IMPACT OF FACILITIES MANAGEMENT IN ACHIEVING SUSTAINABLE BUILDINGS

ABSTRACT

A sustainable environment is the primary focus of many building designers, and even building users in order to attain high level of satisfaction of occupants' safety and comfort and to meet the sustainable development (SD) agenda requirements. Facilities management (FM) has an important part to play in creating this sustainable environment and has been defined by many. It is viewed as a practice, process and profession; that integrates multi-disciplinary activities within the built environment, which includes maintaining, improving and adapting buildings and assets through time, in the most cost effective way, to meet an organisations' agreed business objectives. However, does this integrative role help in achieving sustainable building (SB)? There is limited research in FM view in relation to SB. The aim of this paper is to determine FM functions in relation to SB throughout the phases of the building life-cycle. The research methodology adopted is the review of existing literature sources on SBs and the documents produced by the Building Research Establishment Environmental Assessment Method (BREEAM), the Leadership in Energy & Environmental Design (LEED) and the International Organization for Standardization (ISO). The research methodology also involves a review of the competencies of FM as stated in FM professional standards. The first part of the paper identifies SB constituents with reference to internationally recognised standards (BREEAM, LEED and ISO) and literature in relation to SB. It then evaluates the role of FM in relation to the identified SB constituents at the design, construction and operations phases of the building life-cycle. The findings of this research reveal FM functions in SB constituents in energy consumption and efficiency, water management and efficiency; waste management; pollution; building users comfort which includes (visual, acoustic and thermal comfort) and indoor environmental quality; and building life-cycle costing. These FM functions are found to be operative mostly at the design and operations phase. This paper helps FM practitioners to be aware of their role in SBs. There is need for FM practitioners to function at the construction phase and SB constituents in building material use and efficiency; land use and conserving local heritage and culture.

1.0 Introduction

The creation of sustainable living and workplace environment is the key focus of many building designers, contractors and even building users in order to achieve high level of satisfaction of occupants' safety, health and comfort and to meet the SD agenda requirements. FM in its multi-tasking role has an important part to play in creating these sustainable environments and has been defined by many (Becker, 1990; Pearson, 2003; Armstrong, 2002; Alexander, 2003). It is defined by Atkin and Brooks (2005) as the coordination of the operations of the built environment. FM maintains, improves and adapts buildings and its assets, utilising the principles of multiple disciplines to manage the functions of people, processes, and technology through time in the most cost effective way to meet an organisations' agreed business objectives and deliver customer satisfaction and best value, supporting and enhancing the core business (Atkin and Brooks, 2005). By coordinating these processes and with the help of management skills, FM effects the ability to act proactively and fulfil its multi-disciplinary role (BSI, 2006). This FM multi-disciplinary role involves activities within the built environment, which includes maintaining, improving and adapting buildings and assets through time, in the most cost effective way (BIFM, 2008) and is mostly related to buildings of all types (residential, commercial, healthcare, industrial, government, educational, agricultural, religious, and so on).

In these buildings FM measures customer satisfaction to improve its services reflecting on the extent to which a building meets the needs of its users; addressing such issues as occupant performance, worker satisfaction and productivity (British Council for Offices, 2007; Preiser and Vischer, 2005). FM deals with all aspects of indoor environmental quality (Chan *et al*, 2008; Smith and Pitt, 2011); space management and plays an essential role in healthcare, with the provision of a well-designed and well-maintained good quality environment in hospitals, in order to improve overall healthcare quality (Richardson, 2001). Though FM has contributed immensely to the productivity and profitability of organisations and to the health and well-being of building users, its role in creating SBs is yet to be determined.

2.0 The Concept of Sustainable Building

The SB concept can be integrated into buildings of all types whether commercial, residential, healthcare, sports etc. A SB is a building that minimises the use of resources such as energy and water, unwanted outputs such as greenhouse gas, and maximises the health and wellbeing of users (Eley, 2011). John *et al*, (2005) describes 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.

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 construction industry, making it one of the least sustainable industries in the world (Edwards, 2010). The built environment has a significant impact on the SD agenda as it 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 withdrawals, one quarter of wood harvested and two fifths of all material and energy flows (Emmanuel, 2004). The need for SBs arose as a result of the negative impact of the construction industry on the environment.

