GREEN BUILDING MANAGEMENT PRACTICES MODEL FOR MALAYSIAN GREEN BUILDING

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A thesis submitted in fulfilment of the

requirements for award of the degree of

Doctor of Philosophy (Facilities Management)

Faculty of Geo-information and Real Estate

Universiti Teknologi Malaysia

FEBRUARY 2018

Present thesis dedicated to my inspiring parents and in order to gratitude for their unwavering, endless love, encouragement, support, patience and sacrifices.

ACKNOWLEDGEMENT

I would like to appreciate my supervisors, PROF. SR. DR. MISWAN ABDUL HAKIM BIN MOHAMMED and DR. LOW SHEAU TING for the guidance, insightful ideas, teaching, support and long hour of struggling through this challenging process. Undoubted their support play significant role have done my study. I cannot thank them a sufficient amount.

I would like to express a deep sense of gratitude to my parents who always stood by me like a pillar in times of need and to whom I owe my life for their constant love, encouragement, moral support and blessings. Likewise, thanks are due to my only loving sister and my dear uncle Sohrab Mehregan who always strengthened my morale by standing by me in all situations.

ABSTRACT

Presently, there are serious environmental problems caused by natural and man-made sources. Climate change issues have become a global phenomenon, in particular greenhouse gas emissions such as carbon dioxide (CO_2) emissions, recognized as an important factor contributing to climate change. Previous research has revealed that the building sector is one of the largest sources of greenhouse gas emissions globally. The concept of green building emerged during the late 19th and early 20th centuries and it was designed to reduce negative environmental effects and preserves natural resource. The review of the world green building standard shows that management of green building is a critical issue to attain sustainable development. Presently, Malaysia does not have a set of structured green building management key practices in its green building rating system. Therefore, the main objective of the current study was to ascertain appropriate management key practices to attain sustainable development in Malaysian green buildings. Data was collected in two phases and the respondents comprised of 35 Malaysian green building experts, facilitators and managers in phase one, and 89 respondents in phase two. Phase one involved an expert survey to identify the list of key practices to manage the green building and data were analysed by Relative Importance Index. In phase two, questionnaire survey was utilised to identify management key practices appropriate for Malaysian green buildings. Structural Equation Modeling-Partial Least Square was used to analyse the data. This study identified five management key practices, which play a critical role for green building performance, which include sustainable operation, sustainable procurement, environmental health, resource management and repair and maintenance management. However, only four management key practices effect on optimal performance of green buildings in Malaysia were identified which include environmental health, sustainable procurement, sustainable operation and resource management. The contribution of knowledge of this study is the development of a structural equation modeling green building management key practices for Malaysia.

ABSTRAK

Pada masa kini, terdapat beberapa masalah alam sekitar yang serius yang disebabkan oleh sumber alam semula jadi dan buatan manusia. Isu perubahan iklim telah menjadi satu cabaran fenomena global terutamanya berkaitan pelepasan gas rumah hijau, seperti pelepasan karbon dioksida (CO_2), yang diakui sebagai faktor penting yang mempengaruhi peningkatan iklim. Kajian lepas menunjukkan bahawa sektor pembinaan merupakan salah satu sumber pelepasan gas rumah hijau terbesar di dunia. Konsep bangunan hijau muncul pada abad ke-19 dan awal abad ke-20 dan ia telah direka untuk mengurangkan kesan alam sekitar yang negatif dan mengekalkan sumber semula jadi. Kajian piawaian bangunan hijau dunia menunjukkan bahawa pengurusan bangunan hijau merupakan isu kritikal untuk mencapai pembangunan mampan. Pada masa ini, Malaysia tidak mempunyai satu set amalan utama pengurusan bangunan berstruktur hijau dalam sistem penarafan bangunan hijau. Oleh itu, objektif utama kajian ini adalah untuk memastikan amalan utama pengurusan yang sesuai bagi mencapai pembangunan mampan bangunan hijau di Malaysia. Data dikumpulkan dalam dua fasa dan responden terdiri daripada 35 pakar bangunan hijau, fasilitator dan pengurus di Malaysia dalam fasa pertama, dan 89 responden dalam fasa kedua. Fasa pertama melibatkan satu kaji selidik pakar untuk mengenal pasti senarai amalan utama untuk mengurus bangunan hijau dan data dianalisis oleh Indeks Kepentingan Relatif. Dalam fasa kedua tinjauan soal selidik digunakan untuk mengenal pasti amalan utama pengurusan yang sesuai untuk bangunan hijau di Malaysia. Persamaan Struktur-Kuasa Dua Terkecil Separa digunakan untuk analisis data. Kajian ini mengenal pasti lima amalan utama pengurusan, yang memainkan peranan penting untuk prestasi bangunan hijau termasuk operasi mampan, perolehan mampan, kesihatan alam sekitar, pengurusan sumber dan pengurusan pembaikan dan penyelenggaraan. Walau bagaimanapun hanya empat amalan utama pengurusan yang memberi kesan terhadap prestasi optimum bagi bangunan hijau di Malaysia telah dikenal pasti termasuk kesihatan alam sekitar, perolehan mampan, operasi mampan dan pengurusan sumber. Sumbangan pengetahuan kajian ini adalah pembangunan pemodelan persamaan struktur amalan utama pengurusan bangunan hijau untuk Malaysia.

