RISK MANAGEMENT PRACTICES IN GREEN BUILDING PROJECTS

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A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering (Honours) Civil Engineering

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

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ABSTRACT

Green building projects utilize green construction methods, green materials and energy-efficient operational systems. Risk management in green building projects is a process used to recognize, analyse, treat and monitor risks by prioritizing the sustainability issues – social, economic and environment. Nowadays, incidence on project cost overrun in green building projects is increasing due to the complex green certification process and limited availability of green products in Malaysia. This study aims to propose a risk management model for green building projects through exploration of risk management in green building projects and evaluating best risk management practices adopted by green building project developers. Quantitative research methodology was adopted in this study through the use of questionnaire survey on green building project developer organizations in Malaysia. A total of 192 respondents were obtained and analysed. The findings show that developers tend to identify, analyse and evaluate risks in green building projects by conducting consultation or interviews with professionals and local agencies. It is found that risk transfer through contracts and government financial incentives are favoured by developers in mitigating project risks. Risks in green building projects are monitored and controlled by cooperatively performing Design Assessment (DA) with Green Building Index authority. Outcome of this study proves that risk management practices positively affect the green building project performance. A risk management model for green building projects is established to provide general guidance to green building project developers on best risk management practices that would help enhance project performance in terms of cost, quality and time.

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

Construction industry materializes the human essential needs by providing construction works such as infrastructures, industrial, commercial and residential developments (Ricklopez, 2019). Therefore, construction projects are always being tagged with the terms of “complex” or “dynamic”.

Construction industry provides immense contribution to the economy growth of a nation. In Malaysia, construction sector contributes approximately 4.5% of Malaysia’s Gross Domestic Product (GDP) in 2019 (Department of Statistic Malaysia, 2020).

However, the water that bears the boat is the same that swallows it up. Construction industry has caused various sustainability issues such as emission of greenhouse gases (Oke and Aigbavboa, 2017). It contributes to 40% of water contamination, 23% of air pollution and 50% of landfill waste as well as 29% of global energy consumption (United States Green Building Council, 2015). Construction activities negatively affect the environment in terms of carbon dioxide emission, air pollution, water pollution, discharge of wastes, immense energy consumption and threatening wildlife ecosystem. The pollutions and energy consumption by construction sector could be double by 2050 if construction activities are carried out in the present manner. In order to relieve the negative impacts of construction industry on environment and society, the concept of green building has arisen (Jagarajan, et al., 2017).

According to World Green Building Council (2019), a “green building” is a building that can reduce or eliminate negative consequences and create positive influences on our climate and natural environment regarding to its design, construction and operation. A building is said to be ‘green’ when the building itself is resource-efficient and possessed the minimum negative impacts on our environment. The elements to be considered in a sustainable green building design include indoor air quality, waste reduction, water efficiency and marketability.

The most noticeable distinction between conventional buildings and green buildings is the utilization of sustainable green technology and building materials in green building projects. Therefore, the availability of green construction technology and materials such as lightweight reinforced concrete becomes a vital concern to developers of green building project. Nearly 25 per cent lesser energy is used and 11 per cent of water consumption is reduced in green buildings operations as compared to conventional buildings (U.S Green Building Council, 2015).

The innate risks and uncertainties in green building projects are more complex and intricate than those associated with conventional buildings (Javed, 2019). Although both types of buildings are associated with long construction periods, large financial investment and complex work processes, green building projects have higher risk exposure due to their desire to comply with environmental sustainability and stringent green certification processes.

As such, risk factors involved in green building projects have been studied and investigated by numerous of scholars. Majority of these scholars such as Javed (2019), Mustafa (2015) and Byung (2015) have concluded that project cost overrun, lack of green construction experiences and scarce availability of green technology / products and materials are among the leading risks in green building projects. Xiang, et al. (2018) further concluded that the identification and treatment of project risks should be the top priority in green building project management.

Productivity, efficiency, works quality, time of completion and costs of project are key to building up the rudiment of a successful construction project. Owing to the implementation of green construction practices and requirement of third-party green certification, green building projects are laid on a high-level of project risk management to manage risks in both construction and operation phases.

The Government of Malaysia has committed to reducing 40% of emission intensity of GDP by 2020 at the Copenhagen 15th Conference of the Parties (Choi, 2009). These undertakings are opening the doors for further exploring risk management practices and developing a committed risk management model in green building projects in Malaysia. The outcome of this research is expected to assist green project developers to understand the risk management framework and effectively manage the risks in green building projects.

1.2 Importance of the Study

With the understanding in risk management system, green building construction stakeholders will be aware of the strengths and weaknesses of each risk management practice. In this way, the stakeholders can manage project risks by applying the most effective and efficient risk management practices suited to their project and organisation.

In addition, this study is imperative to help the developers in reducing the probability of overrun of budget. As the outcome of this study, a risk management model in green building project will be formed. This green building project risk management model will serve as a guideline for developers to select suitable and relevant practices in managing projects risks when undertaking green building projects.

Despite the environmental concerns are high among both consumers and project developers, the adoption of green building designs and projects are relatively low in Malaysia (Rohafiz, et al., 2016). It is thus envisaged that this study will help promote awareness of green building construction through an understanding of how to manage risks in these projects.

1.3 Problem Statement

The incidence of project cost overrun is increasing in green building projects in Malaysia. Until 2019, green building projects in Malaysia have seen project cost overruns ranging from 1% to 13% (Chen, et al., 2019). Overrun of project costs is mainly due to the higher construction cost and limited availability of green products (Xiang, 2018 and Nerija, 2012). In addition, green building projects require higher financial investment for green technologies such as efficient LED lighting system; and green building materials such as Uni Eco-Stone (Green Building Market Report South East Asia, 2014). Table 1.1 illustrates average additional construction costs in green building projects in different countries.

Table 1.1: Summary of Extra Construction Costs in Percentage in Green Building Project (Chen, et al., 2019).

Authors	**Country**	**Green Building Type**	**Extra Construction Costs**
Kim, et al., 2014	USA	Residential housing	10.77%
Bartlett, et al., 2000	United Kingdom	Housing, Commercial	5% - 15%
Zhang, et al., 2011	China	Hotel, Office	10.3% - 13.9%
Gabay, et al., 2014	Israel	Office	4.33% - 11.6%
Green Building Index, 2019	Malaysia	Commercial	1% - 13%
Bon, et al., 2017	Singapore	Commercial	5% - 10%

Table 1.1 above shows maximum 14 per cent of cost increment required in green building projects in different building category in different project locations. Majority of these projects indicate project construction cost increment between the ranges of 1 per cent and 15 per cent. The overall construction costs invested in green building projects are also higher than that in conventional building projects (Chen, et al., 2019).

Overrun of project budget in green building projects is also caused by the need to carry out green certification process such as GBI system in Malaysia (Chen, et al., 2019). However, the unstable supply line and limited availability of green building construction materials and equipment do not facilitate the execution of the certification process. For example, progress delays due to materials supply shortage lead to project cost increment as the developers or contractors are required to invest extra labour costs for overtime work, additional rental on machinery and replacement of alternative green materials or equipment.

The situation of budget overrun frequently occurs in green building projects due to high construction cost, unstable supply line and lengthy green certification process (Javed, 2019). Hence, the potential negative impacts due to budget overrun will be reduced by applying risk management practices. For instance, the project developers could identify the risks beforehand through risk management practices to ensure the insurance coverage is aligned with the identified risk exposures. In short, a study on evaluating current adopted risk management practices in Malaysian green building project is mandatory to assist the Malaysian developers in reducing the risk of budget overrun.

1.4 Aim and Objectives

This study aims to propose a risk management model for the green building projects in Malaysia. The objectives of this study are:

i. To study and explore risk management in green building projects.
ii. To evaluate current risk management practices in green building projects.
iii. To establish a relationship between green building project performance and best risk management practices.

1.5 Scope and Limitation of the Study

This study is focused on developers involved in green building projects in Malaysia as the research frame because project developers are seen as among the pioneers in green building projects. Developers manage project investment needs and project feasibility in terms of design, functionality, practicality, cost, location and marketability (Ricklopez, 2019). They are exposed to greater risks compared to contractors or consultants.

More than 75% of identified risks affecting green building projects tend to occur during the planning and construction phase of a project (Xiang, et al., 2018). This study's domain will therefore centralize on risk management practices up to the construction phase of green building project.

1.6 Contribution of the Study

The findings of this study include a proposed risk management model for green building projects in Malaysia. Risk management model will help green building project developers understand the complete risk management process, select appropriate risk management practices and thus, improve project performance in time, quality and cost.

Through an understanding of identifying and managing risks in green building projects, it is hoped that this will increase the strategic role of risk management. In the long term, awareness of the processes and best management practices will promote the use of implementation of green and sustainable materials and work processes within the organisation.

The findings of this study also promote adoption of innovative and sustainable construction materials and operational systems. In addition to identifying risks, risk management helps discover opportunity in green building projects such as green construction techniques and innovative green materials. This study helps developers to analyse and evaluate the performance of innovative operational systems and materials through recommended risk analysis and evaluation practices.

1.7 Outline of the Report

This report consists of five chapters, namely Chapter 1 – Introduction, Chapter 2 – Literature Review, Chapter 3 – Methodology & Work Plan, Chapter 4 – Results & Discussion and Chapter 5 – Conclusions & Recommendations. Chapter 1 – Introduction presents the overall view of this study including the introduction, importance of this study, problem statements, aim and objectives as well as the scope and limitation of this study.

Chapter 2 – Literature Review discusses green buildings and risk management in green building projects including the definitions of risk and sustainability, elements of green building and risk management stages in construction projects.

Chapter 3 – Methodology & Work Plan describes the applied research methodology, data collection and data analysis. This chapter also discusses the suitability of adopting each data analysis methods.

Chapter 4 – Results & Discussion presents the findings obtained from data analysis in tables and charts. Interpretation of data presents in terms of internal consistency of questionnaire, ranking of risk management practices and risk management model for green building projects.

Chapter 5 – Conclusions & Recommendations shows the conclusions drawn from the findings and data in this study. This chapter also discusses a number of recommendations for future studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature review on green buildings and the essential elements associated with these buildings. This chapter also discusses risk management processes and practices in green building projects as well as the performance criteria for green building projects.

2.2 Definitions

2.2.1 Green Buildings

The principle of sustainable construction establishes the concept of green buildings and high-performance buildings. Green buildings refer to buildings that apply green construction technology, utilize environmental-friendly building materials and utilize energy-efficient operational systems.

In the United States, the Office of the Federal Environmental Executive defines ‘green building’ as the practice of improving efficiency in energy, water and material usage in a building as well as reducing building impact on human health and environment (Howe, 2015). The Environmental Protection Agency (EPA) interprets green building as the practice of creating structures by using environmentally responsible and resource-efficient processes through a building’s life cycle (Howe, 2015). In Malaysia, a green building is one that is designed to be efficient in its energy use, water use and building materials (Green Building Index, 2020). According to the World Green Building Council, green buildings are buildings that can reduce or eliminate negative impacts and create positive impacts on the climate and environment. Despite the variations in definitions, all of these definitions focus on the efficiency in energy or resources usage while preserving the natural environment.

Since the life span of buildings is far longer than the construction phase, decisions made during early phase of buildings will affect the building’s life cycle cost, ultimately impacting the overall sustainability of the building.

Green buildings are associated with the concept of sustainability throughout the life cycle of the buildings (Charles, 2006). Green building construction requires the adoption of practices and techniques that considers the efficiency of resources and responsibility to environment beyond its construction phase. Therefore, green buildings and high-performance buildings are interrelated to ensure continuity in construction sustainability.

Utilization of green technology and technique in green building enhances the comfort level and health of building’s occupants, conserves water usage and improves efficiency in energy consumption. Green building opts for green materials for interior and exterior finishes as well as green system to operate the building. The goals of constructing a green building could be divided into the aspects in energy, water, materials, wastes, environmental quality and operation and maintenance of building. Figure 2.1 diagrammatically illustrates both construction and operational systems utilized in green buildings to minimize the footprint and to maximize the energy efficiency. Green buildings typically possess 3 major objectives (MyFlorida Green Building, 2008).

i. Protection of the environment and alleviation of consequences of global warming;
ii. Achievement of low life cycle cost;
iii. Enhancement of value or marketability of the projects.