Though the construction industry has a history of negative impact on the environment such as being responsible for the consumption of major amounts of energy, water and land usage, yet it has a vital contribution towards achieving SD (Gibberd, 2002; Anink *et al*, 1996). It addresses basic human needs in terms of provision of 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). It is increasingly becoming a key consideration for building practitioners in the construction industry to achieve the aim of increasing economic efficiency, protect, and restore ecological systems and at the same time, improve human well-being with the development of SBs (Sinha *et al*, 2013). This according to BIFM (2014), RICS (2014), IFMA (2014) and FMMA (2012) is the sole aim of the FM practice. However, in order for FM practitioners to support the SB concept, there is need to understand the FM function in the phases of the building life-cycle.

3.0 Facilities Management and Phases of the Building life-cycle

The building life-cycle from a facilities manager's view does not start at the building handover but at the initial briefing stage (Shah, 2007). According to Hodges (2005), facilities managers are specialised in the knowledge of the entire life-cycle of a building and manage the different stages as shown in Figure 5.1 in order to derive optimum value of the building at the most economical cost over its life-cycle (Then and Hee, 2013).

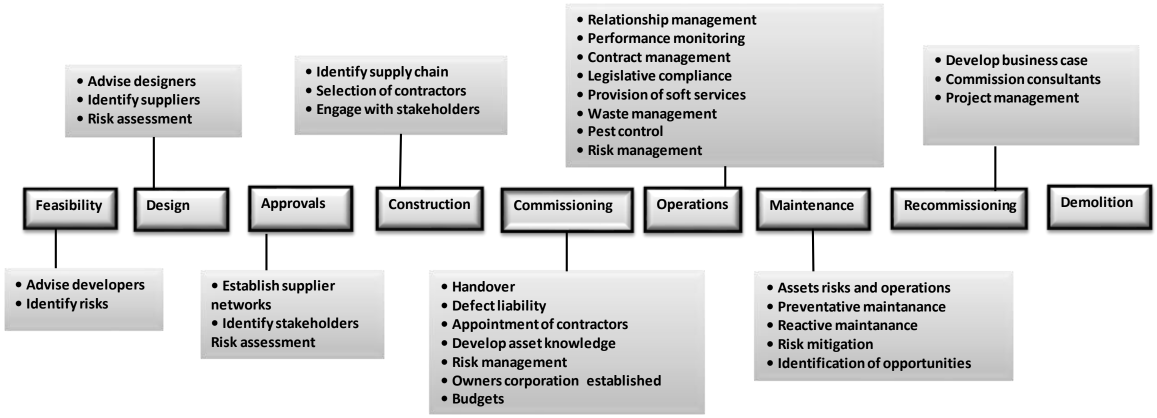

Figure 5.1 FM Role and the Building Life-Cycle. FMA Australia (2012) as cited in Shiem-Shin and Hee, (2013).

In FM, consideration needs to be given to a building over its entire life, that is, from the design phase, through the construction, operation and renovation phases, and to demolition and recycling processes (Feige *et al*, 2013). FM, in its multi-disciplinary role, has an important part to play in helping the construction industry create SBs by carrying out its function at the design, construction and operations phases of the building life-cycle (FMA Australia, 2012). According to Gervásio (2014) a building starts with the design stage and is the most critical stage in the building life-cycle; as most fundamental decisions influencing the life-cycle performance of a building are taken in the very beginning of the design process.

Design is a creative activity by which the client's needs and objectives are collected, interpreted and expressed in three-dimensional physical solutions. According to Santos *et al*, (2014) the design process of a building involves four stages namely, the Project Start-Up Stage, the Concept Design Stage, the Preliminary Design and the Developed Design Stage. The Project Start-Up Stage is where the project brief is developed by identifying the requirements of the building through consultation with stakeholders; the Concept Design Stage is the stage where the building concept is developed and schematic drawings are produced; the Preliminary Design Stage is where schematic diagrams are refined facilitating the estimation of the main quantities for the building project, and finally the Developed Design Stage, which contains every necessary information required for the construction of the building and all data necessary for a sustainability assessment.

After the design of the building has been fully developed, the design is then implemented at the Construction Stage. The building construction stage is the project stage where the building moves progressively from a virtual state to a realised state (Kubicki *et al*, 2005).

However, various challenges are discovered at this stage leading to the complexity of the stage. Numerous aspects have to be faced, which are: Respecting deadlines (anticipating problems and solving conflicts), Costs management, and Quality of execution of the different building elements and conformity with the original drawings. At the construction stage, the design of the facade of a building which forms a barrier to heat, cold, light and air, must be carefully implemented, in order to achieve high building performance (Evins, 2013). Due to limited research of FM at the construction phase, this paper focuses on the design and operations phases.