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AIA	-	American Institute of Architects
ASHRAE	-	American Society of Heating, Refrigerating and Air Conditioning Engineers
ACEM	-	Association of Consulting Engineers Malaysia
AVE	-	Average Variance Extraction
BREEAM	-	Building Research Establishment's Environmental Assessment Method
BSL	-	BEAM Society Limited
CO2	-	Carbon Dioxide
CB-SEM	-	Covariance-based SEM
CMB	-	Common Method Bias
EH	-	Environmental Health
EE	-	Energy Efficiency
EM	-	Energy Management
GHG	-	Greenhouse Gases
GBI	-	Green Building Index
GBMP	-	Green Building Management Practice
GBP	-	Green Building Performance
HQE	-	Haute Qualité Environnementale
HKGBC	-	Hong Kong Green Building Council
H and H	-	Health and Hygiene
IPCC	-	Intergovernmental Panel on Climate Change
IAQ	-	Indoor Air Quality
INC	-	Industrial New Construction
IDP	-	Integrated Design Process
IEQ	-	Indoor Environment Quality
IEB	-	Industrial Exiting Building

LEED	-	Leadership in Energy and Environmental Design
ML	-	Maximum Likelihood
MR	-	Materials and Resources
NRNC	-	Non- Residential New Construction
NREB	-	Non Residential Existing Building
PLS	-	Partial Least Square
RNC	-	Residential New Construction
RM	-	Resource Management
RMM	-	Repair and Maintenance Management
RT	-	Règlementation Thermique
RII	-	Relative Importance Index
SEM	-	Structural Equation Modeling
SP	-	Sustainable Procurement
SO	-	Sustainable Operation
SSPM	-	Sustainable Site Planning and Management
SPSS	-	Statistical Package for the Social Science
US EPA	-	United States Environmental Protection Agency
WM	-	Water Management
WM	-	Waste Management
WE	-	Water Efficiency
World GBC	-	World Green Building Council

CHAPTER 1

INTRODUCTION

1.1 Introduction

This thesis presents a study on green building management practices in Malaysia. Unlike developed countries Malaysia has not included the green building management practices in the green building index. The purpose of this study is to fill the gap identified in previous studies on this topic. This chapter includes research background, problem statement, research questions, research objectives, scope of study, research methodology, and guide to the thesis.

1.2 Research Background

Climate change has become a subject of intense interest all over the world (Lowe *et al.*, 2006). According to the report from the Intergovernmental Panel on Climate Change (IPCC), climate change presents to be one of the main challenges of the 21st century (Bates *et al.*, 2008; Bulkeley and Betsill, 2005; Wang, 2005). Studies predict an increase in the average global surface temperature of about 2° C between 1990 and 2100 (Fong *et al.*, 2008). There is strong evidence that this is due to an increase in the concentrations of certain trace of greenhouse gases. Globally, greenhouse gas emissions, particularly carbon dioxide (CO_2) emissions, are the main

cause of climate change over the past few decades (Fox and Chapman, 2011). The countries with the largest CO_2 emissions are China (29%), United States (16%), European Union (11%), India (6%), Russian Federation (5%), and Japan (approximately 4%) (Olivier *et al.*, 2012).