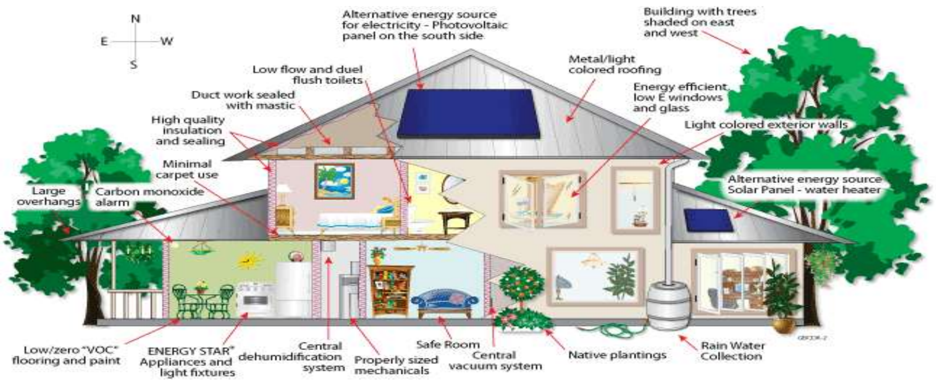

Figure 2.1: Conceptual Green Technologies and Techniques Adopted in Green Building (MyFlorida Green Building, 2008).

2.2.2 Sustainability

Sustainability is meant to optimally utilize the natural resources in an equilibrium condition (Mustafa, 2015). An equilibrium situation in natural resources usage ensures that it will not reach a condition of decay, depletion and un-renewable. Sustainability concept applies to every field including the global development policy to the usage of energy resources (Milena, 2010). The main objective of sustainability is to protect the natural and built environment to ensure the continuity of human beings and natural resources in the future (Osso, et al., 1996).

Sustainability provides continuous development in changing incorrect resources consumption habits without degrading our lives quality. As result, sustainable development aims to create a balanced and continuous synergy between social, economic and environmental aspect (Mustafa, 2015). Figure 2.2 shows the relationship between sustainable development in the aspects of social, economy and environment.

Figure 2.2: Sustainable Development in Social, Environmental and Economic Aspects (Milena, 2010).

Social sustainability focuses on promoting equality and balance to ensure the handing down of resources to future generations. Basic needs include work, accommodation, health care, education and cultural activities. Economic sustainability involves economic growth, economic diversity, employment rate, individual income and personal consumption. The resources needed to conduct those economic activities are slowly depleting day by day without any renewal of these resources (Amr, 2017). Hence, seeking a balance between economic production and consumption becomes a vital prospect in economic sustainable development.

The third domain of the sustainability concept is environmental sustainability. It relates to the protection of the ecological balance and natural cycles or systems from excessive consumption (Milena, 2010). Ecological balance within our ecosystem is essential as the sustainability of our natural resources depends on Mother Nature's ability to renew her resources. For example, uncontrolled or unregulated agricultural activities and industrial processes can cause water and air pollutions which negatively affect the sustainability of the water cycle. Maintaining water and air qualities throughout our human activities will help with the continuity of the earth's natural water cycle.

2.3 Relationship Between Sustainability and Green Buildings

Sustainability focuses on achieving balance and preservation of social, environment and economic aspects. Green buildings are one of the products from principle of sustainability in construction industry. The development of sustainability within construction industry is achieved through adoption of sustainable construction materials in green and high-performance buildings (Mustafa, 2015).

Sustainable construction is defined as the duty of care by the construction industry in achieving sustainability regarding to social, economic and environmental concerns (Anete, 2016). A complete sustainable construction cycle typically involves sustainable planning of resources, sustainable construction technology and management of construction wastes. In order to ensure sustainability as prescribed, the building industry in particular has focused on the development of green and high-performance buildings. Figure 2.3 exhibits framework of sustainable development in construction industry.

Figure 2.3: Framework of Sustainable Development in Construction Industry.

Green buildings are generally associated with sustainable construction methodology such as implementation of green technology and utilization of green building materials in construction phase. Green building concept typically involves construction processes that facilitate construction players to achieving sustainability goals through such green construction process. Green buildings are considered healthy facilities designed and built in a manner of resource-efficient and environmental-harmony (Kamar, 2011).

High-performance buildings are defined as green buildings that address sustainability goals throughout their life cycle (Kamar, 2011). Hence, the sustainability in construction industry encompasses sustainable construction, green buildings and high-performance buildings.

2.4 Elements of Green Buildings

Colburn (2019) outlined 5 core elements that should be considered in a green building project. The elements are:

(a) indoor environment quality

(b) sustainable site design

(c) materials and conservation usage

(d) conservation and quality of water

(e) environment and energy efficiency

2.4.1 Indoor Environment Quality (IEQ)

Indoor Environment Quality (IEQ) is a system to assess the comfort and health of building occupants (GreenNspace, 2019). IEQ is important in reducing the negative impacts on the occupants inside the building. For instance, a well-designed ventilation system in a building can effectively manage the optimum moisture control, energy efficiency and building durability. Poor indoor air quality in a building exposes building occupants to air pollutants, thereby affecting their health (Colburn, 2019).

According to American Cancer Society (2015), long-term exposure of formaldehyde leads to irritation of skin, eyes and nose. By utilising building materials that are formaldehyde-free would prevent such incidences. Planning and designing a sustainable HVAC system helps ensure exchange of fresh air and keep moisture at bay.

2.4.2 Sustainable Site Design

Site location for constructing a green building is a critical element to be considered in terms of sustainability. Harmonising the building structure with local ecosystem, ensuring accessibility of public services and utilization of available local resources play an important part in determining the “greenness” of a building (GreenNspace, 2019). Utilization of natural resources at the surrounding of green building is referred to collaboration between the green building and surrounding natural resources such as streams, storm water runoff and soils (Oke, et al., 2017).

Thomas (2012) claims that one of the popular “natural” method to minimize the environmental footprint of buildings is by orienting the building design to take advantage of sun angles and prevailing winds. Another method adopted by constructors in reducing environmental impact during construction is avoiding excessive soil compaction which will damage the flora around the construction site and replanting cleared areas to prevent erosion.

2.4.3 Materials and Conservation Usage

Building materials selected for building construction must be non-toxic, durable and renewable. The materials and conservation usage in green buildings consider 3 chief aspects namely, quality, strength and cost of the building materials (GreenNspace, 2019). The materials used in constructing green building should be toxic-free, safe and renewable. A study conducted by Thomas (2012) shows that Green Seal rated paints and arsenic-treated lumber are commonly used as they do not release toxins and harmful VOCs.

Engineered materials such as pre-fabricated roof trusses and recycled steel frames are used in green building projects to enhance the durability and to reduce the amount of materials used in construction. Selection of locally-produced materials could minimize the carbon footprint in transportation.

2.4.4 Conservation and Quality of Water

Water efficiency and water quality are another core element that is used to measure the sustainability of a building during both construction and operation phases (GreenNspace, 2019). Green buildings should be designed in a way that able to conserve the water resources through installing water-efficient appliances and constructing landscape with drought-resistant plants to reduce the water usage. In terms of construction, the permeable pavement is widely constructed in parking lots or walkways to ideally manage the storm water runoff and flood control (GreenNspace, 2019). Green garden, green roof design and rainwater harvesting system are proposed in green building to save the energy and water usage. Water quality could be ensured by selecting the plumbing system with green certification to reduce the lead or other contaminant leakages.

2.4.5 Environment and Energy Efficiency

There are 3 major steps in achieving environment and energy efficiency in green building. The first step is to estimate and model the energy requirement for the constructed green building in the planning stage. Next, the suitable energy-efficient systems in HVAC system and lighting could be proposed based on the estimated energy consumption to reduce the energy usage. For example, passive solar heating such as bricks and blocks are ideally sized and placed to ensure proper heat transferring and maintain the optimum temperature inside or outside of the building. The last step involves the utilization of natural sources of energy such as solar to generate electricity for operating the building.

A summary of these 5 core elements to be addressed in green building design is shown in Table 2.1.

Table 2.1: Summary of Green Building Design Core Elements (GreenNspace, 2019).

Elements of Green Buildings	Objective	Design Features
Indoor Environment Quality	To provide a comfortable indoor environment to building occupants.	• Efficient HVAC system • Plywood without formaldehyde
Sustainable Site Design	To effectively make use of surrounding natural resources.	• Natural shading • Proper site planning
Materials & Conservation Usage	To select materials with better quality and resource-efficiency.	• No-VOC paints • Recycled rubber
Conservation & Quality of Water	To conserve the water resources used in building operation and water supply quality.	• Rainwater harvesting • Low volume irrigation system
Environment & Energy Efficiency	To minimize the physical footprint and enhance energy efficiency.	• Solar Panel • High Performance HVAC System

2.5 Policy for Green Buildings

In spite of commitment by world leaders to global sustainability, the participation by stakeholders in the construction industry to implement green features or elements in buildings has been lacklustre. Due to a lack of regulatory guidelines and standards, the inclusion of green building elements in building projects is currently voluntary. However, in recent years, many government or non-government organizations have begun to implement policies, laws, building codes, design guidelines, assessment and certification systems to achieve green building concept in the sustainable construction industry. The objective of such a move is to make these sustainability measures mandatory instead of voluntary and to standardise such measurements.

Countries such as Singapore, United States, Australia and Japan have begun implementing green policies in their building projects. In 2014, the Singapore Green Building Masterplan 3rd version was established to incentivise the private sector to actively undertake green building projects. Serene (2014) highlighted that there is at least 443 completed projects which have been certified as green building projects in Singapore. Under the governance of this policy, the Building Retrofit Energy Efficiency Financing (BREEF) scheme, Green Mark scheme and Green Building Research & Development Framework 2015 – 2014 were also established.

In the United States, the International Green Construction Code and ASHRAE Standard 189.1 are adopted in the American construction industry as a construction guideline in site planning, construction, materials, energy efficiency and water considerations.

Green building rating systems have also been developed to provide an assessment system with defined set of requirements and certifications for green building projects. Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment Method (BREEAM) are proposed by European Union and United States. In South East Asia, similar rating systems such as Green Mark in Singapore, Lotus in Vietnam and Greenship in Indonesia have been established and implemented. However, these rating systems focus on the varying green building parameters and thus create a subjective difference in the assessment and certification of a green building project.

In Malaysia, the Malaysian government has formulated several policies and programmes to promote green building procurement. The National Green Technology Policy was launched in 2009 to strengthen and incentivise the use of energy-efficient technology such as solar photovoltaic, green building materials and rainwater harvesting system (Suhaida, et al., 2013). The National Policy on Climate Change (NPCC) was set out to encourage low energy consumption in design and construction of new buildings. These policies resulted in the establishment of Green Building Index rating system and the successful transformation of Green Township in Putrajaya and Cyberjaya.

Today, existing rating schemes in Malaysia include the Green Building Index (GBI) rating system, Green PASS (Green Performance Assessment System in Construction), PWD Green Rating Scheme and Low Carbon Cities Framework & Assessment System. Despite the difference in the focus of each assessment scheme, the main aim of these rating schemes is identical. Each rating scheme is established to evaluate the structure in terms of environmental, social and economic sustainability. For instance, the GBI rating system is an evaluation and certification system for environmental design, construction and buildings performance in Malaysia; whereas Green PASS is an assessment system that developed by the Construction Industry Development Board (CIDB) to assess the buildings in both construction and operation phases.

The GBI system had practically transformed iconic buildings in Malaysia into sustainable green buildings such as Diamond Building Putrajaya and Kuala Lumpur Securities Commission Building. The University of Malaya and Port Dickson Municipal Council are the green building exemplars of low carbon footprint emission. A summary of green building policies and programs in different countries is formulated in Table 2.2.

The outcomes of aforementioned policies and rating tool are explained through statistical description. There are approximately 1.85 million square feet of space certified by the Leadership in Energy and Environmental Design (LEED) each day in the United States (Gabriel, 2019). In Malaysia, there are 389 registered Green Building Index projects up to the year of 2013 (Asia Green Buildings, 2013). Selangor has 166 registered GBI projects, the highest among all the states in Malaysia. Figure 2.4 below shows a bar graph of the number of registered GBI projects in each state in Malaysia.

Table 2.2: Summary Table of Green Building Policies.