The high performance of the building can only be tested and proven at the operations stage of the building life-cycle. According to Zhang *et al, (*2006) the effectiveness of this stage is dependent on the design of both the structure and the services of the building. It is also dependent on the construction stage and the sustainable 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 it the greatest impact upon the environment, society and the economy. Due to limited research in the subject area, this paper briefly looks into FM and the design and the operations phases of the building life-cycle.

3.1 Facilities Management at the Design Phase

According to Erdener, (2003) the early engagement of FM can contribute to reducing major repairs and alterations that will otherwise occur at the operational phase. However, few efforts have been made in the construction industry to involve FM in the design phase (Nutt and McLennan, 2000). To ensure from the very beginning that building facilities meet the objective of supporting core business and to reduce cost of major repairs and alterations, the facilities manager has to be involved in the entire design process (Kelly *et al*, 2005). According to Preiser (1995), facilities managers when consulted in the design phase of a project, are able to highlight problems early and provide valuable information on building performance and operating costs. At the design phase the facilities manager carries out the following tasks:

- Establishes client brief in collaboration with the client, designers and the facilities user (RICS, 2014);
- Understands designs for the functionality of the building and for the purpose of interrelated user functional efficiency (Pitt *et al*, 2005);
- Reviews project proposals in the context of the operation and core business requirements (El-Haram and Agapiou, 2002);
- Reviews and assesses building design from maintainability, operability and serviceability point of view to liaising with the design and construction team to

select the most cost-effective design option which will optimise whole life costing (Bernard Williams Associates, 1999; Hassanain, 2006).
- Identifies and selects the optimum maintenance and replacement strategies for the facility; and identifying and selecting the optimum operating scenario (El-Haram and Agapiou, 2002).

3.2 Facilities Management at the Operating Phase

FM deals with the management of built assets and incorporates controlling services necessary for successful business operations of an organisation and for the ultimate satisfaction of the building users (Lavy *et al*, 2010). These built assets start to age from the moment they are completed and put in use and consequently needing maintenance throughout the life time of the building in order to achieve its effective and economical usage (Fakhrudin *et al*, 2011). The facility manager's responsibilities during the operating phase includes:

- 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; ensuring that the required level of service is met; and ensuring the availability of the facility (El-Haram and Agapiou, 2002);
- Performance monitoring and improvement in the delivery of the required level of service, to monitoring government regulations on environmental, and health and security standards (Bernard Williams Associates, 1999);
- Ensuring excellent indoor air quality which involves adequate maintaining of Heating, Ventilating and Air-conditioning (HVAC) systems; repair of defective air infiltration; improving energy efficiency which involves monitoring energy consumption and identifying any specific cause of poor energy efficiency (Shah, 2007);
- Providing a comfortable, healthy, safe and productive environment for building occupants through the efforts of a skilled work force (Fennimore, 2014).

This paper sets out to determine FM functions in creating SBs. However, in order to determine this, there is need to identify SB constituents and then determine if FM carries out its functions in line with these constituents.

4.0 Research Methodology

The research methodology used in this study involves an in-depth study and review of existing literature sources on SBs and the documents produced by the Building Research Establishment Environmental Assessment Method (BREEAM), the Leadership in Energy & Environmental Design (LEED) and the International Organization for Standardization (ISO). According to Yuhui (2013) BREEAM and LEED are the two most representative building sustainability assessment organizations in the world due to the wide coverage of building types, and environmental, social and economic issues. BREEAM was the first building sustainability assessment system in the world, it has been practiced and tested for over 10 years and because of its maturity, it has been followed by many countries. On the other hand, LEED developed in the year 2000 has become a nationally accepted benchmark tool for the design, construction and operation of high-performance SBs.

BREEAM and LEED are tools used in achieving SD in the construction industry (Schweber, 2013). These sustainability building assessment tools have contributed to the development of knowledge and understanding of SD in construction. A recent survey of the UK (property) development industry with 7000 respondents found that 64% of respondents which were technical advisors and contractors, considered BREEAM to be an essential tool for the construction sector to meet SD requirements. LEED too has a large number of certified and registered projects across the globe and since its origination; LEED has provided a set of standards for environmentally suitable construction (Jain et al, 2013). According to Reed et al, (2009) sustainability building assessment tools raise awareness of environmental issues and standards, encourage best practice, and stimulate the economy for sustainable construction and property.