Buildings are the largest producer of greenhouse gases worldwide (Hong *et al.*, 2007; Ahadzie *et al.*, 2014; Wu and Low, 2010). Major impacts on the environment include climate change, resource depletion, waste production, air, land, water and transport pollution from buildings, and the ensuing social deterioration that is typically associated with poor environmental conditions (Preiser and Vischer, 2006). According to Initiative (2009), Meggers *et al.* (2012) and Tsai (2013), buildings use 35% of energy in the world and are directly responsible for 35% of global emissions, especially CO_2 emissions both in developed and developing countries.

According to American Institute of Architects (AIA) (2007), approximately 50 percent of entire greenhouse gas emission in the United States are produced by buildings and constructions (Chan *et al.*, 2009b; Low *et al.*, 2009). Buildings consume 40% of the total energy in Europe (Petersdorff *et al.*, 2006). In UK this sector produced around 17 percent of all carbon dioxide emissions by 2013 (UK greenhouse gas emissions statistics, 2014). Buildings in New Zealand account for 17 percent of the country's GHG, while the figure for Australia is 23 percent (Worzala and Bond, 2011). In Hong Kong, buildings use up to 89% electricity resource leading to 17% greenhouse gas emissions (Chan *et al.*, 2009a). The building sector in Singapore accounts for approximately 16% of Singapore's greenhouse gas emissions (Hamilton-Hart and Natasha, 2008). These studies indicate that most developed countries have similar records in terms of greenhouse gas emissions resulting from the building sector.

The idea of a green building emerged during the late 19^{th} and early 20^{th} centuries; however, it wasn't until recently that green building further developed (Wu and Low, 2010). The goal of a green building is to preserve the environment,

improve the quality of life, and achieve sustainable development in buildings in order to reduce energy consumption (Roderick *et al.,* 2009; Fisk, 2011; Kamarudin *et al.,* 2013; Mohammad *et al.,* 2014). From the financial perspective, green buildings are cost effective and help owners to increase their profit by reducing the costs of operation and maintenance (Kamarudin *et al.,* 2013). Green buildings are designed to decrease negative effects on the environment and simultaneously improve public health by addressing six categories: 1) sustainable planning; 2) water protection and water efficiency; 3) energy efficiency, promoting renewable energy and decreasing greenhouse gas emission; 4) preserving and recycling the materials and resources; and 5) improved health and indoor environmental quality (Richardson and Lynes, 2007; Worzala and Bond, 2011; Zhang *et al.,* 2011; Geng *et al.,* 2012; Hwang and Ng, 2013; Samari *et al.,* 2013; Zainol *et al.,* 2013b). Clearly, green buildings have positive effects on the environmental aspects.

In order to protect the environment, a variety of programs are developed around the world to assess environmental and energy impacts of buildings. These environmental certification programs are known as green rating systems which differ from place to place. Green rating systems propose manners of certifying and ranking the environmental supervision of a project. Almost all of the developed countries implement a rating system for green building. For example, UK Building Research Establishment's Environmental Assessment Method (BREEAM) was introduced in 1990, USA Leadership in Energy and Environmental Design (LEED) in 1998, Japan Comprehensive Assessment System for Building Environment Efficiency (CASBEEM) in June 2004, and Norway Eco Profile in September 2010 (Geng *et al.,* 2012). Singapore Green Building Council (SGBC) was launched on the 28th of October, 2009 (Hwang and Tan, 2012). It is clearly significant to apply a rating system for green building around the world to improve and protect environment.

Over the years, greenhouse gas emissions have been increasing in Malaysia. According to the United Nations Development Report, Malaysia with 31 million people was ranked at number 26 over 149 countries with final score of 84.0 (Begum and Pereira, 2010; Safaai *et al.,* 2011, Hosseini *et al.,* 2013). According to Begum and Pereira (2010), Malaysia's growth rate of CO_2 emissions appears dramatically on

the rise. One of the main factors contributing to the CO_2 emissions in Malaysia is construction and buildings. Emissions from commercial and residential buildings approximately constitute 13 percent of the total CO_2 emissions in Malaysia. Thus implementing green buildings seems essential toward supporting the environment and decreasing the greenhouse gas emissions in tropical climate countries such as Malaysia (Papargyropoulou *et al.*, 2012). Although the Malaysian government has exhibited interest in greater implementation of green buildings, compared to Asia-Pacific countries such as Australia, Japan, and Singapore, Malaysia has not achieved considerable progress. Malaysian authorities seek to reach the standards of developed countries and reduce the negative effects of buildings; thus (GBI) was established in May 2009 in accordance with the UK and USA methods with incentives allocated for certified green building (Tony Arnel, 2013; Zainol *et al.*, 2014).