	Programs	Countries which currently practicing	Major Benchmark
Policy or Guidelines or Standards	Singapore Green Building Masterplan 3rd version	Singapore	• Incentivize the private sector
	Building Retrofit Energy Efficiency Financing (BREEF) scheme	Singapore	• Financial subsidy from government
	ASHRAE Standard 189.1	United States	• Green building design checklist
	National Green Technology Policy	Malaysia	• Encourage green technology
	National Policy on Climate Change (NPCC)	Malaysia	• Zero Energy Concept
	Systems	**Countries**	**Major Parameters**
Rating Tools	Green Mark & Lotus& GreenShip	Singapore & Vietnam	• Water efficiency • Energy efficiency • Environmental protection • Building materials & resources
	LEED	USA, Canada, etc	
	BREEAM	EU	
	GBI	Malaysia	
	PWD Green Rating Scheme	Malaysia	• Government buildings
	LCCF Assessment	Malaysia	• Carbon emission

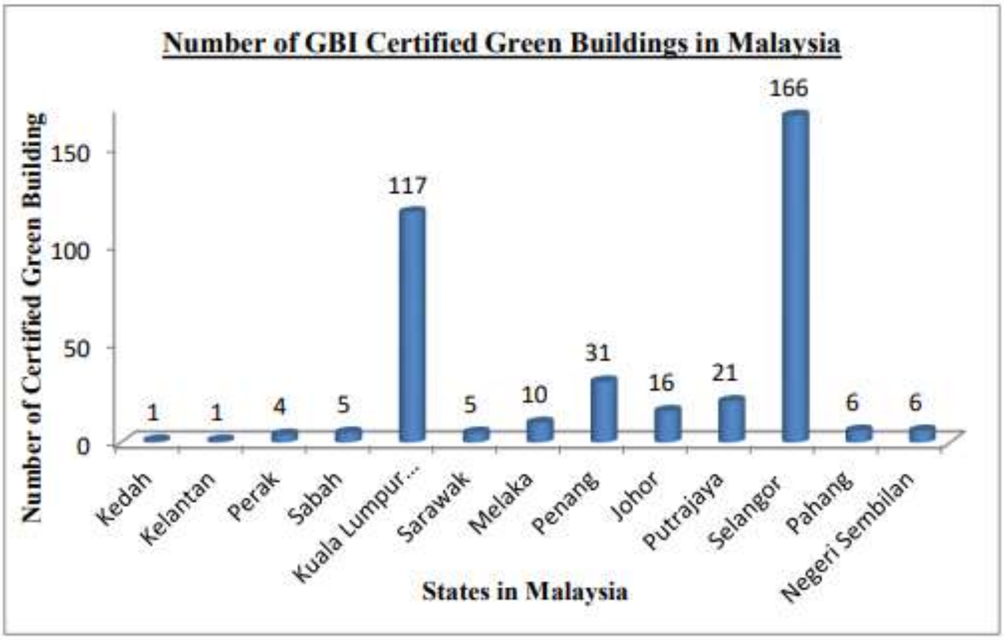

Figure 2.4: Bar Graph of Registered GBI Projects in Malaysia.

2.6 Life Cycle of A Green Building Project

A building project aims to deliver final outcome of product to the owner, client, investor or user of the completed work (Archibald, et al., 2012). The life cycle of a construction project typically consists of 4 major phases namely project initiation, planning of project, execution of project and closing of project. In the case of a building project, its life cycle ends when the project completes its phase of closing-out. The operation and maintenance of the building is classified under the extended project life cycle (Anete, 2016). The extended life cycle of a building includes the operation & maintenance of building, building introduction to the community, growth of the building usage, maturity of building function and decline of building popularity. Figure 2.5 illustrates the comparison of typical project life cycle and extended project life cycle.

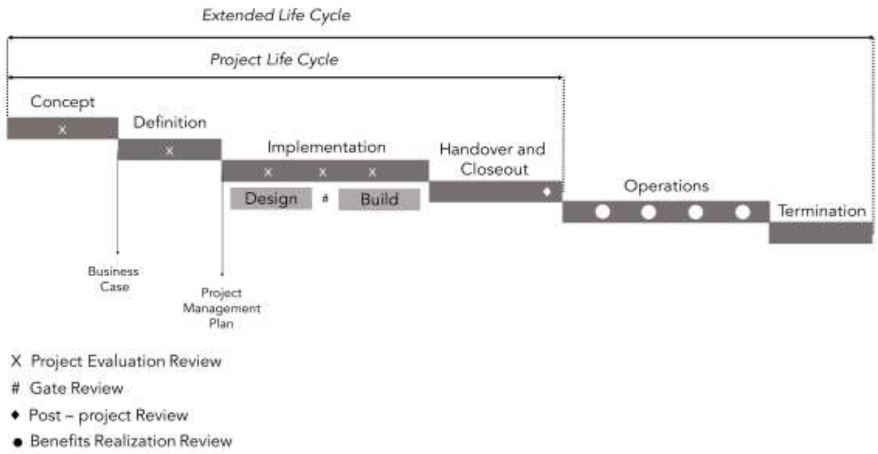

Figure 2.5: Comparison of Typical Project Life Cycle and Extended Project Life Cyle (Anete, 2016).

In green building project life cycle, there exists a minor difference in its life cycle stages as compared to the life cycle of normal construction projects. The methods practised by the building design team in conducting the 4 major project life cycle stages is different from conventional building project life cycles. For instance, the green building project design team will evaluate the building construction materials based on material durability, cost and most importantly, the environmental impact. By taking wood-flooring product as example, the design team evaluates the potential impact of utilizing wood-flooring product in their building construction. Was the wood extracted in a responsible way? Will the wood manufacturer carry out any practices to avoid deforestation? These are the potential inquiries that the green building design team will explore and study. The process of manufacturing building material from extraction to disposal investigated is known as cradle-to-grave approach (Colburn, 2019). Hence, this differentiates the approach taken in project planning by project team in non-green building and green building project life cycles.

Green building projects must offer sustainability enhancement in both construction and operation phases. The project life cycle of a green building encompasses location selection, design, constructions, operation and maintenance of building in providing social, environmental and economic sustainability. Green building construction project life cycle can be classified into 4 major phases as follows:

- Phase 1: Initiate the project regarding to green building concept, green building requirements, identification of eco-friendly construction materials, location selection, project planning and work scheduling.
- Phase 2: Prepare and develop the building feasibility confirmation, demonstration of green building performance and green design prototype.
- Phase 3: Execution of work in implementing green construction technology, installation of green equipment and reliability test on green materials and technology.
- Phase 4: Handover of project that involves termination of construction works, environmental life cycle assessment of building and evaluation on life cycle costing.

The project life cycle of a green building possesses similar stages as that of a conventional building. However, stakeholders involved in the procurement of green buildings focus on the environmental, economic and social impacts of the building throughout the entire life cycle.

2.7 Organizational Management Levels in Developers

Like any building project, green building projects also involve a number of stakeholders such as developers / clients, contractors, architects, consultants, suppliers and local authorities. The organizational management levels in developer organisations are typically strategic, tactical and operational levels (Barrie, 2018).

Strategic level management involves project managers, directors, heads of department, executive managers and chief executive officers who are responsible for strategic planning. This level involves breakdown of the project for time, cost and quality controls. Strategic decision makers are responsible for the coordination and direction of the building projects in terms of project scheduling, resources scheduling, budget allocation, quality of work and performance to construction contracts (Wilbert, 2000).

Tactical level management refers to the level at which engineers, consultants and other project design team members prepare tactical plans to execute the construction. During the design stage of the building project, engineers prepare design documents related to green building specifications and conduct application for approval to authorities. They also outline the work processes need to ensure smooth execution of the project from design to handing-over of the completed building to the client.

Operational level includes supervisors and inspectors of green building projects who execute operational plans that would see the project to fruition. Operational plans generally takes lesser time to complete compared to tactical and strategic plans (Barrie, 2018). Supervisors or inspectors in green building projects monitor work progress, ensure compliance with construction safety regulations, ensure work finishes on time and meet the work quality set out by client and authorities.

2.8 Definition of Risk

Risks in construction projects have frequently been studied by many scholars. Xiang (2018), Ranaweera (2010), Mustafa (2015) highlighted that green building projects experience higher degree of financial risk as compared to the conventional building construction project. The high exposure of financial risk in green building projects is caused primarily by the adoption of eco-friendly or green technologies and strategies which typically required higher financial investment and capital costs. Hence, the phenomenon of risk exposure in both conventional and green building project is unavoidable, but the degree and causing factors of the risks will be varied accordingly.

In a prevailing definition from dictionary, risk is defined as a probability of something bad happening such as damage, accident or any other negative occurrence caused by internal or external vulnerabilities (Berenger, 2016). Meanwhile, Chen Wang, et al. (2015) defined risk as an unexpected event that arises during the process of construction projects. Hillson (2013) stated that risk is the uncertainty that is measurable whereas uncertainty is a risk that cannot be measured.

The 2 types of risks in green building projects are classified as known risks and unknown risks. Known risks are referred to risks that can be identified and where relevant response strategies can be developed in order to tackle such risks. Risk response strategies could be either preventive action or corrective plans that prevent the occurrence and recurrence of similar risks.

One example of a known risk in green building projects is the compliance to requirements as stipulated in different green building rating systems. Low reliability and performance of green building operational systems are also other known risks in green building projects. However, unknown risks are defined as risks that cannot be identified proactively but require emergency risk response plan. One example of unknown risk that is faced by stakeholders is changes in green building policies by the government of the day.

Johnson (2008) stated that risk is an occurrence that has a degree of insignificance. It can either be positive or negative. A positive risk is considered a beneficial opportunity of positive effects whereas a negative risk is considered a threat that might cause damages to the construction project.

Hence, risks should be identified and analysed based on criteria such as risk sources and categories. If a risk has been identified and evaluated, then appropriate risk response action can be taken to reduce the potential negative impact done to the building project.

2.8.1 Category of Risk

Risks in green building projects are classified into 5 categories. Risks under the same category are identical and share characteristics in positively or negatively affecting a green building project. The 5 categories include financial, standard of care or legality, performance of green products, management and supply chain.

a) Financial Risks

Financial risk is defined as risks that impact green design, construction, profitability of owner or client, cost in practicing green technology and achievement in completing the project within the budget given. The outcome of financial risks might be loss of monetary investment and business venture or project cost overrun. By taking the economic downturn due to pandemic Covid-19 in Malaysia as an example, the construction works of building project regardless of conventional or green buildings had ceased and declined tremendously up to 44.9 per cent which amounting to RM 19.80 billion in 2020 (Department of Statistic Malaysia, 2020). Without a proper and specific risk response plan during downturn of economy, green building projects face a higher probability of project failure or cost overrun due to inflation. In addition, the cost in green building certification process and low return-of-investment (ROI) rate are those specifically categorized under the financial risks in green building projects.

b) Legal Risks

Risks involve the aspects of legality and standard of care for a green building project typically affect the green building project performance. The standard of care in green building project is defined as the degree of prudence, caution and liability under a duty of care in construction and operation & maintenance phases (Javed, 2019). For instance, the standard of care for a certified green building project is to attain and fulfil the requirement stated in a green building code or assessment system such as LEED and GBI. Besides, this risk category is also referred to the legality and contractual issues between the construction stakeholders. Ambiguous contract language will beget a debatable risk allocation between the developer, architects, contractors and consultants.

c) Product Performance Risks

The third category of risks in green building project is centralized on the ability of the implemented green products, systems and building materials. The performance and reliability of green products are the typical risk that encircles the green building project. For instance, the bamboo flooring is one of the green building trends in United States as it is a renewable source of materials. (Colbrun, 2019). However, the moisture-prone characteristic of bamboo flooring will reduce the durability and its reliability for a long time period. Hence, the risk of long-term performance of a green product or technology is exposed as one of major risk factors in green building project.

d) Management Risks

Lack of qualified and experienced contractors or consultants in green construction is one of the risk factors that fall under the category of management. Contractors and consultants that lack adequate training, expertise and experience in green building construction face the problem of failing to attain green building standards. Developers are then faced with the challenge of employing the qualified and expertized architects, consultants and contractors in offering a certified product that fulfils requirement of green buildings and expectations of owner.

e) Supply Risks

The supply chain category involves the risks in obtaining a continuous and consistent supply for labour or workforce, green construction technology, eco-friendly building materials and green building structural or architectural designs. For instance, the difficulty in importing and exporting green building operation system such as green heating and cooling system considers as one of the classic supply chain risks in green building project. Hence, Table 2.3 summarizes the aforementioned risk categories developed from 3 main articles and studies (Modugno, 2009; Hwang, 2017; Javed 2019).

Table 2.3: Risks in Green Building Project.