The International Organization for Standardization (ISO) identifies and establishes general principles for SD in building construction. These international standards are set by technical committees made up of governmental and non-governmental international organisations in the UK. Draft international standards adopted by these technical committees are circulated to the member bodies for voting. National standards are set for publication when at least 75% of the member bodies have casted a vote on it. These international standards contribute to the achievement of SD either directly, where they specifically address SD issues, or indirectly, where they relate to testing, products, procedures, services, terminology, management systems or auditing (BSI, 2013).

The documents produced by these organisations are building assessment standards used in assessing a building's sustainable qualities, and these include; the Building Research Establishment Environmental Assessment Method International New Construction (BREEAM-NC) UK, the Leadership in Energy & Environmental Design for New Construction (LEED-NC) US and the International Standard Organisation (ISO) 'Sustainability in Buildings and Civil Engineering Works — Guidelines on the Application of the General Principles in ISO 15392'.

- BREEAM New-Construction is a document produced by BREEAM, a governmental building research Organisation, established by the Building Research Establishment (BRE) in the UK in 1990. BREEAM New-Construction is an assessment method that is used to improve and measure and certify the social, environmental and economic sustainability of new buildings. It is an internationally recognised measure and mark of a building's sustainable qualities and 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, providing reliability of the document for identifying constituents of a SB (BREEAM, 2013).

- LEED New-Construction is a document produced by United States Green Building Council (USGBC), a non-governmental Organisation comprising of many collaborators from industry, academia and government. It is a comprehensive initiative for addressing the impacts of buildings within the environmental, social, and economic context of SD at the design and post construction stages of the building life-cycle. LEED for New- Construction was designed primarily for new commercial office buildings, however it has been applied to many other building types by LEED practitioners. It is applicable for new commercial construction and is widely used in several countries, thereby providing a reliability of the document for identifying constituents of a SB (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. This document 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. As earlier indicated these standards 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 SB 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 designed having put sustainable measures into consideration. Through the years, they have contributed to the increase in awareness about the criteria and objectives of SD in buildings and have become a framework of reference to assess the sustainability of buildings. Though they present their assessment of what a SB is in different ways, yet they share a common framework. Therefore they can be identified as documents that can be used to determine the constituents of SB.

This research also includes an in-depth study and review of the competencies of FM as stated in FM professional standards. According to FMA Australia (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. According to the BIFM Facilities Management Professional Standards Handbook (2014) to be competent is to have the skill or ability to perform a task or function. FM competencies are the quantifiable or noticeable knowledge, skills, abilities, and conducts critical to successful FM job performance. In the context of this research, the competencies stated in these documents can be used as standards for FM functions in the built environment.

These standards contain FM functions as identified by FM associations, mainly; the British Institute of Facilities Management (BIFM) established in 1993, the International Facility Management Association (IFMA) established in 1980 in the United States of America; and the Royal Institute of Chartered Surveyors Facilities Management Group (RICS FM group) established within the Royal Institution of Chartered Surveyors (RICS). These associations were chosen because they are globally accepted as bodies that deal with the FM profession and are the leading FM associations in the world. They define what FM is, explicate the scope of FM and elucidate the knowledge, skills, abilities and behaviours needed to perform FM tasks (Awang *et al,* 2011). These associations have produced documents that describe FM functions and these include: Skills in Facilities Management Investigation into Industry Education (FMAA) 2012; the IFMA Complete List of Competencies as defined in the Global Job Task Analysis (GJTA) 2009 defining 11 core FM competencies including responses from facility managers in 62 countries; the BIFM Facilities Management Professional Standards Handbook 2014; and the RICS Assessment of Professional Competence Facilities Management Pathway Guide 2014.

BIFM Facilities Management Professional Standards Handbook (2014) describes FM competencies as the quantifiable or noticeable knowledge, skills, abilities, and conducts critical to successful FM job performance. 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 (FMAA, 2012). The 'IFMA Complete List of Competencies' is developed according to the Global Job Task Analysis (GJTA) 2009, which defines 11 core FM competencies and includes responses from facility managers in 62 countries. It ensures that the FM body of knowledge encompasses current knowledge, best practices and trends in FM (IFMA, 2014).

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 define 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 bench marking 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 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.

