertake energy audit studies and low awareness of the potential alternatives such as renewable energy technologies (Okoye, 2007).

Even though energy efficiency in buildings is being encouraged, Nigeria has suffered from unreliable supply of energy over the years, causing many building owners to have installed energy generating sets leading to significant environmental pollution. The individual supply of energy constitutes a huge economic loss to the Nigerian economy (Sambo, 1991). The unreliable supply of energy has also led to use of fossil fuels from wood because of its availability and affordability (Alli, 2001); although, it contributes to environmental pollution and deforestation. Studies reveal that in Nigeria, harvesting of wood for energy causes deforestation at a rate of about 400,000 hectares per year (Obueh, 2007).

All participants also are of the opinion that meeting user needs in terms of comfort is a constituent of sustainable building. Comfort, according to Vischer (2007) and Feige *et al.*, (2013), is the presence of pleasant sensations with positive effect on human well-being and can be in terms of visual comfort, thermal comfort, acoustic comfort, and indoor air quality. Larsen (1998) states that body comfort is very essential in building design especially in the tropics. For a hot climate like Nigeria, building design should aim at preventing solar radiation and allow for adequate illumination. When this factor is adequately considered, it will reduce energy used for air-conditioning, ventilation and illumination to attain a high level thermal and visual comfort in buildings (Lawal and Ojo, 2011). The thermal discomfort experienced by occupants during the hot season causes psychological distress, depression and anxiety as well as lower physical health manifested as heart disease, insomnia, headache, fatigue, boredom and poor arousal (Larsen, 1998).

Eleven out of the twenty (20) interviewees, (i.e. 55%) are of the opinion that waste management is a constituent and there is evidence to prove that the building industry in Nigeria is making conscious efforts to achieve effective waste management. However, this effort is mitigated by the waste disposal habit of the people, corruption, work attitude, lack of adequate equipment, plant and tools necessary for waste disposal and collection, overlap of function of waste management agencies, and population effect as stated by Taiwo (2009).

Forty per cent (40%) of the twenty (20) interviewees are of the opinion that building with local materials is a constituent of sustainable building. An example is the use of *compressed earth blocks*, *environmentally friendly mortar*, and *bamboo* as locally sourced materials in the construction of buildings in Nigeria (Akadiri, 2015; Atanda, 2015) as mentioned in Section 6.5. pp. 141. In fact, one of the interviewees concluded that a sustainable building is a building that is built with locally sourced materials as evidenced in the quote below:

So I will say that a sustainable building is a building that has been built with locally produced materials. The building materials that weather well in the warm tropics like Nigeria are easily accessible and available and, therefore, cheaper to purchase. – A1

Thirty per cent (30%) are of the opinion that minimum impact on the environment is a constituent of sustainable building. According to BREEAM-NC (2012) minimum impact on the environment include reduction in carbon emissions in buildings, pollution in terms of construction site, light pollution, and pollution as a result of rain water runoff and discharge to the municipal sewage system. The low response is probably as a result of the lack of enforcement of environmental laws such as the Environmental Impact Assessment of (EIA) Act No. 86 of 1992 as suggested by Dahiru *et al.*, (2012). Therefore, most of the respondents do not regard it as sustainable building constituent that is practiced in Nigeria. Fifteen per cent (15%) are of the opinion that a building surrounded with vegetation such as plants and trees is a constituent of sustainable building. This constituent can be related to the ecological value of the land around the building.

7.2 Sustainable Building Constituents in relation to the Environmental Aspect

Section 7.2 to 7.5 focuses on the analysis of questionnaire findings based on sustainable building constituents as identified in the BREEAM-NC (2012), LEED-NC (2009), and ISO I5293 as follow up to the interviews. The analysis is based on the years of experience of the facilities managers who responded to the questionnaire survey (i.e. low experience, medium experience, and high experience facilities managers) as stated in Section 6.11.12. Low experience indicates respondents with 0 - 5 years' experience, medium experience indicates respondents with 6 - 15 years' experience, and high experience indicates respondents with 16 to 20 years' experience and above.

Respondents were asked to rate the criticality of sustainable building constituents on a scale of 1 - 10 where 1 is '*Not critical at all*' and 10 is '*Extremely critical*'. However, the scale was collapsed into 5 categories for ease of analysis as described in Section 5.11.9 and these are: 1 – 2 = Not Critical, 2.1 – 4 = Less Critical, 4.1 – 6 = Medium Critical, 6.1 – 8 = Critical, 8.1 – 10 = Very Critical. The Criticality index for each constituent under the environmental, social, economic and management aspect were calculated based on the formula used by Zhang (2005) and Dada and Oladokun (2012) and is as follows:

$$Criticality\ index = 10((5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1) / 5(n_5 + n_4 + n_3 + n_2 + n_1))$$

Where n_5 = number of respondents whose answer fall into "very critical"; n_4 = number of respondents whose answer fall into "critical"; n_3 = number of respondents whose answer fall into "medium critical"; n_2 = number of respondents whose answer fall into "less critical"; n_1 = number of respondents whose answer fall into "not critical". The criticality index is actually the equivalent of the mean item scores of the responses to questions assessing the level of criticality of identified constituents to the achievement of sustainable building.

Table 7.3 shows under the environmental aspect, use of energy efficient equipment as the highest ranked constituents critical to the achievement of sustainable building with a critical index of 8.86. This is followed by waste management (2nd ranked), reduction of carbon emissions (3rd ranked), use of construction material with low environmental impact (4th ranked) and use of renewable energy (5th ranked) and with critical indexes of 8.68, 8.52, 8.44 and 8.24 respectively. Table 8.3 shows reduction of light pollution at night (18th ranked) and use of previously developed site (19th ranked) are ranked as the two least critical constituents with criticality indexes of 5.96 and 5.94 respectively. The lowest criticality index is 5.94 indicating that all constituents under the environmental aspect are rated significant and therefore, very important to the achievement of sustainable buildings in Nigeria.

Table 7.3: Constituents of Sustainable Building Environmental Aspect

Environmental constituents	Overall Criticality Index	Category	Ranking
♦ Use of energy efficient equipment	8.86	VCR	1
♦ Waste management	8.68	VCR	2
♦ Reduction of carbon emissions	8.52	VCR	3
♦ Use of construction material with low environmental impact	8.44	VCR	4
♦ Use of renewable energy	8.24	VCR	5
♦ Site management in terms of energy consumption	8.16	VCR	6
♦ Use of energy efficient transportation system	8.12	VCR	7
♦ Minimisation of sewage pollution	8.06	VCR	8
♦ Site management in environmental pollution	8.02	CR	9
♦ Use of responsible sourced materials	7.96	CR	10
♦ Reduction of GHG emissions	7.86	CR	11
♦ Preserving ecological value of land	7.66	CR	12
♦ Constructed in environmentally sourced manner resource use	7.64	CR	13
♦ Maximisation of solar energy	7.52	CR	14
♦ Preserving biodiversity	7.3	CR	15
♦ Minimisation of rainwater pollution	7.22	CR	16
♦ Provision of minimum car parking	7.02	CR	17
♦ Reduction of light pollution at night	5.96	MCR	18
♦ Use of previously developed site	5.94	MCR	19

MCR=Medium Critical, CR=Critical, VCR=Very Critical

In order to identify if there is a variation in opinion in relation to the identified constituents across the low, medium and high experience facilities managers, a Kruskal-Wallis test was carried out. The Kruskal-Wallis test is a non-parametric statistical test that allows comparison of scores on continuous variable for three or more groups (Pallant, 2013). The Kruskal-Wallis test was also carried out for the criticality levels of sustainable building constituents under the social, economic and management aspects as presented in Section 7.3, 7.4 and 7.5.

The results indicate that there is no significant variation in opinion across the low, medium and high experience facilities managers except for four of the constituents which are reduction of greenhouse gases, use of solar energy, use of renewable energy and reduction of light pollution at night with values of 0.008, 0.02, 0.008, and 0.004 respectively as shown in Table 7.4. These values are less than 0.05, meaning there is a statistically significant variation in relation to these constituents and suggest that there is a difference in opinion across the 3 different groups of facilities managers. As such, a post-hoc test is necessary in order to discover where the variation lies across the groups. The Kruskal-Wallis tests are run to show whether there is a difference between groups, it does not indicate which specific groups differed, however the post-hoc tests do (Field, 2013).

Table 7.4: Kruskal-Wallis test showing Difference in Opinion

	Chi-square		
	Value	df	Asymp.Sig.
Waste management	2.591	2	0.274
Provision of minimum car parking	5.456	2	0.065
Reduction of carbon emissions	5.034	2	0.081
Site management in environmental pollution	3.699	2	0.157
Reduction of light pollution at night	9.599	2	**0.008**
Minimisation of rainwater pollution	1.546	2	0.462
Minimisation of sewage pollution	3.167	2	0.205
Use of previously developed site	3.578	2	0.167
Preserving ecological value of land	1.316	2	0.518
Preserving biodiversity	0.368	2	0.832
Use of energy efficient equipment	2.208	2	0.332
Site management in terms of energy consumption	3.255	2	0.196
Reduction of GHG emmissions	7.847	2	**0.02**
Use of solar energy	9.629	2	**0.008**
Use of energy efficient transportation system	2.072	2	0.355
Use of renewable energy	11.224	2	**0.004**
Use of responsible sourced materials	0.635	2	0.728
Use of contruction material with low environmental impact	0.763	2	0.683
Constructed in environmentally sourced manner resource use	3.277	2	0.194

To identify where the variation lies in relation to the opinion of facilities managers (between low and high experience, medium and high experience, and low and medium experience) on the reduction of greenhouse gases, use of solar energy, use of renewable energy and reduction of light pollution at night constituents; a Mann-Whitney U tests between pairs of groups was carried out. Table 7.5 shows the probability value *p* for the constituent *reduction of light pollution at night* to be 0.084 which is more than 0.05 among low and high experience facilities managers; therefore is no significant difference in the opinion between these two groups. However, the results show probability value *p* for reduction of greenhouse gases, use of solar energy, and use of renewable energy as 0.005, 0.003 and 0.003 respectively, which is less than 0.05. This indicates that there is a statistically significance difference in relations to the aforementioned constituents between the low and high experience facilities managers. In carrying out further analysis as shown in Table 7.6, the value of *r* is calculated as 0.31, 0.33 and 0.33 for reduction of greenhouse gases, use of solar energy, and use of renewable energy respectively. This result shows that the statistically significance difference is of medium effect using the criteria by Cohen (1988) that any result more than 0.30 and less than 0.50 has medium effect on results. This indicates that there is no significant difference in the opinion in relations to reduction of greenhouse gases, use of solar energy, and use of renewable energy between low and high experience facilities managers. *r* is calculated as:

$r = z/\sqrt{N}$ where N = total number of respondents

Table 7.5: Low experience and high experience

Test Statistics	Reduction of GHG emissions	Maximisationi of solar energy	Use of renewable energy	Reduction of light pollution at night
Mann-Whitney U	426.000	408.500	418.500	550.500
Wilcoxon W	702.000	684.500	694.500	2380.500
z	-2.803	-2.99	-2.979	-1.728
Asymp. Sig. (2-tailed) *p*	0.005	0.003	0.003	0.084

Table 7.6: *r* Value

Test Statistics	Reduction of GHG emissions	Maximisationi of solar energy	Use of renewable energy
z	-2.803	-2.99	-2.979
p	0.005	0.003	0.003
r	0.31	0.33	0.33

Table 7.7 shows the probability value *p* for the constituent *reduction of greenhouse gases* as 0.15 which more than 0.05 among medium and high experience facilities managers; therefore it is no significant difference in the opinion between these two groups. However, the results show probability value *p* for use of solar energy, use of renewable energy and reduction of light pollution at night as 0.015, 0.001 and 0.002 respectively, which is less than 0.05. This indicates that there is a statistically significance difference in relation to the aforementioned constituents between the medium and high experience facilities managers. In carrying out further analysis as shown in Table 7.8, the value of *r* is calculated as 0.28, 0.38 and 0.36 for use of solar energy, use of renewable energy and reduction of light pollution at night respectively. This result shows that the statistical significant difference is of medium effect using the criteria by Cohen (1988) as earlier stated. This indicates that there is no significant difference in the opinion in relation to use of solar energy, use of renewable energy and reduction of light pollution at night between medium and high experience facilities managers.

Table 7.7: Medium experience and high experience

Test Statistics	Reduction of GHG emissions	Maximisation of solar energy	Use of renewable energy	Reduction of light pollution at night
Mann-Whitney U	478.5	396	344	354
Wilcoxon W	754.5	672	620	1732
z	-1.441	-2.43	-3.273	-3.095
Asymp. Sig. (2-tailed) *p*	0.15	0.015	0.001	0.002

Table 7.8: *r* Value

Test Statistics	Maximisation of solar energy	Use of renewable energy	Reduction of light pollution at night
z	-2.43	-3.273	-3.095
p	0.015	0.001	0.002
r	0.28	0.38	0.36

Table 8.9 shows the probability value *p* for the constituent *reduction of greenhouse gases, maximisation of solar energy, use of renewable energy and reduction of light pollution at night* as 0.123, 0.317, 0.939 and 0.090 which is more than 0.05 among low and medium experience facilities managers. This result, therefore, indicates that there is no statistically significant difference in the opinion of the aforementioned constituents among the two groups. The results in this section indicate that there is no difference in opinion across the low, medium and high experience facilities managers in relation to the constituents under the environmental aspects.

Table 7.9: Low experience and medium experience

Test Statistics	Reduction of GHG emissions	Maximisationi of solar energy	Use of renewable energy	Reduction of light pollution at night
Mann-Whitney U	1289	1397.5	1548	1276.5
Wilcoxon W	2667	2775.5	3378	2654.5
z	-1.542	-1	-0.076	-1.697
Asymp. Sig. (2-tailed) *p*	0.123	0.317	0.939	0.09

The analysis of the data obtained from the questionnaire survey reveal all 19 constituents under the environmental aspect are critical to achieving sustainable buildings. However, the results revealed the use of energy efficient equipment, waste management, reduction of carbon emissions, and use of construction material with low environmental impact and use of renewable energy as the 5 highest ranked constituents under the environmental aspect and critical to the achievement of sustainable building. Use of energy efficient equipment under the environmental aspect is a constituent that is critical during the operational life and construction stage of the building and is related to energy efficiency a constituent under the economic aspect.

With reference to GSSAN (2014), energy efficiency though a constituent has not been legislated into the current Nigerian building code standards. As a result there is inadequate energy conservation measures incorporated into the design of buildings as stated by Akinlo (2008). If energy efficiency is to remain a constituent of sustainable building, there is need for policies that can influence reduction in energy consumption (Tajudeen, 2005).

In relation to renewable energy, a number of technologies have been discovered as feasible and suitable for Nigeria (Sambo, 1991). It is now being encouraged in buildings; however, Nigeria has not yet tapped adequately into this form of energy (Sambo, 2009). Li *et al.*, (2014) indicates sunlight as a source of renewable energy in buildings and of which Newsom (2012) contends that Nigeria has a great amount of solar energy potential as it lies within a high sunshine geographical belt. Building designers should, therefore, maximise sunlight for energy in buildings. As one of the interview participants stated:

"*In my own opinion a sustainable building in the Nigerian context is a building that has been designed with sustainable features such as allows natural sunlight into a building. We have so much sunlight in this country that we can easily make the most of it by considering it in our building designs and save so much energy*". – ME2

Li *et al.*, (2014) argue that maximum use of sunlight will greatly alleviate the pressure of the building energy consumption and align buildings with the SD concept. GSSAN (2014) also encourages designs that provide maximum daylight for building users, however, notes that the conversion of sunlight into solar energy in buildings has not yet been fully exploited in Nigeria. Edomah (2016) contends that this is due to the high initial capital cost for Photo-Voltaic infrastructure. Edomah (2016) also argues that for Nigeria to develop renewable energy sources, the government needs to define realistic and clear energy policies, implement stable regulatory and legal framework to support long term investment in renewable energy, and encourage public and private initiatives that enable innovation and foster research.

GSSAN (2014) confirms the use of low impact environmental and locally sourced materials in constructing buildings in Nigeria. Studies by Ede and Okundaye (2014) and Atanda (2015) also confirm the use of bamboo for construction of buildings in Nigeria and these studies also and affirm that it is a locally sourced material used in Nigeria in the place of steel (these studies have been mentioned in Section 6.5. pp. 142). Akadiri (2015) argues that the use of sustainable materials such as earth blocks, bamboo and timber is a way to reduce the impact that buildings have on the environment in Nigeria. GSSAN (2014) however, encourages the use of locally sourced materials because it encourages economic growth.

In relation to waste management, Nigeria has two major challenges and these are: collection of waste from buildings and disposal of the waste. The problem of waste collection and disposal are usually caused by climatic conditions, public attitude, nature of waste, and transport condition. However, Nwigwe (2008) contends that the government and the building occupants have roles to play in adopting more suitable solutions to these problems. GSSAN (2014) confirms that at present there is basic waste management processes followed on projects in Nigeria, though there is little evidence that these materials are recycled. As evidenced in the statement made by participant B1:

"*Waste management in buildings in Nigeria simply means labelling waste bins outside the building and putting out waste. That is, one for recyclable items like plastics and the other for non-recyclable items but where the recyclable items go from there, nobody knows*". – B1

The GSSAN (2014) encourages waste recycling on construction sites which is a feature yet to be practiced in Nigeria and states that it can be a source of income for contractors. It will also encourage the development and growth of waste management facilities in the country fostering entrepreneurship.

In relation to reduction of carbon emissions as a sustainable building constituent, Olotuah (2015) claims that the Nigerian building industry uses low carbon materials in the development of buildings. The low carbon materials include '*compressed earth blocks*', '*stabilized earth bricks*' and '*environmentally friendly mortar*' for construction of walls. These materials have been identified and discussed in Section 6.5, pp.141. An examination of the interviewee comments show that there is a close link between buildings being sustainable and not harmful to the environment. Research studies such as John *et al.*, (2005); Corinaldesi (2012); and Akadiri and Fadiya (2013) indicate that a building is sustainable if it is built with environmentally friendly materials that have low impact. This is confirmed by interviewee statements such as:

"*In my own opinion a sustainable building is a building with the fundamentals of sustainability, where a building is economically built, with least environmental impact and meeting the needs of occupants*". – E1

"*A sustainable building is a building that promotes health, comfort and productivity of users and that is not dangerous to the environment*". – E3

These statements are consistent with John *et al.*, (2005) that building materials have substantial impact on the environment and that before becoming suitable for use within buildings, they are usually processed with large amounts of energy and various forms of pollution are often created. Therefore, there is need to source for or develop building materials that involve less use of energy and have low impact on the environment. Akadiri and Olomolaiye (2012) contend for the need for building materials with low impact on the environment and describe them as sustainable building materials. However, the use of sustainable building materials has not been encouraged in Nigeria. This may be due to the large number of materials that are needed to be examined to determine whether they can be used, lack of assessment parameters not being consistent, and manufacturing processes lacking transparency (Kibert, 2013). Another reason could be that most housing developers insist on using imported building materials which ultimately prevent the use of readily available local building materials that cost less (Akadiri, 2015).

7.3 Sustainable Building Constituents in relation to the Social Aspect

Table 8.10 under the social aspect shows provision of safe access as the highest ranked constituent with a criticality index of 9.5. This is followed by adheres to ethical standards meeting building standards (2nd ranked), minimisation of water contamination (3rd ranked), provision of indoor air quality (4th ranked), and provision of hazard control (5th ranked) with critical indexes of 9.12, 8.9, 8.56 and 8.52 respectively. Adaptable for different uses (11th ranked) and conservation of local heritage and culture (12th ranked) were least ranked with criticality indexes of 7.00 and 6.72 respectively. It will be noted that lowest criticality index in all is 6.72. This suggests that all constituents under the social aspect are rated significant and therefore, very important to the achievement of sustainable buildings.

In order to identify differences in opinion in relation to the identified constituents across the low, medium and high experience facilities managers, the Kruskal-Wallis test was carried out and it revealed that there is no significance level less than 0.05 among the constituents as shown in Table 7.11. This result indicates that there is no variation in opinion in relation to the identified constituents under the social aspect across the low, medium and high experience facilities managers.

Table 7.10: Constituents of Sustainable Building Social Aspect

Social constituents	Overall Criticality Index	Category	Ranking
♦ Provision of safe access	9.5	VCR	1
♦ Adheres to ethical standards meeting building standards	9.12	VCR	2
♦ Minimisation of water contamination	8.9	VCR	3
♦ Provision of indoor air quality	8.56	VCR	4
♦ Provision of hazard control	8.52	VCR	5
♦ Provision of adequate daylighting	8.5	VCR	6
♦ Provision of appropriate thermal comfort levels	8.32	VCR	7
♦ Space management	8.16	VCR	8
♦ Accessibility to good public transport and infrastructure	7.76	CR	9
♦ Provision of acoustic control	7.66	CR	10
♦ Adaptable for different uses	7	CR	11
♦ Conservation of local heritage and culture	6.72	CR	12

MCR=Medium Critical, CR=Critical, VCR=Very Critical

Table 7.11: Kruskal-Wallis test of difference in opinion

	Chi-square		
	Value	df	Asymp. Sig.
Minimisation of water contamination	3.145	2	0.208
Provision of adequate daylighting	2.536	2	0.281
Provision of appropriate thermal comfort levels	0.313	2	0.855
Provision of safe access	3.636	2	0.162
Space management	1.283	2	0.527
Provison of indoor environmental quality	1.858	2	0.395
Provison of hazard control	2.343	2	0.31
Conservation of local heritage and culture	0.507	2	0.776
Adheres to ethical standards meeting building standards	1.205	2	0.548
Adaptable for different uses	0.292	2	0.864
Provision of acoustic control	0.929	2	0.628
Accesibility to good public transport and infrastructure	0.636	2	0.728

The result under the social aspect did not show any constituent that is less critical or not critical. All 12 identified constituents as shown in Table 7.10 were identified critical to achieving sustainable buildings. However, provision for safe access, adheres to ethical standards meeting building standards, minimisation of water contamination, provision of indoor air quality, and provision of hazard control were ranked most critical. Studies have shown these constituents as vital to the health and wellbeing of occupants (Cole *et al.*, 2008; Palanivelraja and Manirathinem, 2010; Baird, 2010). As such there are various legislations that have been promulgated particularly in developed countries to ensure the health, wellbeing and safety of people at construction and during occupancy. These laws include: the Health and Safety at Work Act 1974, the Management of Health and Safety at Work Regulations 1999, the Workplace (Health Safety and Welfare) Regulations 1992 and Construction (Design and Management) Regulations 1994 (CDM). In the light of all these legislations, the provision of safe access to carry out repairs, maintenance or the inspection of the buildings for both workers and occupants must be carefully considered, and implemented. BREEAM-NC and ISO 15392 encourage designs that make provision for safe access to and from buildings. Berardi (2013) and Kibert (2013) encourage practices that promote ethical standards such as standards set by government entities such as British Standards Institution during construction of a building and building operations and technological developments that are safe for both to people and the environment during the operations stage.

The health and wellbeing of building users is also adversely affected by water contamination which Keeler and Burke (2009) consider is majorly affected by storm water runoff that pollutes the water; however, they argue that careful site design can reduce the impacts of water contamination. BREEAM-NC (2014) encourages that all water systems in the building are designed in compliance with the measures outlined in the relevant national health and safety best practice guides and regulations to minimise the risk of microbial contamination. The design of water systems to ensure minimal water contamination is encouraged by LEED-NC (2009) which also states that a storm water management plan should be developed to ensure reduction of pollutant.

Various studies such as Daisey *et al.*, (2003); Seppänen and Fisk (2006); Wargocki *et al.*, (2008); Steskens and Loomans (2010); ASHRAE, (2010); De Giuli *et al.*, (2012); and Al horr *et al.*, (2016) have shown the criticality of indoor air quality to the health and wellbeing of building occupants. The World Health Organisation Constitution advocates for human right to a healthy indoor environment (WHO, 1985). Healthy indoor environment includes clean air, thermal comfort, and visual comfort (WHO, 2000). BREEAM-NC (2012), LEED-NC (2009) and ISO 15392 encourage minimisation of air pollution and increase in natural ventilation. Paola (2011) argues that if indoor air quality is lacking in a building it can cause Sick Building Syndrome. Smith and Pitt (2011) also support the need for comfortable working environment for building occupants and proved that an improved indoor environment leads to higher occupant satisfaction and which leads to increase higher financial returns as established by Wargocki *et al.*, (2008). These studies in essence support that a sustainable building increases productivity and leads to financial benefits, thereby increasing the value of the building.

According to Seppa¨nen and Fisk (2002), occupants of naturally ventilated offices have fewer sick building syndrome symptoms than occupants of air-conditioned offices. However, natural ventilation can be harmful due to exposure to particulate matter and greenhouse gases (Weschler, 2006). Al horr *et al.*, (2016) argue for incorporation of mechanically ventilated systems. This supported by Siew (2011); Charde and Gupta (2013); and Billie (2012) who also promote the installation of ventilation mechanisms and openings to be incorporated into the design of buildings to enhance indoor environmental quality. However, there is limited experience of the use of mechanically ventilated systems in buildings in Nigeria.

An unhealthy indoor environment can be caused by the effects of hazardous materials which can be irreversible on human health (GSSAN, 2014). However, BREEAM-NC (2012) promotes that at the outline proposal or concept design stage, a risk assessment of any potential natural hazard should be carried out. ISO 15392 also encourages that measures should be taken to avoid occupants being exposed to any hazard. LEED-NC (2009) requires a healthy indoor environment during construction in order to help safe guard the health of workers.

7.4 Sustainable Building Constituents in relation to the Economic Aspect

Table 7.12 shows energy efficiency as the highest ranked constituent under the economic aspect with a criticality index of 9.32. This is followed by water efficiency with a criticality index of 8.68 (2nd ranked). The least ranked constituent is building life-cycle cost with a criticality index of 7.62 (6th ranked). It will be noted that lowest criticality index in all is 7.62. This suggests that all constituents under the economic aspect are rated significant and therefore, very important to the achievement of sustainable buildings.

In order to identify differences in opinion in relation to the identified constituents across the low, medium and high experience facilities managers, the Kruskal-Wallis test revealed that there is no significance level less than 0.05 among the constituents and as shown in Table 7.13. This result indicates that there is no variation in opinion in relation to the identified constituents under the economic aspect across the low, medium and high experience facilities managers.