Risk Category	Example of Risk	Authors
Financial	➢ High initial investment cost ➢ High cost of certification / approval process ➢ Being fined for falling to achieve Green Building Index (GBI) ➢ Overrun of project budget due to delays ➢ Price fluctuation of green materials ➢ Inaccurate project cost estimation due to inflation	Modugno (2009), Hwang (2017) and Javed (2019)
Standard of Care / Legal	➢ Exposed to lawsuit for falling to achieve green building standards ➢ Inconsistency between local and federal green building regulations ➢ Imprecise definitions of responsibility of stakeholders in contract ➢ Ambiguous contract conditions for dispute resolution or claims	Modugno (2009), Hwang (2017), Javed (2019) and Nerija (2012)

	➢ Long approval process and green policies	
Performance of Green Products	➢ Faulty performance in green technology ➢ Longevity & warranty of new green technology / product ➢ Design errors in architectural / construction / installation ➢ Use of non-certified green construction materials ➢ Unfamiliarity of latest green product requirements	Kaveh and Yamini (2016), Hwang (2017), Javed (2019) and Milena, et al (2010)
Management	➢ Lack of experienced green building contractors ➢ Late submission of green design detailing ➢ Inexperienced green building management ➢ Poor communication among parties ➢ Unsatisfying work schedule	Modugno (2009), Hwang (2017) and Javed (2019)
Supply Chain	➢ Limited availability of green suppliers ➢ Reliability of green product suppliers ➢ Import/export restrictions of new green products ➢ Delays in supply of materials / workforce	Modugno (2009), Hwang (2017), Nerija (2012) and Javed (2019)

2.8.2 Consequences of Risk

There are various consequences of failure in managing the negative risks such as project cost increment, damage of company reputation and low quality of work. Hillson (2013) mentioned that risk and uncertainty is indirectly outlined the outcome of an event where it is likely to diverge from the expectation.

The risks such as inaccurate estimation of green material prices and replacement of unsatisfying green products will increase the overall project cost and lead to overrun of project budget. Thence, the additional costs bear by the project investor or developers to replace green products with better quality or to increase the labour supply to catch up the expected site progress. All of these additional financial spending might lead to another issue – inaccessibility of extra project funds.

Furthermore, delay of project completion time is always being the common phenomenon in construction projects. For instance, the high degree of complexity in green building designs and construction methods will require more time spending for the contractors and consultants to perform their works respectively. The processes of design planning, analysis and work schedule preparation are time-consuming. As results, late delivery of design drawings slow down the site work and complex structural designs reduce the work efficiency of contractors on site. In the end, the site work progress could not meet up the expectation in project completion time.

In addition, the consequence of risk management failure is worsening as the project is said to be failed. A project failure implies that the project is unable to deliver the expected functions and marketability to the client, building users, community and environment. In other words, the business venture and financial investment that had embedded in this construction project are wasted. The reputation and review of the respective company will be damaged and affected for future work.

2.9 Risk Management in Green Building Projects

In general, risk management in green building project management environment is recognized as a structured way of recognizing, analysing and responding to the risks (Nerija, 2012).

The main objective of risk management is to create and provide a framework to support the decision making in green building construction project (Cheng, 2015). Risk management handles and manages the risk efficiently instead of merely eliminating the risks. Risk management is to control the risks in a proper way before the impacts of respective risk could be magnified and eventually affected the overall project performance. Early detection of risk and prioritization of risk handling process develops through practicing risk management in green building projects.

Figure 2.6 below illustrates the correspondence between the risk management and green building project life cycle. It is obviously shown that the highest frequency of risk occurrence is placed at the planning and developing stages of a project. This is because the objective and function of a green building project are haven't been defined in details. However, the impact of risks is determined as the greatest as the project is undergoing the execution of designs and construction works.

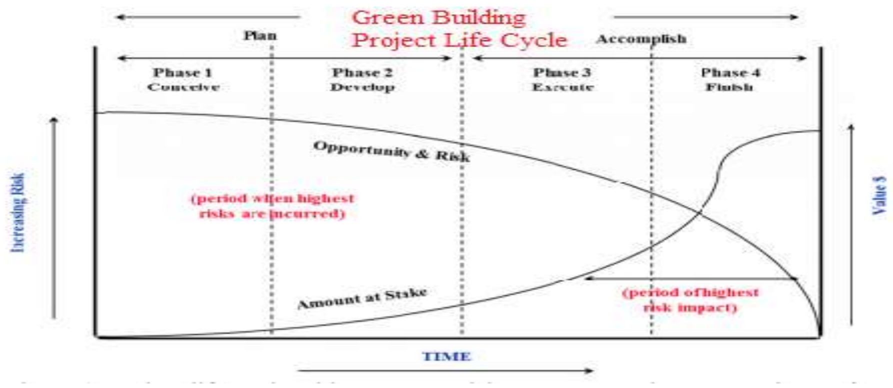

Figure 2.6: Relationship Between Green Building Project Life Cycle and Risk Management (Milena, et al., 2010).

A systematic risk management is composed of 5 major stages which are risk identification, risk analysis, risk evaluation, risk response and risk monitoring & controlling. Different risk management stages that associated with different practical techniques or tools could be applied from the planning to the closing stages of a project (Chen Wang, et al., 2015). An effective and correct risk management system ought to be implemented throughout the entire flow of green building project. Figure 2.7 exhibits simplified flow chart of risk management process in green building project.

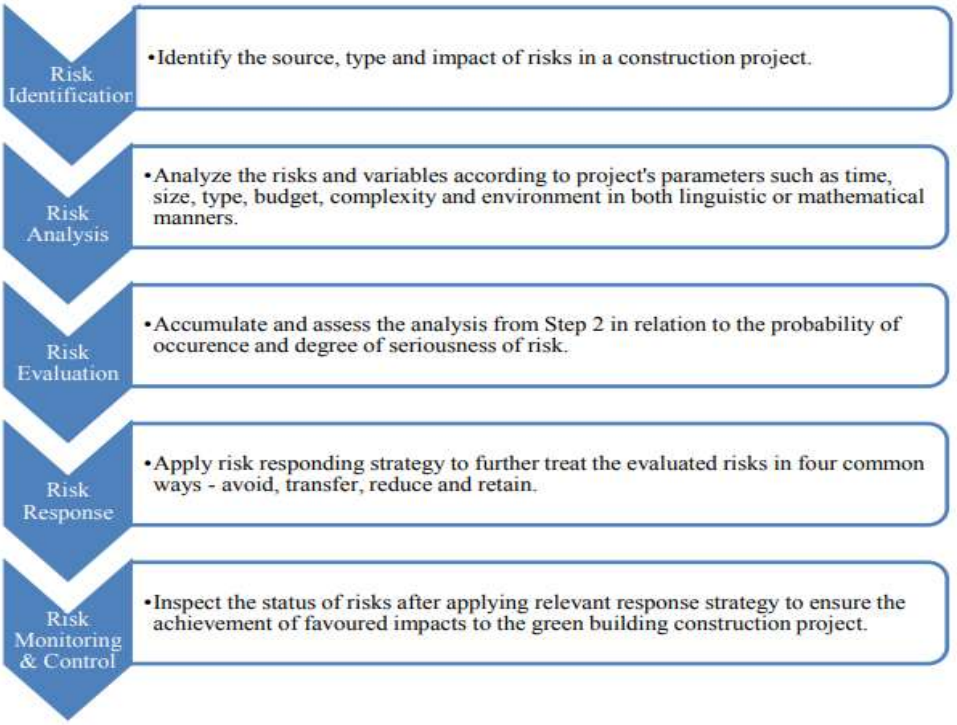

Figure 2.7: Risk Management Process in Green Building Project.

2.9.1 Risk Identification

The very first step of developing risk management system in a green building project is through applying the process of risk identification. According to Cheng (2015), risk identification is defined as the process in establishing an understanding of the type, source, factor, category and effect of the risks to the respective green building project. Similarly, risk identification portrays as the first stage of risk management that involves the recognition and classification of risk responsibilities. For instance, a green building project undergoes both project planning and risk identification stages simultaneously to pre-identify the potential risks. Next, the determined risks could be legally declared in the respective construction contract. In this way, the risk responsibilities could be assigned equally among the construction parties to avoid future confusion.

The stage of risk identification is considered as the most crucial and imperative stage out of the five major risk management stages (Anete, 2016). However, this stage requires complete knowledge and understanding of the green building project parameters and variables. There exist several methods in developing risk identification in a green building project. The methods such as brainstorming, workshops, interviews, questionnaire surveys and SWOT analysis are the prevalent techniques that applied in project risk identification. Besides of those interpretation and discussion among the construction participants, there exists computerized software to forecast the green product performance through Building Information Modelling (BIM).

Even though the aforementioned risk identification methods that applied might possess different techniques, the procedure in identifying the risk is more or less the same. In general, the first step in performing risk identification is through classifying the nature of risks into 2 main classes which are external and internal risks. The external risks are often occurred in international green building project that might experience political and social issues among nations in terms of environmental and building requirements matters. Then, the identified risks will be further break down into several risk categories as financial, legal, performance and management. Therefore, the risk identification provides the essential data for the following risk analysis.

2.9.2 Risk Analysis

Risk analysis or also known as risk estimation is practiced by 2 typical methods which are qualitative and quantitative analysis. Qualitative method is focused on determining the probability of a risk occurring and its corresponding impact in a linguistic manner. The qualitative analysis involves interviewing with specialists or experts, descriptive analysis and professional judgement from experts. However, the limitation of this qualitative method is the subjective-prone data that highly based on the personal judgement of analyst. Hence, the qualitative risk analysis is involved the determination of frequency of occurrence of the identified risks and its possible impacts in a green building project. The rhetorical results from qualitative analysis will be further evaluated in the next step.

Besides qualitative analysis, some construction stakeholders preferred to utilize quantitative method when analysing high ranked of risks. This is because the subjective-prone analysis from qualitative method could be less accurate when only small-scale of risk information is available. The probability analysis, sensitivity analysis, scenario analysis and simulation analysis are the prevalent quantitative risk analysis methods. In brief, the quantitative analysis applies statistical approach in obtaining the numerical probability and importance of identified risks. The numerical data could be further modelled the impact of determined risks. In particular situation, the qualitative analysis is used in formulate and analyse the pre-identified risks and further applied in quantitative analysis to obtain both linguistic and numerical results.

2.9.3 Risk Evaluation

After the risks are being qualitatively or quantitatively analysed, the risk evaluation is subsequently conducted to evaluate the analysed risks according to degree of risk consequences and repetition of potential risks. In this risk evaluation stage, the relevant information and findings of experienced engineering point of view will be applied to evaluate the risks in a project. For instance, the reliability and performance of green building materials will be evaluated based on the reviews and opinions from users or specialists in green building project. The potential consequences such as low reliability and non-fulfilled green standard products will be proactively tackled with relevant risk response strategies.

The criteria such as likelihood of an unfavourable occurrence, the degree of seriousness, project parameters, green standards and requirement are imperative to be considered in risk evaluation stage. One of the common risk evaluation techniques is risk matrices method. Risk matrices are usually implemented to identify and classify the ranking of risks in a green building project. In this way, the critical risks that been evaluated could be prioritized and developed corresponding risk responses. Meanwhile, the tolerance of risks will be evaluated based on the findings from other assessments to decide whether the risks are acceptable or unacceptable. The assessments include green materials' life cycle assessment and Social Baseline assessment. The following decisions will be made based on the risk acceptability level to decide relevant countermeasures to be taken in the next stage.

2.9.4 Risk Response

The corresponding risk response strategy will established to resolve the identified and evaluated risks in 4 approaches which are risk avoidance, risk transfer, risk reduction and risk retention. Owing to the complexity and uniqueness of different green building projects, the risk response strategy will be varied accordingly when responding to certain risks.

Risk avoidance is basically referred as risk elimination. If a risk from conducting an activity is analysed and deduced that it might give rise to a negative consequence in the green building project, the construction stakeholders might decide not to conduct this activity at all. However, the risk avoidance might also lead to a possibility of losing out the potential benefits. As illustration, a green building project stakeholder decides not to apply green construction technique such as straw bale wall construction due to its high construction cost. In contrast, the great insulation properties of straw bale wall will be omitted in the green building construction.

In addition, risk transfer is conducted through transferring the risks to other parties by using the construction contracts or insurance. The assigned parties involve construction participants and non-construction participants such as insurance firm. In other words, the shift of risk responsibility to another party such as collaborates with insurance underwriter to ensure the relevant compensation tied to scope. According to Wang and Chou (2003), the building construction contractors frequently apply 3 channels to transfer the risk to other parties. The 3 channels are described as through insurance to insurance firms, through contractors to subcontractor and lastly through editing the contract terms and condition with other construction parties.

Another risk response strategy is through risk reduction that looking for the corresponding methods to reduce the likelihood of recurrence of risk and degree of seriousness. This strategy is mainly to reduce the risks rather than eliminating the risks in the project. For example, the risks of construction cost increment in green building project will be reduced as considering alternative funding sources such as oversea banks' resources, advance payment from clients and government financial incentives.