Buildings will be awarded the GBI Malaysia rating based on six key criteria: energy efficiency, indoor environmental quality, sustainable site planning and management, material and resources, water efficiency, and innovation. Satisfying these criteria will mean that the building will likely be more environment-friendly than those that do not address such issues (Mun, 2009). According to Mun (2009), depending on the scores achieved in environmental design and performance, buildings are awarded GBI ratings of GBI Malaysia – Platinum, Gold, Silver, or Certified. It is a benchmarking rating system that incorporates internationally recognised as best practice in environmental design and performance. According to the GBI certified projects since 15 October 2015, there are many certified green building projects in Kuala Lampur (114), Selangor (119), Penang (30), Putrajaya (23), and Johor (20) (GBI, 2017). Table 1.1 illustrates that buildings to be rated include categories Non Residential Existing Building (NREB), Non-Residential New Construction (NRNC), Residential New Construction (RNC), Industrial New Construction (INC), Industrial Existing Building (IEB), and Township since 15 February 2017 throughout Malaysia. This study is focused on NREB.

Table 1.1: GBI Certified Projects by Categories (Green Building Index, 2017)

Update on GBI	Total as of 15 February 2017	Non Residential New Construction (NRNC)	Residential New Construction (RNC)	Industrial New Construction (INC)	Non Residential Existing Building (NREB)	Industrial Existing Building (IEB)	Township
Applied	780	411	299	24	22	5	19
Registered	729	381	284	21	20	4	19
Total Certified	388 (100%)	190 (50%)	164 (41%)	9 (3%)	13 (3%)	3 (1%)	9 (2%)

Key practices are techniques that, through experience and research, have been proven to reliably lead to a desired result (Baek and Bullock, 2014; Gilbert, 2006). Green building management key practices effect on environment and social and economic aspects. Likewise, green they can reduce a building's operating costs, increase building values, and realise increases in return on investment (Tony Arnel, 2013). The considerable cost savings over time and improvement of quality of life for building tenants becomes possible through implementation green principles to building management. The main purpose of the green building is to reduce environmental impact to achieve sustainable development. Green building improves the environment in several ways; it protects the natural environment, promotes healthy living, and minimizes environmental negative impacts.

1.3 Problem Statement

It will be a great challenge to decrease the impact of CO_2 on a global level in the next decade (Hoel and Kverndokk, 1996). Increasing CO_2 emission and global climate change are created through both natural and man-made sources. One of the most enormous industrial polluters of the environment is the construction industry (Horvath, 1999; Akadiri and Olomolaiye, 2012; Samari et al., 2013). Green building

is an important alternative for implementing sustainable goals set to produce a healthier environment, utilize less energy and resources than conventional buildings, and mitigate impacts on the environment (Hwang and Ng, 2013; Hwang and Tan, 2012). Indeed, green building has been adopted by both developed and developing countries (Geng *et al.*, 2012). Researchers have highlighted that management practices can play a key role in advancing the sustainability agenda on account of its potential contribution to sustainability goals in green building (Ikediashi *et al.*, 2012). Likewise, comprehensive and extensive researches are available regarding impacts of building management on building performance (Yau and Ho, 2009). Mismanagement of buildings has resulted in a large number of complaints about the dangers of buildings and accidents involving building structures in the past decade (Yau, 2010). Researchers claim that despite the proliferation of green buildings, there are impediments on management of green and sustainable buildings (Ikediashi *et al.*, 2012; Kato *et al.*, 2009). Disregarding the significant role of green building management in attaining sustainable development can lead to irreparable damages in Malaysia context.

It is clear that green building management has played the most significant role in reducing CO_2 emissions and mitigating negative impacts on environment. For this purpose, World Green Building Council (World GBC) has formed a global community comprising national GBC members. World GBC is an independent and developed organization that drives the best practices of the international GBC model. The GBC members fall into one of three categories based on the way they develop their organization: established, emerging, or prospective. Based on the World GBC, majority of regions with established positions include "management" standards in their green building criteria (www.worldgbc.org). Table 1.2 illustrates indicators for each country, showing that the management criteria are significant and indispensable.