Table 7.12: Constituents of Sustainable Building Economic Aspect

Economic constituents	Overall Criticality Index	Category	Ranking
♦ Efficient energy use	9.32	VCR	1
♦ Efficient use of water	8.68	VCR	2
♦ Maintenance of building and services	8.6	VCR	3
♦ Management of construction waste	8.3	VCR	4
♦ Material efficiency	7.98	CR	5
♦ Building life-cycle cost	7.62	CR	6

CR=Critical, VCR=Very Critical

Table 7.13: Kruskal-Wallis test of difference in opinion

	Chi-square		
	Value	df	Asymp. Sig.
Efficient use of water	2.716	2	0.257
Material efficiency	0.518	2	0.772
Management of contruction waste	2.578	2	0.276
Maintenance of building and services	1.415	2	0.493
Effcient energy use	0.31	2	0.856
Building life-cycle cost	0.09	2	0.956

All 6 of the constituents under the economic aspect as shown in Table 7.12 are critical to the achievement of sustainable buildings. The results indicate efficient use of water and efficient energy use as two very critical sustainable building constituents. Interview participants commented that in their view water efficiency is currently being incorporated into building designs in Nigeria. It was observed that when interview participants mentioned efficient use of water, they would also mention efficient energy use in the same context. For example:

"*A sustainable building is a building designed with low energy consumption fittings such as low energy air-conditioning units and with low water supply taps and flush systems*". – ME1

"*I consider a sustainable building to be a building that is designed to use minimal water and designed with enough openings for fresh cool air because of our mostly warm weather and the entrance of sunlight in order to save on energy*". – ME7

This shows the link between the two constituents and the appreciable knowledge of participants on issues of '*water and energy*' in sustainability issues and establishes the finding by Glogabl (2011) in relation to '*energy and water*' being two closely linked and interdependent resources. Energy too on its own is a general measure by which building professionals ascertain the sustainable qualities of a building and as evidenced by interview participants B1 and ME5 stating that:

"*A sustainable building is a building that is designed to use minimum energy*". – B1

"*In my own opinion a sustainable building is a building that is energy efficient requiring less energy in cooling of the building to achieve a comfortable environment and use of LED lights to save energy. Sustainable buildings can be achieved in Nigeria by making use of the natural sunlight available to us to save on energy in our buildings"*. – ME5

This supports the finding of Alrasheda and Asifa (2014) that efficient energy use plays a vital role in the context of SD because it contributes to energy savings and the reduction of co_2 emissions (Arik, 2014). As a higher demand for energy use will cause a significant increase in co_2 emissions contributing to environmental pollution energy-efficient buildings can have lower life-cycle costs than their traditional counterparts (Tajudeen, 2015). GSSAN (2014) confirms efficient energy use as a requirement for sustainable buildings in Nigeria. The efficient use of energy in the country is quite crucial as energy is a resource in high demand due to feeding an estimated population of 170 million and with an average annual growth rate of 3% (Tajudeen, 2015). Hence, this has led to the introduction of prepayment meters by the Power Holding Company of Nigeria (PHCN) Plc for energy monitoring, control and reduction in energy consumption; this now widely accepted by building users (Oseni, 2015). However, GSSAN (2014) states that there are currently no energy efficiency requirements legislated in Nigeria. This is consistent with the findings of Dahiru *et al.*, (2012) that the current Nigerian building code standards does not dwell much on issues of sustainable design and construction standards and these include energy efficiency measures to save energy.

Other issues discovered in relations to the inadequate measures in efficient energy use, is monitoring of energy consumption and which is not a common practice in Nigeria. Instead most buildings only use energy meters for payment of energy bills and not monitoring for major consuming systems such as domestic hot water, cooling, fans, lighting, humidification, space heating, and energy efficient light fittings. Monitoring of energy use is a major requirement for energy efficiency in BREEAM-NC (2012). Other aspects of energy efficiency is efficient lighting design and which is not widely practiced enough as stated in GSSAN (2014), though the facilities managers interviewed stated that they usually make recommendation for the use of energy efficient lighting fittings as evidenced in the statement by participant ME5.

"*When we are called in at the design stage, we normally recommend and advise the use of energy efficient bulbs and lights and including sensor lights too, seeing that these measures help in the efficient management of energy in the building*". – ME5

The efficient management of energy in the buildings however, comes at a high initial cost and adds to the eventual cost of the building which is a concern for facilities managers. This evidenced in the statement of interview participant A1:

"*It is sad to say that buildings built for the general masses are completed at such outrageous costs and after including associated costs such cost for energy efficiency and of maintaining the building in long run, the average Nigerian cannot even afford to rent one, let alone buying one*". – A1

One way of mitigating this challenge is to develop financial arrangements that should be made available so that the extra costs could be accepted with the help of financing arrangements and claimed back later through rents as argued by Sayce *et al.*, (2007); and Sodagar and Fieldson (2008). Split incentives by both the building owner and the occupants are another way of mitigating the problem. Bond (2010) explains split incentives as the building owner investing in the building and then getting returns through structured payments of rents and mortgages and the building occupant benefits through cost savings in reduced energy and water consumption and better health and productivity. Though, the split incentive is a sustainable economic solution, it can be challenged by the weariness of both the building owner and the occupant due to its long term benefit. In relation to maintenance of building and services, it has been often proofed that the maintenance of a building gives value for money. Monetary value is one of the topmost critical factors for effective maintenance as identified in (Tucker *et al.*, 2014).

7.5 Sustainable Building Constituents in relation to the Management Aspect

Table 8.14 shows '*involve innovation of technology*' as the highest ranked constituent under the management aspect with a criticality index of 8.74. This is followed by '*involves 6-12 months defects liability period*' (2nd ranked), '*involves commissioning and handover initiatives*' (3rd ranked), '*involves yearly building tuning initiatives'* (4th ranked) and '*engages professionals that assist with sustainability assessment schemes*' (5th ranked) with criticality indexes of 8.58, 8.56, 8.48, and 8.46 respectively. The least ranked are '*involves encouragement of environmental initiatives by occupants*' (13th ranked) and '*reduction of air leakage in building*' (14th ranked) with 7.42 and 7.10 respectively. It will be noted that lowest criticality index in all is 7.10. This suggests that all constituents under the management aspect are rated critical and therefore, very important to the achievement of sustainable buildings. In order to identify differences in opinion in relation to the identified constituents across the low, medium and high experience facilities managers, the Kruskal-Wallis test revealed that there is no significance level less than 0.05 among the constituents and as shown in Table 7.15. This result indicates that there is no variation in opinion in relation to the identified constituents under the management aspect across the low, medium and high experience facilities managers.

Table 7.14: Constituents of Sustainable Building Management Aspect

Management constituents	Overall Criticality Index	Category	Ranking
♦ Involve innovation of technology	8.74	VCR	1
♦ Involves 6-12 months defects liability period	8.58	VCR	2
♦ Involves commissioning and handover initiatives	8.56	VCR	3
♦ Involves yearly building tuning initiatives	8.48	VCR	4
♦ Engages professionals that assist with sustainability assessment schemes	8.46	VCR	5
♦ Designed in consultation with building users	8.22	VCR	6
♦ Incorporates building Management Systems	8.08	CR	7
♦ Involves initiatives to educate building occupants	7.92	CR	8
♦ Incorporates building user's guide	7.92	CR	9
♦ Establishes legal and contractual environmental management initiates	7.66	CR	10
♦ Incorporates waste recycling management plan	7.64	CR	11
♦ Engages agents for building maintenance	7.48	CR	12
♦ Involves encouragement of environmental initiatives by occupants	7.42	CR	13
♦ Reduction of air leakage in building	7.1	CR	14

CR=Critical, VCR=Very Critical

Table 7.15: Kruskal-Wallis test of difference in opinion

	Chi-square		
	Value	df	Asymp. Sig.
Designed in consultation with building users	1.736	2	0.42
Reduction of air leakage in building	2.528	2	0.283
Incorporates waste recycling management plan	1.59	2	0.452
Involve innovation of technology	3.211	2	0.201
Incorporates building Management Systems	0.506	2	0.776
Establishes legal and contractual environmental management initiates	2.913	2	0.233
Engages professionals that assist with sustainability assessment schemes	1.988	2	0.37
Engages agents for building maintenance	1.345	2	0.51
Involves initiatives to educate building occupants	1.514	2	0.469
Involves encouragement of environmental initiatives by occupants	0.529	2	0.768
Incorporates building user's guide	1.111	2	0.574
Involves commissioning and handover initiatives	1.089	2	0.58
Involves 6-12 months defects liability period	0.845	2	0.655
Involves yearly building tuning initiatives	1.875	2	0.392

The 14 constituents listed in Table 7.14 are critical to achieving sustainable buildings. However, the most critical are innovation of technology, involves 6-12 months defects liability period, involves commissioning and handover initiatives, involves yearly building tuning initiatives and engages professionals that assist with sustainability assessment schemes. Sustainability assessment systems have been known to play an important role in raising public awareness and in helping to achieve sustainable buildings as argued by Carmody *et al.*, (2009) and Braganca *et al.*, (2010) and therefore, need a professional proficient in the act of assessing a building's sustainability (BREEAM-NC, 2012; LEED-NC, 2009; GSSAN, 2014).

BREEAM-NC (2012) emphasises any innovation technology, method or process that improves the sustainability performance of a building's design, construction, and operation and maintenance. This is similar in LEED-NC (2009) which encourages innovation in energy performance and water efficiency in the bid to improving services in relation to water and energy consumption. The 6 – 12 months defects liability period has the advantage of ensuring the contactor corrects all defective works so that the building can perform optimally. GSSAN (2014) encourages the incorporation of this period into the building contract as consultants and contractors work to ensure that the building gives value for money (Eggleston, 2001).

Just before the defects liability period, commissioning and handover initiatives are executed. This is encouraged by GSSAN (2014) which makes reference to the guidelines for commissioning of building services developed by Chartered Institute of Building Services Engineers (CIBSE) an international professional engineering association for building services and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) for mechanical systems commissioning. GSSAN also encourages the employment of an independent commissioning agent to ensure that all systems are working efficiently and that all corrective measures are taken in cases where systems are faulty. Building tuning as a sustainable building constituent and is for the optimum performance of a building in relation to energy savings, safe operations and comfort of the building user (GBCA, 2014).

7.6 Synthesis of Findings of Interview and Questionnaire Survey

The 8 sustainable building constituents identified by the interview survey indicate that the facilities managers have a reasonable idea on what constitutes a sustainable building in Nigeria. However, when compared against the 51 constituents identified by the content analysis and the results of the questionnaire survey, it showed that they do not have detailed knowledge of what constitutes a sustainable building. The findings were not sufficient to determine sustainable buildings in Nigeria, even though, from the view of facilities managers; hence, the reason for the questionnaire survey. This result is similar to Wright and Wilton (2012), who found 8 common themes when interviewees gave their responses to what SD meant to them. When participants were given a list of items on SD concepts to choose from, they had more opinions. This indicates that on issues of SD, people require in-depth information to have an adequate understanding of the processes of SD which includes sustainable buildings. Based on literature, the 8 constituents mentioned by the interviewees can be categorised into the environmental, social, and economic aspects.

Table 3.2 shows constituents under the environmental aspect which include waste management, built with materials that are locally sourced, surrounded with vegetation (ecological value) and minimum impact on environment. Buildings having minimum impact on the environment involve reduction of carbon emissions in buildings and on construction sites (Abdallah *et al.*, 2015; Jang *et al.*, 2015). It similarly includes maximum use of sunlight (renewable energy), reduction in light pollution at night (Kuechly *et al.*, 2012; Lyytimäki, 2015), and reduction in pollution as a result of rain water runoff and discharge to the municipal sewage system (Zhang *et al,* 2015). These constituents categorised under pollution (Section 3.3.2. pp.50). Carbon emissions from buildings arise majorly from the use electricity which has been generated from fossil fuels. Significant carbon emissions are also generated through construction materials, in particular insulation materials, and refrigeration and cooling systems (Abdallah *et al.*, 2015). However, they can be reduced by using products with low carbon emissions as in sustainable buildings (Luo *et al.*, 2016).

As shown in Table 8.2 the constituents under the social aspect include meeting user needs in terms of comfort and building performance. This involves the comfort of building users and takes into account the building performance in relation to visual, thermal and acoustic comfort, and indoor air quality. The constituents under the economic aspect include exhibiting efficient use of water and energy. These constituents have been explained in Sections 3.3.18 and 3.3.21.

The findings of the interview reveal more constituents under the environmental aspect than the social and the economic aspects. This shows the peculiar nature of the environmental aspect even when it is related to different issues. It presents more features to be considered under sustainable buildings. It can therefore, be inferred as the most significant aspect of sustainable building and is consistent with Maude (2004)'s finding on the environmental dimension as the most rated aspect of SD. It is argued by Maude (2004) that the ability of the environment to preserve itself and provide an opportunity for people to meet their economic and social needs, makes it the most vital aspect of SD (Maude, 2004). This is supported by Wright and Wilton (2012) who are of the opinion that the environment aspect is the key and only aspect of sustainability that is usually considered to be important.

The findings of the questionnaire survey show that the 51 sustainable building constituents identified in the document analysis are essential to achieving sustainable buildings in Nigeria. This indicates that sustainable building in Nigeria might be very similar to a sustainable building in the UK and US, as the constituents were identified in sustainability tools that have been developed for these countries. This is supported by the view of A1 who stated that:

"*A sustainable building is a sustainable building anywhere in the world no matter the geographical location*". *For there are basic features or rather standards that any sustainable building located anywhere, whether in Europe, United States, China, Africa or even Nigeria should have*". – A1

The aforementioned view seems to be true because the developers of BREEAM-NC believe that there are certain standards that a sustainable building should attain irrespective of location. They, therefore, endorse their tool to be adapted by countries that have not yet developed their own. BRE gives permission for BREEAM-NC to be used as a guide and can be adjusted where necessary, having in mind that difference in geographical location and climatic conditions can affect some features. This is supported by Berardi (2013) who states that differences in climatic conditions can make a sustainable building in one part of the world, different from another sustainable building in another part of the world.

According to Grace (2008), BREEAM has been used as a template for designing other sustainability assessment tools around the world. Examples are the Green Star in Australia and HK-BEAM in Hong Kong. The developers of BREEAM-NC are aware that factors such as weather and locally found building materials are regional determinants of what constitutes a sustainable building in different parts of the world. Users' perspective can also be used to dictate what constitutes a sustainable building.

In relation to the findings of interviews and the questionnaire survey, a sustainable building in Nigeria can be described as one that uses energy efficiently, maximises the abundant supply of sunlight for indoor lighting during the day and solar energy for energy efficient equipment. It is a building built with locally sourced materials such as bamboo, earth blocks and environmentally friendly mortar. It is a building that is designed and operated to use energy and water efficient fittings and promotes comfort and wellbeing for occupants.

Iwuagwu and Iwuagwu (2015) suggest that sustainable buildings have been in Nigeria probably before the worlds' urgent cry for it, yet the identification of what constitutes a sustainable building in the Nigerian environment was deemed necessary. The facilities managers view needed to be examined, as they are believed to be vast in the knowledge of the entire life-cycle of a building and manage the different stages. They also stay with the building from inception to the end of life of the building as argued by Hodges (2005); Shah (2007); and Shiem-Shin and Hee (2013).

7.7 Chapter Summary

The chapter has discussed the findings from the interviews and the questionnaire survey on what constitutes a sustainable building in Nigeria from the view of facilities managers. Twenty (20) interviews were conducted among medium experience (6 - 15 years) and high experience

(16 to 20 years and more) facilities managers. The interviews were carried out in order to gain an understanding of the focus of the research which is achieving sustainable buildings through the facilities manager's role. However, there was need to first of all investigate if facilities manager's understand what constitutes a sustainable building. The findings of the interviews conducted revealed that the interviewed facilities managers are familiar with 8 sustainable building constituents. It can be concluded that the facilities managers have some knowledge and practice of sustainable building, although it can be considered that they have limited knowledge in the context of the 51 constituents revealed by the content analysis.

A questionnaire survey was carried out in order to investigate if facilities managers are knowledgeable in how critical identified constituents are to achieving sustainable buildings in Nigeria. The findings indicate that facilities managers are able to assess how critical the 51 sustainable building constituents identified by the content analysis are to the achievement of sustainable buildings in Nigeria. The questionnaire survey was conducted among 139 facilities managers who are members of the IFMA Nigeria. The findings reveal that there is no significant variation in the criticality of the identified sustainable building constituents across the three categories of facilities managers which are low experience (0 - 5 years), medium experience (6 - 15 years), and high experience (16 to 20 years and above). The results reveal that the 51 constituents are critical to the achievement of sustainable buildings in Nigeria and this indicates that facilities managers are knowledgeable in the sustainable building qualities despite the differences in their years of experience.

The results reveal that the use of energy efficient equipment, waste management, reduction of carbon emissions, and use of construction material with low environmental impact and use of renewable energy as the 5 most critical constituents under the environmental aspect in the achievement of sustainable buildings. Under the social aspect the most critical aspects are: provision for safe access, adheres to ethical standards meeting building standards, minimisation of water contamination, provision of indoor air quality, and provision of hazard control. The results similarly reveal the efficient use of water and efficient energy use as two most critical constituents under the economic, and under the management aspect, the most critical constituents are: innovation of technology, 6-12 months defects liability period, commissioning and handover initiatives, yearly building tuning initiatives and the engagement of professionals that assist with sustainability assessment schemes.

The findings of this stage of the research, reveal the constituents critical to achieving sustainable buildings in Nigeria, however, there is need for further research into constituents such as efficient use of energy and water, optimum use of sunlight, sustainable materials, and indoor air quality. Measures that will encourage the efficient use of energy and water should be investigated, as energy and water supply are limited resources in Nigeria. The government should promulgate legislations and fund programmes that will encourage setting up of local manufacturing building industries, so that local building materials can be utilised in the construction of buildings. Designs that incorporate maximum ventilation in buildings should be mandated to promote indoor air quality as Nigeria is located in humid tropical zone.

In summary, a sustainable building in Nigeria in relation to the findings of interviews and the questionnaire survey is a building that uses energy efficiently, maximises the abundant supply of sunlight for indoor lighting during the day and solar energy for energy efficient equipment. A sustainable building in Nigeria is also a building built with locally sourced materials such as bamboo, earth blocks and environmentally friendly mortar. It is a building that is designed and operated to use energy and water efficient fittings and promotes comfort and wellbeing for occupants. This answers the research question, i.e. *what constitutes a sustainable building in the Nigerian context*?

CHAPTER8: FACILITIES MANAGER'S ROLE (PERCEPTION OF EXTENT, BARRIERS AND DRIVERS TO SUSTAINABLE BUILDINGS)

8.0 Introduction

This research supports that the view of facilities managers is necessary in identifying sustainable buildings as they are involved with a building from inception to its end of life. However, there is need for them to identify what their specific roles are in sustainable buildings. This chapter, therefore, examines the facilities manager's role in sustainable buildings. The chapter focuses on the interviews and the questionnaire survey conducted to determine FM role in sustainable buildings. The chapter fulfils Objective 4 which is to evaluate the perception of facilities managers in relation to their competence in achieving sustainable buildings and Objective 5 which is to investigate the drivers and barriers to the facilities manager's role in achieving sustainable buildings in Nigeria. The chapter addresses the research question: *What is the current FM role in achieving sustainable buildings in Nigeria*? And *are facilities managers in Nigeria competent in FM roles in achieving sustainable buildings*?

8.1 The Facilities Manager's Role in Nigeria

Few studies have been carried out in relation to the facilities manager's role in Nigeria and have been highlighted in Section 4.4. Twenty (20) interviews were carried out to examine if facilities managers in Nigeria can identify what their role is in achieving sustainable buildings. This section, therefore, focuses on the findings of the twenty (20) interviews.

The interviewees were asked what they consider as FM role in Nigeria and whether these roles fit into the design, construction or the operations stages of the building life-cycle. Table 8.1 shows common themes highlighted by the NVivo software in relation to what interview participants consider as FM role in Nigeria. The findings revealed twenty (20) FM roles. Based on literature, the themes were categorised into the environmental, social, economic, and management aspects. Under the environmental aspect, three roles emerged which are: *Energy management* mentioned by Ninety-five per cent (i.e. 19 of the interviewees), *advise on sustainable building material* mentioned by sixty per cent (i.e. 12 of the interviewees), and *waste management* which was mentioned by forty per cent (i.e. 8 of the interviewees). This result supports the finding by Elmualim *et al.*, (2012) who states that energy management, carbon footprint in relation to sustainable building material, and waste management are key sustainability issues being handled by facilities managers.

Under the social aspect, 6 roles emerged which are: *Management of cleaning services, space management, visual comfort, thermal comfort, indoor air quality,* and *acoustic performance*. All participants made mention of these roles one way or another and based on literature they are considered under the social aspect. According to Palich and Edmonds (2013), these roles are categorised under human benefits of sustainable design and are centered on three primary topics: health, comfort, and satisfaction. Under the economic aspect, 6 roles emerged which are: *Property and asset management* and *maintenance of building and services*; mentioned by all 20 interviewees; *efficient use of water and energy* are roles mentioned by ninety-five per cent (i.e. 19 of the interviewees). *Optimum use of building* mentioned by sixty-five per cent (i.e. 13 of the interviewees), and *financial management* mentioned by five per cent (i.e. 1 of the interviewees). Under the management aspect 6 roles emerged and which are: *advise and checks design* mentioned by seventy per cent (i.e. 14 of the interviewees) of the interviewees, *integration into the design team* mentioned by sixty per cent (i.e. 12 of the interviewees), *planning proposed building in consultation with current building users* mentioned by ten per cent (i.e. 2 of the interviewees), *project management* and *engagement of other professionals* each mentioned by five per cent (i.e. 2 of the interviewees).

Table 8.1: FM Role in Nigeria

FM Role in Nigeria	A1	E1	ME1	A2	ME2	ME3	B1	ME4	ME5	ME6	ME7	ME8	ME9	B2	ME10	ME11	Q1	E2	E3	ME12	Total No of participants mentioning the role	%
ENVIRONMENTAL																						
1 Energy management	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	19	95
2 Advise on sustainale building materials	√		√		√	√		√		√	√	√	√	√	√	√					12	60
3 Waste management		√		√		√		√	√					√		√		√			8	40
SOCIAL																						
4 Management of cleaning services	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	100
5 Space management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	100
6 Ensuring visual comfort	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	100
7 Thermal comfort	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	100
8 Indoor air quality	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	100
9 Acoustic comfort	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	100
ECONOMIC																						
10 Property asset management	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	65
11 Building performance for optimum use of building	√		√	√	√	√	√			√			√	√	√			√	√	√	13	65
12 Maintenance of builidng and services	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	20	30
13 Efficient use of water	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√		√	√	19	30
14 Efficient energy use	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√		√	19	20
15 Financial management									√												1	5
MANAGEMENT																						
16 Advise and checks designs	√	√		√	√		√	√	√	√		√	√	√		√		√		√	14	70
17 Integration into the design team	√	√	√		√	√	√	√		√			√			√			√	√	12	60
18 Planning proposed building in consultation with current building users					√					√											2	10
19 Project management	√			√											√						1	5
20 Engagement of other professionals																		√			1	5

There is similarity between the roles highlighted in Table8.1 and the facilities manager's roles in sustainable buildings highlighted in Table 4.3. '*Waste management', 'energy management'* and '*advise on sustainable building material*' identified categorised under the environmental aspect are among the 9 FM roles discovered by the content analysis. Waste management is identified as a key area of the facilities managers' role (Elmualim *et al.*, 2010). The findings of the study by Ikediashi *et al.*, (2015) affirm that waste management is a major focus in the development of sustainability policies by facilities managers in Nigeria. This may be due to the ineffective waste management system that operates in Nigeria which is majorly caused by waste disposal habit of the people, corruption, work attitude, and inadequate plants and equipment (Taiwo, 2009).

Energy management has been identified as a critical role for facilities managers as inadequate competence in this area can lead to an organisation's inefficient operations (Clear and Young, 2011; Taylor, 2013). Federal government parastatals, private organisations, companies and individuals are beginning to realise the financial advantage of managing energy, as they discover that the huge amount of money invested every year in providing energy to run operations can be reduced by taking energy efficiency measures (Akinlo, 2008). Due to the new trend, Nigeria is now working towards producing buildings that are energy efficient (Nwofe, 2014). Therefore, facilities managers are challenged with the responsibility of helping to produce and manage energy efficient buildings. This has probably encouraged building services professionals into the FM practice.

There is a general consensus in relation to the roles that facilities managers carry out in relation to *management of cleaning services, space management, visual comfort, thermal comfort, indoor air quality*, and *acoustic performance*. These roles are identified under the social aspect and are also among the 44 FM roles discovered by the content analysis. According to Brown *et al.*, (2010) and Saley *et al.*, (2011), these roles help in ensuring the comfort and wellbeing of the building user and increase their productivity. The effective execution of these roles according to Tolman and Parkkila (2009) is a major achievement for facilities managers, as this affects their perception of the satisfactory nature of the internal environment. According to a participant, the comfort that a building provides enhances the building users' experience as evidenced below.

"*FM is about enhancing the experience of the user of a building or the customers that come to the place of business. People should have seamless experience where they come to do business, from staircases to elevators to the escalators which are all part of the experience. When they are comfortable and have a good feel of the building environment they will like to stay and do business or even come again for business and if it is that they live in the building they will like to stay and not move away, this in turn is business for the building owner"* – ME1.

It can be deduced from the above statement that FM is beyond just managing buildings, it is about the people that use the buildings and the impact that the building has on them. With reference to Barret and Baldry (2003) the scope of FM services is not constrained by the physical structure of the building, the services go from managing the building to ensuring that building users feel comfortable, cared for and safe. This in turn can produce financial returns which is profitable for all stakeholders.

In relation to the economic aspect; *maintenance of building and services*, *optimum use of the building*, *water efficiency*, *energy efficiency*, and *financial management* are among the 10 FM roles discovered by the content analysis. *Property and asset management* and *Optimum use of building* are roles that are related to the maintenance of the building. With reference to Balch (1994), property management involves maintaining the building itself, such as cleaning, heating and lighting, and maintenance of all M&E equipment and maintenance of the building fabric in terms of its redecoration and repair, both internally and externally. These activities indicate roles that ensure that occupants are provided with an enabling environment. Building maintenance has been in operations even before the evolvement of FM as a profession. This is evidenced by Atkin and Brooks, (2009) stating that: "*As recently as forty years ago there was only fleeting mention of facilities management. Buildings were maintained, serviced and cleaned: that was largely it"*. Interview participants expressed their view that the maintenance role is a major role that facilities managers perform in Nigeria. One of the participants particularly stated that:

"FM role in Nigeria involves majorly maintenance of buildings. When we started out as an FM company, nobody was doing FM as a core business in Nigeria. Building contractors executed their contracts but did not extent it to maintaining the built structure. They only maintained their own units in-house. Some real estate agents provide maintenance of buildings as part of the services they offered. Basically it was more of cleaning and facial maintenance, and not proper maintenance. It was more of a fire brigade kind of approach, they repair this and that, when it breaks down. We offer a full maintenance package, from the building structure to services and so on." – B1.

The statement indicates that Nigeria is still in the age of FM being merely about maintenance; not to say, that the maintenance role is not important. However, FM worldwide has grown to now support organisations to fulfil their core objectives. Adewunmi *et al.*, (2009) are of the view that FM in Nigeria has moved from being a maintenance department to that of assisting organisations to achieve their goals. According to them, multinational companies and other corporate organisations have located their businesses in Nigeria, seeking management of their facilities with the deliberate employment of FM services in their establishments.

In relation to "*facial maintenance*" in the statement above, it can be deduced that maintenance does not seem to be a major consideration for Nigerians. This supported by Odediran *et al.*, (2012) that maintenance of existing buildings has not received much attention which may be due to the emphasis on the development of new properties. This is consistent with Kunya *et al.*, (2007) who observed that there is an apparent lack of maintenance culture in Nigeria, and that emphasis is placed on the construction of new buildings, neglecting the aspect of maintenance which should start immediately the building has been handed over.