Lastly, risk retention is defined as the loss or gain from a risk is accepted when it is occurred. There exist 2 types of retention methods which are passive and active retentions (Goh, et al., 2013). The passive retention is through accepting the risks without any response action, whereas active retention is to allocate essential allowance as back-up or contingency plan whenever it is required. Therefore, the fourth stage of risk management process is through applying risk response strategy accordingly in different conditions and circumstances.

2.9.5 Risk Monitoring and Control

The last stage of risk management process is defined as the risk monitoring and control. As the risks are identified, analysed, evaluated and responded respectively, the risk monitoring and control is applied to portray as a character in monitoring, observing and controlling the status of risks. The status of risk could be opened, resolved or closed. The open risks are those risks that haven't been treated and responded, whereas resolved risks could be the risks that are being treated.

If a risk is determined as successfully responded and a favourable outcome is achieved, the risk status is known to be closed risk. In this way, this stage of risk monitoring and control could conclude the risk management process. However, the risk monitoring is a stage that should be applied continuously and consistent throughout the green building project life cycle. The risk will be re-analysed if an unfavourable impact is occurred after conducted respective risk response actions. Then, the risk management process will be applied again like a process cycle. Risk monitoring is practised by conducting workshop in developing work performance report, inspections conducted by independent third parties and Design Assessment (DA) conducted by green building authority such as Green Building Index. Table 2.4 exhibits the potential risk management practices to be adopted in green building project.

Table 2.4: Potential Risk Management Practices in Green Building Projects.

Risk Management Stages	Risk Management Practices	Authors
Risk Identification	1. Discussion 2. Interviews 3. Checklist guideline that certified by International Standard Operation (ISO) 9000 4. Questionnaire surveys 5. Scenario simulation (BIM)	Aliagha, et al. (2017), Xiang and Shu (2018), Nerija (2012), Mustafa (2015), Javed (2019),

Risk Analysis	Qualitative methods: 1. Interviews 2. Brainstorming discussions 3. Descriptive analysis 4. Professional judgement Quantitative methods: 1. Probability analysis 2. Scenario analysis 3. Simulation analysis	Aliagha, et al. (2017), Hilson (2013), Osso (1996), Nerija (2012), Hwang (2017)
Risk Evaluation	1. Professional Judgement 2. Social Baseline Assessment 3. Life Cycle Assessment	Vatalis (2013), Xiang and Shu (2018),
Risk Response	1. Risk Reduction: opt for government financial aids 2. Risk Transfer: risk transfer to other parties 3. Risk Avoidance: choose alternative option 4. Risk Retention: conduct workshop for workers	Javed (2019), Nerija (2012), Aliagha, et al (2017),
Risk Monitoring & Control	1. Independent third parties inspections 2. Work Performance Report 3. GBI Design Assessment	Goh and Hamzah (2013) and Byung (2015)

2.10 Definition of Project Performance

Azlan (2012), Berenger (2016), Anete (2016) highlighted cost, time and quality as the criteria of measuring project performance. The iron-triangle concept is the basic aspects of construction project success. The risk management is likely to enhance the project success rate, maximize the profitability and project value as well as minimizing the negative impacts of risks. Risk management intends to enhance the green building projects in 3 dominant ways:

i. Ensure the project tied within the estimated and forecasted construction cost of green building project. (cost)

ii. Ensure the project to be completed on-time. (time)

iii. Ensure the project is fulfilled the green quality and requirements regarding to technical, design, operational, function, environmental, social and political. (quality)

Cost performance of a green building project is a vital aspect as it represents successfulness of its construction quality, building performance, profitability, marketability, competency of architects and efficiency of contractors or consultants (Azlan, 2012). Project completion time, planning and site progresses measure the time performance of green building projects. Nerija (2012) claimed that cost and time are effective indicators to measure success of green building projects. However, the quality performance of green building projects is measured by examining the degree of fulfilment of green building construction guidelines (Anete, 2016).

2.11 Relationship Between Risk Management and Project Performance

In terms of cost performance, the cost-budget ratio is always being applied in determining the cost performance of a green building project. A high cost-budget ratio is exhibited a successful building project as the cost is minimized in the meantime of ensuring the quality of work is fulfilled. In other words, the cost growth in a project illustrates the performance of green building project in terms of financial concern (Azlan, 2012). In addition to cost on structural work, green building projects always require additional spending on green materials or products and green certification process.

The time performance refers to the completion time, planning & constructing work sequence and site progress performed by a green building project. A delay in green building projects could be sourced from several issues such as late delivery of design detailing, time-consuming green certification process, delivery of eco-friendly construction materials and complex structural work on site. To illustrate, a green building project is considered as successful if the actual construction and certification progress is followed the organized schedule. According to Javed (2019), green building projects require longer time for project planning, design and execution phases due to complex structural designs and compliance of regulations.

Lastly, the quality performance portrays as another interrelated aspects in green building project. The functionality of green operational system, sustainability of built environment, acceptance of society and reliability of green construction materials become the vital concerns in assessing the quality performance of a green building project. Even though different construction project participants might possess different expectations of the end-product, but the overall quality performance should be strictly complied to the corresponding green building guidelines and green rating schemes. The rating of green building projects by Green Building Index (GBI) directly indicates the quality performance of the respective green building projects (Mustafa, 2015). For instance, a completed green building project undergoes assessment undertaken by GBI authority to assess the work quality on energy efficiency, indoor environment quality, sustainable site planning, material usage, water efficiency and innovation of the projects.

2.12 Risk Management Model

Risk management model is the framework of systematic process involved identifying, analysing and responding to project risks (Nerija, 2012). Brian and Williams (2009) had outlined a risk management model for construction industry. Figure 2.8 shows the risk management model computed by Brian and Williams in 2009.

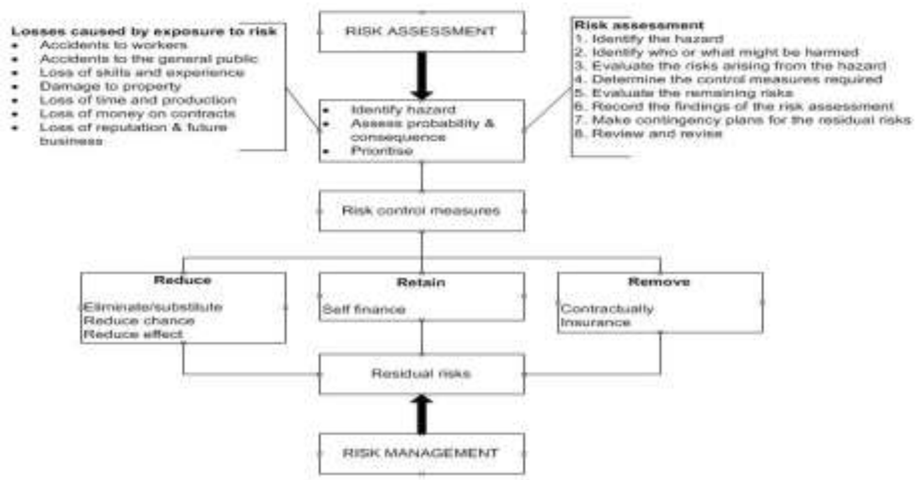

Figure 2.8: Risk Management Model (Brian and Williams, 2009).

This model is comprehensive in listing the negative impacts due to exposure of risks. A series of risk assessment process was outlined including identification, evaluation and review of risks. Risk responses were highlighted as 3 major methods namely risk reduction, retention and removal. However, there are few shortcomings in this model. The risks highlighted are the typical risk factors occur in conventional building projects (Brian and Williams, 2009). Besides, this model doesn’t outline the relevant risk management practices to be taken in each stage. There is lack of framework shows the relationship of different risk management practices on project performance.

2.13 Summary

The principle of sustainability in construction industry was discussed against the definitions of green buildings in sustainable constructions. Based on the 3 pillars of sustainability, green buildings typically focus on features such as site location, green materials, indoor air quality, water and energy conservation.

Occurrence of risks throughout green building project life cycle is inevitable. High initial investments in green building projects increase the risk exposure of stakeholders. Risk management processes of identifying, analysing, evaluating, mitigating and monitoring risks is therefore required to minimize negative risks and impacts in green building projects. These processes and their impact on project performance in terms of cost, time and quality were reviewed. These variables are verified and their relationship evaluated based on the methodology outlined in the next chapter.

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Introduction

This chapter presents the methodology of conducting the research including the type of research method adopted, the population frame and the type of analysis methods applied in this study. In this chapter, the work flow of research methodology is discussed by presenting the flow of activities and tools. Various data analysis techniques are discussed in terms of their strength and suitability.

3.2 Research Methodology

Research methodology is defined as an organized process in conducting a research. A research methodology works as a system to solve the research problem (Nurdiana, 2017). It aims to resolve the questions on: "Why does this research study is required to be conducted?", "What is the research problem statement?" and "Which method should be adopted for this research?" To carry out the research methodology, it involves the formulation of problem, literature review, research approach, data collection and data interpretation (Johnson, 2008).

Research methodology is categorized into quantitative and qualitative methods. Qualitative methodology includes the data collection tools as a narrative research and case study or interview (Nurdiana, 2017). It focuses on collecting and analysing the verbal data, textual data and body language. This type of methodology is applicable when the research aims are exploratory in nature. It is good at uncovering the trends in thought or point of view of the participants.

The quantitative methodology applies the experimental or non-experimental designs such as survey and questionnaire in collecting numeric or statistic data (Nerija, 2012). This methodology is recommended when the research aim is confirmatory in nature. Quantitative methodology quantifies the problem and understands the trends based on the statistical analysis.

In this study, quantitative research methodology was adopted in order to propose a risk management model for green building projects. The research problem statement was formulated as overrun in project budget for green building projects had urged a specific study to explore the relation between risk management practices and green building project performance. The output of this research methodology is the establishment of a risk management model for green building projects to assist project managers in improving their work process throughout implementation of projects.

3.3 Research Approach

A research approach is defined as the orientation of plans and procedures to conduct the research from the broad assumptions to the detailed method of data collection and data interpretation (Nurdiana, 2017). Research approach is divided into qualitative and quantitative approaches.

Qualitative approach explores on the meaning of particular individual or groups ascribe to a given study field (Wang, 2003). Qualitative approach allows detailed and flexible data collection and analysis. The researcher can quickly modify questions if useful insights are not being captured during data collection. However, it requires more time to conduct.

Quantitative approach examines the relationship between the variables by using statistical procedures. Quantitative approach involves larger sample size and less time-consuming in data collection (Johnson, 2008). The disadvantage of quantitative approach is the difficulty in setting up the research model. If any error occurs during model setting up, bias will be occurred in the results.

In this study, the quantitative research approach was adopted. It was adopted in this study as it allowed an approach to a large number of respondents from targeted population in a short duration during data collection. The adopted quantitative research approach in this study involved 3 major stages. Firstly, it was to formulate the research problem, whereas conducted literature review in the following stage. The last stage was involved the data collection, validation and analysis.

Based on the recommended stages, Figure 3.1 illustrates the flow of activities in quantitative research approach adopted in this study – Risk Management Practices in Green Building Project.

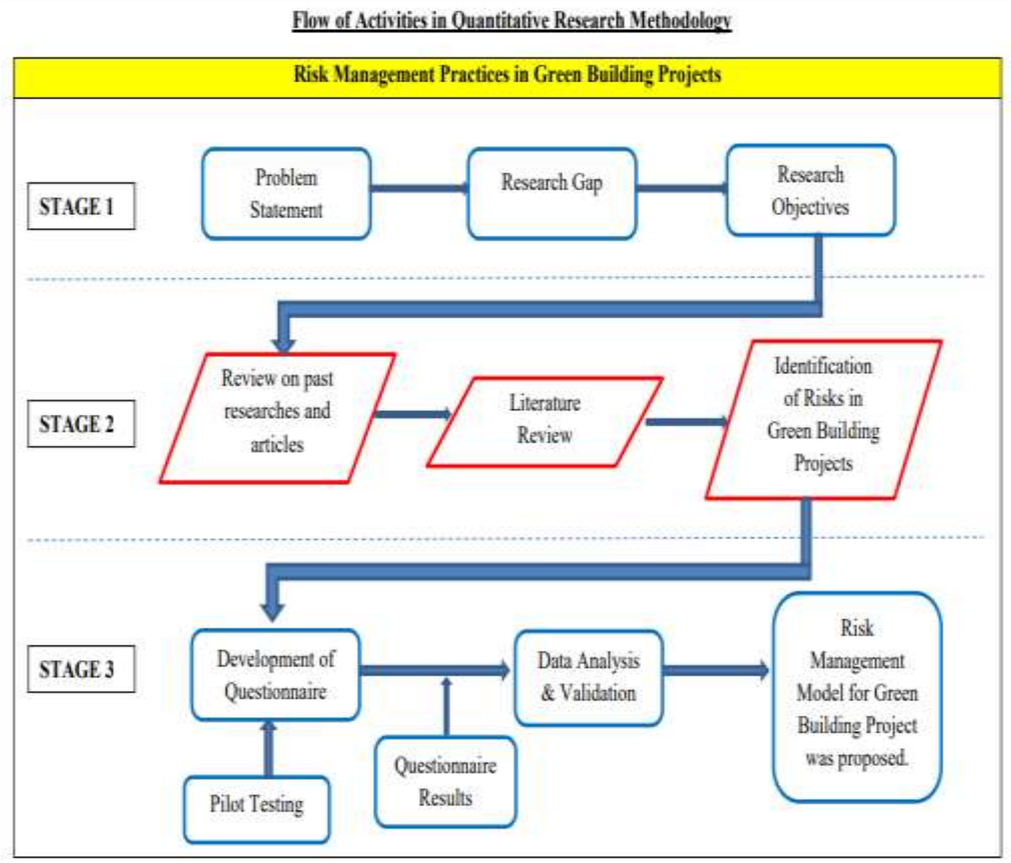

Figure 3.1: Flow of Activities in Quantitative Research Methodology.