These documents were selected on the basis that; they are produced by the above named associations; are set as standards for facility managers and are relevant to the research study. Hence, the justification for using them to determine FM functions. The documents were studied and the FM functions as stated in each document were identified and examined. The various processes and activities involved in the design, construction and operations phases of the building life-cycle were also examined, in order to map identified FM functions in relation to SB at each phase. This was carried out in order to determine FM function in relation to SB.

5.0 Findings

5.1 Sustainable Building Constituents

A review of the Building Research Establishment Environmental Assessment Method International New Construction (BREEAM-NC) UK, the Leadership in Energy & Environmental Design for New Construction (LEED-NC) US and the International Standard Organisation (ISO) 'Sustainability in Buildings and Civil Engineering Works — Guidelines on the Application of the General Principles in ISO 15392' and of existing literature sources on SBs, has identified certain features as constituents of SBs and are as shown in Table 1. The table shows 25 constituents common to both literature on SB and the above mentioned documents. The SB constituents include: Under the environmental aspect – building material use, energy, land use efficiency, pollution and waste management; under the social aspect - adhering to ethical standards, adaptability for different uses, conserving local heritage and culture, accessibility, visual comfort, indoor environmental quality, thermal control, acoustic control, water quality and safe access; and under the economic aspect – building life-cycle cost, energy efficiency and management, water efficiency and management, material efficiency, and maintenance and management.

FM's role in planning, designing and management of buildings and helping to improve the environmental performance of buildings by the reduction of energy and material waste has made it contribute in some way to creating SBs. However, this role cannot be fully determined without identifying the FM functions that support achieving SBs.

Table 1. 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	John *et al*, 2005	Hodges 2005
	Environmental Aspect																								
1	Building material use - Use of construction materials with low environmental impact and responsibly sourced materials. This constituent involves use of LCA tools to measure environmental impact.			•												•							•		
2	Energy - Appropriate use of local energy generation from renewable sources, reducing operational GHG emissions resulting from refrigeration systems energy use, reducing co_2 emissions from refrigeration systems, and energy efficient transportation systems in buildings (lifts, elevators, escalators or moving walks);						•	•		•	•		•							•	•			•	•
3	Energy - Maximum use of solar energy.						•	•			•										•				
4	Land use efficiency - Use of previously developed sites and/or contaminated land, and Non-use of virgin land;			•	•	•			•							•			•						
5	Land use efficiency - Protect ecological value of land during site preparation and completion of costruction works;			•	•	•			•							•			•						
6	Land use efficiency - Preservation and enhancement of biodiversity.			•	•	•			•							•			•						
7	Pollution - Use of systems that reduce GHG emissions, ozone depleting gas emissions, and No_x emissions;	•																				•	•		
8	Pollution - Use of rainwater collection systems to reduce water pollution and land;	•																				•	•		
9	Pollution - Reduction of night light pollution.	•																				•	•		
10	Waste management - Effective and appropriate management of waste; Reuse of recycled materials; and Provision of operational related recyclable waste facilities.																		•						
	Social Aspect																								
11	Adhering to ethical standards.					•			•			•													
12	Adaptability for Different Uses - Providing a place that meets needs with a mix of tenure types and ensuring flexibility wherever possible.																								
13	Conserving local heritage and culture - A building that contributes to social and cultural attractiveness of the neighbourhood leading to users and neighbours satisfaction.								•			•													

	Esen & Esen 2005	Milani 2005	Godfaurd *et al*, 2005	Puettman *et al*, 2005	Paola 2006	Dair and Williams 2006	Spiegel and Meadows 2006	Lowe, 2007	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
Environmental Aspect																								
1		•	•	•	•	•	•	•						•			•							
2	•									•		•						•						•
3	•																							
4					•																			
5					•																			
6					•																			
7					•	•		•	•		•		•											
8					•	•		•	•		•		•											
9					•	•		•	•		•		•											
10																								
Social Aspect																								
11						•													•					
12																								
13						•													•					

	Lund 2011	Tiwari *et al*, 2011	Siew *et al*, 2011	Bribian *et al*, 2011	Gething 2011	Fakhrudin et al, 2011	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	BREEAM 2013	LEED 2005	BS 2014	Total no. of Literature mentioning constituent
Environmental Aspect																									
1					•									•								•	•	•	17
2	•	•					•				•									•		•	•	•	22
3		•									•														7
4													•	•	•							•	•	•	13
5													•	•	•							•	•	•	13
6													•	•	•							•	•	•	13
7														•								•	•	•	13
8														•								•	•	•	13
9														•								•	•	•	13
10														•								•	•	•	5
Social Aspect																									
11																									5
12					•									•	•									•	4
13														•	•									•	7