The lack of providing a maintenance plan for buildings after they have been developed is also supported by Asiabaka (2008) and Odediran *et al.*, (2012). According to them, when new properties are developed and taken over by the appropriate authorities, no plan is made by the building owner for future maintenance of such buildings and even the users of buildings do no better due to poor maintenance culture and the low economic situation. The maintenance of a building affects its performance and which in turn affects the way people live, learn, and work. No building is maintenance free and more than 90 per cent of the building life-cycle requires active maintenance in order for the building to perform optimally (Rawlinson and Brett, 2009). The role of the facilities manager in ensuring optimum use of the building is confirmed in interviewee statements as below:

"I believe FM role is to ensure that the fabric and services of a building or an estate are maintained to the optimum and putting all skills, materials and services to work to ensure the building gives it optimum performance". – A1

"*It is the role of FM to see how best to bring out the optimum use of a facility, in such a way that the occupants are satisfied and the building achieves the purpose for which it was built".* – ME5

The facilities manager provides necessary support for an organisation when a building is maintained and performs at its best. This FM role is supported by Wiggins (2010) stating that part of the work of the facilities manager is to get the maximum effectiveness of the working environment of the organisation.

The business of cleaning is one area that the Nigerian built environment relates with and is evidenced by Alaofin (2003) who states that the oldest and perhaps the biggest component of FM services in Nigeria is the janitorial services, which is over fifty years old. Like in any other country where FM is practiced, cleaning is one of the most outsourced services and it indicates a great deal about the values held by an organisation and their FM function and provides a suitable working environment as claimed by (Wiggins, 2010). Cleaning also promotes health and prolongs the life of assets such as equipment, fixtures and fittings; and improves the appearance of the establishment. All these leading to improved productivity.

Property asset management involves understanding the needs of an organisation in terms of facilities and its services and ensuring the most cost effective approach is applied to managing the delivery and operation of these facilities both now and in the future (Best *et al.*, 2003). One of the interviewees mentioned FM's involvement in property asset management in relation to the state of the infrastructure for the country's massive population of 170 million people:

"*In Nigeria, the nature of FM responsibility and the degree is in line with the state of the asset, and the infrastructure that we have and the current practice. For example Nigeria has about*

170 million people and FM role is to ensure that the existing properties and infrastructure meet the needs of these 170 million people. Facilities managers are to ensure that new infrastructure are built with sustainable measures to avoid damage to the environment and that they are managed sustainably; so that the people can be provided with shelter and social infrastructure that is safe and healthy". – ME6

Therefore, it can be inferred that FM in Nigeria in relation to property asset management is working towards meeting the needs of the populace in accordance with the available infrastructure and seeing ways to make available the needed infrastructure that is lacking and at the same time doing it in a sustainable manner to provide necessary social infrastructure.

The low result of financial management as an FM role in Nigeria may be as a result of facilities managers being inadequate in financial management matters and is consistent with Hodges (2005) and Wiggins (2014) who are of the opinion that facilities managers seem not to have adequate knowledge in financial management. They encourage facilities managers to develop good working relationship with colleagues in their finance department, so they can understand the principles of financial management, its benefits, and what information is needed in its development. The financial management of the efficient use of energy and water and building maintenance positions it as an economic aspect of sustainable building. This supports the well-known fact that when buildings are well maintained they result in lower running costs which is of economic benefit to both owner and occupier of the building (Taylor, 2013). The result also confirms facilities manager's role in energy efficiency as promoted by (BIFM, 2014) and the facilities manager's role in water efficiency (Taylor, 2014).

The FM roles identified under the management aspect are roles found among the 8 FM roles discovered by the content analysis. These include *advice and checks design*, *integration into the design team*, *engagement of other professionals*, *planning proposed building in consultation with current building users*, and *project management*. This result is consistent with El-Haram and Agapiou (2002); Hassanain (2006); and Mohammed and Hassanain (2010) that the facilities manager checks design in order to select the most cost-effective design option which will optimise whole life costing and ease maintainability at the operations stage. The result also supports Jensen (2008) claim that the most important FM specific task in building design is the transfer of experiences from the management of existing building. However, in order for the facilities manager to share experiences from past projects and management of existing buildings, he needs to be integrated early in the briefing and design stage (Nutt, 1993; Pitt *et al.*, 2005).

In relation to FM roles at the design stage, there was a general consensus among the interviewees that the facilities manager gives advice on designs that affects the efficient use of energy and water. The effective use of energy and water saves cost. There was also a general agreement on the facilities manager giving advice on designs that will promote building performance, ease of maintenance and reduce major repairs and alterations at the operations stage. It has been argued by El-Haram and Agapiou (2002) that a facilities manager's role on the design team is to check building designs for easy accessibility to maintenance. This with reference to Mohammed and Hassanain (2010) will reduce the cost of maintenance. The facilities manager advising on space management and suitable selection of sustainable building materials was also mentioned as part of FM role at the design stage.

At the construction stage, the interviewees agreed that the facilities manager practically has no role to play. This disagrees with the view of Shah (2007) that facilities managers in conjunction with other building consultants monitor that designs are implemented on site. It is worthy of note that, the role of the facilities manager is not to take over the job of the building designer but to give advice on designs that can help create 'sustainable' buildings. The operations stage, interviewees mentioned that FM role included ensuring building performance for optimum use of building, maintenance of building and services, meeting user need in terms of comfortable, healthy and safe environment promoting productivity, management of efficient use of energy and water, and waste management.

8.2 FM Role in Sustainable Building in relation to the Environmental Aspect

Section 8.2 to 8.5 focuses on the analysis of questionnaire findings based on the facilities manager's role in sustainable building as identified in the BIFM Professional Standards Handbook, IFMA Complete List of Competencies (GJTA), FMAA Skills in Facilities Management Investigation into Industry Education, and RICS Assessment of Professional Competence FM Pathway Guide. The questionnaire survey is a follow up to the interviews. The analysis is similar to the analysis carried out in relation to sustainable constituents in Nigeria and is also based on the years of experience of the facilities managers who responded to the questionnaire survey (i.e. low experience, medium experience, and high experience facilities managers) as stated in Section 6.11.12. Low experience indicates respondents with 0 - 5 years' experience, medium experience indicates respondents with 6 - 15 years' experience, and high experience indicates respondents with 16 to 20 years' experience and above.

Respondents were asked to rate the competence level of facilities managers in relation to sustainable building constituents in the Nigerian context on a scale of 1 - 10 where 1 is '*Not competent at all*' and 10 is '*Highly competent*'. However, the scale was collapsed into 5 categories for ease of analysis as described in Section 6.11.9 and these are: 1 – 2 = Not Competent, 2.1 – 4 = Low Competence, 4.1 – 6 = Medium Competent, 6.1 – 8 = Competent, 8.1 – 10 = Very Competent. As described in Section 6.11.7, the Criticality Index for each FM role under the environmental, social, and economic and management aspect were calculated based on the formula used by Zhang (2005) and Dada and Oladokun (2012):

Criticality index = $10((5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1) / 5(n_5 + n_4 + n_3 + n_2 + n_1))$

Where n_5 = number of respondents whose answer fall into "very competent"; n_4 = number of respondents whose answer fall into "competent"; n_3 = number of respondents whose answer fall into "medium competent"; n_2 = number of respondents whose answer fall into "less competent"; n_1 = number of respondents whose answer fall into "not competent". The criticality index is actually the equivalent of the mean item scores of the responses to questions assessing the level of criticality of identified constituents to the achievement of sustainable building.

Table 8.2 shows the level of the facilities manager's competence under the environmental aspect. It shows '*coordinates waste management at the operations stage*' as the highest ranked competence with an index of 7.84. This is followed by '*advises on effective construction waste management system*' (2nd ranked). The two highest ranked competences confirms Wiggins, (2014) position that waste management whether at the operations stage or at construction is a major part of the job description of facilities managers. '*Develops, advises and implements policies that protect environment around building*' ranked the 3rd highest competence. This supports Shah (2007) that facilities managers are the key figure to aiding and supporting their organisations towards environmental protection. '*Ensures use of recycled materials at construction*' ranked lowest with an index of 6.76, followed by '*carries out building life-cycle cost exercises for building material selection*' with an index of 6.20. The results indicate that facilities managers whether of low, medium or high experience believe they are competent in all FM roles under the environmental aspect.

Table 8.2: FM Role in relation to the Environmental Aspect

Environmental Aspect	Overall Competence Level	Category	Ranking
♦ Coordinates waste management at the operations stage	7.84	CT	1
♦ Advises on effective construction waste management system	7.62	CT	2
♦ Develops, advises and implements policies that protect environment around building	7.60	CT	3
♦ Educates design team ecological value of land	7.06	CT	4
♦ Educates on the use of renewable energy	7.06	CT	4
♦ Maintains systems that minimise carbon emissions	7.00	CT	6
♦ Advises on systems that reduce carbon emissions	7.02	CT	7
♦ Influences and installs refrigeration systems that minimise carbon emissions	6.96	CT	8
♦ Advises on minimum car parking	6.82	CT	9

CT = Competent

In order to identify if there is a variation in opinion in relation to the identified constituents across the low, medium and high experience facilities managers, a Kruskal-Wallis test was carried out. As stated in Section 7.2, the Kruskal-Wallis test is a non-parametric statistical test that allows comparism of scores on continuous variable for three or more groups (Pallant, 2013). The Kruskal-Wallis test was also carried out for competence levels under the social, economic and management aspects as presented in Section 8.3, 8.4 and 8.5 respectively.

The results as shown in Table 8.3 indicate that there is no significant variation in opinion across the low, medium and high experience facilities managers as the results are greater than 0.05 except in two of the roles as indicated. It means there is a statistically significant variation in relation to '*advises on effective construction waste management system*' and '*develops, advises and implements policies that protect environment around building*' across the 3 different groups of facilities managers. The results suggest that there is a difference in opinion across the low, medium and high experience facilities managers in relation to the aforementioned roles. A plausible reason for the variation in opinion may be due to the deep understanding that high experience facilities managers have in matters pertaining to the buildings (Dania *et al,* 2015) as when compared to the low and medium experience facilities managers with lesser experience.

Though, the medium experience facilities managers have less year of experience, their years of experience indicates good years of experience (Oladokun, 2011). The low experience facilities managers can be said to have reasonable years of experience. As such, a post-hoc test is necessary in order to discover where the variation lies. The Kruskal-Wallis test shows whether there is a difference between groups, it does not indicate which specific groups differed, however, the post-hoc tests do. Post-hoc tests are run to confirm where the differences occurred between groups (Field, 2013). The post-hoc tests were also run on results of the variations in opinion of low, medium and high experience facilities managers in relation to the social, economic and management aspects of sustainable buildings.

Table 8.3: Kruskal-Wallis test showing Difference in Opinion

	Chi-square	df	Asymp. Sig.
Advises on effective construction waste management system	6.487	2	**0.039**
Coordinates waste management at the operations stage	2.958	2	0.228
Advises on minimum car parking	5.656	2	0.059
Advises on systems that reduce carbon emissions	0.110	2	0.947
Influences and installs refrigerations systems that minimise carbon emissions	1.818	2	0.403
Maintains systems that minimise carbon emissions	0.172	2	0.917
Develops, advises and implements policies that protect environment around building	6.294	2	**0.043**
Educates design team to preserve plant and animal life around building	4.871	2	0.088
Educates on the use of renewable energy	2.584	2	0.275

To identify where the variation lies in relation to the opinion of facilities managers in relation to their competence levels (between low and high experience, medium and high experience, and low and medium experience) on the '*Advises on effective construction waste management* *system*' and '*Develops, advises and implements policies that protect environment around building*': a Mann-Whitney U tests between pairs of groups was carried out. The Mann-Whitney U Test is a test used to test for the differences between two independent groups on a continuous measure (Pallant, 2013).

Table 8.4 shows the probability value *p* for the role '*Develops, advises and implements policies that protect environment around building*' as 0.078 which is more than 0.05 among low and high experience facilities managers; therefore is no significant difference in the opinion of the competence levels between these two groups. However, the results show probability value *p* for '*Advises on effective construction waste management system*' as 0.051 which can be approximated to 0.05. This indicates that there is a statistically significant difference in relation to the aforementioned role between the low and high experience facilities managers and the need to carry out further analysis. In carrying out further analysis as shown in Table 8.5, the value of *r* is calculated as 0.19. This result shows that the statistically significant difference is of small effect using the criteria by Cohen (1988) that any result more than 0.10 but less than 0.30 ($\geq 0.10 \leq 0.30$) has having small effect on results. This indicates that there is no significant difference in the opinion of facilities managers in relations to the role: '*Advises on effective construction waste management system*' between low and high experience facilities managers. *r* is calculated as:

$r = z/\sqrt{N}$ where N = total number of respondents

Table 8.4: Low experience and high experience

Test Statistics	Advises on effective construction waste management system	Develops, advises and implememnts policies that protect environment around building
Mann-Whitney U	473.000	498.000
Wilcoxon W	2069.000	2151.000
z	-1.953	-1.765
Asymp. Sig. (2-tailed) p	0.051	0.078

Table 8.5: Low experience and high experience

Test Statistics	Advises on effective construction waste management system
z	-1.953
p	0.051
r	0.19

Table 8.6 shows the probability value *p* for the role *'Advises on effective construction waste management system*' and '*Develops, advises and implements policies that protect environment around building* as 0.011 and 0.014 respectively, which is less than 0.05. This indicates that there is a statistically significant difference in relations to the aforementioned roles between the medium and high experience facilities managers. In carrying out further analysis as shown in Table 8.7, the value of *r* is calculated as 0.29 and 0.28 for the aforementioned roles respectively. This result shows that the statistically significant difference has low effect on the results using the criteria of low effect value (≥ 0.10 ≤ 0.30) by Cohen (1988) as earlier stated. This indicates that there is no significant difference in the opinion in relations to *Advises on effective construction waste management system*' and '*Develops, advises and implements policies that protect environment around building* between medium and high experience facilities managers.

Table 8.6: Medium experience and high experience

Test Statistics	Advises on effective construction waste management system	Develops, advises and implememnts policies that protect environment around building
Mann-Whitney U	386.000	401.500
Wilcoxon W	1764.000	1832.500
z	-2.548	-2.454
Asymp. Sig. (2-tailed) p	0.011	0.014

Table 8.7: Medium experience and high experience

Test Statistics	Advises on effective construction waste management system	Develops, advises and implememnts policies that protect environment around building
z	-2.548	-2.454
p	0.011	0.014
r	0.29	0.28

Table 8.8 shows the probability value *p* for the role *'Advises on effective construction waste management system*' and '*Develops, advises and implements policies that protect environment around building* as 0.433 and 0.280 respectively, which is more than 0.05. This indicates that there is no statistically significant difference in relations to the aforementioned roles between the low and medium experience facilities managers.

Table 8.8: Low experience and Medium experience

Test Statistics	Advises on effective construction waste management system	Develops, advises and implememnts policies that protect environment around building
Mann-Whitney U	1333.500	1337.500
Wilcoxon W	2711.500	2768.500
z	-0.783	-1.080
Asymp. Sig. (2-tailed) p	0.433	0.280

The results in this section indicate that facilities managers are competent in their roles in achieving sustainable building constituents and view cuts across the low, medium and high experience facilities managers under to the environmental aspect. The results of the survey are consistent with the previous studies of Elmualim *et al.*, (2008) and Elmualim *et al.*, (2010) where waste management and implementing environmental policies are identified as key areas of the facilities managers work. With reference to Shah (2007) facilities managers have vast experience in managing all types of waste that are produced as a result of operational activities in buildings. They are generally competent in legislative requirements concerning waste management, which includes handling waste from its generation within an organisation or estate to transfer to a station where it is disintegrated or recycled. Evidence also suggests that waste management is a major part of the facilities managers' goal in Nigeria as they develop and implement sustainability policies in the direction of environmental protection (Ikediashi *et al.*, 2015).

Though, waste management is ranked highest by survey participants, facilities managers in Nigeria are faced with the problem of waste disposal and management which has contributed to Nigeria being tagged as one of the dirtiest countries in the world (Oyeniyi, 2011). This is due to the rate of waste collection and evacuation which continually lag behind the rate of waste generation. However, this problem can be solved by promulgation of government policies and legislations and the change in attitude of people towards waste management (Uwadiegwu and Chukwu, 2013).

Advising and maintaining systems that minimise carbon emission in buildings, is another major role of facilities managers. This as a result of carbon emitted from the use of energy during the operational life of the building and of which the facilities manager is mostly responsible. Carbon is also emitted through building materials and with reference to Moussatche and Languell (2001) the facilities manager is often required to give advice on suitable material selection and burdened to provide the lowest possible cost in sustainable material selection instead of the most economical choice.

8.3 FM Role in Sustainable Building in relation to the Social Aspect

Table 8.9 shows the level of the facilities manger's competence under the social aspect. It shows *'maintains systems that provide safe access and security'* as the highest ranked competence with an index of 8.12. This result supports Spedding (1994) position and Hassanain (2008) where the facilities manager is argued as the building manager that ensures safe access to and from the building and general safety during occupancy. The 2nd ranked indexes are *'maintains a thermally comfortable environment for occupants within the building'* and *'maintains ventilation equipment and outlets'* with indexes of 7.92 each. Ventilation outlets have been proofed to help with the thermal comfort associated with buildings (Siew, 2011) and the result is consistent with the findings of Baird (2010) where the facilities manager was charged with making the internal environment of the building condusive for occupants. The 4th ranked index is *'coordinates waste management at the operations stage'* with an index of 7.76. Facilities managers are argued to be responsible for efficient processes in waste management handling, movement and control (Shah, 2007). '*Executes space management plan*' (16th) and *'monitors installation of acoustic systems'* (17th) are the lowest ranked roles. Though, these roles are ranked lowest, they are rated competent roles for facilities managers. The results indicate that facilities managers are competent in all FM roles under the social aspect and as listed in Table 4.2. The results show the facilities managers with high experience with a competence level of 8.10, 8.44, 8.08 and 8.52 in '*maintains installations that give visual comfort'*, '*ensures installation of thermal control systems (A/C)*', '*advises on apportioning of space for occupants wellbeing*' and '*monitors installation of ventilation equipment to provide good indoor environment*' respectively.

Table 8.9: FM Competence in relation to the Social Aspect

Social Aspect	Overall Competence Level	Category	Ranking
♦ Maintains systems that provide safe access and security	8.12	VCT	1
♦ Maintains a thermally comfortable environment for occupants within the building	7.92	CT	2
♦ Maintains ventilation equipment and outlets	7.92	CT	2
♦ Maintains installations that give visual comfort	7.76	CT	4
♦ Advises on safe access and security at design stage	7.74	CT	5
♦ Help to provide healthy indoor environment	7.60	CT	6
♦ Monitors installation of ventilation equipment to provide good indoor environment	7.58	CT	7
♦ Ensures installation of thermal control systems (A/C)	7.54	CT	8
♦ Ensures installation of visual comfort fittings	7.40	CT	9
♦ Advises and specifies systems that provide thermal control (A/C)	7.30	CT	10
♦ Advises on apportioning of space for occupants wellbeing	7.20	CT	11
♦ Advises on visual comfort	7.18	CT	12
♦ Maintains acoustic systems	7.16	CT	13
♦ Advises on acoustic performance	7.06	CT	14
♦ Advises on building design adaptable for different tenure types	7.04	CT	15
♦ Executes space management plan	7.00	CT	16
♦ Monitors installation of acoustic systems	6.96	CT	17

VCT = Very Competent, CT = Competent

In order to identify variation in opinion in relation to the facilities manager's competence across the low, medium and high experience facilities managers, a Kruskal-Wallis test was carried out like in environmental aspect. The results as shown in Table 8.10 indicate that there is no significant variation in opinion across the low, medium and high experience facilities managers as the results are greater than 0.05 except in four of the roles as indicated. It means there is statistically significant variation in relation to '*ensures installation of visual comfort fittings'*, '*ensures installation of thermal control systems (A/C)*', *'advises on apportioning of space for occupants wellbeing*' and *'monitors installation of ventilation equipment to provide good indoor environment*' across the 3 different groups of facilities managers. The results suggest that there is a difference in opinion across the low, medium and high experience facilities managers in relation to the aforementioned roles. As such, a post-hoc test is necessary in order to discover where the variation lies.

Table 8.10: Kruskal-Wallis test showing Difference in Opinion

	Chi-square	df	Asymp. Sig.
Advises on visual comfort	5.602	2	0.061
Ensures installation of visual comfort fittings	6.410	2	**0.041**
Maintains installations that give visual comfort	1.266	2	0.531
Advises on acoustic performance	3.730	2	0.155
Monitors installation of acoustic systems	3.206	2	0.201
Maintains acoustic systems	5.102	2	0.078
Advises and specifies systems that provide thermal control (A/C)	4.967	2	0.083
Ensures installation of thermal control systems (A/C)	6.130	2	**0.047**
Maintains a thermally comfortable environment for occupants within the building	5.637	2	0.060
Advises on safe access and security at design stage	1.237	2	0.539
Maintains systems that provide safe access and security	3.116	2	0.211
Advises on apportioning of space for occupants wellbeing	6.586	2	**0.037**
Executes space management plan	4.796	2	0.091
Help to provide healthy indoor environment	4.601	2	0.100
Monitors installation of ventilation equipment to provide good indoor environment	6.830	2	**0.033**
Maintains ventilation equipment and outlets	3.108	2	0.211
Advises on building design adaptable for different tenure types	3.053	2	0.217

To identify where the variation lies in relation to the opinion of facilities managers (between low and high experience, medium and high experience, and low and medium experience) on the '*ensures installation of visual comfort fittings'*, '*ensures installation of thermal control systems (A/C)*', *'advises on apportioning of space for occupants wellbeing*' and *'monitors installation of ventilation equipment to provide good indoor environment*': a Mann-Whitney U tests between pairs of groups was carried out. Table 8.11 shows the probability value *p* for the role '*ensures installation of visual comfort fittings',* '*ensures installation of thermal control systems (A/C)*' and *'advises on apportioning of space for occupants wellbeing*' as 0.111, 0.055 and 0.81 respectively in relation to the variation in opinion between low and high experience. These values are more than 0.05, therefore, is no significant difference in the opinion between among low and high experience facilities managers in relation to the aforementioned roles.

Table 8.11, however, shows the probability value *p* for the role *'monitors installation of ventilation equipment to provide good indoor environment*' as 0.03. This indicates that there is a statistically significant difference in relation to the aforementioned role between the low and high experience facilities managers and the need to carry out further analysis. In carrying out further analysis as shown in Table 8.12, the value of *r* is calculated as 0.24. This result shows that the statistically significant difference is of small effect using the criteria by Cohen (1988) that any result ($\geq 0.10 \leq 0.30$) has small effect on results. This indicates that there is no significant difference in the opinion of facilities managers in relations to the role: *'monitors installation of ventilation equipment to provide good indoor environment*' between low and high experience facilities managers.

Table 8.11: Low and High Experience

Test Statistics	Ensures installation of visual comfort fittings	Ensures installation of thermal control systems (A/C)	Advises on apportioning of space for occupants wellbeing	Monitors installation of ventilation equipment to provide good indoor environment
Mann-Whitney U	513.000	466.000	500.500	453.000
Wilcoxon W	2166.000	2006.000	2153.500	2049.000
z	-1.593	-1.917	-1.743	-2.168
Asymp. Sig. (2-tailed) *p*	0.111	0.055	0.081	0.03

Table 8.12: Low and High Experience

Test Statistics	Monitors installation of ventilation equipment to provide good indoor environment
z	-2.168
p	0.030
r	0.24

Table 8.13 shows the probability value *p* for the role '*ensures installation of visual comfort fittings'*, '*ensures installation of thermal control systems (A/C)*', *'advises on apportioning of space for occupants wellbeing*' and *monitors installation of ventilation equipment to provide good indoor environment*' as 0.019, 0.016, 0.016 and 0.009 respectively in relation to the variation in opinion between medium and high experience. These values are less than 0.05 and, therefore, indicate that there is significant difference in the opinion between among medium and high experience facilities managers in relation to the aforementioned roles and the need to carry out further analysis. In carrying out further analysis as shown in Table 8.14, the value of *r* is calculated as 0.27, 0.28, 0.28 and 0.30 respectively. This result shows that the statistically significant difference of 0.27 and 0.28 is of small effect using the criteria by Cohen (1988) that any result (≥ 0.10 ≤ 0.30) has small effect on results. The *r* value of 0.30 is of medium effect. This result indicates that there is no significant difference in the opinion of facilities managers in relations to the aforementioned role between medium and high experience facilities managers.

Table 8.13: Medium and High Experience

Test Statistics	Ensures installation of visual comfort fittings	Ensures installation of thermal control systems (A/C)	Advises on apportioning of space for occupants wellbeing	Monitors installation of ventilation equipment to provide good indoor environment
Mann-Whitney U	409.500	397.500	396.000	385.000
Wilcoxon W	1840.500	1775.500	1774.000	1763.000
z	-2.338	-2.401	-2.411	-2.606
Asymp. Sig. (2-tailed) *p*	0.019	0.016	0.016	0.009

Table 8.14: Medium and High Experience

Test Statistics	Ensures installation of visual comfort fittings	Ensures installation of thermal control systems (A/C)	Advises on apportioning of space for occupants wellbeing	Monitors installation of ventilation equipment to provide good indoor environment
z	-2.338	-2.401	-2.411	-2.606
p	0.019	0.016	0.016	0.009
r	0.27	0.28	0.28	0.30

Table 8.15 shows the probability value *p* for the role '*ensures installation of visual comfort fittings', 'ensures installation of thermal control systems (A/C)*', *'advises on apportioning of space for occupants wellbeing*' and *monitors installation of ventilation equipment to provide good indoor environment*' as 0.146, 0.384, 0.190 and 0.647 respectively in relation to the variation in opinion between low and medium experience. These values are more than 0.05, therefore, the result indicates that there is no significant difference in the opinion between among medium and high experience facilities managers in relation to the aforementioned roles.

Table 8.15: Low and Medium Experience

Test Statistics	Ensures installation of visual comfort fittings	Ensures installation of thermal control systems (A/C)	Advises on apportioning of space for occupants wellbeing	Monitors installation of ventilation equipment to provide good indoor environment
Mann-Whitney U	1276.000	1295.500	1275.500	1385.000
Wilcoxon W	2707.000	2673.500	2653.500	2763.000
z	-1.455	-0.870	-1.311	-0.458
Asymp. Sig. (2-tailed) *p*	0.146	0.384	0.190	0.647

The results of this section indicate that facilities managers are proficient in advising, monitoring and maintaining systems that provide thermal, visual, and acoustic comfort and indoor air quality. These constituents deal with areas that affect the wellbeing of occupants as stated by Baldry (1999) and Herman *et al.*, (2011). Studies have also proven the criticality of constituents to the wellbeing of building occupants (Goldstein, 1990; Palanivelraja and Manirathinem, 2010; Smith and Pitt, 2011). Facilities managers in Nigeria are particularly obligated to provide a thermally comfortable environment for occupants within buildings. This is due to the still air that is a common feature in the Nigerian climate and the warm air, thereby, requiring buildings to be cooled and thermally comfortable all year. Therefore, facilities managers make it an obligation to be competent in this role. The results of this section shows facilities managers across low, medium and high experience are competent in the identified FM roles under the social aspect and indicates that facilities managers believe they have the adequate skill that is needed to fulfil the social aspect of sustainable buildings in Nigeria.

The facilities manager advising on building design adaptable for different tenure types, acoustic, visual and thermal comfort, apportioning of space for occupants wellbeing safe access and security are FM roles at the design stage and are under the social aspect. The facilities manager maintaining systems that provide safe access and security, a thermally comfortable environment for occupants within the building, ventilation equipment and outlets, installations that give visual and acoustic comfort are FM roles at the operations stage even though under the environmental aspect. Ensuring installation of thermal control systems and installation of systems for visual comfort are FM roles at the construction stage. These roles have been extensively discussed in Section 4.3.5 to 4.3.7 and 4.4.1 to 4.4.3.