Stage 1:

The problem statement was formulated based on evidence from newspapers such as The Sun Daily and The Star that highlighted the problems facing in green building projects. Next, the research gap was determined. It was found many research scholars focused on identifying risks in green building projects. However, a research gap between risk management practices and green building projects was evident. This led to the development of the aim and objectives of this study. The research aim and objectives are defined as mentioned in Chapter 1.4.

Stage 2:

The flow of activities continued with an in-depth review of past articles related to risk management and green building projects through online platforms such as Google Chrome, ScienceDirect.com and the university's resource library service. Keywords such as "risk management techniques" and "green building projects" were used to search for relevant articles. The literature review covered aspects related to definition of green building, risk management and project performance. The activities at this stage were performed to achieve Objective 1. A conceptual model was developed from the collection of literature carried out.

Stage 3:

Questionnaire was developed from the findings of the literature review on the research topic. Feedback on the suitability of the questionnaire content was obtained through a pilot test conducted on 4 respondents from property developers in Malaysia. After the pilot test was completed, the feedbacks from the respondents were incorporated and the questionnaire was amended. The questionnaire survey was conducted from February 2021 to March 2021. The questionnaire result obtained was analysed by Statistical Package for Social Science (SPSS) and Microsoft Office Excel software. The statistical tests such as Chi-Square test, reliability test and Relative Important Index were conducted to evaluate the risk management practices. The risk management model for green building projects was thus validated.

3.4 Research Design

A research design is the plan to answer the research questions (Johnson, 2008). Quantitative research design is defined as a systematic planning to gather quantifiable data and to perform statistical analysis for answering the research question (Tahmina, 2018). There are few types of quantitative research designs including survey research, correlational research, causal-comparative research and experimental research. The casual-comparative and experimental research designs focus on verifying the influence of variables on one another and proving a theoretical statement. Survey research design involves the administration of a survey to a sample of people to statistically analyse the data based on response trends.

The survey research design is divided into cross-sectional and longitudinal survey designs. A cross-sectional survey design involves data collection at one point in time, whereas longitudinal survey design collects the data across various time durations to observe the changes (Johnson, 2008). The cross-sectional survey design has the advantages of measuring current practices and providing information in a short amount of time.

This study was adopted the cross-sectional survey research design to identify the current risk management practices implemented by green building project developers in Malaysia. The cross-sectional survey design was adopted due to its easiness in measuring the adopted risk management practices in shorter duration from the property developers.

This survey design was also applied to study the relationship between the independent and dependent variables within a population. In this study, the risk management techniques applied in each stage in green building projects were defined as the independent variables. The risk management practices adopted by developers are independent of other variables in this study. The dependent variable was the green building projects performance. As mentioned in Chapter 2.9, the project performance affects by the application of risk management practices. The project performance depends on the independent variables in this study – risk management practices.

3.5 Research Tool

Research tool is used to conduct a research design plan (Nurdiana. 2017). The research tool includes questionnaire, interviews and experiments. Questionnaire typically contains multiple choice questions in closed-ended or open-ended structures. Interview is conducted in person such as face-to-face conversation. The experiment usually involves various tests to measure the cognitive abilities.

Cross-sectional survey research design can be conducted by questionnaire or interviews. There are 2 major factors to be considered while selecting the appropriate research tool, namely time available for data collection and type of data analysis. In comparison, questionnaire is designed with closed-ended questions, whereas interviews always possess the open-ended questions.

In this study, questionnaire was adopted as the research tool. A set of questionnaire was distributed to developers listed as being involved in green building projects. Questionnaire was chosen as a research tool in this study because of its reliability and easiness in collecting information from multiple respondents. It was also quick and efficient method for data collection when it comes to large and complex projects or fields such as construction industry (Javed, 2019).

Besides, the closed-ended questions structure in questionnaire offered a clear comparison to identify the risk management practices adopted by Malaysian green building developers. In the questionnaire, the respondents were asked to select their options in rating scale manner for the closed-ended questions. The responses that collected in rating scale were easier to compare.

3.6 Data Collection

3.6.1 Instrument Design

The data was collected through the questionnaire survey. Google form was used to develop the questionnaire.

The questionnaire was divided into 3 sections. The first section was aimed at identifying the respondents' demographic information such as the working experience, organization, involvement in green building projects and position in the organization. This information would ensure that the respondents fulfilled the criteria for taking this survey.

Section 2 dealt with rating of risk management practices adopted by respondents within their organizations. A total of 17 techniques identified from literature review were asked of respondents to rate the risk management practices based on their frequency of use within their job scope or organisation.

Section 3 was aimed at determining the respondents' viewpoint on the impact of risk management processes on green building project performance. A total of 22 statements were provided in the questionnaire. Respondents were asked to rate their level of agreement on each statement provided.

A pilot test was conducted to pre-test and check questionnaire's suitability in study area – green building project developers. The questionnaire was distributed to 4 respondents from the targeted population. Each respondent was chosen from different levels within their organizations to ensure better validity of the testing. They included project manager, site supervisor, project engineer and clerk of work. Eventually, the final questionnaire was developed and amended by taking into consideration all feedbacks obtained from the pilot testing.

3.6.2 Population and Sampling

A population is a complete set of people that shares the similar specialized characteristics (Amitav, 2010). The criterion such as geographic, working field and age are typically used to define the study population. A sample is a group of people or objects that taken from the study population (Amitav, 2010).

The target population of this study was construction developers in Malaysia that participated or have experience in green building projects. The developers were selected among the construction stakeholders such as contractors, architects and consultants. This is because developers were exposed to more risks in building projects when compared to other stakeholders such as contractors and consultants (Chen, 2019). Hence, developers involved in green building projects in Malaysia were adopted as the study population for this study due to their higher risk exposure.

According to Yasmin (2020), there are a total of 49 Malaysian property developer organizations currently involved in green building construction and who have applied sustainability practices in their respective green building projects. Therefore, these organizations were adopted as the population for this study. Table 3.1 shows the 49 listed developer organizations.

Table 3.1: Targeted Developer Organizations in Malaysia (Yasmin, 2020).

Property Developers Involved in Green Building Projects			
1	Sime Darby Berhad	26	Guacoland Berhad
2	Mah Sing Group	27	Nomad Group
3	Sp Setia Berhad	28	Asas Dunia
4	Eco World Development Group	29	BCB Berhad
5	Gamuda Land	30	Damansara Realty Berhad
6	Ken Rimba Sdn Bhd	31	Hua Yang Berhad
7	Leisure Farm Corporation	32	Glomac Berhad
8	IJM Land	33	MK Land Holdings
9	Sunway Group	34	Mulpha Land
10	KLCC Property Holdings	35	Tambun Indah Land
11	UEM Land Holdings	36	Ibraci Berhad
12	IOI Properties	37	Land and General Berhad
13	Wing Tai Malaysia	38	Nadayu Properties
14	Country Height Holdings Berhad	39	Meda Inc. Berhad
15	Dijaya Corporation Berhad	40	Malaysia Pacific Corporation
16	LBS Bina Group	41	MKH Berhad
17	Perduren Berhad	42	Petaling Tin Berhad
18	SHL Consolidated	43	Symphony Life
19	South Malaysia Industries	44	YTL Land and Development Berhad
20	Crescendo Corporation	45	Asian Pacific Holdings Berhad
21	Dutaland Berhad	46	Majuperak Holdings
22	IGB Corporation Berhad	47	Eastern & Oriental Berhad
23	PJ Development Berhad	48	Malton Berhad
24	Seal Incorporated Berhad	49	OSK Property Holdings
25	Selangor Properties		

In this study, non-probability sampling was applied to determine the sampling frame. Non-probability sampling is a process that select the sample from a population without any statistical or probability theory (Nurdiana, 2017). It was adopted in this study because it ensured the member of the targeted population to have the equal chance in responding the questionnaire.

According to Javed (2019), it is appropriate to apply when random sampling cannot be utilized to select respondents from the whole population. The sample chosen from the targeted population in this study was the employee or staffs that working at the 49 listed developer organizations in Table 3.1.

Snowball sampling approach was applied in this study to obtain adequate sample size from targeted developers. A snowball approach is a type of non-probability sampling method. The process of snowball sampling was through the nomination of another person that shared same traits with the observed respondents. This technique is simple and cost-efficient. It allowed the researcher to reach the population at ease and in a shorter duration. However, the researcher possesses little control over the sampling process as the new subjects were mainly based on previous that were observed.

The sample size was formulated by taking 90% of confidence level and 6% of margin error. Similar confidence level and margin of error were applied by Hwang (2017), Albert (2017) and Javed (2019) who also adopted the snowball sampling technique. The average number of employee in the 49 listed construction developer companies was computed as approximately 257 (Financial Times, 2021). Thus, the expected sample size for this study was determined as 186 or above with 90% of confidence level and 6% of margin of error.

The questionnaire was sent through various platforms including the formal and informal social podiums. The invitation of participating in the questionnaire was sent to the potential respondents and companies through Email, Facebook and WhatsApp. The duration of questionnaire survey was set as 2 months starting from February 2021 to March 2021. The social medium platforms were used for distributing the online questionnaire due to its easiness in reaching the potential respondents. It required lesser time for respondents to fill in the online questionnaire compared to paper questionnaire.

3.7 Data Analysis

Statistical Package for Social Science (SPSS) software was applied to analyse data obtained from the questionnaires. SPSS offers complex statistical analysis features to help the researchers to understand and validate the data or the trend.

The statistical analysis was involved multiple steps such as identifying, classifying and assigning a numeric value to the data.

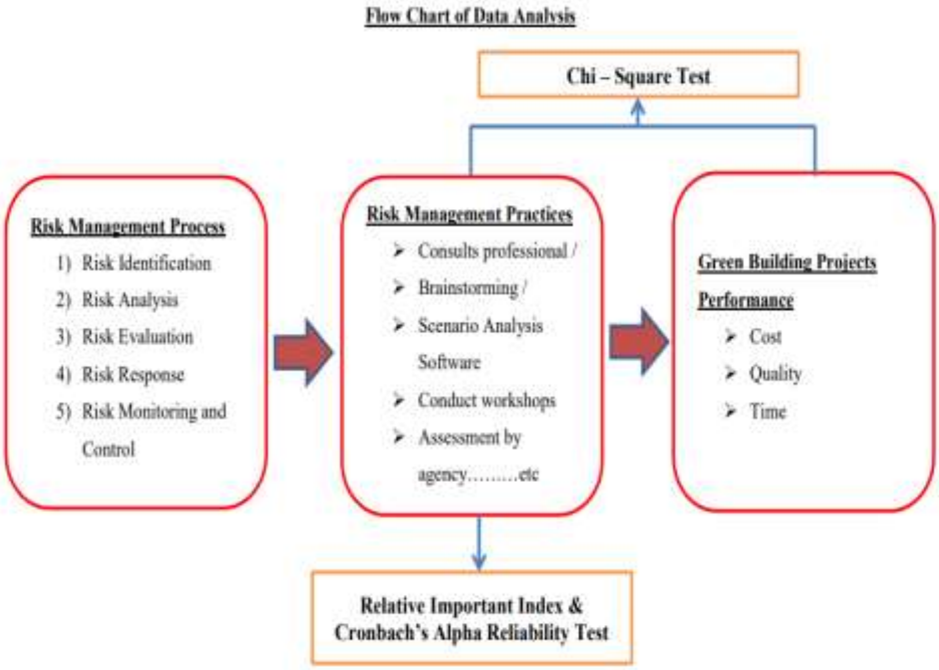

Figure 3.2: Flow Chart of Data Analysis.