Table 1.2: Criteria of World Green Building Standard

Status	Criteria	GB CERTIFICATION SYSTEM	Management	Energy Efficiency	Indoor Environment Quality	Land use, Site and Ecology	Water Efficiency	Material & Resource	Emission and Pollution	Mobility and Transportation	Health and Well being	Economic	Cultural and Social	Innovation
Established	Canada	Green Globe	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
	Colombia	LEED	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
	Brazil	LEED	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
	US	LEED	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
	Dutch	BREEAM -NL	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓
	France	HQE	✓	✓	✓	✓	✓	×	✓	×	✓	×	×	×
	German	DGNB	×	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	×
	Espana	LEED	×	×	✓	×	×	✓	×	×	×	✓	✓	×
	Polish	LEED	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
		BREEAM	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓
		EU GB												
	Sweden	Eco Effect	×	×	×	×	×	✓	✓	×	✓	×	×	×
	Turkish	LEED	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
		BREEAM	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓
		DGNB	×	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	×
	UK	BREEAM	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓
	Emirates	LEED	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
		BREEAM	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓
		Estidama												
	Jordan	LEED	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
	Australia	Green Star	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓

	Criteria	GB CERTIFICATION SYSTEM	Management	Energy Efficiency	Indoor Environment Quality	Land use, Site and Ecology	Water Efficiency	Material & Resource	Emission and Pollution	Mobility and Transportation	Health and Well being	Economic	Cultural and Social	Innovation
	Indian	BREEAM	×	✓	✓	✓	✓	✓	×	✓	✓	×	×	✓
		LEED	×	✓	✓	✓	✓	✓	×	✓	✓	×	×	✓
		IGBC	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓
	Hong Kong	BEAM	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
		BEAM PLUS	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓
	Japan	CASBEE	×	✓	✓	✓	✓	✓	✓	×	✓	×	×	✓
	Singapore	SGBC	×	✓	×	×	✓	✓	×	×	✓	×	×	✓
	New Zealand	Green Star NZ	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓
	South Africa	Green Star SA	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	✓
	Malaysia	GBI	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
Emerging	Finland	LEED	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
		BREEAM	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓
	Italia	LEED	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
	Panama	LEED	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
	Qatar	BREEAM	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓
	Russia	LEED	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
		BREEAM	✓	✓	×	✓	✓	✓	✓	✓	✓	×	×	✓
	Serbia	LEED	×	✓	✓	✓	✓	✓	×	×	×	×	×	✓
Total			15	25	20	22	26	26	18	15	18	3	3	22

Discuss there are various criteria included in the “management” criteria according to different green building certification system.

For example, the management criteria of Green Globe certification system adopted by Canada explain the integrated design process (IDP). According to ECD Energy & Environment Canada (2004), using integrated design process produces

cost-effective and achieves a greater degree of sustainability compared to the conventional design process. IDP is one of the best tools that contribute to choose the most appropriate design path. It provides the alternative to adopt the design strategies and move society towards sustainability during the project (Zimmerman and Eng, 2006). Environmental purchasing (including energy efficient products) is to select materials, products and equipment that have minimal impact on the environment in terms of resource use for the purpose of energy-saving and utilisation of high-efficiency equipment (ECD Energy & Environment Canada, 2004). Emergency response plan are applied to reduce the hazard of hurt and the environmental impact of disaster emergency (ECD Energy & Environment Canada, 2004). Commissioning is to design, construct, and calibrate building systems so that they can operate as intended (ECD Energy & Environment Canada, 2004). Indeed, Green Globe has allocated approximately 50% to management practices including the commissioning item, which includes the structural system, heating, ventilation, air conditioning HVAC system, electrical system, etc. The reason is that with the commissioned systems, quality is assured and environmental protection practice is applied from the start (Wu and Low, 2010). The Green Globe rating system recognized the highest level alternative to attain sustainable development in Canadian green building context.