8.4 FM Role in Sustainable Building in relation to the Economic Aspect

Table 8.16 shows the level of the facilities manager's competence under the economic aspect. The table shows the highest ranked role to be *'monitors energy consumption to reduce energy usage'* with an index of 7.92. The 2nd highest ranked role is *'monitors water consumption'* with an index of 7.72 and the 3rd ranked is *'monitors installation of energy efficient light fittings and equipment'* with an index of 7.38. The least ranked are *'carries out building life-cycle cost exercises for building material selection*' (Ranked 8th) and *'ensures use of recycled materials at construction'* (Ranked 9th).

Table 8.16: FM Competence in relation to the Economic Aspect

Economic Aspect	Overall Competence Level	Category	Ranking
♦ Monitors energy consumption to reduce energy usage	7.92	CT	1
♦ Monitors water consumption	7.72	CT	2
♦ Monitors installation of energy efficient light fittings and equipment	7.38	CT	3
♦ Advises on frequency of material replacement at design	7.28	CT	4
♦ Advises and specifies water efficient fittings	7.22	CT	5
♦ Ensures installation of water efficient fittings	7.20	CT	6
♦ Advises on design for energy efficiency	7.20	CT	6
♦ Carries out building life-cycle cost exercises for building material selection	6.76	CT	8
♦ Ensures use of recycled materials at construction	6.20	CT	9

CT = Competent

In order to identify variation in opinion in relation to the facilities manager's competence across the low, medium and high experience facilities managers, a Kruskal-Wallis test was carried out like in economic aspect. The results as shown in Table 8.17 indicate that there is no significant variation in opinion across the low, medium and high experience facilities managers except in '*carries out maintenance of building and services*' across the 3 different groups of facilities managers. The results suggest that there is a difference in opinion across the low, medium and high experience facilities managers in relation to the aforementioned role. As such, a post-hoc test is necessary in order to discover where the variation lies.

Table 8.17: Kruskal-Wallis test showing Difference in Opinion

	Chi-square	df	Asymp. Sig.
Advises and specifies water efficient fittings	5.007	2	0.082
Ensures installation of water efficient fittings	5.312	2	0.070
Monitors water consumption	0.431	2	0.806
Advises on frequency of material replacement at design	0.634	2	0.728
Ensures use of recycled materials at construction	1.056	2	0.59
Carries out maintenance of building and services	8.313	2	**0.016**
Advises on design for energy efficiency	1.657	2	0.437
Monitors installation of energy efficient light fittings and equipments	3.462	2	0.177
Monitors energy consumption to reduce energy usage	2.493	2	0.287
Carries out building life-cycle cost exercises for building material selection	5.707	2	0.058

To identify where the variation lies in relation to the opinion of facilities managers (between low and high experience, medium and high experience, and low and medium experience) on the *'carries out maintenance of building and services'* role: a Mann-Whitney U tests between pairs of groups was carried out. Table 8.18 shows the probability value p for the role as 0.006 in relation to the variation in opinion between low and high experience. This value is less than 0.05 and indicates that there is a statistically significant difference in relation to the aforementioned role between the low and high experience facilities managers and also dictates the need to carry out further analysis. In carrying out further analysis as shown in Table 9.19, the value of r is calculated as 0.31. This result shows that the statistically significant difference is of medium effect using the criteria by Cohen (1988) that any result of 0.3 but less than 0.4 has medium effect on results. This indicates that there is no significant difference in the opinion of facilities managers in relations to the role: *'carries out maintenance of building and services'* between low and high experience facilities managers.

Table 8.18: Low and High Experience

Test Statistics	Carries out maintenance of building and services
Mann-Whitney U	385.500
Wilcoxon W	1981.500
z	-2.756
Asymp. Sig. (2-tailed) p	0.006

Table 8.19: Low and High Experience

Test Statistics	Carries out maintenance of building and services
z	-2.756
p	0.006
r	0.31

Table 8.20 shows the probability value *p* for the role '*carries out maintenance of building and services'* to be 0.011 in relation to the variation in opinion between medium and high experience. This value is less than 0.05 and therefore, indicates that there is significant difference in the opinion among medium and high experience facilities managers in relation to the aforementioned role and also dictates the need for further analysis. In carrying out further analysis as shown in Table 8.21, the value of *r* is calculated as 0.30. This result shows that the statistical significance difference is of medium effect using the criteria by Cohen (1988). These results indicate that there is no significant difference in the opinion of facilities managers in relations to the aforementioned role between medium and high experience facilities managers.

Table 8.20: Medium and High Experience

Test Statistics	Carries out maintenance of building and services
Mann-Whitney U	1363.5
Wilcoxon W	1692.5
z	-2.546
Asymp. Sig. (2-tailed) *p*	0.011

Table 8.21: Medium and High Experience

Test Statistics	Carries out maintenance of building and services
z	-2.546
p	0.011
r	0.30

Table 8.22 shows the probability value *p* for the role '*carries out maintenance of building and services'* to be 0.011 in relation to the variation in opinion between low and medium experience. This value is less than 0.05, the result, therefore, indicates that there is significant difference in the opinion between among medium and high experience facilities managers in relation to the aforementioned role and also dictates the need for further analysis. In carrying out further analysis as shown in Table 8.23, the value of *r* is calculated as 0.25. This result shows that the statistically significant difference is of low effect using the criteria by Cohen (1988). These results indicate that there is no significant difference in the opinion of facilities managers in relations to the aforementioned role between low and medium experience facilities managers.

Table 8.22: Low and Medium Experience

Test Statistics	Carries out maintenance of building and services
Mann-Whitney U	1363.5
Wilcoxon W	1692.5
z	-2.546
Asymp. Sig. (2-tailed) p	0.011

Table 8.23: Low and Medium Experience

Test Statistics	Carries out maintenance of building and services
z	-2.546
p	0.011
r	0.25

The results of this section indicate that facilities managers are skilled in energy management measures at the design and operation stage. With reference to Määttänen *et al.*, (2014) facilities managers are in a good position to provide energy management services because they possess the most information on the day-to-day operations of a building, and as a result, they hold much potential in contributing to a building's energy efficiency. Määttänen *et al.*, (2014) claim that with a combination of the facilities managers' knowledge of buildings, management skills and the support of building services engineers, energy efficiency can be achieved.

This claim seems to hold true as participants B1 and ME6 stated that their training as electrical building services engineers has helped them in providing energy management services to their clients. Energy management and efficiency has been proven to improve cost savings (Malina, 2012). The results of this section shows facilities managers are competent in the identified FM roles under the economic aspect and indicates that facilities managers across the three levels of experience believe they have the adequate skills that is needed to fulfil the economic aspect of sustainable buildings.

8.5 FM Role in Sustainable Building in relation to the Management Aspect

Table 8.24 shows the level of the facilities manager's competence under the management aspect. The table shows *'executes yearly building tuning initiates'* as the highest ranked role with an index of 7.46. *'Incorporates building management systems for effective control of building services'* as the 2nd highest role index of 7.44. '*Develops initiatives that educates the occupants on sustainability issues*' as 3rd highest role index of 7.40. '*Delivers functional buildings in consultation with building users'* with index of 7.04 is ranked 6th while '*Establishes legal and contractual environment management initiatives'* is ranked 7th.

Table 8.24: FM Competence in relation to the Management Aspect

	Management Aspect	Overall Competence Level	Category	Ranking
♦	Executes yearly building tuning initiates	7.46	CT	1
♦	Incorporates building management systems for effective control of building services	7.44	CT	2
♦	Develops initiatives that educates the occupants on sustainability issues	7.4	CT	3
♦	Assesses the application of technology within building operations	7.14	CT	4
♦	Monitors and evaluates technology trends and innovation	7.1	CT	5
♦	Delivers functional buildings in consultation with building users	7.04	CT	6
♦	Establishes legal and contractual environment management initiatives	7	CT	7

CT = Competent

In order to identify variation in opinion in relation to the facilities manager's competence across the low, medium and high experience facilities managers, a Kruskal-Wallis test was carried out like in management aspect. The results as shown in Table 8.25 indicate that there is no significant variation in opinion across the low, medium and high experience facilities managers except in *'delivers functional buildings in consultation with building users*' across the 3 different groups of facilities managers. The results suggest that there is a difference in opinion across the low, medium and high experience facilities managers in relation to the aforementioned role. As such, a post-hoc test is necessary in order to discover where the variation lies.

Table 8.25: Kruskal-Wallis test showing Difference in Opinion

	Chi-square	df	Asymp. Sig.
Delivers functional buildings in consultation with building users	8.171	2	**0.017**
Monitors and evaluates technology trends and innovation	0.355	2	0.838
Assesses the application of technology within building operations	3.700	2	0.157
Incorporates uilding management systems for effective control of building services	0.038	2	0.981
Establishes legal and contractual environment management initiatives	0.272	2	0.873
Develops initiatives that educates the occupants on sustainability issues	0.438	2	0.803
Develops users guide to optimise building performance	0.358	2	0.836
Executes yearly building tuning initiates	0.262	2	0.877

To identify where the variation lies in relation to the opinion of facilities managers (between low and high experience, medium and high experience, and low and medium experience) on the *'delivers functional buildings in consultation with building users*' role: a Mann-Whitney U tests between pairs of groups was carried out. Table 8.26 shows the probability value *p* for the role as 0.155 in relation to the variation in opinion between low and high experience. This value is more than 0.05 and indicates that there is no statistically significant difference in relation to the aforementioned role between the low and high experience facilities.

Table 8.26: Low and High Experience

Test Statistics	Delivers functional buildings in consultation with building users
Mann-Whitney U	517.500
Wilcoxon W	2113.500
z	-1.422
Asymp. Sig. (2-tailed) *p*	0.155

To identify where the variation lies in relation to the opinion of facilities managers (between low and high experience, medium and high experience, and low and medium experience) on the '*delivers functional buildings in consultation with building users*' role: a Mann-Whitney U tests between pairs of groups was carried out. Table 8.27 shows the probability value *p* for the role to be 0.007 in relation to the variation in opinion between low and high experience. This value is less than 0.05 and indicates that there is a statistically significant difference in relation to the aforementioned role between the low and high experience facilities. In carrying out further analysis as shown in Table 8.28, the value of *r* is calculated as 0.32. This result shows that the statistical significance difference is of medium effect using the criteria by Cohen (1988) that any result of 0.3 but less than 0.40 has medium effect on results. This indicates that there is no significant difference in the opinion of facilities managers in relations to the role: '*delivers functional buildings in consultation with building users*' between medium and high experience facilities managers.

Table 8.27: Medium and High Experience

Test Statistics	Delivers functional buildings in consultation with building users
Mann-Whitney U	354.500
Wilcoxon W	1629.500
z	-2.701
Asymp. Sig. (2-tailed) *p*	0.007

Table 8.28: Medium and High Experience

Test Statistics	Delivers functional buildings in consultation with building users
z	-2.701
p	0.007
r	0.32

To identify where the variation lies in relation to the opinion of facilities managers (between low and high experience, medium and high experience, and low and medium experience) on the *'delivers functional buildings in consultation with building users*' role: a Mann-Whitney U tests between pairs of groups was carried out. Table 8.26 shows the probability value *p* for the role to be 0.067 in relation to the variation in opinion between low and medium experience. This value is more than 0.05 and indicates that there is no statistically significant difference in relation to the aforementioned role between the low and medium experience facilities.

Table 8.29: Low and Medium Experience

Test Statistics	Delivers functional buildings in consultation with building users
Mann-Whitney U	1119.000
Wilcoxon W	2394.000
z	-1.833
Asymp. Sig. (2-tailed) *p*	0.067

Though, *'executes yearly building tuning initiates'*, *'Incorporates building management systems for effective control of building services'*, and '*Develops initiatives that educates the occupants on sustainability issues*' are rated highest, other FM roles as listed in Table 8.24 are also necessary to the achievement of sustainable buildings under the management aspect. This indicates that facilities managers have gone beyond merely managing buildings for sustainable solutions to monitoring, evaluating and assessing technology trends and innovations in buildings (Pitt and Hinks, 2001). FM roles under the management aspect are essential due to FM roles that do not necessarily fall under the environmental, social or economic aspects. The management aspect has been emphasised as a necessary aspect in the achievement of sustainability (Lueg and Radlach, 2016).

Therefore, facilities managers are encouraged to develop themselves in the skills that enable them manage and deliver their roles effectively. These roles include managing building management systems for effective control of building services (Taylor, 2006) and monitoring technological trends in relation to buildings (Heywood *et al.*, 2004). Consequently, facilities managers are being encouraged to increase their knowledge of technological developments due to the rise in energy use in facilities (Cardellino and Finch, 2006). The results of this section indicate facilities managers are competent in the identified FM roles under the management aspect and that facilities managers across the three levels of experience believe they have the necessary skill that is needed to fulfil the management aspect of sustainable buildings.

8.6 Barriers to FM Role in achieving Sustainable Buildings

Barriers to FM in sustainable buildings have been highlighted in Section 5.2 and these include inadequate technical knowledge and understanding of intelligent buildings, lack of awareness of sustainable buildings, lack of training and tools, perceived higher upfront costs, split incentives, lack of government policies that support sustainable buildings etc. This section discusses findings of the interviews in relation to barriers that hinder the facilities manager's role in achieving sustainable buildings in Nigeria. The data provided by participants was analysed using the Relative Importance Index (RII) which was used to rank barriers affecting the achievement of FM role in sustainable buildings. RII was computed based on the formula provided by Adnan *et al.*, (2007) as:

$$RII = (5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1) / 5(n_5 + n_4 + n_3 + n_2 + n_1)$$

Where n_5 = number of participants who answered "strongly agree"; n_4 = number of participants who answered "agree"; n_3 = number of participants who answered "neither agree nor disagree"; n_2 = number of participants who answered "disagree"; n_1 = number of participants who answered "strongly disagree".

Table 8.30 shows the results on the barriers to FM role in achieving SBs. The findings revealed 18 barriers to FM in achieving sustainable building. The five highest ranks are: lack of acceptance of FM role at design and construction stages (1st); lack of incentives for sustainable building implementation among developers (2nd); lack of awareness among public about FM role in sustainable building (3rd); Non-affordability by the public and lack of government financial support (4th), and Lack of government policies or legislation to support implementation of FM role in sustainable building (5th). The Table shows lack of awareness among government about FM role in SB as the (17th) ranked and lack of locally based building material manufacturing industries as the (18th) ranked.

Table 8.30: Barriers to FM role in Achieving Sustainable Buildings in Nigeria

Barriers to FM Role in Sustainable Building	Mean	Std. Error	Std. Deviation	RII	Rank
♦ Lack of acceptance of FM role at design and construction stages	4.51	0.381	4.447	0.902	1st
♦ Lack of incentives for SB implementation among developers	4.43	0.067	0.776	0.886	2nd
♦ Lack of awareness among public about FM role in SB	4.32	0.065	0.76	0.864	3rd
♦ Non- affordability by the public and lack of government financial support	4.32	0.067	0.777	0.864	3rd
♦ Lack of government policies or legislation to support implementation of FM role in SB	4.31	0.069	0.796	0.862	5th
♦ FM awareness by IFMA Nigeria	4.3	0.074	0.859	0.860	6th
♦ Lack of technical skill expertise in the construction industry	4.25	0.07	0.811	0.850	7th
♦ Low awareness among government about the benefits of SB	4.2	0.07	0.811	0.840	8th
♦ Lack of FM skills and expertise	4.17	0.07	0.822	0.834	9th
♦ Social integration and cultural background in relation to non-appreciation of SB	4.11	0.071	0.823	0.822	10th
♦ Lack of training of building professionals in design and construction of SB	4.1	0.066	0.771	0.820	11th
♦ Lack of industry structure to promote FM in SB	4.1	0.077	0.892	0.820	11th
♦ Low maintenance culture	4.1	0.074	0.86	0.820	11th
♦ Lack of building industry standards	4.07	0.075	0.869	0.814	14th
♦ Too much bureaucracy in housing policies	4.07	0.087	1.016	0.814	14th
♦ Lack of awareness among building professionals about FM role in SB	4	0.082	0.954	0.800	16th
♦ Lack of awareness among government about FM role in SB	3.94	0.085	0.983	0.788	17th
♦ Lack of locally based building material manufacturing industries	3.53	0.099	1.148	0.706	18th

Based on the findings of the interviews, the barriers to FM role in the achievement of sustainable building as presented in Table 8.30 were used in the questionnaire survey to confirm these barriers and establish their relative importance. The results as presented in the Table 9.30 are consistent with findings of Elmualim *et al.*, (2010) on barriers to sustainable FM practice. It also consistent with the findings of Ikediashi *et al.*, (2014) whose research was based on Nigerian settings in relation to barriers affecting sustainable FM practice in Nigeria. Elmualim *et al.*, (2010) identified barriers to sustainable FM as customer constraints, physical/historical constraints, organisational engagement, lack of training, lack of tools, lack of awareness, financial constraints, lack of senior management commitment, lack of knowledge and time constraint.

The study of Ikediashi *et al.*, (2014) was set to investigate the drivers of sustainable FM practice in corporate organisations in Nigeria. Their investigation led to barriers of sustainable FM, these include lack of awareness, lack of senior management commitment, lack of government support and incentives, uncertainty of outcomes and benefit, lack of training and tools, lack of relevant laws and regulation, financial constraints, corruption, Physical/historical constraints, and customer demand and constraints. Though, these findings are for the state of sustainable FM practice in corporate organisations in Nigeria, they can be related to FM role in sustainable buildings.

The general *lack of acceptance* of FM role at the design stage seems to also affect FM role in sustainable buildings. According to Cousins *et al.,* (2005) facilities managers are involved too late into the design process and even when employed at the operations stage, they are not integrated well enough. There is tendency for the lack of acceptance to be as a result of the lack of awareness of FM role in sustainable buildings which in turn can be as a result of low awareness of sustainable buildings among the public, government, and other building professionals. Building professionals generally have an idea of a sustainable building; however, they lack the broad knowledge of what a sustainable building entails. This is evidenced from the findings of the interview. The populace and the government also need to be enlightened in what a sustainable building is and its benefits. The low awareness of sustainable buildings may indirectly affect the promotion of FM role in achieving sustainable buildings. The low awareness among government is a barrier towards developing policies that promote FM in achieving sustainable buildings.

The '*lack of awareness*' supports the discovery by Ikediashi *et al*., (2014) that FM, although practiced in major cities in Nigeria, yet, this role faces a major challenge due to a lack of awareness by building professionals, government and the general public, and ultimately is a major impediment facing the profession in the country. In fact estate surveyors who normally double as property managers and take up the role of the facilities manager, argue whether FM should be a distinct professional calling in Nigeria (Adewunmi *et al.,* 2009). According to Durodola (2009), there is a general opinion among people that FM and estate surveying are the same and many doubt the practicability of FM being applied in business circles in Nigeria. As a result, the FM practice is viewed as an upcoming profession in Nigeria and building professional are seizing the opportunity to create business due to the increase in demand for FM services by multinational companies, banks, manufacturing companies, schools and government parastatals. Even though, awareness seems to be low, Adewunmi *et al.,* (2009) and Ikediashi *et al.,* (2012) affirm that property management is the most popular component of FM practiced in the country.

The research of Finch and Clements-Croome (1997) has proven that *lack of adequate professional and scientific training on operations of intelligent buildings* can be an impediment to successful sustainable FM practice. Though, the research of Finch and Clements-Croome (1997) is on intelligent buildings, the findings are relevant to sustainable buildings. With reference to Ikediashi *et al.,* (2012), the average facilities manager in Nigeria does not have the skill expertise that their job requires in relation to sustainable practices. The facilities managers are from different professions within the building industry and need to be trained in FM roles for sustainable buildings. An interview participant even commented that facilities managers in

Nigeria generally need to be trained continuously in FM skills. This is evidenced in the comment made by one of the participants interviewed as stated below:

"*Even with the few existing FM companies, the skill expertise in FM is lacking. Only three FM companies are getting it right when it comes to carrying out FM functions. You can now imagine trying to function in a sustainable environment. Facilities managers need continuous training to meet up with today's sustainable practices*". – A1

The *lack of technical skill expertise* among construction industry participants, construction industry participants include the client, architects, civil engineers, mechanical and electrical engineers, quantity surveyors, estate surveyors, land surveyors and the building contractor (Gollenbeck, 2008). There is a general lack of skill expertise among construction industry participants in Nigeria as evidenced in the statement below:

"*The fundamentals of FM are yet to be understood in Nigeria, thus the cost is never budgeted for, aside from this, Nigeria lacks the skills and expertise to deliver the required services such as but not limited to experienced and qualified FM professionals, qualified and skilled engineers and artisans due to lack of technical schools and the likes*". – ME3

Usman *et al.*, (2012) confirms that the *lack of skills expertise* in the Nigerian construction industry is a barrier to the successful delivery of building projects and which can be said to indirectly affect the delivery of sustainable buildings and FM role in achieving them. The Industrial Training Fund of Nigeria (ITF) (2005) refers to skilled artisans as bricklayers (masons); steel fixers; electricians; carpenters; painters; plumbers; artisans; etc. According to Dantong (2007), they are construction operatives who contribute skilfully with their hands in the practical realisation of a project and are under the directive of the building contractor (Usman *et al.*, 2012). Ihua-Maduenyi (2015) and Lamudi (2015) are also of the opinion that many Nigerians lack inadequate skills needed to perform their tasks in the building industry. According to them, this is as a result of the neglect of technical and vocational education in the country by both the government and the public in general. Artisans from other countries such as Ghana and Togo are better skilled than Nigerian artisans in the technical works of wall and floor tiling, carpentry, wall plastering and so on. The lack of skill inadvertently affects the delivery of sustainable building by the facilities manager, since the facilities manager works in a team to achieve sustainable building.

Lack of government policies or legislation is another barrier to FM in achieving sustainable buildings as established by Ikediashi *et al.*, (2012) and evidenced in statements made by interview participants.

"*There is no legislation backing up the FM profession in Nigeria, so it makes it difficult to practice FM the way it is practiced in the developed countries. IFMA Nigeria Chapter is not* *performing its role in promoting FM. It is not making demand on the government to develop legislation that will promote good quality buildings that sustainably built and that have the interest of users in mind*" – ME1.

"*No policy mandating the need by the government for sustainable buildings. No due process is followed to ensure that buildings meet sustainability requirements. This is the main barrier that hinders FM in carrying out its role towards sustainable buildings*". – ME3

"*Lack of awareness by the government of the role FM in achieving SBs and the fact that even the government does not like to spend money on maintenance of their buildings is a major barrier and this due to the fact that they are unaware of the role FM plays in SD. Government does not set aside cost of maintaining their facilities. Lack of government policies backing the role of FM and lack of professionals who have a training and knowledge in sustainable building design and construction is a barrier to FM in SB*". – ME7

These participants were strongly opinionated about the issue of lack of government policies that support and promote FM practice. This supported by Malina (2012) as discussed in Section 5.4 who believes strongly that the government initiatives towards standards for sustainable building practices will foster FM role in sustainable buildings. The Nigerian Government needs to create an enabling environment for FM through provision of adequate infrastructure, legislative backing and effective regulatory framework to enforce standards (Akintunde, 2009).

The barrier in relation to *lack of government financial support* refers to the need for the government to fund construction of sustainable buildings. This supports Fanimokun (2014) that the constrained access to credit for the construction of building projects has huge implication. In building projects in Nigeria, developers are required to pre-finance projects before they are mobilised. However, if the government arrange funds to be made available for developers, encourage sustainable buildings. FM is also viewed as being expensive and particularly in relation to the overheads carried by an FM company as against directly hiring individual technicians and workers for building services maintenance and repair works without considering the expertise of the facilities manager and with his wealth of experience. This is evidenced in the statement below:

"*The average Nigerian company views the overheads carried by an FM company as substantial when compared to individuals. So many companies directly hire technicians or even quacks to do their repair works without considering the expertise of the facilities manager due to his years of experience and the cost saving FM can bring. FM in Nigeria is still considered to be expensive. I think the reason is that most people, who do their maintenance works, do it in-house, so they hire technicians to do whatever he can do and since he has no reputation to consider, he does what he likes. What these companies do not realise is that they are carrying* *individual cost whereas if it was an FM company, it will hire these same technicians and add their individual cost to theirs and use the same technicians on 4, 5, or 10 sites. Even though the FM company will have to add overhead cost such as salaries for staff like accountant, manager, office vehicles, and so on but in the end your cost might be slightly higher than just employing one electrician but at the end of the day you are getting better services because you are relying on a guy who has years of experience, and relying on a guy who can respond in case of an emergency, you are relying on someone who will not only give you repair works but advisory services as well*" – A2.

8.7. Drivers to FM Role in achieving Sustainable Buildings

The data provided by participants was analysed using the Relative Importance Index (RII) as stated above in Section 8.6. The Relative Importance Index (RII) was used to rank drivers promoting the achievement of FM role in sustainable building. RII was computed based on the formula provided by Adnan *et al.*, (2007) as:

$$RII = (5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1) / 5(n_5 + n_4 + n_3 + n_2 + n_1)$$

Where n_5 = number of participants who answered "strongly agree"; n_4 = number of participants who answered "agree"; n_3 = number of participants who answered "neither agree nor disagree"; n_2 = number of participants who answered "disagree"; n_1 = number of participants who answered "strongly disagree".

Table 8.31 shows 17 drivers to the facilities manager's role in achieving sustainable buildings. The results shows the rankings of the drivers and these are: awareness of FM role in sustainable building among top management in organisations (1st), demand for best building practices by government (2nd), High level of FM competencies (3rd), Development of the economy (4th), the facilities manager's involvement at the design stage (5th). Government as a major employer of FM is ranked (16th) and demand for SB by investors, users, top management, public, government is ranked (17th).

Table 8.31: Drivers to FM Role in achieving SBs in Nigeria

Drivers to FM Role in Sustainable Building	Mean	Std. Error	Std. Deviation	RII	Rank
♦ Awareness of FM role in SB among top management	4.03	0.098	1.123	0.806	1st
♦ Demand for best building practices by government	4	0.733	8.418	0.800	2nd
♦ High level of FM competencies	3.92	0.088	1.005	0.784	3rd
♦ Development of the economy	3.84	0.093	1.069	0.768	4th
♦ The facilities manager's involvement at the design stage	3.82	0.09	1.043	0.764	5th
♦ Promotion of SB by the building industry	3.74	0.092	1.06	0.748	6th
♦ Awareness of FM role in SB among investors/ developers/ building owners	3.68	0.098	1.128	0.736	7th
♦ Awareness of FM role in SB among government	3.54	0.099	1.138	0.708	8th
♦ Demand for best building practices by building professional bodies	3.53	0.098	1.122	0.706	9th
♦ Development of legislation to promote FM in SB	3.48	0.096	1.112	0.696	10th
♦ Training of facilities managers in their role in SB	3.4	0.114	1.314	0.680	11th
♦ Training of building professionals towards SB	3.39	0.106	1.224	0.678	12th
♦ Development of a maintenance culture	3.37	0.081	0.936	0.674	13th
♦ Awareness of FM role in SB among building users	3.34	0.103	1.174	0.668	14th
♦ Awareness of FM role in SB among building professionals	3.16	0.103	1.202	0.632	15th
♦ Government as a major employer of FM	3.1	0.113	1.288	0.620	16th
♦ Demand for SB by investors, users, top management, public, government	2.87	0.106	1.221	0.574	17th

Based on the findings of the interviews, the drivers to FM role in the achievement of sustainable building as presented in Table 8.31 were used in the questionnaire survey to confirm these drivers and establish their relative importance. The role of senior management as a key driver of sustainability in organisations is documented in Elmualim *et al.*, (2010) and Price *et al.*, (2011) and this driver in the view of this research can be related to the *awareness of FM role among top management in organisations*. When the leading members of organisations are aiming towards sustainability, the achievement of sustainable building is made easier for the facilities manager. Price *et al.*, (2011) revealed only medium-sized to large FM organisations were mostly having a sustainability policy in place, therefore, revealing that within the FM industry sustainable business practice is not yet embedded. This indirectly affects FM in sustainable buildings.