Figure 3.2 shows the flow chart of data analysis in this study. The consistency of 17 practices and 22 statements provided in the questionnaire were analysed by using Cronbach's Alpha Reliability test. The Relative Important Index was then applied to identify and rank the risk management practices adopted by property developers in green building projects. The relationship between the risk management practices and green building project performance was tested and analysed by the Chi-Square Test.

3.7.1 Demographic Analysis

A demographic analysis is considered as one of the most effective methods is demonstrating the respondent's profile from a particular study (Karim, et al., 2020). Demographic analysis is used to assess the surveyed respondents and break down the overall survey responses into meaningful categories. The assessment from demographic profiles tells the characteristics of respondents and fulfilment of criteria in answering the survey questions (Tahmina, 2018).

The demographic analysis was performed in this study to prevent sampling biasness and to reduce coverage error in survey. The demographic analysis helped ensure responses obtained were from targeted population. Frequency and percentage were used to present the organizational, experience and position profiles of the respondents. The relevant particulars of the respondents are presented in tables and charts.

3.7.2 Chi-Square Test (x^2)

The Chi-Square test of Independence is commonly used in cross-tabulation to examine the distribution and convergence between distinct categorical variables (Research Optimus, 2021). Chi-square test examines 2 variables which are either independent from or connected to each other.

Chi-square test provides robust information and analysis that enable deeper research understanding by testing the validity of hypothesis. There are 2 criteria to apply chi-square test. They are measurement of nominal or ordinal variables and exclusive categorical variables (McHugh, 2013). In this study, the data collected were considered as ordinal data (strongly agree, agree, neutral, disagree, strongly disagree) and mutually exclusive. For instance, the categories of agree and disagree could not happen together. Hence, it fulfilled the conditions of chi-square test application.

The Chi-square test was applied in this study to analyse the relationship between independent and dependent variables. In fact, a small chi-square test statistic (x^2) indicates the collected data fits with the expected data (Nurdiana, 2017). Conversely, a large chi-square value exhibits a significant difference between expected and observed data. In this study, the risk management practices were considered as the independent variables, whereas the green building project performance was defined as dependent variables. Hence, chi-square test was adopted to assess whether a relationship exists between risk management practices and green building project performance. The chi-square statistic was formulated by:

$$x^2 = \sum \frac{(Oi - Ei)^2}{Ei} \tag{3.1}$$

where

X^2 = chi-square statistic

Oi = observed value / data

Ei = expected value / data

The obtained p-value from chi-square test that is smaller than or equal to chosen significance level indicates there is valid enough to reject null hypothesis (Nurdiana, 2017). The null hypothesis (H_o) and alternative hypothesis (H_1) in this test were defined. Besides, confidence interval of 95% was adopted and degree of freedom was computed as 2.

H_o: Risk management practices have no effect and influence to the project performance of green building projects.

H_1: Risk management practices affect the project performance of green building projects.

3.7.3 Relative Importance Index (RII)

RII method determines the ranking between the variables in an analysis (Karim, et al., 2020). RII analysis helps to identify the most important criteria or factors based on participants' responses. In general, the computation of RII values prioritizes the indicators such as factors, statements, practices or criterion based on the rated Likert scale (Rooshdi, 2018).

In this study, the respondents rated the risk management practices from values 1 to 5 to indicate the frequency of use of respective practices and level of agreement on the statements provided. However, RII does not indicate the consistency and relationship between the internal variables (Tayeh, 2020). Hence, the Cronbach's Alpha Reliability test was conducted only to analyse the internal reliability between the risk management practices and statements that provided in the questionnaire.

The relative importance index (RII) method was applied to formulate the rank of risk management practices in each particular risk management stage. It was adopted because it identified and ranked the risk management practices frequently practised by respondents. This method was also applied to rank the statements related to impact of risk management process on project performance based on the level of agreement of respondents.

RII value is ranged from zero to one (Karim, et al., 2020). A high value of RII indicates the greater impact of the attribute. This pre-coding process was constructed while formulating the questionnaire. A Likert scale ranged from 1 to 5 was assigned to the question responses. The 5-point Likert scale indicated the frequency of practicing each risk management practices in the ascending order. Similar 5-points Likert scale was used to measure the level of agreement for respondents in rating the statements provided in questionnaire. Figure 3.3 presents the 5-points Likert scale used in the questionnaire with their respective indicators.

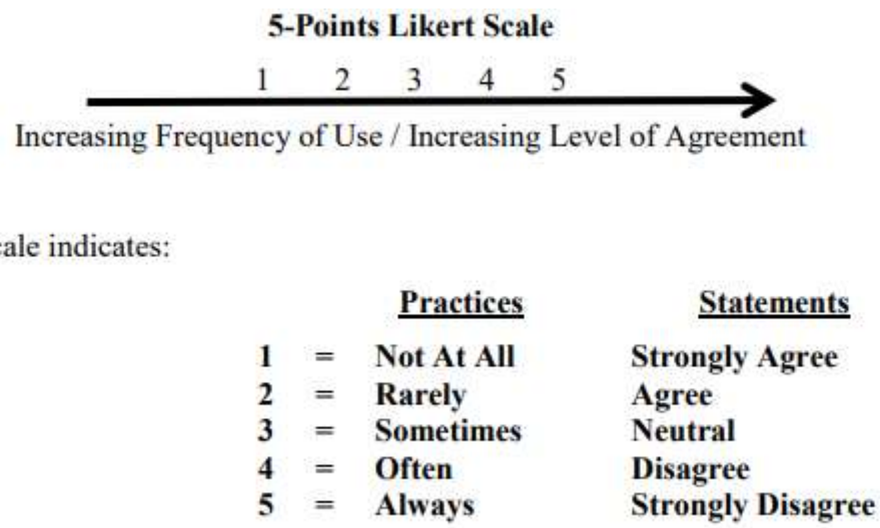

Figure 3.3: Likert Scale 1 to 5.

The relative importance index was computed as:

$$RII = \frac{\Sigma W}{A\,N} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5\ x\ N} \qquad (3.2)$$

where

W = the weight given to each statement by the respondents (from 1 to 5);

A = the highest weight (i.e. 5 in this study);

N = the total number of respondents

n_i = frequency of being chosen (i = 1,2,3,4,5)

3.7.4 Reliability Analysis

Cronbach's alpha reliability analysis is defined as a test that measures the internal consistency of the survey questions under the same factor (Nurdiana, 2017). Since it is not feasible to ask participants to fill the questionnaire in multiple times, thus measuring the internal consistency by applying Cronbach's alpha reliability analysis could examine the consistency of survey questions. In order to determine whether the Liker scale applied in questionnaire is reliable or redundant, it was appropriate to apply the Cronbach's alpha coefficient method in this study.

A threshold of Cronbach's alpha coefficient was determined as the guideline of reliability test. This method was adopted due to the RII method as mentioned previously could not show the reliability between the risk management practices. Besides, this reliability test helped in ensuring the adequate scale was applied in the questionnaire.

Cronbach's alpha coefficient method was applied to show the relationship between the internal variables - risk management practices in green building projects. The higher the Cronbach's alpha coefficient, the greater is the consistency and reliability among the risk management practices for each risk management stage (Kamar, 2011). An acceptable minimum reliability threshold level is 0.7 (Nunnally, et al., 1994). The formula of Cronbach's alpha coefficient was mathematically established as:

$$\alpha = \frac{N \times \bar{c}}{[v + (N - 1) \times \bar{c}]} \tag{3.3}$$

where

N = number of items

$\bar{c}$ = average covariance between the item-pairs

$\bar{v}$ = average variance

The Likert scale provided in questionnaire for rating purpose was analysed by Cronbach's Alpha Reliability analysis to ensure the adequacy of scale provided. Furthermore, the Relative Importance Index analysis was conducted to rank the risk management practices based on collected responses.

Chi-Square test was implemented to prove whether there exists an association between risk management practices and green building project performance.

3.8 Summary

Quantitative research methodology was adopted in this study to evaluate the risk management practices in green building projects and their impacts on project performance. The property developer organizations were identified to participate in this survey. In addition, the data was collected by questionnaire with a non-sampling strategy and analysed through demographic analysis, chi-square test, Relative Importance Index (RII) and Cronbach's Alpha coefficient methods. The results obtained are discussed in the next chapter.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the findings from questionnaire survey on risk management practices adopted within respective green building project developers in Malaysia and their impacts on green building projects.

4.2 Demographic Profile of Respondents

Due to movement restrictions due to COVID-19, questionnaire was distributed via online platforms in a snowball sampling manner. A total of 450 copies of questionnaire were distributed to employees from 49 listed property developer organizations. The online questionnaire survey was carried out for 2 months, from February 2021 to March 2021. Within this period, a total of 192 responses were successfully collected. The response rate for this survey was computed as 42.67%. A survey response rate of 33% or higher is considered acceptable in most circumstances (Changwan, 2013).

A total of 192 responses were received and accepted. Table 4.1 presents the working profile of the questionnaire respondents. As mentioned in Chapter 3.5, the required sample size is 186 or above with 90% confidence level and 6% of confidence interval. Hence, the collected responses fulfilled the sample size requirement. 86 out of 192 respondents were found to be employees of SP Setia Berhad, one of the many listed developer organisations in Malaysia. This is followed by Eco World Development Group (37.50%), Mah Sing Group (7.29%), Gamuda Land (4.17%) and etc.

From the demographic profile of respondents, 11 out of 49 companies (22.44%) participated in this survey. The low coverage rate of organizations is due to the low response rate from electronic questionnaire and the limited time allocated for the survey. However, 22.44% is said to be adequate to represent the developer industry in green building projects in Malaysia. This is because the 11 responded developer organizations are involved in more than 62% of green building projects in Malaysia (Yasmin, 2020).

Table 4.1: Organizational Profile of Respondents.

Profile	Frequency	Percentage (%)
Organization		
SP Setia Berhad	86	44.79
Eco World Development Group	72	37.50
Mah Sing Group	14	7.29
Gamuda Land	8	4.17
IOI Properties	3	1.56
Sunway Group	3	1.56
YTL Land and Development Berhad	2	1.04
UEM Land Holdings	1	0.52
Malton Berhad	1	0.52
OSK Property Holdings	1	0.52
Majuperak Holdings	1	0.52
Total =	**192**	**100.00**

Figure 4.1 shows the work experience of respondents. 40.63% of them have 5 to 10 years working experience in construction industry, followed closely by those having less than 5 years working experience (38.54%). The respondents' working experiences are evenly distributed between 5 to 10 years and less than 5 years.

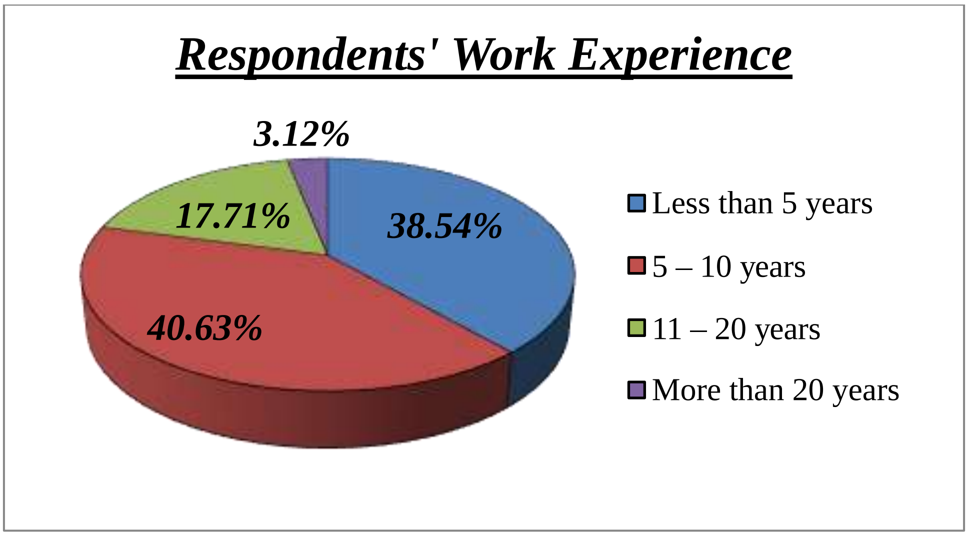

Figure 4.1: Respondents' Working Experience.