14	**Accessibility to good public transport network and local infrastructure and services and alternative modes of transportation for occupants to reduce transport related pollution and congestion.**																																											•																											•	•	•	4
15	**Visual comfort - Daylighting, artificial lighting and occupant controls at the design stage to ensure best visual performance and comfort for building occupants**																																																																							•	•	•	3
16	**Indoor environmental quality - A healthy internal environment through the specification and installation of appropriate ventilation equipment and finishes.**	•																				•	•							•	•		•	•		•		•							•							•									•		•			•	•			•	•	•	•	19
17	**Thermal control - Appropriate thermal levels through design and installation of controls to maintain a thermally comfortable environment for occupants within the building**	•																																		•									•							•									•					•	•			•	•	•	•	11
18	**Acoustic control - The building's acoustic performance including sound insulation meeting the appropriate standards**		•											•																•										•						•																										•	•	•	8
19	**Water quality - Minimising risk of water contamination in building services through design and implementation and the provision of clean and fresh drinking water for building occupants.**																																								•			•																											•	•	•	5
20	**Safe access - Effective design measures that promote safe access to and from the building.**																																																																							•		•	2
	Economic Aspect																																																																									
21	**Building life-cycle cost - Provision of economic value overtime and financial affordability for beneficiaries.**		•	•					•			•		•	•								•				•	•	•		•	•							•	•				•		•	•	•					•	•	•				•					•				•					•	25
22	**Energy efficiency - Minimise operational energy consumption through good design, monitoring by sub-metering, use of energy display devices and use of energy efficient light fittings and equipment.**						•	•		•	•		•							•	•			•	•										•		•						•						•	•						•													•		•	•	•	19
23	**Water efficiency - 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 portable water for sanitary and occupants use from all sources.**															•	•	•																																							•	•							•						•	•	•	9
24	**Material efficiency - Maximising building material optimisation and minimising the frequency of material replacement and use of recycled materials.**		•	•										•									•				•	•	•	•	•	•	•						•	•		•				•	•						•	•					•						•			•			•	•	•	24
25	**Maintenance -This includes maintenance of the building and services which ensures the durability and economic value.**														•																																	•							•																				•	4
	Total Number of Constituents identified by each author	5	3	6	3	4	3	3	6	2	3	3	2	3	2	5	1	1	4	2	3	4	7	2	2	2	3	3	3	10	9	3	6	4	2	5	2	4	3	3		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	19	19	24	71

5.2 Facilities Management Functions in Sustainable Buildings

The review of the documents; Skills in Facilities Management Investigation into Industry Education by FMAA; the IFMA Complete List of Competencies as defined in the Global Job Task Analysis (GJTA); the BIFM Facilities Management Professional Standards Handbook; and the RICS Assessment of Professional Competence Facilities Management Pathway Guide have also identified certain number of FM competencies and these include 90 FM competencies under 7 categories by FMAA, (2012); 92 sub-competencies under 11 core competencies by IFMA, (2014); 71 competencies under 10 functional areas sub-divided into 24 functional area components by BIFM, (2014); and 22 competencies by RICS, (2014). An analysis of these documents was carried out using key word search of FM functions that are common to at least two of the documents selected above and these were compared to the identified SB constituents in Table 3.1.

FM functions were found to relate to 14 of the SB constituents as shown in Table 2 and these include under the environmental aspect: building material use, energy, land use efficiency and waste management; under the social aspect: visual comfort, indoor environmental quality, thermal control and acoustic control; under the economic aspect: building life-cycle cost, energy efficiency and management, water efficiency and management, material efficiency, and maintenance and management. Therefore, FM in relation to SB carries out the following roles:

- FM incorporates practices that promote healthy, secure, good working environment, good indoor air quality, thermal comfort, visual comfort and noise control; contributing to the wellbeing of building users.
- FM incorporates practices that deal with 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.
- FM incorporates practices that deal with reduction of water usage, water efficiency equipment installation, operations and maintenance and water monitoring measures.
- FM incorporates practices that influence specification of materials and resources with low environmental impact, sustainable specification and selection of materials including life-cycle cost that minimise frequency of replacement and maximise materials optimisation and performance monitoring and transportation.
- FM incorporates practices involving environmental management in relation to waste management.
- FM incorporates practices relating to environmental management and stewardship involving reduction of pollution from storm water.