In relation to *high level of FM competencies*, Elmualim *et al.*, (2012) argues that sustainability is a key issue where facilities managers have to develop their competencies in order to face the demands, challenges and opportunities of SD and practices and which includes sustainable buildings. IFMA report (2007) emphasised the need for facilities managers to develop and implement programs to reduce, reuse and recycle waste, and work closely with end users to anticipate changes and conserve energy. The report also emphasised reviewing or monitoring the amount of energy used by the buildings managed by facilities managers; adopting energy efficiency measures like switching to efficient lighting equipment, matching heating and cooling and ventilation equipment to facility loads to reduce energy consumption.

In recognition of the need to improve the competence level of facilities managers is apparent in the development of the FM competency documents by BIFM, IFMA and RICS and in the steps taken by these organisations for qualification into different levels of membership. IFMA has even developed a certification for Sustainability Facility Professional in view of this. BIFM (2014) makes it mandatory for facilities managers to educate building occupants concerning meeting environmental legislative requirements in buildings. BIFM also encourages facilities managers to improve environmental awareness amongst key stakeholders.

The result as presented in Table 9.31 is consistent with findings of Elmualim *et al.*, (2012). A major driver to the achievement of sustainable buildings by facilities managers is the establishment of government policies, which Elmualim *et al.*, (2012) argues is crucial to promoting sustainable FM practices. They argue that if organisations do not have policies supporting sustainability at all levels, the achievement of sustainability will be impaired. Government's role in promoting FM and as a major employer of FM services has been confirmed by Kamaruzzaman and Zawawi (2010) where the main drivers impacting the FM industry in Malaysia is government's outsourcing practice to local bumiputera companies and the expectation that more contracts will be tendered out. Government's involvement in developing and implementing policies that promote sustainable building practice to aid the role of FM involves the demand for best building practices by the government. According to Ofori (2006), governments have the important role to promote sustainable building.

8.8 Synthesis of Interview and Questionnaire Findings

The findings of the interviews on FM role in Nigeria produced twenty (20) roles that facilities managers carry out in their day to day activities. These roles were discovered to be similar to the roles carried out in the achievement of sustainable buildings. This supports Shah (2007) who states that facilities managers in their daily functions have met to some degree the sustainable building criteria. The 20 FM roles revealed by the interview indicate that facilities managers do not have adequate knowledge in FM roles in sustainable buildings when compared to the 44 FM roles discovered by content analysis. However, the 20 FM roles can be used as their role in sustainable buildings. For when they were asked about FM role in sustainable buildings, interviewees claimed that the answers they provided for FM role can be used for their role in sustainable buildings.

In order for the research to achieve Objective 4, it was then necessary to use findings of the content analysis on FM role in sustainable buildings in the questionnaire survey to evaluate the perception of facilities managers in relation to their competence in achieving sustainable buildings in Nigeria. The findings of the questionnaire revealed that facilities managers are competent in all the identified FM roles, however, hindered by lack of acceptance of FM role at design and construction stages, lack of incentives for sustainable building implementation among developers, lack of awareness about FM role in sustainable buildings among the public, government and building professionals, lack of government financial support, lack of government policies or legislation to support implementation of FM role in sustainable buildings etc.

8.9 Chapter Summary

Twenty (20) interviews were conducted among medium experience (6 - 15 years) and high experience (16 to 20 years and more) facilities managers in relation to FM role in Nigeria and the facilities managers' role in achieving sustainable buildings in the Nigerian context. The findings of the interview reveal that facilities managers have a reasonable knowledge of their role in sustainable buildings. Their roles include management of waste, energy management and advice on sustainable building material under the environmental aspect; under the social aspect the identified facilities management roles include: management of cleaning services, space management, ensuring visual comfort, management of thermal comfort, indoor air quality, and acoustic comfort under the social aspect. Under the economic aspect is property asset management, management of building performance for optimum use of building, maintenance of building and services, management of efficient use of water and efficient energy use, and financial management. The role of the facilities manager under the management aspect include: advice and checks designs, integration into the design team, planning proposed building in consultation with current building users, project management, and engagement of other professionals. This answers the research question, i.e. *what is the current FM role in achieving sustainable buildings in Nigeria*?

The questionnaire survey was conducted among 139 facilities managers who are members of the IFMA Nigeria in order to determine if facilities managers are competent in the identified FM roles in sustainable buildings. The findings reveal that there is no significant variation in the competence level of the facilities managers across the three categories (low experience (0 - 5 years), medium experience (6 - 15 years), and high experience (16 to 20 years and above). Therefore, the results indicate that facilities managers in Nigeria are competent in FM roles in achieving sustainable buildings and this indicates that they are knowledge in the sustainable qualities of a building. This answers the research question: *Are facilities managers in Nigeria competent in FM roles in achieving sustainable buildings*? This chapter fulfils Objective 4 of the research which is to evaluate the perception of facilities managers in relation to their competence in achieving sustainable buildings in Nigeria.

The chapter concludes that the competence of facilities managers in sustainable buildings will invariably aid the effectiveness of the proposed framework if used in projects; however, there is need to further investigate if they carry out these roles.

CHAPTER 9: FRAMEWORK FOR FACILITIES MANAGERS IN ACHIEVING SUSTAINABLE BUILDINGS

9.0 Introduction

The constituents of sustainable buildings have been identified and with the facilities manager's role in them, thereby, providing the essential components needed for the development of the FM framework proposed by this research for facilities managers in achieving sustainable buildings in Nigeria. There is need for an FM framework that facilities managers can use in delivering sustainable buildings in Nigeria. The concept of sustainable buildings itself, is still in an evolving phase and likewise the role of the facilities manager in achieving sustainable buildings in Nigeria. There is also a dearth of literature in relation to it. The chapter describes the need for the framework, similar frameworks developed for the achievement of sustainable buildings and the development of the framework itself. The development of the framework is based on findings from the literature review, content analysis, interviews and questionnaire survey. The chapter helps to finalise the achievement of the aim and objectives of this research.

9.1 Need for a FM Framework for Sustainable Buildings

The business dictionary (2013), describes a framework as a comprehensive outline of interlinked concepts that have been systematically organised to provide structure and serve as a guide to achieving an objective goal; it can be adapted, revised or improved. Accordingly, this research provides an FM framework that brings together data that has been systematically obtained and relates to constituents that makes a building sustainable and the facilities manager's role according to these constituents. The framework has been developed to provide an integration of functions that together act as a tool for the facilities manager in the achievement of sustainable buildings.

A framework provides comprehensive understanding of a concept or theory (Jabareen, 2009). The FM framework is a collection of information that gives comprehensive understanding of the facilities manager's role in achieving sustainable buildings and barriers and drivers towards the achievement of the role. According to Vaughan (2008) a framework can be developed from the analysis of data obtained from literature and people's views. The FM framework for this research is based on data obtained and analysed from extensive reviewed literature, content analysis of documents such as BREEAM-NC, LEED-NC and the ISO 15392, expert interviews, and questionnaire survey among FM professionals. The information gathered from these various procedures were used in the development of the framework.

In relation to the need for the FM framework proposed by this research, the researcher observed that there is limited research in relation to FM role in sustainable buildings in Nigeria. The very nature of the facilities manager's role in buildings already tends towards the achievement of the environmental, social and the economic aspects of SD; as reflected in many studies (Bernard William Associate, 1994; Barret and Baldry, 2003; Kok, 2011; Jensen *et al.*, 2013; Wiggins, 2014; Rafidee *et al.*, 2014). The studies have shown that the production of greenhouse gases emission take place during the operations phase of buildings and FM helping to reduce this negative impact on the environment, thereby contributing to the environmental aspect.

In relation to the social aspect Barret and Baldry (2003) argue that the scope of FM services includes ensuring that building users feel comfortable, cared for and are safe. Kok (2011) affirms that FM services affect academic performance because of the performances of HVAC systems, acoustic systems and cleaning which directly affects the learning environment and indirectly affects the educational process. Rafidee *et al.*, (2014) also argue FM as a conserver of cultural values in heritage buildings. With regards to the economic aspect, Bernard William Associate (1994) claim that FM, involves guiding and managing the operations and maintenance of buildings to achieve efficiency and effectiveness at an optimal combination of cost, quality and time. Yet, these studies did not relate FM with the nitty-gritty of sustainable FM practices in buildings such as those highlighted in Section 4.3 and shown in Table 4.3.

Studies such as Shah, (2007); Elmualim *et al.*, (2010); Saleh *et al.*, (2011); Price *et al.*, (2011); Elmualim *et al.*, (2012); Collins and Junghans (2015); and Dixit *et al.*, (2016) went further in research towards sustainable FM practices that can be related to building. They investigated practices that help organisations achieve environmental, social and economic sustainability; help businesses become more environmentally focused; and help FM practice in the development and commitment to sustainability policies to achieve sustainable business practices. Yet, these studies did not capture the facilities manager’s role in the constituents that makes up a sustainable building. Shah (2007) provided a comprehensive information on the facilities manager’s general role in sustainable practices which involves increased environmental commitment, improved comfort of building users and increased economic value at the design, construction and operations stages of the building’s life-cycle. Nonetheless, with this said, it did not relate this FM role to sustainable building constituents.

In view of this, the FM framework proposed by this research provides comprehensive information on the constituents that make up a sustainable building and the facilities manager’s role in relation to these constituents. It offers practical guidance to facilitate FM as a tool for achieving sustainable buildings. The framework can serve a guide for facilities managers in order to aid the integration of FM roles in sustainability issues in the building life-cycle, that is, right from the design stage of the building to the operations stage.

9.2 Related Frameworks for the Achievement of Sustainable Buildings

As earlier stated in Section 4.4, it is clear that sustainable buildings cannot be achieved without the cooperation of members of the building project team comprising of the design, construction, and operations team members. Table 9.1 shows six (6) frameworks that have developed for sustainable buildings and showing the role of the design team in efforts towards the achievement of sustainable buildings. 5 out of the 6 frameworks shown in Table 10.1 are frameworks related to the achievement of sustainable buildings through the integrated effort of the design team. Various frameworks have been developed for FM practice these include a framework developed by Amaratunga and Baldry (2003) to measure FM performance in order to support management and practice of FM within an organisation. Liyanage and Egbu (2008) developed a framework for performance management of domestic services under FM in hospitals. Jensen (2010) developed a conceptual framework for better understanding of the different ways in which FM can add value to a core business. However, these frameworks were not developed for sustainable buildings. The frameworks selected for this research were selected due to their aim towards the achievement of sustainable buildings.

Table 9.1: Related Frameworks towards Sustainable Buildings

Author	Date	Tilte	Focus
Tucker et al,	2015	Optimising the Role of FM in the Development Process: The Development of FM-DP Integration Framework for Sustainable Property Development.	Development of an FM development process framework to establish the critical success factors needed to integrate FM into a building's full developmental process.
Akadiri et al,	2012	Design of A Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector.	Implementation of the economic, social and environmental issues in facilitating the sustainability of building industry.
Entrop and Brouwers	2010	Assessing the sustainability of buildings using a framework of triad approaches.	An assessment framework for techniques and measures that lower the environmental impact of buildings and infrastructure.
Biswas et al,	2009	Framework for Sustainable Building Design.	To provide a general approach to processing informational needs of any rating system, by identifying, categorizing and organizing relevant data requirements.
Al-Yami and Price	2006	A framework for implementing sustainable construction in building briefing project.	Integration of sustainable construction to enable the project team put into action sustainability principles in the briefing process.
Edén et al,	2003	Design for sustainable building - development of a conceptual framework for improved design processes.	Integration of contemporary design theory into the issues of sustainable building, in order to reach a deeper understanding of the obstacles to implementing strategies for sustainable building into

Eden *et al.*, (2003) developed a framework to improve the design process and in the process investigated efforts made by the design team in achieving sustainable buildings. The work identified the following barriers: (1) concepts of sustainability are not transformed and adapted into the different phases of the design stage; (2) lack of communication within the design team and between the design team and construction team members, and with particular focus on the management and maintenance of the building at the operations stage and inadequate consideration at the design stage; (3) inadequate specific environmental tools that are developed to meet the need of individual building projects; and (4) lack of incorporating lessons learnt from past projects, in order to avoid mere reproduction of what has already been built. The research was not specific about the role of any individual design or construction team member.

However, the barriers stated above are roles that the facilities manager carries out and in the process initiates sustainability measures and contribute to the functionality of designs due to his experiences on past projects and with building users.

The framework developed by Akadiri *et al.*, (2012) laid a foundation for the development of a decision support tool for the design team to improve the decision making process in implementing sustainability in building projects in order to achieve sustainable buildings. The framework contained resource conservation (energy, material, water and land); cost efficiency (initial or purchase cost, cost in-use and recovery cost) and design for human health and comfort and protection of physical resources that enhances human wellbeing, as important ingredients. The framework gave a collective role to the design team and did not assign a specific role to any member of the team and in particular the facilities manager.

Al-Yami and Price (2006) developed a framework based on the value management approach that identifies sustainability principles in order to enable the design team to put into action some consideration for sustainability at the briefing stage of the building process and accelerate the understanding and implementation of sustainable building construction in Saudi Arabia. The framework also offers a crucial method for the client to achieve a better built environment through the efficient use of natural resources, minimisation of any negative impact on the environment as well as satisfaction of human needs and improvement of the quality of life.

Entrop and Brouwers (2010) developed an assessment framework based on five triads that can be used to rank sustainable measures for the built environment in terms of space, transport, energy, water and materials for the ultimate purpose of measures to lower the environmental impact of buildings and infrastructure. The framework of triads can be used in combination with any system which offers to assess the environmental impact of buildings. The framework can be used by town planners, architects, facilities managers, building owners, real estate agents and other parties in the building sector to communicate and make decisions on adopting sustainable measures, which will help to decrease the environmental impact of the building sector and to stimulate the development of sustainable buildings.

Biswas *et al.*, (2009)'s framework offers the design team a full overview of techniques and measures to assess the environmental impact of buildings. It offers a common platform for different rating systems and can be used by the design team from the early design phases to the completion of the project. This helps to assess the environmental impact of buildings in the goal towards achieving sustainable buildings. The framework enables the use of information collated from a building life-cycle in a sustainable manner and offers a general approach to processing the informational needs of any rating system, by identifying, categorising and organising relevant data requirements. The framework presents a way of creating a flexible framework to be ultimately integrated with a design system to facilitate endeavours in sustainable building design.

Though, all the above stated frameworks are not FM related frameworks, they were developed for the purpose of achieving sustainable buildings. They have only been able to identify the role of the integrated design team in achieving sustainable buildings and not the role of the facilities manager in sustainable building. This research however, investigates and develops the specific role for the facilities manager in the design team towards the achievement of sustainable building. The framework is intended to improve the design team process at the design stage like the above stated frameworks, however, with specific roles for the facilities manager as an integral part of the design team.

Tucker *et al.*, (2012) was referred to in this research, due to its initial research into the development of an FM Development Process Framework establishing the critical success factors needed to integrate FM into a building's full developmental process. The development process embraces project initiation, preparation of business case, design, construction proper, space utilisation, building operational and maintenance, and business of the buildings (Chodasova, 2004). Tucker *et al.*, (2012) argued that the integration of FM in the full development process of a building will not only have a significant impact on the longevity of the building, but will have a positive influence on its sustainability. Though, their research is related to FM role in the development process to ensure a building's durability with less impact on the environment; they did not investigate FM role in sustainable building constituents. This new framework prepared by this research study incorporates the integration of FM role into the building life-cycle comprising of the design, construction and the operations stages.

9.3 Proposed FM Framework

The conceptual framework developed in Section 5.1 has been refined to suit achieving sustainable buildings in Nigeria. The sustainable building constituents identified in the conceptual framework were adopted into a questionnaire survey as described in Section 6.11. The findings of the questionnaire survey were used to identify constituents that are critical in achieving sustainable buildings in Nigeria. The findings of the questionnaire were similarly used to identify the roles in which facilities managers in Nigeria are competent in relation to achieving sustainable buildings. Interviews were conducted to identify barriers and drivers to the facilities manager's role in efforts towards achieving sustainable buildings in Nigeria. The findings of both the questionnaire survey and the interviews helped in refining the conceptual framework and also helped in developing a framework that can be used by facilities managers in achieving sustainable buildings.

The proposed FM framework as shown in Figure 10.1 comprises of 3 integrated sections: Section A: Identification of sustainable building constituents; Section B: Identification facilities manager's role at the design, construction stage and operations stage; and Section C: Identification of the barriers and drivers to FM in achieving sustainable buildings. The framework has been developed according to the stages of the RIBA Plan of Work 2013 as shown in Figure 4.4 (the RIBA Plan of Work 2013 developed by the Royal Institute of British Architects incorporates sustainable design principles and promotes integrated working between project team members). This new framework allows for the organisation and management of building projects along important building stages.

The work plan has been selected because it aligns the process of briefing, designing, constructing, maintaining, operating and using buildings into key stages. The stages of the RIBA Plan of Work includes strategic definition stage, preparation and brief stage, concept design stage, developed design stage, technical design stage, construction stage, handover and close out stage and finally the in-use stage. It serves as a guidance tool for the preparation of detailed professional services contracts and building contracts. It details the tasks required at each stage and enables the identification of the facilities manager's role at these stages as discussed in Section 4.5.

Section A of the framework as earlier mentioned comprises of the constituents that make up a sustainable building. This has been identified and discussed in Chapter 3; Section B comprises of the role of the facilities manager in 3 main stages which are: the design stage (strategic definition, preparation and brief, concept design, developed design, technical design stages); the construction stage and which includes the handover and close out; and the in-use stage which is the operations stage. These stages are the stages outlined by the RIBA Plan of Work 2013 (see Section 3.4) and the role of the facilities manager at the various stages has been identified in Section 4.5). The RIBA Plan of Work 2013 details the tasks and outputs required at each stage of the building process which may vary or overlap to suit specific project requirements. According to Gervásio (2014) the strategic definition, preparation and brief, concept design, developed design and technical design stages are all part of the design stage and the briefing stage, where the wishes of the client is developed by identifying the requirements of the building. Section C comprises of interview findings on the barriers that hinders the facilities manager's role and drivers that facilitates the facilities manager's role in sustainable buildings in Nigeria as identified and discussed in Chapter 5.

The framework provides a brief overview of sustainability measures for buildings and emphasises the need for an integrated and holistic approach for implementing sustainability in the development of buildings starting from the conception stage. It is intended to provide a systematic approach for the facilities manager towards achieving sustainable buildings. The facilities manager can, however, work in collaboration with the project manager by sharing his experience on building performance and building users requirement at the stages in the development of the building. The facilities manager can contribute vital suggestions to facilitate ease of maintenance of the building during the operations stage. The framework also identifies and describes aspects of the sustainable building that is to be taken into account when proposing a new building at the design, construction and operation stages. The following sections discuss the three sections of the framework.

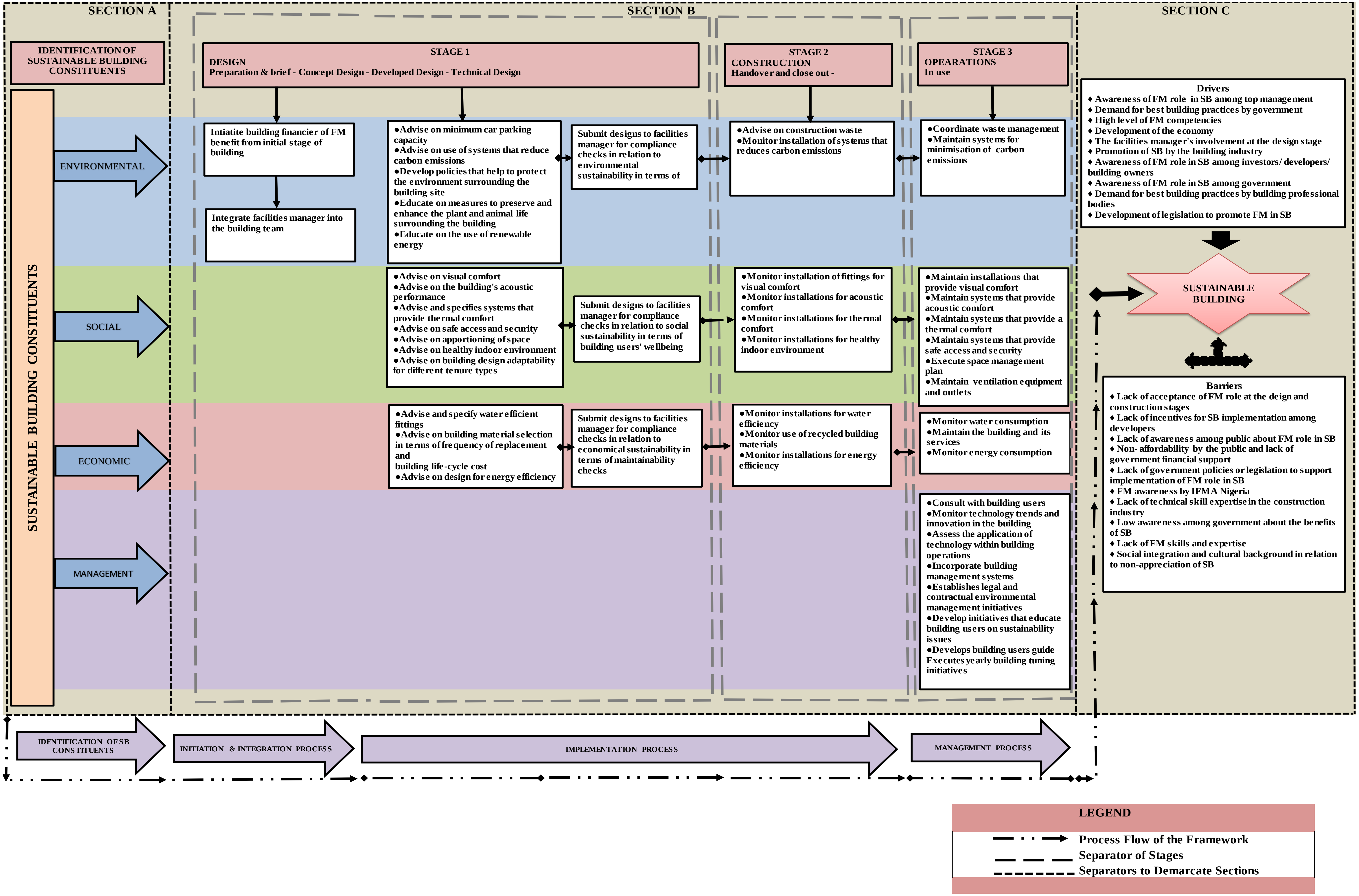

Figure 9.1: Framework for Facilities Managers in achieving Sustainable Buildings

9.4 Section A: Sustainable Building Constituents

Section A of the framework consists of the identification of sustainable building constituents as shown in Figure 9.2. (The constituents have been discussed in detail in Section 3.3). This Section of the framework has been developed based on the findings of the literature review and the document analysis of BREEAM-NC (2012), LEED-NC (2009) and ISO 15392. The research supports that before FM role in sustainable buildings is articulated, there is need for the facilities manager to first of all identify the constituents that make up a sustainable building. The framework provides facilities managers with a detailed view of what constitutes a sustainable building. This should enable facilities managers appreciate their role in sustainable buildings and act as a catalyst to the achievement of sustainable buildings using FM as a tool. Studies have shown FM as a major contributor to sustainable buildings at the design, construction and operations stages of the building life-cycle (Nutt, 1993; Preiser, 1995; McLennan 2000; Eley, 2001; El-Haram and Agapiou, 2002; Hodges, 2005; Shah, 2007; Mohammed and Hassanain, 2010; Shiem-Shin and Hee, 2013).

The framework comprises of 19 environmental constituents, 12 social constituents, 6 economic constituents and 14 management constituents. In total there are 51 constituents across the design, construction, and operations stages of the building life-cycle. These constituents of sustainable building embrace a balance of the economic, social, and environmental aspect in building life-cycle. If this balance can be achieved, then the link between SD and the buildings becomes clearer than ever (Alnaser *et al.*, 2008). The integration of these three aspects in buildings fosters the creation of sustainable buildings (John *et al.*, 2005). This FM framework is based on the integration of these three aspects and the management aspect to bring about reduced impacts on the environment, promotion of human adaptation and cost efficiency as promoted by Akadiri *et al.*, (2012).

Sustainable building is considered as a way for the building industry to move towards protecting the environment, safe guarding lives and at the same time ensuring economic value. The environmental aspect of a sustainable building is expected to minimise air pollution; minimise noise; have adequate waste management operation; protect sensitive ecosystems through good construction practices and supervision; encourage low energy consumption; minimise water use, minimise material use and have a sustainable selection of building materials (Kang, 2015). The social aspect is expected to safe guard health, and provide a conducive environment; help to maintain morale and employee satisfaction; provide best value for the building owner and the building user (Cole *et al.*, 2008).

SECTION A

SUSTAINABLE BUILDING CONSTITUENTS

ENVIRONMENTAL ASPECT

1. Waste management to reduce environmental pollution
2. Transport accessibility to public transport in order to reduce pollution caused by motor vehicles
3. Use of systems that reduce GHG emission
4. Site managed in environmentally sound manner in terms of pollution
5. Reduction of night light pollution
6. developemnts that minimise rainwater run-off to reduce pollution of water courses
7. Developments that minimise discharge to the municipal sewage system
8. Use of previously developed sites and or contaminated land, and Non-use of virgin land
9. Protect ecological value of land during site preparation and completion of costruction works
10. Preservation and enhancement of biodiversity
11. Use of energy efficient equipment
12. To recognise and encourage construction sites managed in an environmentally sound manner in terms of energy consumption
13. Reducing greenhouse gas emissions from refrigeration systems, hot water production
14. Maximum use of solar energy
15. Energy efficient transportation systems in buildings (lifts, elevators, escalators or moving walks)
16. Appropriate use of local energy generation from renewable sources
17. Use of responsibly sourced materials
18. Use of construction materials with low environmental impact and which involves LCA tools
19. Construction of building managed in an environmentally sound manner in terms of resource use

SOCIAL ASPECT

1. Water quality which involves minimising risk of water contamination in building services
2. Visual comfort which involves provision for daylighting, artificial lighting and occupant controls at the design stage to ensure best visual performance and comfort for building occupants
3. Thermal control to maintain a thermally comfortable environment for occupants within the building
4. Safe access which involves effective design measures that promote safe access to and from the building
5. Provision of space for occupant privacy and wellbeing 6. Indoor environmental quality
7. Hazard control which involves materials that are harmful to the comfort and wellbeing of occupants
8. Conserving local heritage and culture
9. Adheres to ethical standards
10. Adaptability for different uses
11. Acoustic control which involves the building's acoustic performance including sound insulation
12. Accessibility to good public transport network and local infrastructure and alternative modes of transportation for occupants

ECONOMIC ASPECT

1. Water efficiency by use of water efficient components and equipment and water consumption monitoring system
2. Material efficiency which involves maximising building material optimisation
3. Management of construction waste for economic value
4. Provision for maintenance which includes maintenance of the building and services which ensures the durability and economic value
5. Energy efficiency which involves minimising operational energy consumption
6. Building life-cycle cost which involves provision of economic value overtime and financial affordability for beneficiaries

MANAGEMENT ASPECT

1. Post occupancy evaluation
2. To encourage and recognise management practices that minimise the amount of construction waste going to disposal
3. Management of reducing air leakage in buildings
4. Innovation involving any technology, method or process that can be shown to improve the sustainability performance of a building's design, construction, operation, maintenance or demolition
5. Incorporation of Building Management Systems to actively control and maximise the effectiveness of building services
6. Establishment of legal and contractual environmental management initiatives
7. Engagement of professional to assist with the integration of sustainability assessment shcemes
8. Engagement of independent commissioning agent with regard to future maintenance
9. Development of initiatives to educate building occupants on how the sustainability issues in building work
10. Development of green lease to encourage environmental activities by occupants
11. Development of a building user's guide to enable building users optimise the building's performance
12. Commissioning and handover initiatives that ensure that all building services can operate to optimal design potential
13. Inclusion of 6-12 month defects liability period
14. Involves yearly building tuning initiatives to ensure optimum occupant comfort and energy efficient services

Figure 9.2: Section A: Identification of Sustainable Building Constituents

The economic aspect of a sustainable building includes comparative cost assessments made over a specified period of time; it involves consideration for initial costs and future operational costs. The economic impacts also includes assessment of financial benefits for the building owner, and occupants and high efficiency in the use of resources such as energy, water and building materials throughout the building's life-cycle (Braganca *et al.*, 2010; Roaf *et al.*, 2004). The management aspect of sustainable building cannot be achieved without the management role. The management role involves managing processes such as: monitoring of building users' comfort in terms of visual, environmental indoor quality, acoustic and thermal comfort, monitoring of maintenance schedules. The facilities manager manages these processes as part of post occupancy evaluation. He monitors innovation technology in relation to sustainability performance of the building. The facilities manager also monitors environmental impacts with the use of legal and contractual environmental management initiatives and develops and monitors the use of building user's guide (BIFM, 2014).