BREEAM criteria management adopted by UK includes sustainable procurement, which was as a key initial step to reducing their environmental impacts and stimulating markets for sustainable products and services (Berry *et al.*, 2011; Thomson and Jackson, 2007). Sustainable procurement has positive effective outcomes for the economy, environment, and society (Walker and Brammer, 2009). This is a process whereby organisations meet their needs for goods, services, works, and utilities in a way to achieve value for money on a whole life basis in terms of generating benefits not only for the organisation, but also for the society and economy, while minimising damage to the environment (Berry and McCarthy, 2011). Responsible construction practices attempt to recognise and encourage construction sites which are managed in an environmentally and socially considerate, responsible, and answerable procedure (BREGlobal, 2012). Construction sites recognise and encourage the management of resource use, energy consumption, and

pollution (BREEAM, 2011; BREGlobal, 2012). Stakeholder participation, according BREEAM (2011), included consultation with pertinent parties, accessible design, building user information, and post-occupancy evaluation. In fact, stakeholders get involved in designing, planning, and delivering available practical and inclusive buildings in consultation with current and future building of users and other stakeholders (BREGlobal, 2012). Service life planning and costing to recognise and encourage life cycle costing and service life planning to improve design, specification and through-life maintenance and operation (BREGlobal, 2012). BREEAM rating system is the best tool for reducing the environmental impacts and cost saving to attain sustainable development by various criteria, particularly management criteria.

HQE criteria management is another standard system, which was adopted by France. It involves energy management, water management, waste management, and repair and maintenance management. In BEAM Plus, the management practices include encouraging to develop the systematic building management systems that cause to achievement safety, health, and environmental performance. Green Star management practices adopted by Australia include credits addressing the adoption of sustainable development principles from project conception through design and construction. Commissioning is adequate and important for all buildings, including those with simple design and without much equipment, tuning, and operation; it recognizes the policies, procedures, targets, and strategies put in place to ensure buildings operate to their perfect sustainable potential. According to Green Building Council of Australia (2013), the effective management of building operations and services plays a key role to attain the sustainable performance. In an ideal world, an overall result based on previous studies, which has been shown as the main objective of any mentioned rating system, is conservation and preservation of environment, protecting natural resource, reducing greenhouse gas emissions particularly CO_2, energy saving, and cost effectiveness to achieve sustainable development on construction industry in various countries. Table 1.3 presents a summary of countries that include management.

Table 1.3: Management Criteria of Various Green Building Certification Systems

No	Country	GB Certification System	Management Criteria
1	Canada	Green Glob	Integrated design process, Environmental purchasing (including energy efficient products), Commissioning, Emergency response plan
2	UK	BREEAM	Sustainable procurement, Responsible construction practices, Construction site impacts, Stakeholder participation, Service life planning and cost
3	France	HQE	Energy management, Water management, Waste management, Repair and maintenance management
4	Australia	Green Star	Addresses the adoption of sustainable development principles from project conception through design, construction, commissioning, tuning and operation
5	Hong Kong	BEAM PLUS	Health, Safety and environmental management
6	New Zealand	Green Star NZ	Addresses the adoption of sustainable development principles from project conception through design, construction, commissioning, tuning and operation
7	South Africa	Green Star SA	Addresses the adoption of sustainable development principles from project conception through design, construction, commissioning, tuning and operation

According to Table 1.2, the green building certification standards, such as BREEAM, Green Globe, HQE, Green Star, Green Star NZ, Green Star SA, and BEAM Plus, have included management practice in their green building certification standard. Green Globe, BREEAM, HQE, Green Star, BEAM Plus, Green Star NZ, and Green Star SA have management practices in their green building standard system. However, some green building standards, including LEED, DGNB, CASBEE, SGBC, and GBI in Malaysia, have no management practices (Bond and Worzala, 2014; Christensen, 2012a, 2012b; Lowe and Ponce, 2010; Zainol *et al.*, 2013a). here are some potentialities for green building management in Malaysia; however, findings indicate that poor key management practices is a critical factor that leads to poor green building management in Malaysia (Kamarudin *et al.*, 2013; Nurul Nadiah Zainol, 2014). It means that a management criteria is essential and green buildings are required for reducing the overall impact of the built environment.

Based on review of GBI of Malaysia, it has different criteria in such as energy efficiency, indoor environmental quality, sustainable site planning & management, material & resource, water efficiency, and innovation, but it does not include the "management" criteria as other GB standards such as BREEAM, Green Globe, Green Star, and HQE. Most of the countries in "established" membership status have included "management" as a criterion in their GB standard; however, Malaysia is not among them. In this respect, with identifying green building management key practices, the present research attempts to highlight the significance of the inclusion of "management" criteria in the Malaysian GB Standard. The findings shows that the presence of management criteria in Malaysian GBI inspire the necessity of the including that in the GBI implementation in Malaysia, that has important role in developing the sustainability agenda on account of its possible contribution to the country sustainability aims in GB.