This is supported by studies carried out on FM services and have shown FM to include supporting their organisations to become more environmentally sound and provide environment and energy related services (Hodges, 2005; Roper and Beard, 2006; Wood, 2006; Junnila, 2007; Nousiainen and Junnila, 2008). According to Elmualim *et al*, (2010) facilities managers, report and recommend on improving environmental performance of their companies. However, FM's journey on the SD agenda has been found to be challenging, as documented by Elmualim *et al*, (2010) in the barriers to the implementation of sustainable FM practice.

Table 2. FM Functions in Relation to SB Constituents

		Constituents of Sustainable Building	FMAA	IFMA	BIFM	RICS
		Environmental Aspect				
1	√	Building material use - The faciliities manager advises, establishes and maintains specification of construction materials with low environmental impact and responsibly sourced materials.		•		•
2	√	Energy - The faciliites manager influences appropriate use of local energy generation from renewable sources, alternative energy sources, reduction of operational GHG emissions resulting from refrigeration systems energy use, reduction of co_2 emissions from refrigeration systems, and energy efficient transportation systems in buildings (lifts, elevators, escalators or moving walks);	•	•	•	•
3		Energy - Maximum use of solar energy.				
4		Land use efficiency - Use of previously developed sites and/or contaminated land, and Non-use of virgin land;				
5	√	Land use efficiency - The facilities manager develops, implements and reviews procedures that protect the ecological value of land during site preparation and completion of construction works.		•	•	
6	√	Land use efficiency - The facilities manager introduces processes that encourage preservation and enhancement of biodiversity.		•	•	
7		Pollution - Use of systems that reduce GHG emissions, ozone depleting gas emissions, and No_x emissions;				
8		Pollution - Use of rainwater collection systems to reduce water pollution and land;				
9		Pollution - Reduction of night light pollution.				
10	√	Waste management - The facilities manager introduces, encourages and implements effective and appropriate management of waste; Reuse of recycled materials; and Provision of operational related recyclable waste facilities.	•	•	•	•
		Social Aspect				
11		Adhering to ethical standards.				
12		Adaptability for Different Uses - Providing a place that meets needs with a mix of tenure types and ensuring flexibility wherever possible.				
13		Conserving local heritage and culture - A building that contributes to social and cultural attractiveness of the neighbourhood leading to users and neighbours satisfaction.				
14		Accessibility to good public transport network and local infrastructure and services and alternative modes of transportation for occupants to reduce transport related pollution and congestion.				
15	√	Visual comfort - The facilities manager using the client requirement brief advices on daylighting, artificial lighting and occupant controls at the design stage to ensure best visual performance and comfort for building occupants.	•		•	

16	√	Indoor environmental quality - The facilities manager ensures a healthy internal environment through the specification and monitoring installation and maintenance of appropriate heating, ventilation and air-conditioning equipment and finishes.	•		•	
17	√	Thermal control - The facilities manager using the client requirement brief advices on appropriate thermal levels to be implemented at the design phase and monitors installation of controls to maintain a thermally comfortable environment for occupants within the building.	•		•	
18	√	Acoustic control - The facilities manager using the client requirement brief advices on the building's acoustic performance including sound insulation meeting the appropriate standards.			•	•
19		Water quality - Minimising risk of water contamination in building services through design, implementation, maintenance of relevant equipment and the provision of clean and fresh drinking water for building occupants.				
20		Safe access - Effective design measures that promote safe access to and from the building.				
		Economic Aspect				
21	√	Building life-cycle cost - The facilities manager carries out life-cycle cost exercises in order to provide economic value of the building overtime and financial affordability for beneficiaries.		•		•
22	√	Energy efficiency and management - The facilities manager acquires knowledge and advises on energy efficiency principles, advises on minimising operational energy consumption through good design, monitoring by sub-metering, use of energy display devices and use of energy efficient light fittings and equipment.	•	•	•	•
23	√	Water efficiency and management - The facilities manager influences the 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 portable water for sanitary and occupants use from all sources.	•	•	•	
24	√	Material efficiency - The facilities manager advises on maximising building material optimisation and minimising the frequency of material replacement and use of recycled materials.				•
25	√	Maintenance and management - The facilities manager processes that involve the maintenance of the building and its services and minor works and repairs which ensures the durability and economic value.	•			•

6.1 FM in Sustainable Building at the Design Phase

In relation to FM functions in SB, the facilities manager at the design phase has the competence to advise designers and developers on building material use. He creates specification of construction materials with low environmental impact and responsibly sourced materials. He ensures that the designers specify these materials and the developer or the contractor complies with the specified materials. The facilities manager also advises on maximising building material optimisation and minimising the frequency of material replacement (IFMA, 2014; RICS, 2014).