9.5 Section B: FM Role in Building Life-cycle in Sustainable Buildings

The focus of this research study is to achieve sustainable buildings through the facilities manager's role and in order to achieve this, a framework is being developed. Section A of the framework comprises of the constituents that make a sustainable building, the next step is to show the facilities manager's role in relation to the identified constituents. Therefore, Section B of the framework consists of the 3 stages as shown in Figure 9.3; this has been developed based on the Stages of the RIBA Plan of Work 2013 as described in Section 3.4 and on the functions of the facilities manager as described by the BIFM Operational Readiness (2016) which is also developed based on the RIBA Plan of Work 2013. The stages in this section include: Stage 1 - FM role at the design stage; Stage 2 - FM role at the construction stage; and Stage 3 - FM role at the operations stage.

9.5.1 Stage 1 - FM Role at the Design Stage

Stage 1 consists of the design stage which includes the strategic and definition, preparation and brief, concept design, developed and technical design stages; the role of the facilities manager at these various stages with reference to the BIFM Operational Readiness (2016) has been described in Section 4.5. In the strategic and definition stage in relation to the BIFM Operational Readiness (2016), the facilities manager stands as a representative of the end users of the building as the scope of the building project is being defined. The preparation and brief stage involves initiation of the client about FM role at preparation and briefing stage and proper integration of the facilities manager into the design team. The RIBA Plan of Work 2013, (see Figure 3.4) shows that the core objectives of the project team at this stage are: developing quality objectives and project outcomes, sustainability aspirations, project budget, other parameters or constraints and production of initial project brief. It also includes undertaking feasibility studies and review of site information (Shah, 2007).

The facilities manager at this stage initiates the client or owner of the building about the benefit of the facilities manager's early engagement in the project. The facilities manager according to RICS (2014) helps in establishing the client brief. Nutt (1993) adds that this stage should comprise of a briefing team consisting of the client, the designers (architect, structural engineer, and M&E engineers), the facilities manager and the building user. According to the BIFM Operational Readiness (2016), the involvement of the facilities manager helps to clarify and define the initial operational requirements for sustainability, budget and service quality. This stage affords the facilities manager the opportunity to implement sustainability principles into the early stages of the design. According to Preiser (1995), facilities managers when consulted in the early planning and pre-design phases of a project, are able to highlight problems early and provide valuable information on building performance and operating costs. Consideration of sustainability issues during this stage has the potential to minimise negative impacts on environment and satisfy the needs and requirements of the user in addition to minimising the whole life cost of a project. It can also aid the reduction of material consumption and energy during both the construction and operational stages (Al-Yami and Price, 2006). This stage involves the facilities manager integrating himself into the design team after the client or the building owner has engaged his services. The main task of the facilities manager is to educate the client or client representative, the project manager, the building contractor, and the design team on sustainability issues.

In order to achieve truly sustainable solutions, Boecker *et al.*, (2009) emphasise that engaging all stakeholders early on in the design process is key to challenging deeply held assumptions and achieving better solutions that are environmentally, functionally, aesthetically, and economically viable. They state that diversity of values, opinions, expectations and perspectives among stakeholders is expected at this stage but there is need to properly manage these viewpoints and turn it from a liability that can significantly impede project success into an asset. This, with reference to Hodges (2005) is a role that a facilities manager is equipped to carry out. Another task performed by the facilities manager is to facilitate defining the scope and objectives of the project by presenting the drivers of sustainable design and construction to the design team in order to obtain their support in relation to implementing sustainable principles in the building project. Once the sustainability objectives have been set at the onset of the project, it gives clear directions to all design team members and makes it easier to implement sustainability measures during the life cycle of the project development (Cousins *et al.*, 2005).

The concept design stage is the stage in which outline proposals for structural design, building services systems, outline specifications and preliminary cost information with relevant project strategies in accordance with the design programme are presented. According to the BIFM Operational Readiness (2016), the facilities manager should be involved in reviewing drawings, specifications produced by the design and construction team in order to ensure that the end user and client requirements are incorporated. It is at this stage that the facilities manager can make useful contribution on sustainability issues particularly in terms of achieving comfort for the end user (Jensen, 2008). The involvement of the facilities manager at this stage also helps in reducing facility maintenance cost and time (Mohammed and Hassanain, 2010). The facilities manager can provide the architect with organisational plans which includes the purpose of the facility and future requirements for space which includes working space, storage space for equipment, loading and off-loading space, escape routes and so on. The facilities manager can also provide the structural engineer with related information on nature size and weights of various machines and equipment to be accommodated in the facility and future load expectation for consideration by the structural engineer in the design process. The facilities manager can makes recommendation to the mechanical engineer on efficient systems in terms of maintainability by providing information that pertains to procurement and transportation of materials and equipment including quantity and transportation of these materials vertically or horizontal and frequency of their transportation (Mohammed and Hassanain, 2010).

With reference to the BIFM Operational Readiness (2016), the developed design stage is the stage in which the facilities manager continues in the activity of ensuring that the client's and end user's requirements are appropriately considered and incorporated into the developing design proposal. These activities include the facilities manager's input in relations to value engineering exercises, development of project execution plan and any proposed design changes. At the technical design stage, the facilities manager similarly advances in his role at the developed design stage as he supports the design and construction team to ensure that architectural, structural, building services and specialist systems designs are produced in order to sort out unresolved technical work of the core design team members. At the technical design stage, the facilities manager reviews and assesses the design for maintainability, operability and serviceability with a view of selecting the most cost-effective design option.

According to RIBA Plan of Work (2013), the design team do not complete their work at this stage until they have responded to all design queries. The facilities manager at this stage can carry out sustainability checks to ensure reduced environmental impacts, compliance with social sustainability in terms of occupants' health and wellbeing and the achievement of economic value as argued by Mohammed and Hassanain (2010). The involvement of the facilities manager with the design team if implemented efficiently has the potential to contribute to reducing the need for major repairs and alterations in the lifespan of the facility and improve the practices of preventive, planned and immediate responsive approaches to building maintenance as opined by Ogungbile and Oke (2015).

With reference to Eden *et al.*, (2012) the obstacles to the design team achieving sustainable buildings from the design stage creates an opportunity for the facilities manager to introduce concepts of sustainability into the different phases of the design stage; communicate to the team about lessons learnt from past projects, in order for them to be incorporated into the new project. Another task of the facilities manager at this stage is to advise on the best alternatives on sustainable design and the impact of value for money. This will enable the design team to make informed decision on the project's feasibility for implementation.

Figure 9.3 shows the various roles performed by the facilities manager at the design stage. For example the facilities manager advises on minimum car parking capacity; advises on use of systems that will reduce carbon emissions; develops policies that will help to protect the environment surrounding the building site; educates on measures that will preserve and enhance plant and animal life surrounding the building; and educates on the use of renewable energy. The facilities manager carries out the aforementioned roles in order to mitigate the environmental impact caused by buildings.

The facilities manager can advise on the social aspect embracing visual comfort, acoustic comfort, thermal comfort, safe access and security, apportioning of space, healthy indoor environment; and building design adaptability for different tenure types (Van der Linden *et al.*, 2007; Booty, 2009). On the economic aspect, the facilities manager can advise on water efficient fittings, building material selection in terms of frequency of replacement and building life-cycle cost, and design for energy efficiency (Ruuska and Häkkinen, 2014). Each of these roles has been discussed in Section 4.3.

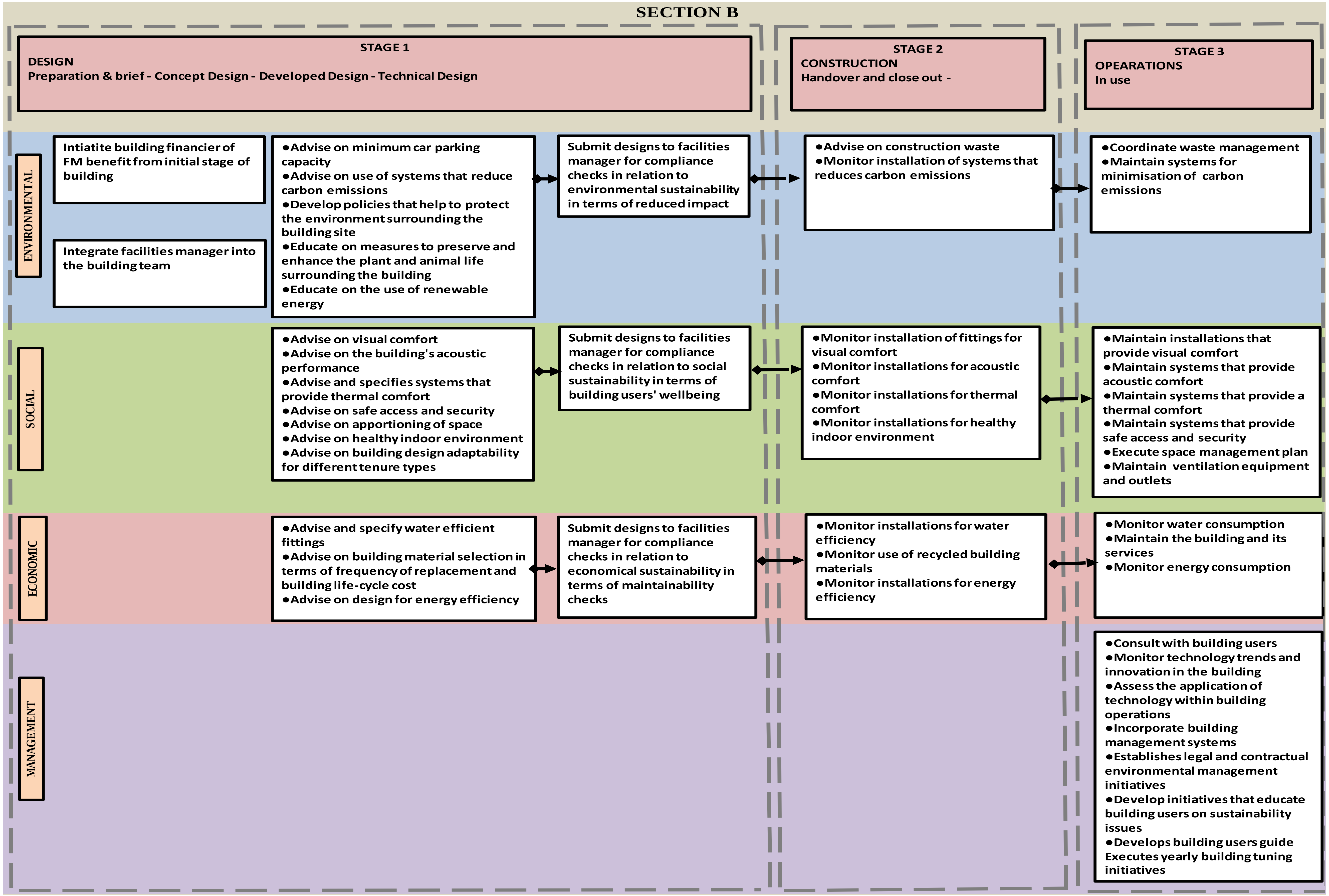

Figure 9.3: Section B: Identification of Facilities Manager's Role in achieving Sustainable Buildings

9.5.2 Stage 2 - FM Role at the Construction Stage

Stage 2 is the implementation process of decisions on the design of the building initiated from the design stage. This Section consists of the construction and handover and close out stage. Though, there are two different stages under the RIBA Plan of Work 2013, for the purpose of this research, they are combined because the handover and close out is the end of the construction period. At the construction stage the facilities manager plays more of a monitoring and supervisory role and shares this with other team members (Latham, 2001). Shah (2007) adds that the monitoring role is to ensure that all sustainability issues during construction and the processes that will affect operations at the occupancy stage are effectively managed. With reference to the BIFM Operational Readiness (2016), the facilities manager's role at this stage also includes ensuring that the operational impact of design changes is considered before implementation on site. At the handover stage, after the building and its services have been commissioned, the facilities manager continues the monitoring role while this ends for other consultants and the contractor. Shah (2007) argues that the last two decades have seen significant growth in FM, as a result of this emerging role.

With reference to Figure 9.3 the facilities manager at the construction stage under the environmental aspect can monitor installation of systems that reduce carbon emissions. Under the social aspect the facilities manager can monitor installation of fittings for visual comfort, installations for acoustic comfort, installations for thermal comfort, and installations for healthy indoor environment. Under the economic aspect the facilities manager can monitor installations for water efficiency, use of recycled building materials; and installations for energy efficiency.

9.5.3 Stage 3 - FM Role at the Operations Stage

Stage 3 of Section B of the framework consists of the operations stage which is the in-use stage. At this stage buildings are put in use and the facilities manager's responsibilities majorly include: management and control of maintenance strategies and maintenance costs; management and control of operating activities and operating costs; collection and analysis of FM data for improvement (El-Haram and Agapiou, 2002). According to Fennimore (2014), the facilities manager's job at the operations stage incudes maintenance of operations which involve activities that provide a comfortable, healthy, safe and productive environment for occupants.

Figure 9.3 shows the facilities manager's role at the operations stage. Under the environmental aspect the facilities manager can coordinate waste management and maintain systems for minimisation of carbon emissions. Under the social aspect, the facilities manager, can maintain installations that provide visual comfort, systems that provide acoustic comfort, systems that provide a thermal comfort, systems that provide safe access and security, can execute space management plan and ventilation equipment and outlets.

In order to respond to the economic aspect, the facilities manager can monitor water consumption, maintain the building and its services and monitor energy consumption. It is also at the operations stage that the facilities manager can carry out his roles under the management aspect and these include: consulting with building users, monitoring technology trends and innovation in the buildings, assessing the application of technology within building operations, incorporating and managing building management systems, establishing legal and contractual environmental management initiatives, and developing initiatives that educate building users on sustainability issues. The achievement of the facilities manager's role at the operations stage should lead to sustainable buildings.

9.6 Section C: Drivers and Barriers to FM Role in Sustainable Buildings

Barriers and drivers to sustainable building practice have been discussed earlier on in this research. The barriers against sustainable building practice include: lack of education on sustainable buildings, lack of adequate knowledge in relation to sustainable building constituents, perceived higher upfront costs, split incentives, lack of government policies and building services as an afterthought (Smith and Baird, 2007; Gleeson and Thomson, 2012; Murray and Cotgrave, 2007; Häkkinen and Belloni, 2011; Rydin *et al.*, 2006; Djokoto *et al*., 2014).

Drivers to sustainable building practice include: increase in the awareness of clients about the benefits of sustainable building, the development and adoption of methods for sustainable building requirement management, the mobilization of sustainable building tools, the development of designers' competence and team working, and the development of new concepts and services (Tarja and Belloni, 2009).

These barriers and drivers also act as barriers and drivers to FM role in sustainable buildings. The argument is that, if certain factors prevent sustainable buildings from being achieved, and then it invariably prevents the existence of sustainable buildings and provides no opportunity for the facilities manager to perform his or her role in sustainable buildings. For example, when the government is not aware of sustainable building, it will not develop policies that promote sustainable buildings. In this same light, when people are generally not aware of sustainable buildings, they might not appreciate the facilities manager's role in achieving sustainable buildings. Other examples are the lack of locally based building material manufacturing industries is directly related to barriers to sustainable building practice, lack of building industry standards, too much bureaucracy in housing policies, and low maintenance culture.

9.6.1 Barriers to FM Role in achieving Sustainable Buildings

Figure 9.4 shows 10 most ranked barriers against the promotion of the facilities manager's role in sustainable buildings and represents Section C of the framework. Barriers to the facilities manager's role in sustainable buildings have been discussed in Section 9.6. These barriers include: lack of awareness among building professionals, the public and the government about FM role in sustainable buildings, lack of FM skill, lack of technical skill expertise in the construction industry, lack of training of building professionals in design and construction of sustainable building, social integration and cultural background in relation to non-appreciation of sustainable building, lack of incentives for sustainable building implementation among developers and so on.

The 5 topmost barriers are: lack of acceptance of FM role at design and construction stages; lack of incentives for sustainable building implementation among developers; lack of awareness among public about FM role in sustainable building; non-affordability by the public and lack of government financial support, and lack of government policies or legislation to support implementation of FM role in sustainable building. These barriers are consistent with the findings of Elmualim *et al.*, (2010) and Ikediashi *et al.*, (2012) as highlighted in Section 8.6 .

The lack of awareness among building professionals and the government could be as a result of inadequate promotion of FM role in sustainable buildings by relevant professional bodies and which has led to the lack of industry structure to promote FM in sustainable buildings. The lack of awareness by building professionals has made it difficult for the design and the construction teams to accept FM role at the design and the construction stages. Low awareness among government about the benefits of sustainable building can lead to lack of government policies or legislation to support implementation of FM role in sustainable building and which can lead to lack of government financial support towards sustainable buildings. The government has been identified as the biggest financier of sustainable buildings as stated in Section 8.7.1. When the government does not financially support the development of sustainable buildings, it makes it difficult for developers to access the huge capital needed to develop these buildings. Developers therefore, go after loans with high interest rates and which they recover from the lease to the building users. In relation to lack of FM skills, facilities managers often seem to lack basic skill that is needed to implement sustainability procedures (Finch and Clements-Croome, 1997; Elmualim *et al.*, 2012).

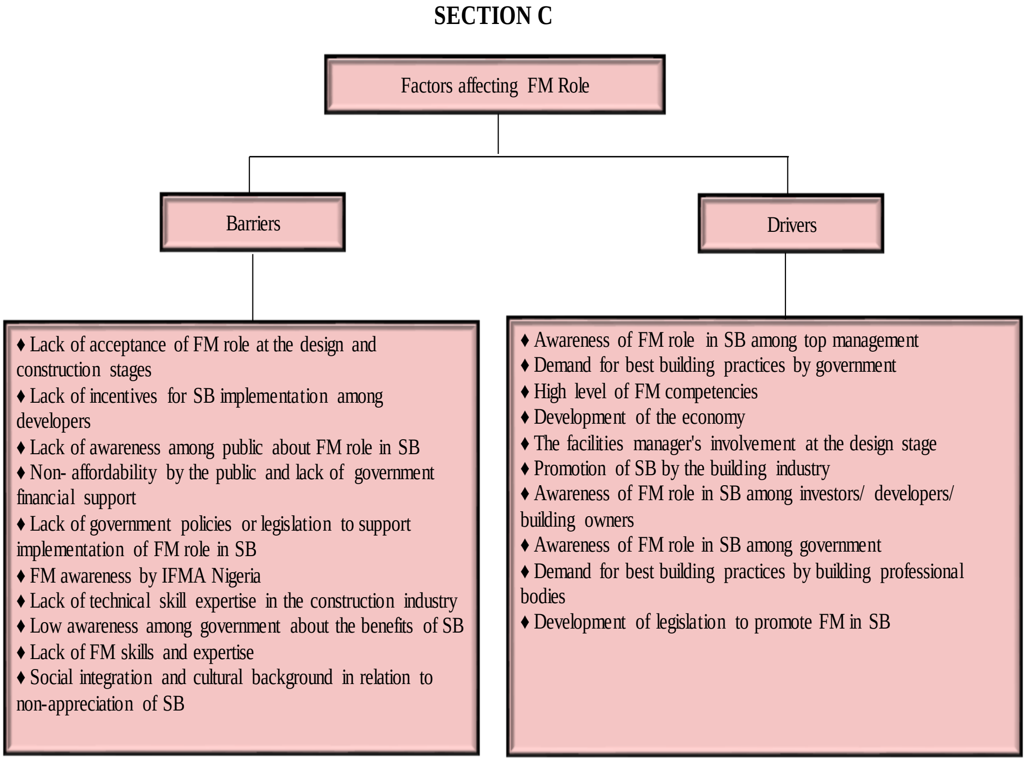

Figure 9.4: Barriers and Drivers to FM Role in Sustainable Buildings

9.6.2 Drivers to FM Role in achieving Sustainable Buildings

Figure 9.4 shows 10 most ranked drivers towards the promotion of the facilities manager's role in sustainable buildings and represents Section C of the framework. The topmost 5 drivers from the findings of the research are: awareness of FM role in sustainable building among top management in organisations, demand for best building practices by government, high level of FM competencies, development of the economy, and the facilities manager's involvement at the design stage.

Drivers such as awareness of FM role in sustainable building among top management have been confirmed by Elmualim *et al.*, (2010) and Price *et al.*, (2011) as a driver towards the achievement of FM role in SD. Therefore, it can be inferred that this driver contributes to sustainable building. The development of legislation to promote FM in sustainable building, awareness of FM role in sustainable building among government, and the demand for best building practices by government have been identified by Elmualim *et al.*, (2012) and Kamaruzzaman and Zawawi (2010) as drivers to FM role for sustainable practice. Pitt and Hinks (2001) suggest that an increase in the awareness of FM role will increase the value attached to FM. Therefore, this research study suggests that awareness of FM role in sustainable building among professional bodies, awareness of FM role in sustainable building among investors/ developers/ building owner and awareness of FM role in sustainable building among building users; will pave way for the achievement of sustainable building.

If barriers such as lack of acceptance of the facilities manager's role at design and construction stages, lack of awareness FM role in sustainable building and lack of government policies or legislation to support implementation of FM role to achieve sustainable building, can be overcome; and drivers such as awareness of the facilities manager's role in sustainable building among top management in organisations, high level of competency by the facilities manager and increase in involvement at the design stage are encouraged; It will boost the achievement of sustainable buildings in Nigeria through the facilities manager's role.

This research is presented on the premises that the facilities manager's competence in relation to sustainable building will promote sustainable buildings (Elmualim *et al.*, 2012). Hence, the research advocates for the development of FM competencies by international FM associations in relation to the constituents that make a building sustainable in order for facilities managers to be better equipped in the specific roles that will make them to contribute to a building's sustainability. The benefit of facilities manager's involvement at the design stage has been discussed in Section 4.5.1 to 4.5.3.

9.7 Expected Benefits of the Framework

The framework gives details of what constitutes a sustainable building and the facilities manager's role in relation to environmental, social, economic and the management aspects, and in relation to design, construction and the operations stages of the building life-cycle. The framework shows barriers that need to be overcome in order to achieve of sustainable buildings. The framework also indicates drivers that could encourage FM role in achieving sustainable buildings. The framework, therefore, serves as a non–prescriptive guide for achievement of sustainable building through the FM role. It provides guidance for the achievement of sustainable building through the facilities manager's role.

The framework shows 5 major steps which are considered appropriate for the delivery of sustainable buildings by facilities managers. The effectiveness of facilities managers in the execution of these steps should help in the achievement of sustainable buildings. These steps are:

- Step 1: Identification of sustainable building constituents.
- Step 2a: Initiation of the building financier or owner about the facilities manager's role in achieving sustainable buildings and particularly at the briefing and design stage.
- Step 2b: Integration of the facilities manager into the design team.
- Step3: Give advice on designs and maintainability checks for compliance with sustainability.

- Step 4: Monitoring of installations for compliance with approved designs that will be managed at the operations stage.
- Step 5: Management of operational services within the building to achieve sustainability.

The facilities manager needs to be able to identify what makes up a sustainable building; this is required as a foundation for the facilities manager's competence in sustainable buildings. Though the facilities manager's activities adequately fit into sustainable practices, it is still needed to identify specific roles that will help in achieving sustainable buildings. The facilities manager needs to have a comprehensive knowledge of the constituents of a sustainable building. This can enable the facilities manager effectively advise on each constituent that makes a building sustainable. When the facilities manager is adequately knowledgeable, he can confidently introduce FM role to the building owner or financier and can also integrate himself into the design team.

Due to the facilities manager's competency in the environmental aspect at the operations stage, the facilities manager can offer advice on building services designs, ventilation designs, water and energy efficiency designs, waste management plan etc. A facilities manager can be in the position to check these designs for ease of maintenance. At the construction stage of a building, the facilities manager can play a monitoring role to ensure that all agreed designs are implemented.

9.8 Validation of the FM Framework

Yahaya (2008) explains that a framework validation process can take the form of either validating a conceptual model, or computerised model, or operational model or data used to construct and validate a framework. The framework developed for this research study was adopted from the initially constructed conceptual model developed from data obtained from literature review and content analysis. Therefore, the validation process for this research study is of a conceptual model form.

Patton (1987) defines validation of framework as a scientific method used in evaluating whether the objectives of a research aim have been achieved. The main reason for validating a framework is to test the workability and practicability of the framework so as to measure if the framework fulfils the purpose for which it has been developed. According to Martis (2006), the purpose of validating a framework is to ensure that it provides appropriateness of structure, logical sequence, effectiveness, practicality and clarity. It involves verifying research evidence through from the view point of others (McNiff and Witehead, 2010) which can be done through interviews, questionnaires and video-recordings. Validation of a framework can be achieved by seeking experts' opinion and feedback (Alan, 1999) and which could be through a qualitative approach or a quantitative approach (Shaw, 1999).

The validation of the developed framework for this research was done by FM experts in Nigeria using open-ended questions that reflected all the aspects of the research (see questions below). The validation process started by identifying potential participants which involved four (4) FM experts who are viewed qualified to help in validating the framework; The research took into consideration their years of experience, professional backgrounds, and position held and type of firm they work for. These criteria are as explained below and details are as shown in Table 9.2:

- Professional backgrounds: A professional background qualifies a person in a particular area of expertise. The participants chosen are FM experts with building professional background.
- Their years of experience: Years of experience usually qualifies for competence and expertise and adequate knowledge in a particular field of study. Therefore, the information given by the participants can be relied on. The participant with the least years of experience is Participant 3 with 14 years' experience, followed by Participant 4 with 18 years' experience; while Participant 1 and 2 have over 20 years' experience.
- Position held: Their position indicates that they are responsible and there is high level of credibility with regards to any information given by them. As shown in Table 9.2, the participants all hold senior positions of responsibility.
- Type of firm they work for: This includes two (2) international and two (2) reputable local FM companies. The firms they work for is relevant so as to have representation of views from both international and local firms.