As mentioned earlier, based on the review of the world green building standards (Table 1.3), Malaysia does not have management criteria in the GBI rating purpose, despite the fact that it is essential for achieving the building's sustainability. To achieve sustainable development in green building, green building management practice is required. The management of green building is a critical issue practitioners face in the building industry (Kamarudin *et al.*, 2013). The Malaysian management construction industry still does not include a long-range planning policy particularly regarding the maintenance of common features (Tiun, 2006). Consequently, there is a superior consciousness regarding the necessity for these features to be managed well (Azmi and Azmin, 2006). It is clearly shown that green building has a positive impact on the environment by increasing the efficiency of natural resources such as water and energy. The main mission of green building is reducing impact of building on human health and decreasing greenhouse gases emissions especially CO_2 during its building life cycle. Ideally, green building management requires appropriate key practices in order to achieve sustainable development objectives. However, currently the appropriate management key practices are not available.

1.4 Research Questions

1- What are the green building management practices?

2- What are the green building performance parameters?

3- What are the relationships between the green building management practices and the green building performance?

1.5 Research Objectives

The objectives of this study are as follows:

1- To identify the green building management practices in Malaysia;

2- To identify green building performance parameters;

3- To develop a model for the green building management key practices and the green building performance.

1.6 Research Methodology

The present study was devoted in two phases: Phase I and Phase II. Phase I used expert survey and Phase II used a questionnaire survey as data collection instrument. Prior to the questionnaire development, a sample (totally 35 green building experts, facilitators, and managers) was collected during a four months period. In the first phase, the data obtained were analysed using Relative Important Index (RII), which was performed by the statistical package of SPSS. In the second phase, after final development of the questionnaires, a sample (totally 89 green building experts, facilitators, and managers) was collected during five months. The

data collected were analysed by Structural Equation Modeling-Partial Least Square (SEM-PLS). The sample for this study was extracted from a list of the Green Building Index Malaysia. Likewise, entire green building (office building) in Malaysia was chosen as the sampling frame. It means that this sample covered all the office green buildings in Malaysia.

1.7 Scope of the Study

As discussed above, present study covered all office green buildings in Malaysia. In Phase I, a set of questionnaires was distributed among 200 experts, facilitators, and managers. In Phase II, a set of questionnaires was distributed among 750 experts, facilitators, and managers. Experts, facilitators, and managers were targeted in this study because they were involved in overall management in green building context. Therefore, the most knowledgeable about green building management practices. Their opinions were taken into account in the outcomes of this study, which seeks to make improvements on green building performance and effective on green building performance to achieve sustainable development of green building management in Malaysia.

1.8 Guide to the Thesis

This thesis consists of seven chapters as follow:

Chapter 1 introduces the research background, problem statement, research questions, research objectives, research methodology, and scope of the study. Chapter 2 reviews the literature and provides a broad overview of green building management practices in the world. The extensive literature review covers previous studies conducted on green building, benefits of green building, commercial green

building, global standards of green building, and green building performance. Subsequently, it attempts to identify proper and competent management practices for Malaysian green building management. The literature review also provides a deep insight into the relationship between green building management practices and green building performance. Chapter 3 discusses the methodology and design of the research and the process of data collection to achieve the research objectives. Research population and sampling method is also discussed in this chapter. The chapter also describes the constructs of questionnaire and it concludes with a discussion of the statistical methods used to analyze data. Chapter 4 presents the empirical findings from the expert survey. The chapter presents the ranking of factors and categories revealed pertaining to their significance rank on improvement in green building management using Relative Importance Index. Chapter 5 discusses the results of data analysis and findings of the questionnaire survey. The chapter starts with description of green building, which is targeted for this study, in order to examine the bias within responses using Harman's single factor method. This is followed by outer loadings of the model, which will be assessed using validity and reliability. Finally, structural model will be analyzed to test the hypotheses. This chapter makes use of SEM-PLS for data analysis. Chapter 6 presents a summary of the study aims and objectives, followed by recapitulation of findings and discussion of results based on the empirical examinations of the theatrical framework of the study. Finally, Chapter 7 provides achievements pertaining to the research objectives and main findings of this research. Moreover, it discusses the conclusions drawn and provides recommendations of future works. Likewise, the limitations encountered in conducting the study are described and possible ways for future research are mentioned.

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