The facilities manager plays a major role in advising designers and developers on energy use, and ensuring appropriate use of local energy generation from renewable sources and alternative energy sources. He advises on the reduction of co_2 emissions from refrigeration systems and energy efficient transportation systems in buildings (lifts, elevators, escalators or moving walks). The facilities manager acquires knowledge and advises on energy efficiency principles, minimising operational energy consumption through good design, monitoring by sub-metering, use of energy display devices and use of energy efficient light fittings and equipment (IFMA, 2014; RICS, 2014; FMAA, 2012; BIFM 2014).

The facilities manager is in a position to advise on the use of water efficient components and equipment, installation of water recycling systems, water consumption monitoring systems, water leak detection and prevention systems that help to reduce consumption of portable water for sanitary and occupants use from all sources (IFMA, 2014; FMAA, 2012; BIFM 2014). He is also in a position to recommend an appropriate waste management system; provision for reuse of recycled materials; and operational related recyclable waste facilities (IFMA, 2014; RICS, 2014; FMAA, 2012; BIFM 2014).

He can give guidance on indoor environmental quality. The facilities manager ensures a healthy internal environment through the specification of appropriate heating, ventilation and air-conditioning equipment and finishes (FMAA, 2012; BIFM, 2014). He recommends on issues that deal with daylighting, artificial lighting and occupant controls using the client requirement brief at the design stage to ensure best visual performance and comfort for building occupants (FMAA, 2012; BIFM, 2014). The facilities manager using the client requirement brief advises on appropriate thermal comfort levels to be implemented at the design phase and monitors installation of controls to maintain a thermally comfortable environment for occupants within the building (FMAA, 2012; BIFM, 2014). He can also advise on acoustic control, that is, the building's acoustic performance including sound insulation meeting the appropriate standards for the health and safety of occupants (BIFM, 2014; RICS, 2014). At the design phase of the building life-cycle, the facilities manager carries out building life-cycle cost exercises in order to provide economic value of the building overtime and financial affordability for beneficiaries (IFMA, 2014; RICS, 2014). Though the facilities manager has the competence and ability to carry out the above named functions, he is hardly ever involved in the early stages of the design process (Nutt and McLennan, 2000).

6.2 FM in Sustainable Building at the Construction Phase

As stated above, there is limited research on FM at the construction phase. However, in relation to FM functions in SB constituents, the facilities manager has the skill to develop, implement and review procedures that protect the ecological value of land and introduces processes that encourage preservation and enhancement of biodiversity during site preparation and up until completion of the construction works (IFMA, 2014; BIFM, 2014). He also has the ability to identify and advise on suppliers of electrical and mechanical systems with low energy consumption and low co2 emissions during installation works in preparation for the operations phase of the building (FMAA, 2012).

6.3 FM in Sustainable Building at the Operations Phase

The facilities manager at the operations phase in relation to SB has the ability to maintain and manage processes that involve the maintenance of the building and its services and minor works and repairs which ensures the durability and economic value of the building (FMAA, 2012; RICS, 2014). He can advise on thermal control and monitor installation of controls to maintain a thermally comfortable environment for occupants within the building (FMAA, 2012; BIFM, 2014). The facilities manager monitors installation and maintenance of appropriate heating, ventilation and air-conditioning equipment and finishes, thereby ensuring indoor environmental quality (FMAA, 2012; BIFM, 2014).

7.0 Conclusion

In creating SBs, the facilities manager at the design phase which is the most critical phase of a building life-cycle, has the competence to advise the design team on sustainable measures that can be incorporated into the design of the building and adopted at the construction phase in order to target the sustainable operability of the building at the operations phase. At the design phase, he advises on issues such as building material use, energy use and efficiency, water use and efficiency, indoor air quality, thermal and acoustic comfort, and carries out building life-cycle cost exercises in order to provide economic value of the building. The facilities manager monitors the installation works of the various services equipment at the construction phase, in preparation for the operations phase. At the operations phase he maintains and manages the building which he has practically created as a result of his recommendations.

8.0 References

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