The research also took into consideration their interest in buildings in Nigeria attaining sustainability standards and their being involved in sustainable building developments. Their involvement in such building projects from the design stage right through to the operations was similarly considered. This criterion was included so that the framework can be validated by facilities managers who have been involved in projects from the inception process of a building life-cycle and can comment on the validity of the framework from an informed angle.

Table 9.2 Participants Information for Validation of Framework

Participants	Years of Experience	Professional Background	Position Held	Type of Firm
PI	Over 20 years	Estate surveying	Managing Director	International/Local
P2	Over 20 years	Building services M&E	Managing Director	Local
P3	14 years	Building surveying	Senior Builder	Local
P4	18 years	Building services M&E	Head of FM Division	International

The four (4) potential participants were identified in the course of the interviews and included 1 FM professional who has worked with a reputable international FM company based in Nigeria and now manages a local FM company, 2 FM professionals who currently work with respected local FM companies and 1 FM professional that works with one of the few reputable international FM companies based in Nigeria. The developed framework, details explaining the framework and questions were sent out to the participants via email after seeking their consent for participation in the validation process. The open ended questions covered the following aspects:

- Comprehensive nature of the main concepts represented in the framework
- Depth of information in each section of the framework
- The ease of understanding of sustainable building constituents and facilities manager's role in sustainable buildings, logic, or flow of the framework
- Practicability of the framework to FM role in sustainable building practice
- Areas considered for improvement or not necessary.

The questions are as below:

1. In your own opinion does the framework cover the constituents of sustainable building from the environmental, economic, social, and management aspects in the Nigerian contest?
2. Has the framework covered the facilities manager's role in sustainable buildings at the design, construction and at the operations stages?
3. Has the framework covered barriers and drivers to the facilities manager's role in achieving sustainable buildings in Nigeria?
4. In your own opinion can the framework be understood in terms of arrangement of the sections, flow of concepts, simplicity of contents or logic of the construction?
5. To what extent do you think a framework of this nature would help the FM profession towards sustainable buildings in Nigeria?
6. Do you find this framework useful for achieving sustainable buildings?
7. To what extent do you agree that a framework of this nature is needed in the Nigerian building industry?
8. Do you have any suggestions towards the improvement of the framework?
9. Are you aware of any framework of this nature that has been developed for FM in Nigeria?
10. Please, state your years of experience, professional background, and position held in your company and the type of firm you work for, whether international FM firm or local FM firm?

The following section provides discussions on the participants' responses to the above stated questions.

9.9 Participants' Responses on the Developed FM Framework

Response from participants was not detailed enough, therefore, simple content analysis was used to analyse their response. The participants all have positive views about the framework and there is no area of disagreement concerning the content and practicability of it. They all agreed that the content is detailed enough and easy to understand. Below are some of the major contributions captured from the comments made by participants on the framework:

"*The framework is exceptionally easy to understand and has captured all the ingredients of sustainable building. The framework has been presented in such a way that if any facilities manager follows it religiously or is given the opportunity to follow it religiously by the client and the project team, it will effectively guide towards sustainable building in Nigeria. In fact, I believe the framework is not only useful in Nigeria but in any part of the world*" - Interviewer P1

"*The framework can definitely work. I must admit that I am impressed with its wide coverage of issues pertaining to facilities managers in aligning with sustainable development for buildings. However, the government is the major driver towards sustainable practices in the building industry. If policies are in place, facilities managers will find it easier to carry out the roles covered by the framework*" - Interviewer P2

"*This a fantastic outline of the nitty-gritty of our tasks in buildings generally and will work in any building type. If shows how sustainable buildings can be achieved for both new and existing developments*" - Interviewer P3

"*It is interesting to know that we are already carrying some of the functions highlighted in the framework, however, the framework gives a better view of all functions that a facilities manager needs to carry out in order to contribute his quota towards sustainable buildings. The framework covered a comprehensive list of FM roles that should be carried out in order to create a building that can be rated as being sustainable*" - Interviewer P4

Generally, there was a consensus in the opinion of participants that the framework in Section A covers sustainable building constituents and the facilities manager's roles in sustainable buildings at the design, construction and the operations stages as shown in section B. In relation to Section C of the framework, the participants all agreed that the framework to very large extent covers a wide range of issues on the barriers and the drivers to FM role in sustainable buildings in Nigeria. The participants also agreed that the flow and the logic of the framework were clear and simple, not difficult to understand and easy to catch up with.

Overall, the participants felt that the framework provides a checklist that facilities managers can use in achieving sustainable buildings. They all agreed that the framework can help with achieving sustainable buildings if the barriers listed are dealt with and the drivers are promoted.

The participants considered the framework to be a tool that can help promote a greater understanding of sustainable buildings as a whole. It was mentioned that a framework of this nature will be useful for FM profession if facilities managers and key stakeholders understand the concepts of the framework and can form a full curriculum of learning in Nigeria. It was also mentioned that implementation of a framework of this nature can cause a total paradigm shift in the Nigerian building industry as such is needed in achieving sustainability.

Table 9.3 Responses of Participants for Framework Validation

Questions	P1	P2	P3	P4
1 In your own opinion does the framework cover the constituents of sustainable building from the environmental, economic, social, and management aspects in the Nigerian contest?	The elements of environmental, social, economic and management are widely addressed in the framework and thus makes for a good reference for FM professionals, sustainable building architects and project managers	Yes the economic, environmental and social dimensions are well covered	To extremely large extent	To an appreciable level of practicality, this piece covers the constituent for sustainable building within the measured parameters
2 Has the framework covered the facilities manager's role in sustainable buildings at the design, construction and at the operations stages?	The facilities manager's role is well covered in the framework in terms of advisory on sustainable building designs and conceptualisation	Yes it has	To a very large extent	It is an extensive role for the FM and in some instance, there is a limitation in the Nigerian context for inter-role acceptability. This however captures the role of the FM in an ideal scenario.
3 Has the framework covered barriers and drivers to the facilities manager's role in achieving sustainable buildings in Nigeria?	Yes	Yes it does	To a very large extent	I already alluded to this above, this framework is apt in that regard. It has appropriately covered the barriers and drivers.
4 In your own opinion can the framework be understood in terms of arrangement of the sections, flow of concepts, simplicity of contents or logic of the construction?	The sections are in logical sequence and the FM involvement in sustainability is clear	The concept of sustainable building has been simplified by the model	To a very large extent	It is easy to catch up with
5 To what extent do you think a framework of this nature would help the FM profession towards sustainable buildings in Nigeria?	It will be very useful if well understood by facilities managers and key industry players and adapted to suit our local environment and current level of development	It will help facilities managers understand what they need to do to create sustainable buildings	To a very large extent	This can form a full curriculum of learning
6 Do you find this framework useful for achieving sustainable buildings?	Yes	Yes I do	Yes	Absolutely
7 To what extent do you agree that a framework of this nature is needed in the Nigerian building industry?	Same as 5 above.	It is much needed	To extremely large extent	It will be a total paradigm shift
8 Do you have any suggestions towards the improvement of the framework?	A copy of the Nigeria FM Roundtable for the World FM Day of Year 2015 will be quite useful.	No	This is a very comprehensive framework with practical relevance and as such, there is no	None
9 Are you aware of any framework of this nature that has been developed for FM in Nigeria?	No	No	No	Yes, but may be not this detailed

The comments above were useful and can be considered as significant for validating the developed FM framework for achieving sustainable buildings in Nigeria.

9.10 Chapter Summary

This chapter has helped to achieve the aim and the objectives of this research as stated in Section 1.3. The chapter presents a framework for achieving sustainable buildings through the facilities manager's role. The framework presents the constituents that make up a sustainable building, the facilities manager's role in relation to the achievement of sustainable buildings and also presents barriers and drivers to FM role in achieving sustainable buildings.

The framework serves as a vital guiding tool for enhancing the facilities manager's role at the design, construction and operations stages of the building life-cycle. The framework presents the processes in which the facilities manager contributes to the achievement of sustainable buildings. The facilities manager starts this role by identifying sustainable building constituents and identifying what FM role is in relation to these constituents. The facilities manager then proceeds to introduce and educate the client or owner of the building about the facilities manager's role at the design stage and the benefits of engaging FM right from the briefing stage. The facilities manager initiates and integrates FM role into the project team by implementing all decisions made at the design stage in the construction stage. The facilities manager then manages the operations stages. The goal of this developed framework is to help guarantee a sustainable environment, comfort and health, and a functional and economical building for the building user.

CHAPTER 10: CONCLUSION AND RECOMMENDATION

10.1 Summary

The building industry has developed sustainable building practices in the bid to reduce the negative impact of buildings on the environment. Research studies have highlighted buildings as a major contributor to greenhouse gases, the major consumption of substantial amounts of energy and water, and vast land usage. This has led many governments to develop policies to encourage sustainable construction in order to produce sustainable buildings. Sustainable buildings have been identified in literature as buildings that aim is to use resources and energy minimally and efficiently, reduce greenhouse gas emissions, promote the health of occupants by providing indoor air quality, thermal, visual, and acoustic comfort. Literature has also revealed the sustainable practices that facilities manager's carry out in efforts towards achieving sustainable buildings.

The Nigerian building industry has made some efforts in developing sustainable buildings. However, there is limited literature for identifying the sustainable buildings in Nigeria. In addition, there is a lack of evidenced-based literature for identifying the facilities manager's role in sustainable buildings in Nigeria. Therefore, the primary aim of this research study seeks to develop a framework that will identify sustainable building constituents with regards to the building industry in Nigeria and the role facilities managers can play in sustainable buildings. The research sought to address the following objectives:

1. Identify the constituents of sustainable building with reference to internationally recognised standards.
2. Evaluate the role of FM in relation to sustainable building at the design, the construction and operations stages of the building life-cycle.
3. Develop a conceptual framework that shows the facilities manager's role in sustainable buildings.
4. Evaluate the perception of facilities managers on the extent of FM practice in relation to sustainable buildings.
5. Investigate the drivers and barriers to FM in achieving sustainable buildings.
6. Develop and validate a framework for sustainable building practice for FM in Nigeria.

The aforementioned aim and objectives were achieved through a three-stage research approach mentioned below.

- The first stage consisted of two steps; literature review and content analysis of documents. The first step included a critical review of literature on SD and its impact on the building industry which has led to the production of sustainable buildings. The literature review produced 28 sustainable building constituents and assisted in establishing a background understanding of what a sustainable building is and the constituents that make it up. The literature review also assisted in establishing a background understanding of the facilities manager's functions that relate to sustainable buildings.

The second step examined documents by content analysis. This involved 3 documents (BREEAM-NC, LEED-NC and ISO 15392) and 4 documents that could be used in identifying the facilities manager's role in sustainable buildings. These documents are Skills in Facilities Management Investigation into Industry Education; the IFMA Complete List of Competencies as defined in the Global Job Task Analysis; the BIFM Facilities Management Professional Standards Handbook; and the RICS Assessment of Professional Competence Facilities Management Pathway Guide.

The content analysis produced 51 sustainable building constituents as shown in Table 3.2. These include 19 under the environmental aspect, 12 under the social aspect, and 6 under the economic aspect. The research discovered a fourth aspect of SD in relation to buildings and this is the management aspect. This aspect comprises of 14 constituents which are processes already in place in conventional buildings. However, they are identified as necessary procedures that are needed in achieving sustainable buildings. This comprehensive number of sustainable building constituents has not been identified previously in literature.

The content analysis also produced 44 roles that the facilities manager carries out at the design, construction and operations stages of the building life-cycle to achieve sustainable buildings (see Table 4.2). The roles are categorised into the environmental, social, economic, and management aspects of SD. These roles include 9 under the environmental aspect, 17 under the social aspect, 10 under the economic aspect, and 8 under management aspect. The roles of the facilities manager are yet to be identified in literature. This finding provides improved knowledge and understanding of the facilities manager's role in the achievement of sustainable buildings in Nigeria..

- The second stage similarly included two steps comprising of 20 interviews and a questionnaire survey of 139 facilities managers who are members of IFMA Nigeria. The first step involved interviews conducted to determine the view of facilities managers with regards to the constituents of a sustainable building in Nigeria and the facilities manager's role in sustainable buildings. The first step also was used to determine the participants' perception on the extent of FM practice towards sustainable buildings. The findings of the interview produced 8 sustainable building constituents and 20 FM roles in sustainable buildings in Nigeria. The second step involved a questionnaire survey and produced 51 constituents critical to achieving sustainable buildings in Nigeria and 44 FM roles in sustainable buildings in which facilities managers in Nigeria have competency. The interviews were also conducted to identify barriers and drivers to the facilities manager's role in achieving sustainable buildings. The findings of the interviews produced 18 barriers to the facilities manager's role in achieving sustainable buildings in Nigeria and 17 drivers to this role as shown in Section 8.6 and 8.7. The findings of the interviews and questionnaire survey were used to refine the conceptual framework developed in stage 1. The second stage addressed Objectives 4 and 5 of the research.

Stage three is the development of a framework for sustainable building practice in Nigeria. The achievement of Objectives 1, 2, 3, 4, and 5 assisted in developing the framework for achieving sustainable buildings through the facilities manager's role in Nigeria. The framework was validated by four (4) FM experts who validated the framework by answering open ended questions as found in Section 9.8. This third stage helped in achieving the overall aim of this research study.

10.2 Conclusions of the Research

The main findings of this study are chapter specific and were discussed within the respective chapters, presented as follows: the role of sustainable development (SD) in the building industry and as the initiator of sustainable construction (SC) and which in turn has birthed sustainable buildings (Chapter 2); what constitutes a sustainable building (Chapter 3) and the facilities manager's role in sustainable buildings (Chapter 4); and sustainable buildings, barriers and drivers to the facilities manager's role in sustainable buildings in Nigeria (Chapter 7 and 8); and a framework that can be used in achieving sustainable buildings in Nigeria through the facilities manager's role (Chapter 5 and 9). Based on the above, this section seeks to present the conclusions of the findings to the aforementioned objectives of this study.

10.2.1 SD and the Building Industry

Sustainable development (SD) has been recognised as the integration of the environmental, social, and economic dimensions; in order to satisfy human needs, attain a viable economy and a healthy environment. It is making provision for people now and in the future to meet their aspirations for a better life by improving economic development without depleting the limited natural available resources, and without harming the environment. In the process of assessing the progress of SD, it has been being applied to various industries and in particular the construction industry due to the significant negative impact that buildings have on the environment. The building industry contributes to environmental pollution at different stages of the building process. The processes include the manufacture of building materials, the construction process itself, the operational process when buildings are in use and produce a number of greenhouse gases and pollutants caused by synthetic chemicals used in the construction process. Buildings also consume a significant amount of energy from fossil fuels, nuclear power, hydropower and wind power used during these various processes. Yet, these same buildings also provide a place for people to live, socialise and work in and can serve as long term assets.

Therefore, in order to maximise the efficacy of buildings, the environmental, social and economic aspects of SD have to be applied to the construction process. However, the research discovered that in order to apply these three aspects, a fourth aspect which is the management aspect of SD needs to be introduced. The application of these four aspects of SD has led to the development of sustainable construction which is a process of producing buildings in an environmentally friendly manner, in terms of production and use of products that are not harmful to the environment and human health. It similarly involves the efficient use of renewable and non-renewable energy during production of building materials and the operational phase and waste management in order to address climate change. Sustainable construction is expected to assist to reduce the adverse effect of buildings on the environment and improve in the quality of life, health, and well-being. Literature has helped to unveil sustainable buildings as a product of sustainable construction (SC). SC is a process that allows the principles of sustainability to be applied to the design, construction, operations and demolition of buildings. As a process it is not sufficient in itself to meet the human basic need of shelter and comfort, however, needs an end point and which is the development of sustainable buildings. The creation of sustainable buildings has enabled the construction industry to evaluate its progress towards achieving SD.

10.2.2 Sustainable Buildings

Sustainable buildings promote the course of SD, by being designed and built to preserve the environment, people and economy. It is revealed in literature that sustainable buildings have environmental, social, and economic benefits. The environmental benefits include preservation of the environment by reducing emissions, conserving energy and water, use of sustainable materials and reducing waste. The social benefits include improvement of building users comfort in terms of indoor air quality, thermal, visual and acoustic comfort, and water quality. The economic benefits include reduction in energy consumption, reuse of materials, and increase in water efficiency leading to reduced operating costs which increases the demand and market value of buildings. Economic benefits are enhanced due to increased health and comfort of building users, thereby resulting in increased productivity in organisations and which in turn aids economic growth.

An additional benefit of sustainable buildings is emphasis on practices that guarantee the sustainability and in particular management of the building at the operations stage; practices such as post occupancy evaluation, implementation of building user's guide, commissioning of all building services to ensure energy efficient services. Literature as shown that, even though these practices are present in conventional buildings they are highly needed in achieving sustainable buildings. It is clear that the benefits of having sustainable buildings help to improve the environment and people’s lives; therefore, there is need to encourage the development of such buildings.

Evidence shows that buildings that have not been designed to meet sustainability criteria usually have undesirable effects on the environment, quality of life and economy. Undesirable effects include air and water pollution, material wastage, poor health, exhaustion, discomfort, and stress as a result of poor thermal conditioning, indoor air quality, lighting, and material selection and high building cost. Sustainable buildings, however, have been discovered as a solution to reducing these problems through sustainable design. Sustainable building designs include adequate design for energy, water and waste management, and ventilation. These designs take into consideration the performance of the building on long term. Sustainable building in itself is a product of sustainable construction which has evolved from SD.

Findings of this research have revealed certain constituents that make a sustainable building under the environmental, social, economic, and management aspects. The constituents under the environmental aspect include processes that protect the environment; the social aspect includes practices that aid the comfort and well-being of occupants; the economic aspect includes the financial benefits of sustainable building; and the management aspect as mentioned above includes processes that ensure the building’s sustainability at the operations stage. These constituents have been listed and described in Section 3.3 and Table 3.2.

The identified constituents revealed that sustainable buildings in Nigeria are similar to those in the United Kingdom and United States, in the sense that the documents used in investigating the constituents in both countries are similar to that used for investigating same in Nigeria. The research discovered that there are basic features that a sustainable building should have irrespective of geographical location and climatic conditions. These features are those relevant to the reduction of emissions of greenhouse gases, waste management, comfort and well-being of building users, and economical value. However, features such as thermal comfort are most likely to be different due to geographical location. For example, Nigeria is in a sunny warm belt geographical area, and requires building users to be in buildings that are cool all year.

This research study shows sustainable buildings in Nigeria as buildings that have less impact on the environment and manages waste effectively both at construction and during the operational phase. They are buildings that maximise the natural light from sun that is available all through the year for indoor lighting during the day and for solar energy. They similarly include buildings that use materials that have been locally sourced. There is evidence of locally sourced building materials that have been discovered to be sustainable. These include compressed earth blocks made from a mixture of lime and earth, environmentally friendly mortar made from either recycled concrete or masonry rubble fractions and bamboo used for structural works. These materials have been discovered to reduce the overall cost of the building. Sustainable buildings in the Nigerian environment also use energy and water efficiently, manage waste and provide comfort in terms of adequate ventilation and designs that allow emission of heat due to the warm climate. The research has revealed sustainable buildings in Nigeria as buildings that make the best use of the natural environment. Research has shown that contact with nature generates emotional, mental and physiological benefits.

The research provides valuable insight into the components that make up a sustainable building in Nigeria. The identified sustainable building constituents can aid the development of a tool that can be used to assess a building's sustainability in Nigeria. Government legislation can facilitate the development of such a tool specific for the Nigerian built environment. The assessment tool can be used at the design, construction and operations of buildings to achieve sustainable buildings. This will ensure that the building industry aligns with the goal of SD and contribute to Nigeria's efforts towards the meeting the SD agenda.

10.2.3 Role of Facilities Managers in Achieving Sustainable Buildings

Section 10.2.2 above lays emphasis on the benefits of developing sustainable buildings and which according to the findings of this research, can be achieved through the facilities manager's role. The facilities manager's role as a tool to achieving buildings that are environmentally friendly and suitable for occupants is the focus of this research. Findings have revealed that facilities managers have the competence to deliver sustainable buildings because they are involved right from the very beginning of the design process as they are conversant with building operations that affect the performance of the building. Facilities managers are familiar with the building users' perception of a building's optimum performance and what makes them comfortable. They are familiar with energy and water saving strategies in buildings. Therefore, facilities managers can facilitate the achievement of sustainable buildings. There is even evidence to show that if the facilities manager is allowed to work in collaboration with the project manager, issues relating to sustainability and building performance can be more effectively achieved.

The research, however, discovered that there is a dearth of research studies in relation to the facilities manager's role in achieving sustainable buildings in Nigeria. Therefore, more research should be carried out on sustainability and buildings and the facilities manager's role in order that sustainable buildings can be achieved. The findings of the interviews and the questionnaire survey reveal that the role of the facilities manager in sustainable buildings should be encouraged due to the facilities managers' competence in processes that contribute to a building's sustainability at the design, construction and operations stages of the building life-cycle. Facilities managers in Nigeria with the building services background (mechanical and electrical engineers M&E) seem to have better knowledge of sustainability in buildings. This may be as a result of their involvement in services such as electricity, water supply, air-conditioning, mechanical services, and waste management in buildings. These services are critical issues in buildings and if adequately managed can significantly add to the building's sustainability. Therefore, building professionals with this background should be encouraged in the field of FM.

In spite of the facilities managers' competence in achieving sustainable buildings in Nigeria, their role is often hindered majorly by lack of awareness among building professionals, government, general populace about FM role in sustainable buildings. At present, building professionals have not yet understood the role of the facilities manager at the design and construction stages. Therefore, there is a lack of acceptance of their role at these stages and lack of awareness of the benefits of having the facilities manager on the project team. There is generally a non-appreciation of sustainable buildings by the populace and the government. It is believed that government legislation in relation to sustainable building practices will encourage building industry structure, building industry standards and skill training in sustainable buildings, which will support facilities managers in achieving sustainable buildings.

The major drivers that facilitate the facilities manager's role in sustainable buildings include awareness of FM role in sustainable buildings among top management in organisations. Awareness of among investors, developers, building owners and users, and government can also help in promoting FM role in achieving sustainable buildings. The research study has also revealed that IFMA Nigeria needs to promote the competency of facilities managers as a tool to achieving sustainable buildings and particularly the benefit of their involvement from the design stage. Demand for best building practices by government and building professional bodies, will encourage trainings to be organised by IFMA to facilitate the facilities managers' competence in sustainable buildings. Development of legislation to promote the facilities manager's role in sustainable buildings and the government as a major employer of FM services will help promote the FM profession as a promoter of SD.

This section has illustrated that sustainable buildings can be achieved through the facilities manager's role. The building industry can take advantage of facilities managers' knowledge of sustainability issues in buildings and in particular during the operational period. Facilities managers have the expertise to advice on the design of a building to achieve sustainability due to their direct involvement with environmental, social and economic issues in the management of buildings; issues such as management of waste, electricity supply and use, water supply and use, air quality, and visual, acoustic and thermal comfort of the building user. If facilities managers are allowed to carry out this role at the design stage and the designs are implemented during construction, then sustainable buildings can be achieved. The development of these buildings will give facilities managers the opportunity to manage buildings that have been designed to achieve sustainability from the on-set.

10.2.4 Facilities Manager's Framework in achieving Sustainable Buildings

Sustainable building constituents were identified in Section 3.3 and are shown in Table 3.2. The facilities manager's roles that relate to the identified constituents were revealed in Section 4.6 and shown in Table 4.3. The identification of the facilities manager's role in the sustainable building constituents helped in discovering FM as a tool that can help in achieving sustainable buildings. These findings have been used in developing a framework can be used in achieving sustainable buildings. The framework has considerable potential to accelerate the understanding and implementation of sustainability in buildings in Nigeria. The framework provides an overview of the constituents that make a sustainable building and indicates the role that the facilities manager plays in informing the client or the building owner, and the building project team about the constituents and processes that ensure that a building is sustainable.

The framework provides a systematic approach for the facilities manager in ensuring that sustainable buildings are developed for the benefit of the building user. The framework gives detailed information of facilities manager's role and serves as a non–prescriptive guide for achievement of sustainable building through the FM role. The framework should help facilities managers to identify what constitutes a sustainable building in Nigeria, and to appreciate their role at the design, construction and operations stages of the building life-cycle. It is when they understand what their role is, that they can improve their competence in the achievement of sustainable buildings. The framework can be used by facilities managers to effectively perform their role in relations to sustainable buildings. By adopting the framework facilities managers can be at the forefront of sustainability matters in the building industry and invariably provide satisfaction to end users.

For the framework to be effectively utilised, there is a need for the facilities manager to be part of the project team and be involved from the design stage. When the facilities manager is involved from the design stage, and carries out a monitoring role in conjunction with other design consultants and the project manager, this will lead to a building that will most likely perform at its optimum. The facilities manager's engagement in sustainable buildings at the operations stage has the potential to lead to a building that meets sustainability criteria.

At the design stage the facilities manager has the opportunity to influence the building design in such a way as to maximise physical features of the building such as windows and openings for natural light and ventilation. Adequate allowance for natural light saves energy use and adequate ventilation promotes indoor air quality. The facilities manager at the design stage can influence water conservation strategies such as designs for water recycling and low-flow water taps, showers, WCs, and urinals. The facilities manager can also advise on the use of materials that have less impact on the environment and health of occupants. At the operations stage, the facilities manager carries out sustainable practices in the management of the building. In summary, the facilities manager can influence the design of the building to align with the environmental, social, economic, and management aspects of sustainable building and consequently SD.

10.3 Original Contribution to Knowledge

This research contributes to the existing body of knowledge on sustainable buildings by identifying that sustainable buildings can be achieved through the facilities manager's role. The development of sustainable buildings has been the focus of the building industry ever since the advent of SD. The goal towards SD has created awareness of the negative impact that buildings have on the environment and the need to create a more sustainable environment. Therefore, the building industry is continuously working to mitigate these negative effects and one of which is the development of sustainable buildings. Building professionals are therefore, making efforts towards attaining them. For it has been discovered that achieving sustainable buildings is not the job of one individual or profession; but the joint effort of all stakeholders. Yet, there is need to identify the individual roles of all parties in the development of sustainable buildings. This research study has therefore, been able to identify the role that facilities managers can make in relations to their own contribution towards achieving sustainable buildings.

The research study has also been able to develop a framework that can be used as a guide by facilities managers towards achieving sustainable buildings in Nigeria. Firstly, the framework provides improved knowledge and understanding of the facilities managers' role in the development of sustainable buildings at the design stage and which includes the strategic definition stage, preparation and brief stage, concept design stage, developed design stage, and technical design stage. Secondly, the framework shows the facilities manager's role at the construction stage and which includes the handover and close out stage. Thirdly, the framework provides improved knowledge of the facilities manager's role at the in-use stage and which is the operations stage. The framework informs building professionals of what constitutes a sustainable building in Nigeria in relation to the environmental, social, economic, and management aspects. The framework can be adopted by facilities managers in achieving sustainable buildings in different geographical locations other than Nigeria.

10.4 Limitations of the Research

This research was basically limited to the development of a framework for facilities managers in efforts to achieve sustainable buildings. The framework only covers sustainable building constituents in relation to the environmental, social, economic, and management aspects from BREEAM-NC, LEED-NC and ISO 15392 perspectives. The research did not include other sustainability assessment tools and documents that define sustainability in buildings. The framework covers the facilities manager's role at the design, construction and operations stages with regards to the aforementioned aspects in sustainable buildings; however, it does not cover the demolition stage. Data obtained was limited to related literature on sustainable buildings published from 1991 to 2015. Data obtained was also limited to content analysis of 3 documents on sustainable building constituents and 4 documents on the facilities manager's role in sustainable buildings. The participants involved in both the interviews and the questionnaire survey were limited to members of IFMA Nigeria. Other limitations of the research are as follows:

- It is was obvious that participants of the interview survey had limited knowledge of what constitutes a sustainable building and these are from facilities managers perspectives in Nigeria; responses were not in-depth as the participants were only able identify few constituents. Therefore, the findings of the interviews alone were not adequate to determine sustainable buildings in the Nigeria context and the facilities manager's role in sustainable buildings. However, detailed information had been obtained from the content analysis, which was used in the questionnaire survey for both the identification of sustainable building constituents and the facilities manager's role in sustainable buildings in Nigeria.

- The questionnaire survey had a low response rate of 15% as only 139 out of 907 members of IFMA Nigeria responded to the survey. This might have been as a result of the questionnaires being sent as an attachment to email and the low number of people that have access to internet facilities in the country. This might also be as a result of participants not having much knowledge about sustainability in buildings. It was also discovered that 63.3% of the participants have building services M&E backgrounds as against those with architecture backgrounds who were 10.8% of the population who participated in the survey. Those with quantity surveying backgrounds were 8.6%, estate management background 6.5% and building surveying background 0.7%. This indicated an uneven distribution among survey participants; therefore, the research analysis was based on the years of experience of the participants.

  The methods of data analysis were limited to simple descriptive analysis and non-parametric tests such as Criticality Index, Kruskal-Wallis test, Mann-Whitney, and

Relative Importance Index. These methods were used helped in achieving the objectives of this research study, nonetheless, they strengthened the empirical findings.

- The framework needs to be tested on a real life project from the strategic definition stage to the in-use stage, in order to validate its practical use. Due to exigency of time, the facilities managers who were given the framework to validate could not test the framework on any actual project and therefore, the research cannot identify its practicality. The framework can however, be used as a guide by facilities managers in the achievement of sustainable buildings.

10.5 Recommendations and Future Research

Based on the findings of this research, there is evidence to suggest the Nigerian building industry from FM perspective is currently not sufficiently aware of what constitutes a building sustainable in the Nigerian context. This can adversely affect facilities managers in fulfilling their role in achieving sustainable buildings as the enabling environment to carry this role is lacking. Facilities managers will often be confronted with non-cooperation from their other building professionals due to their limited understanding of sustainable buildings. There is a need to promote the facilities managers' contribution to the concept of sustainable building. Exploring the following recommendations can assist in encouraging the facilities manager's role in achieving sustainable buildings in Nigeria.

10.5.1 Recommendations for Stakeholders

- It is obvious that facilities managers can make significant contributions to sustainable buildings. However, it requires the collaborative efforts of all members of the building project team. The architect and the M&E building services engineers in particular need to closely work with facilities managers who have vast knowledge of a building's operations and performance and handle sustainability issues as part of the day to day operations in buildings. While the other professionals end their role at the end of the construction stage, the facilities manager usually stays with the building during the operations stage and till the end of its life. The facilities manager is, therefore, qualified to share from his wealth of experience on a building's sustainability and building performance from the view of building users. This will ensure buildings meet sustainable building standards and are delivered to give optimum performance.

- It is recommended that project managers gain understanding of the benefits of initiating the facilities manager earlier enough into the design process. At the design stage, the project manager can collaborate with the facilities manager who is an expert in the management of buildings and sustainability matters in building operations in order to deliver better functioning buildings. The facilities manager's expertise in energy and water management, waste management, provision of comfort etc. enables him to make useful contributions at the design stage.

- It is recommended that the architect who is in charge of the physical design of the building, work hand in hand with the facilities manager in order to have a thorough understanding of how to merge aesthetics of the building with sustainable functioning. The M&E building services engineer who is majorly responsible for designing for provision of electricity, heat, cooling, water supply etc. needs to collaborate with the facilities manager in order to have a better understanding of the performance of the aforementioned services at the operations stage in relation to the building's sustainable performance.

- It is also recommended that the facilities manager educates the owner/client of what a sustainable building is and the need to develop such. The facilities manager should also educate the owner/client of the rewards of having the facilities manager to start FM role from the design stage. The owner/client has a lot of influence on whether the facilities manager is called into the project team at the design stage or not, as the client is the financier of the project and can request for the facilities manager to be his eyes and hears on the project.

- There is need for the government to develop policies that will create an enabling environment for the promotion of sustainable buildings. The government should develop policies that will ensure that building professionals develop buildings that are sustainably designed, constructed and operated so as to achieve sustainability in the building industry. The government should also develop policies that will encourage the facilities manager role in achieving sustainable buildings. The government should provide funds for developers to borrow at reasonable rates in order to encourage development of sustainable buildings. This is needed particularly, in a developing country like Nigeria, where sustainable building practice is limitedly currently practiced.

10.5.2 Recommendations for Future Research

- This research has identified a total of 51 sustainable building constituents with 19 constituents under the environmental aspect, 12 under the social aspect, 6 under the economic aspect, and 14 under the management aspect of SD. However, there is probably more empirical studies that can be conducted to identify more constituents under each of these aspects. This may be essential in order to expand the scope for further research in relation to sustainable buildings.

- This research also identified 44 roles that the facilities manager can carry out at the design, construction and operation stages of the building life-cycle in achieving sustainable buildings. These are 9 roles under the environmental aspect, 17 roles under the social aspect, 10 roles under the economic aspect, and 8 roles under management aspect. More empirical studies that can be conducted to identify additional FM roles in relation to sustainable buildings.

- The identification of the sustainable building constituents and the associated facilities manager's role was used in developing a framework that facilities managers can use as a guide for achieving sustainable buildings in Nigeria. Further research can be conducted to develop a framework that can incorporate the facilities manager's role and the roles of other building professionals to achieve sustainable buildings. This would be needed in order to provide a framework that is robust for the building industry's wide application involving all building professionals in achieving sustainable building practice.

- The research study is based on the opinion of facilities managers who have various backgrounds in building industry. This research therefore, recommends further research to determine the opinion of other building professionals, developers, and building users in Nigeria in relation to what they perceive as sustainable buildings. It is believed that this will foster increase in understanding and awareness of sustainable building developments among all the building industry professionals and help with the SD goal in Nigeria.

- The research also recommends further research to determine what other building professionals understand as the facilities manager's role towards sustainable buildings. It is believed that this will encourage the FM role in sustainable buildings. It is believed that this will not only help the FM practice to moderate its contribution to sustainable building and SD but will also add to understanding individual professional attributes and how they can each contribute to sustainable building practices.

- This research recommends further research for the development of FM competencies specific to the roles that relate to constituents that make a building sustainable in order for facilities managers to be better equipped in the specific roles that make them contribute to a building's sustainability.

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APPENDICES

APPENDIX A: ETHICS APPROVAL

University of Central Lancashire

Dear Olayinka,

Re: STEMH Ethics Committee Application
Unique Reference Number: STEMH 298_4th Stage

The STEMH ethics committee has granted approval of your proposal application 'Development of a Facilities Management Competence Framework for Sustainable Building Practices in Nigeria'. Approval is granted up to the end of project date* or for 5 years from the date of this letter, whichever is the longer.

Yours sincerely,

Kevin Butt
Vice Chair
STEMH Ethics Committee

26th March 2015

Andrew Smith/Olayinka Oluseyi Olaniyi
The Grenfell-Baines School of Architecture, Construction & Environment
University of Central Lancashire

Dear Andrew/Olayinka,

STEMH Ethics Committee Application Unique Reference Number: STEMH 298

The STEMH ethics committee has granted approval of your proposal application 'Facilities Management Approach for Achieving Sustainable Commercial Buildings in Nigeria'. Approval is granted up to the end of project date* or for 5 years from the date of this letter, whichever is the longer.

It is your responsibility to ensure that

- the project is carried out in line with the information provided in the forms you have submitted
- you regularly re-consider the ethical issues that may be raised in generating and analysing your data
- any proposed amendments/changes to the project are raised with, and approved, by Committee
- you notify roffice@uclan.ac.uk if the end date changes or the project does not start
- serious adverse events that occur from the project are reported to Committee
- a closure report is submitted to complete the ethics governance procedures (Existing paperwork can be used for this purposes e.g. funder's end of grant report; abstract for student award or NRES final report. If none of these are available use e-Ethics Closure Report Proforma).

Yours sincerely,

Gill Thomson
Vice Chair
STEMH Ethics Committee

APPENDIX B: CONSENT FORM

Title of Project: Development of a Facilities Management Framework for Sustainable Building Practices in Nigeria

Researcher: Olayinka Olaniyi, PhD Student, University of Central Lancashire, UK (OOOlaniyi@uclan.ac.uk)

Director of Studies: Dr Andrew Smith, University of Central Lancashire, UK (AJSmith3@uclan.ac.uk, Tel. 0044 (0)1772 89 4208)

1. I understand that my participation in the above study will involve answering interview questions. ……………………………….. (Initials of participant)
2. I understand that the data from my interview will be used within reports, publications or presentations generated from this study, will not be disclosed for any other purpose, and I will not be identifiable. (Initials of participant)
3. I understand that my participation is voluntary and that I am free to withdraw at any time without giving reasons. ……………………………….. (Initials of participant)
4. I understand that I do not have to answer all the questions and I may end the interview at any time, without giving a reason. ……………………………….. (Initials of participant)
5. I understand that the interview will be audio recorded and I consent to this. ……………………………….. (Initials of participant)
6. I understand that I can withdraw any information given by me for the purpose of the study up until final analysis of the data. ……………………………….. (Initials of participant)
7. I agree/do not agree (delete as appropriate) to take part in the above study. ………………………………..

Name of Participant --- Signature ----------------------------
Date ------------------------

Name of Researcher --- Signature ----------------------------
Date -------------------------

APPENDIX C: INTERVIEW QUESTIONNAIRE USED IN THIS STUDY

Research Title: Facilities Management Approach for Achieving Sustainable Commercial Buildings in Nigeria.

Aim of Research Study: This research aims to develop a conceptual framework that will embed FM practice into the building life-cycle to achieve sustainable commercial buildings in Nigeria.

The interview will be addressing facilities management (FM) practitioners who are qualified International Facility Management Association (Nigerian Chapter) members. The aim of the interviews is to address Objective 3 and Objective 4 of the research study and is as stated below:

Objective 3 of the research: To ascertain the perceptions of FM practitioners with regard to FM in achieving sustainable building (SB) and evaluate the extent of FM practice in relation to SB in Nigeria.

Objective 4 of the research: To investigate the drivers and barriers to FM in relation to SBs in Nigeria.

Interview Questions Addressing Objective 3 and Objective 4.

Section one:

This section attempts to obtain the general information about the participant and some background information about the firm/Organisation.

1. What position do you hold in your company?

2. What years of experience in FM do you have?

3. What level of IFMA membership are you?

4. What is your job description?

5. What type of Organisation do you work for? (E.g. FM consultant, FM supplier (single service or multi-service), Total FM provider, non-FM Company (providing in-house FM services to an Organisation not primarily in the FM industry).

6. What main industry sector(s) do you operate within? (Commercial, Healthcare, Education, Banking, Government, Sports, Manufacturing etc.)

Section Two:

This section attempts to obtain information from the participant about his/her perception of FM role in sustainable building in Nigeria and the questions are as below:

1. What do you consider FM role involves in Nigeria?

2. In your view, what do you consider as FM's main role(s) during the operation stage of a building in Nigeria?

3. Do you think that FM has any role to play outside of the operation phase, e.g. in design or construction? If so, what do you consider it to involve?

4. Is FM widely practiced in Nigeria? If YES what is the general perception of the FM profession? (i.e. is it recognised by the government? Is it recognised by other professionals in the building industry? Is it recognised by the public?) If no, why do you think that's the case?

5. Do you think FM has a role in sustainable development? If so, what is that role?

6. Are you familiar with the sustainable building concept? YES / NO

7. If YES, in your own opinion what is a sustainable building?

If the answer to Question 7 is NO, a simple definition of sustainable building (SB) will be given to the participant, so they can answer the questions below. The definition to be used is: ‘A sustainable building can be defined as a building characterised by reduced energy consumptions and reduced greenhouse gas emissions, reduced water consumption, reduced impacts on the health of building users and the environment throughout its life-cycle and high affordability for masses’.

8. As you have described what a SB is/ or as you have an idea of what a SB is, what do you think constitutes a SB in the Nigerian context?

9. Is the concept of SB widely practiced in Nigeria?

10. Do you think FM has a role to play in achieving SB in Nigeria? YES / NO

11. If YES, what is that role and in Nigeria?

12. If NO, please state why.

13. What extent is FM currently contributing towards SB?

14. Who do you think has a pivotal role in making buildings sustainable in Nigeria?

15. Given your answers in Question 11, what do you think are the barriers to FM role in achieving SB in Nigeria?

16. Given your answers in Question 11, what do you think are the drivers to FM role in achieving SB in Nigeria?

17. In your view, what are the solutions that can overcome the aforementioned barriers in Question 15 for FM to help in achieving SBs in Nigeria?

18. Please state any other issues/comments with regard to FM and SB concept in Nigeria.

Note: The results to be obtained through the interviews will only be used for the purpose of this research study and will not be used for any other purpose. All responses remain completely confidential.

Please supply your email address if you would like to receive a summary of the interviews conducted…………………………………………………………………………..

Thank you.

APPENDIX D: QUESTIONNAIRE USED IN THIS STUDY

Topic: Development of a Facilities Management Competence Framework for Sustainable Building Practice in Nigeria.

This questionnaire examines facilities management competencies in efforts towards achieving sustainable buildings (SB). Please tick appropriate answers based on your knowledge.

SECTION 1: General Information

1. Name of your organisation {optional}…………………………………………………………………………………… ……………………………………………………………………………………………….

2. Please tick your professional discipline background to facilities management and write down any professional associations of which you are a member (e.g. NIA, COREN, NIOB, NIQS, NIEWS, IFMA, etc.).

[ ] Architecture ……………………………………………………………………

[ ] Building services (M & E)………………………………………………………………...

[ ] Building surveying ……………………………………………………………………

[ ] Quantity surveying …………………………………………………………………….

[ ] Estate management …………………………………………………………………….

[ ] Facilities management ……………………………………………………………………

[ ] Other {please specify} ……………………………………………………………………

3. How many years of experience do you have in the Nigerian building industry?

[ ] 0 – 5 years

[ ] 6 – 10 years

[ ] 11 – 15 years

[ ] 16 – 20 years

[ ] More than 20 years

SECTION 2: Sustainable Buildings in Nigeria

From the review of literature carried out on this research, a sustainable building can be described as a building designed with high efficiency use of energy and water, promoting human health and comfort and built with environmentally friendly materials that are locally sourced and therefore economical.

4. Having this definition in mind, please answer on a scale of 1 - 10 (where 1 is Not Critical at All and 10 is Extremely Critical) to what extent should the following constituents be critical to the practice of sustainable building in Nigeria?

	Sustainable Building Constituents	
1	**Waste management** system that is effective and appropriate both at construction and during the operational life of the building.	
2	Provides **minimum car parking capacity** in order to help reduce transport related pollution.	
3	Use systems that reduce **carbon emissions**.	
4	Building construction sites managed in an environmentally sound manner in terms of **pollution**.	
5	Reduces **light pollution** at night .	
6	Minimises rainwater run-off to reduce **pollution** of natural watercourses.	
7	Minimises **pollution** in terms of discharge to the municipal sewage system.	
8	Use of previously developed sites and non-use of virgin land.	
9	Preserving **ecological value of land** in terms of protecting the environment surrounding the building site .	
10	**Biodiversity** in terms of preserving and enhancing plant and animal life surrounding the building site.	
11	Uses **energy efficient** equipment.	
12	Building construction site managed in an environmentally sound manner in terms of **energy consumption**.	
13	**Reduces greenhouse gas emissions** from refrigeration systems and hot water production.	
14	Maximises use of **solar energy**.	
15	Uses **energy efficient** transportation systems in buildings (lifts, elevators, escalators or walkways).	
16	Makes use of **renewable energy**.	
17	Uses **responsibly sourced materials**.	
18	**Uses construction materials with low environmental impact** and which involves Life Cycle Assessment tools.	
19	Constructed in an environmentally sound manner in terms of **resource use**.	
20	**Minimises risk of water contamination** in building services through design and implementation and the provision of clean and fresh drinking water for building occupants.	

21	**Provides adequate daylighting** and artificial lighting and lighting controls for occupants' comfort.	
22	**Provides appropriate thermal comfort levels** through design and installation of controls to maintain a thermally comfortable environment for occupants within the building.	
23	Provides **safe access** to and from the building.	
24	**Management of space** for occupant privacy and wellbeing .	
25	**Provides indoor air quality** which involves providing a healthy internal environment through the specification and installation of appropriate ventilation equipment and finishes.	
26	**Provides hazard control** which involves reducing the use of materials that are harmful to the comfort and wellbeing of occupants.	
27	**Conserves local heritage and culture** which involves a building that contributes to social and cultural attractiveness of the neighbourhood, leading to users' and neighbours' satisfaction.	
28	Adheres to **ethical standards in terms of meeting building standards**.	
29	**Adaptable for different uses** and which involves providing a place that meets needs with a mix of tenure types and ensuring flexibility wherever possible.	
30	**Provides acoustic control** which involves the building's acoustic performance including sound insulation meeting the appropriate standards.	
31	**Accessible to good public transport network and local infrastructure** and services and alternative modes of transportation for occupants to reduce transport related pollution and congestion.	
32	**Water efficiency**-Makes use of water efficient fixtures, installation of water recycling system, water consumption monitoring system, water leak detection and prevention systems to reduce consumption of potable water for sanitary and occupants.	
33	**Material efficiency** in terms of building material optimisation and replacement and use of recycled materials.	
34	Manages **construction waste** during construction.	
35	Provision for **maintenance** of the building and services which ensures the durability and economic value.	
36	Minimises operational energy consumption, monitors energy usage, uses energy display devices and uses energy efficient light fittings and equipment (**Energy efficiency**).	
37	Makes use of **building life-cycle cost** which involves provision of economic value over time and financial affordability for beneficiaries.	
38	Designed, planned and delivered in consultation with current and future building users and other stakeholders.	
39	Reduces air leakage in buildings.	
40	Incorporates waste recycling management plan.	
41	Involves **innovation of technology**, method or processes that improve the sustainability performance of the building's design, construction, operation, maintenance or demolition.	

42	Incorporates **Building Management Systems** to actively control and maximise the effectiveness of building services.	
43	Establishes **legal and contractual environmental management initiatives** embedded within the formal management structures of the development.	
44	Engages **professionals that assist with the integration of sustainability assessment schemes**', aims and processes through design and construction.	
45	Engages **independent commissioning agents** with regard to future building maintenance.	
46	Involves the development of **initiatives to educate building occupants** on how the sustainability issues in buildings work.	
47	Involves the encouragement of **environmental initiatives** by occupants.	
48	Has a building user's guide to enable building users to optimise the building's performance.	
49	Involves **commissioning and handover initiatives** that ensure that all building services can operate to optimal design potential.	
50	Involves a **6-12 month defects liability period** after all works have been completed at the construction stage.	
51	Involves **yearly building tuning initiatives** to ensure optimum occupant comfort and energy efficient services performance.	
	Other [please specify and rank]	

SECTION 3: This section addresses the competence level of facilities managers towards achieving sustainable buildings in Nigeria.

5. On a scale of 1- 10 (where 1 is Not Competent at All and 10 is Highly Competent) what is the competence level of the facilities management profession in undertaking the following roles in sustainable buildings?

	FM Role in Sustianable Buildings	
	Environmental Aspect	
	Waste management	
1	Advises on an effective waste management system.	
2	Coordinates waste management during the operational life of the building.	
	Pollution	
3	Advises on minimum car parking capacity in order to help reduce transport related pollution.	
4	Advises the use of systems that reduce carbon emissions.	
5	Influences and installs refrigeration systems that minimise carbon emissions.	
6	Maintains systems that minimise carbon emissions.	
	Biodiversity	
7	Develops, advises and implements policies that help to protect the environment surrounding the building site.	

8	Educates the design team on measures to preserve and enhance the plant and animal life surrounding the building site.	
	Energy	
9	Encourages on the use of **renewable energy**.	
	Social Aspect	
	Visual comfort	
10	Advises on visual comfort in terms of daylighting and artificial lighting and lighting controls for the comfort of building occupants.	
11	Ensures installation of fittings that will give visual comfort to building occupant.	
12	Maintains all installations that give visual comfort.	
	Acoustic performance	
13	Advises on the building's acoustic performance including sound insulation meeting the appropriate standards.	
14	Monitors installation of systems that provide acoustic comfort.	
15	Maintains systems that provide acoustic comfort.	
	Thermal comfort	
16	Advises and specifies system that provide thermal control (air-conditioning) at design.	
17	Ensures installation of thermal controls such as air-conditioning units.	
18	Maintains a thermally comfortable environment for occupants within the building.	
	Safe access	
19	Advises on safe access and security to and from the building at design stage.	
20	Maintains systems that provide safe access and security in the building.	
	Space management	
21	Advises on apportioning of space for occupant privacy and wellbeing.	
22	Executes space management plan.	
	Indoor air quality	
23	Helps to provide a healthy indoor environment through advice and specification of designs that encourage ventilation.	
24	Monitors installation of appropriate ventilation equipment to provide good indoor environment.	
25	Maintenance of ventilation equipment and outlets.	
	Adaptability for different uses	
26	Advises on building design that is adaptable for different tenure types and ensuring flexibility wherever possible.	
	Economic Aspect	
	Water efficiency	
27	Advises and specifies water efficient fittings.	
28	Ensures installation of water efficient fittings.	
29	Monitors water consumption and carries out activities that reduce waste of water.	
	Material efficiency	
30	Advises on minimising the frequency of material replacement at design.	
31	Ensures use of recycled materials at construction.	
	Building maintenance	
32	Carries out **maintenance of the building and services** which ensures the durability and economic value.	

	Energy efficiency	
33	Advises on design that ensures energy efficiency.	
34	Monitors installation of energy efficient lighting fittings and equipment.	
35	Monitors energy consumption to reduce energy usage.	
	Building life-cycle costing	
36	Carries out building life-cycle cost exercises for building material selection.	
	Management Aspect	
37	Post occupancy evaluation that ensures delivery of functional buildings in consultation with current and future building users and other stakeholders.	
38	Monitors and evaluates technology trends and innovation in the building.	
39	Assesses the application of technology within building operations.	
40	Incorporates building management systems that actively control and maximise the effectiveness of building services.	
41	Establishes legal and contractual environmental management initiatives.	
42	Develops initiatives that educate building occupants on how the sustainability issues in building work.	
43	Develops a building users guide to enable building users to optimise the building's performance.	
44	Executes yearly building tuning initiatives that ensure optimum occupant comfort and energy efficient performance.	
	Total number of FM roles indentified in documents	

6. Please indicate to what extent you agree or disagree with each of the following as barriers to the facilities manager’s role in sustainable buildings in Nigeria. Please rate as follows: 1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly Agree.

	Barriers to FM role in achieving sustainable buildings (SB) in Nigeria	**1**	**2**	**3**	**4**	**5**
1	Lack of awareness among building professionals about FM roles in SB.					
2	Lack of awareness among the public about FM roles in SB.					
3	Lack of awareness among government about FM roles in SB.					
4	Lack of technical skill expertise in the construction industry.					
5	Lack of training of building professionals in the design and construction of SB.					
6	Lack of FM skills and expertise.					
7	Lack of industry structure to promote FM in SB.					
8	Lack of acceptance of FM role at the design and construction stages.					
9	Low maintenance culture.					
10	Social integration and cultural background in relation to non-appreciation of SBs.					
11	Lack of incentives for SB implementation among developers.					
12	Lack of building industry standards.					
13	Lack of locally based building material manufacturing industries.					
14	Low awareness among government about the benefits of SB.					
15	Lack of government policies or legislation to support implementation of FM role in SB.					

16	Too much bureaucracy in housing policies.					
17	Non-affordability by the public and lack of government financial support towards funding of SB.					
18	Other [please specify].					

7. Please indicate to what extent you agree or disagree with each of the following as drivers to ensure implementation of the facilities manager's role towards achieving sustainable buildings in Nigeria. Please rate as follows: 1 = Strongly disagree 2 = Disagree 3 = Neither agree nor disagree 4 = Agree 5 = Strongly Agree

	Drivers to FM role in achieving sustainable buildings in Nigeria	**1**	**2**	**3**	**4**	**5**
1	FM awareness promotion by International Facilities Management Association Nigeria Chapter.					
2	Training of facilities managers in their role in SBs.					
3	The facilities manager's involvement at the design stage.					
4	Training of building professionals towards SB.					
5	Demand for SBs by investors, users, top management, public, government etc.					
6	Awareness of FM role in SB among building professionals.					
7	Awareness of FM role in SB among building users.					
8	Awareness of FM role in SB among investors/ developers/ building owners.					
9	Awareness of FM role in SB among government.					
10	Awareness of FM role in SB among top management in organisations.					
11	Development of a maintenance culture.					
12	Development of legislation to promote FM in SB.					
13	Government as a major employer of FM.					
14	Demand for best building practices by government.					
15	Demand for best building practices by building professional bodies.					
16	Development of the economy.					
17	Promotion of SBs by the building industry.					
18	High level of FM competencies.					
19	Other [please specify].					

8. Please state any other comments on sustainable building practices and the facilities manager's role in sustainable buildings in Nigeria you consider relevant to this questionnaire……………………………………………………………………………………..

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Thank you for completing the questionnaire. Please supply your email address if you would like to receive a summary of the survey results.

Email: ……………………………………………………………………………

APPENDIX E: ACHIEVEMENTS AND CONFERENCE PAPERS PUBLISHED
Achievements during the course of the PhD:

1. Grant awarded by Allan and Nesta Ferguson Charitable Trust Scholarship (2015-2016)

Conference papers published:

1. Olaniyi, O. O., Smith, A., Liyanage, C. and Akintoye, O. O. (2014). Facilities Management Approach for Achieving Commercial Buildings in Nigeria. Research symposium, 13th EuroFM Conference, 4-6 June 2014, Berlin, Germany.

2. Olaniyi, O. O. and Smith, A. (2015). Impact of Facilities Management in Achieving Sustainable Buildings. Research symposium, 14th EuroFM Conference, 1-3 June 2015, Glasgow UK.

Presentations:

Olaniyi, O. O. (2013). Facilities Management Approach for Achieving Sustainability in Commercial Buildings in Nigeria. Seminar Series, School of Engineering, University of Central Lancashire, UK.

Olaniyi, O. O. (2014). Facilities Management Approach for Achieving Sustainability in Commercial Buildings in Nigeria. Poster presentation, School of Engineering, University of Central Lancashire, UK.

Olaniyi, O. O. (2015). Development of a Facilities Management Framework for Achieving Sustainable Buildings in Nigeria. Poster presentation, School of Engineering, University of Central Lancashire, UK.