From Figure 4.2, 67.19% of the respondents indicated that they have been involved in green building projects for less than 5 years. It was also noted that none of the 192 respondents had been involved in green building projects for more than 20 years. This is most likely due to an upward trend in green building procurement only from 2000 following the release of the Eighth Malaysia Plan in 2001 and the Green Building Index in 2009 (Aliagha, 2017).

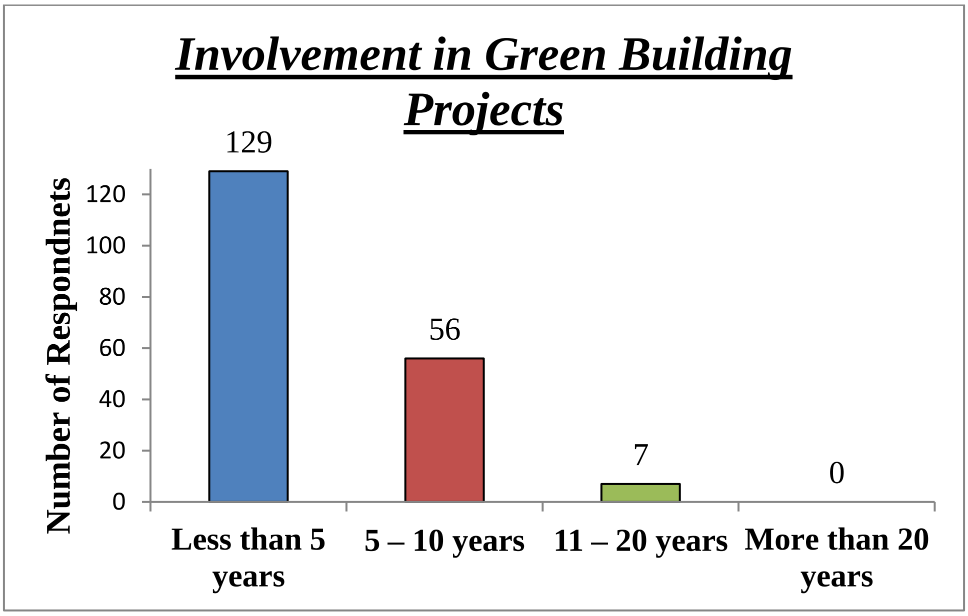

Figure 4.2: Respondents' Involvement in Green Building Projects.

Figure 4.3 shows the position of respondents in their respective organizations. Amongst the 192 respondents, 42.71% of them hold the position of supervisor or inspector in their organizations, compared to engineer (32.29%) and project manager or above (19.27%). The other positions in organization such as clerk of work, quantity surveyor and site manager comprise 5.73% of the respondents. In terms of organizational management level, the positions of project manager or above and engineer are categorized under the same level – strategic & tactical level. The supervisor and other positions such as clerk of work are classified into operational level. The organizational position of respondents is evenly distributed between the strategic & tactical (51.56%) and operational levels (48.44%).

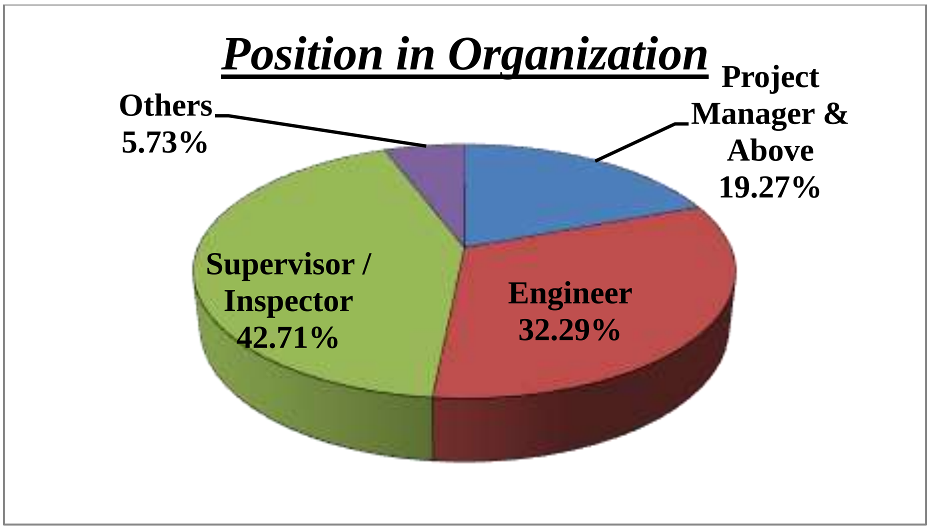

Figure 4.3: Respondents' Positional Profile.

4.3 Reliability Test

Cronbach's Alpha reliability test was applied to internally test the consistency between the listed risk management practices and statements regarding risk management impact on project performance. Higher Cronbach's Alpha coefficient indicates greater consistency among the items for each component (Adekele, 2020).

Table 4.2 illustrates Cronbach's Alpha reliability coefficients for five risk management stages with respective items. The items mentioned are referred to risk management techniques applied in each risk management stage. All Cronbach's Alpha values obtained in this study are greater than 0.70 with the highest value of 0.875 and lowest value of 0.741. Based on these findings, it is concluded that risk management practices listed in questionnaire are reliable and closely related with each other within its risk management stage.

Table 4.2: Reliability Test of Risk Management Practices.

Risk Management Stage	No of Items	Cronbach's Alpha
Risk Identification	4	0.741
Risk Analysis	3	0.759
Risk Evaluation	3	0.811
Risk Response	4	0.767
Risk Monitoring and Control	3	0.875

A series of statements were provided in questionnaire to study the impact of risk management processes on green building project performance. Cronbach's Alpha values were computed as shown in Table 4.3. The statements provided in questionnaire are reliable and consistent since all Cronbach's Alpha coefficients are higher than 0.70. In conclusion, the risk management practices and statements regarding project performance are provided in the questionnaire with adequate consistency and reliability.

Table 4.3: Reliability Test of Risk Management Statements.

Risk Management Stage	No of Items	Cronbach's Alpha
Risk Identification	5	0.806
Risk Analysis	6	0.907
Risk Evaluation	3	0.716
Risk Response	6	0.719
Risk Monitoring and Control	2	0.840

4.4 Risk Management Practices in Green Building Projects

This section discusses on risk management practices adopted by property developer organizations in green building projects. The data obtained were analysed by descriptive analysis such as mean and standard deviation to establish the dispersion pattern of individual data from the mean values. Furthermore, Relative Important Index (RII) was used to rank the risk management practices according to the frequency of use.

4.4.1 Risk Identification Practice

Identifying risks in green building projects is one of the most important steps in risk management to minimize negative impacts. Risk identification techniques are highly dependent on the nature of construction projects (Javed, 2019). It comes to a higher complexity level in green building projects due to sustainability concerns. Table 4.4 illustrates the current risk identification techniques adopted by green building project developers in Malaysia.

Table 4.4: Current Risk Identification Practices Implemented by Malaysian Property Developers.

Risk Identification Practices	Mean	Std. Dev	RII (%)	Rank
Consult professionals / experts regarding green construction technique, equipment and materials.	4.333	0.707	86.67	1
Discuss with green equipment or product supplier.	3.671	0.866	73.33	2
Conduct interview with local agencies to identify sustainability risks regarding compliance of regulations.	3.233	1.001	66.67	3
Apply scenario simulation software to identify and forecast potential risks related to green element performances.	3.004	1.772	62.22	4

The most common risk identification method in green building projects is through consultation with professionals or experts (RII 86.67%) in green construction field. It has a mean value of 4.333 and standard deviation value of 0.707. Developers often identify risks in green building projects through consulting the professionals on design, technical, operational, material and economic aspects. Next, discussing with green product suppliers and conducting interview with local government departments or agencies are ranked in 2nd and 3rd place with RII percentage of 73.33% and 66.67% respectively. The application of scenario or simulation software with RII 62.22% ranked at the 4th place with a lowest mean value of 3.104. Figure 4.4 shows the radar chart for risk identification technique.

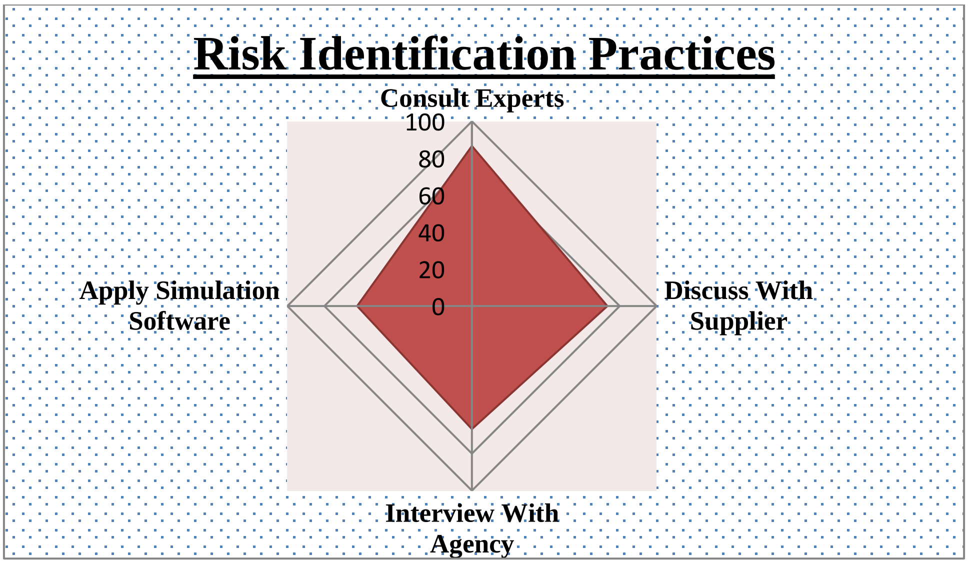

Figure 4.4: Radar Chart of Risk Identification Techniques.

Developers seek advice from green construction consultancy firms to obtain information regarding green technique, equipment and building materials to further identify green risks during planning and design phases. This is because developers lack adequate information and knowledge on sustainable construction techniques and machinery. Limited availability of green building materials and products is a typical green risk in sustainable projects (Tayeh, 2020). The finding above agrees with Tayeh (2020) as developers tend to discuss with green product suppliers to determine supply risk in green building projects due to the unstable supply of green products.

To register regulatory risks, project developers interview and keep themselves update from local agencies such as Malaysian Green Technology Corporation, Construction Industry Development Board (CIDB), Department of Environment Malaysia (DOE) and Energy Commission (ST).

The high deviation (1.772) and low RII percentage (62.22%) for application of simulation software such as Building Information Modelling (BIM) are due to the slow adoption of new Information Technology (IT) in Malaysian construction industry and high cost in periodically upgrading their software (Zainon, 2016). In conclusion, developers prefer to identify risks through consultation and interview with professionals and agencies regarding availability or requirements for green products and design.

4.4.2 Risk Analysis Practice

Risk analysis forecast the possibility and likelihood of risk occurrences. Table 4.5 establishes the current risk analysis methods adopted by green building projects developers. Analysing risks based on professional judgement and scientific data has the highest RII percentage and mean (77.78% and 3.891), followed by appointment of consultancy company (70.13% and 3.587) and application of scenario analysis software (64.27% and 3.116). In terms of dispersion of the data, these methods reveal a standard deviation range between 0.744 and 0.852. This deviation pattern shows that the individual data is slightly clustered around respective mean values.

Table 4.5: Current Risk Analysis Practices Implemented by Malaysian Property Developers.

Risk Analysis Practices	Mean	Std. Dev	RII (%)	Rank
Forecast likelihood of risk occurrences based on simulation and scenario analysis software.	3.116	0.852	64.27	3
Analyse risks based on professional judgement and scientific data on green elements.	3.891	0.774	77.78	1
Appoint consultancy company to assess green risks.	3.587	0.744	70.13	2

Due to a lacking of knowledge and historical data on innovative products and green construction, developers in green building projects tend to analyse risks based on professional judgement and scientific data provided by manufacturers. Consequently, developers are willing to seek expert’s judgement or directly appoint consultancy firms as advisor to analyse the risks related to material reliability, performance, cost, technical, design and operational factors.

Even though integrated design of green building is based on simulation tools, but it requires complicated system of engineering along for technical support (Olsen, 2016). In this way, the results show similar trend with Olsen (2016), the utilization of scenario analysis software such as S-Frame software is the least applied technique in analysing risk in green building projects. The developers seldom use simulation tools to analyse risk due to the additional cost required for software maintenance purpose. Figure 4.5 presents radar diagram for adopted risk analysis practices based on RII magnitude.

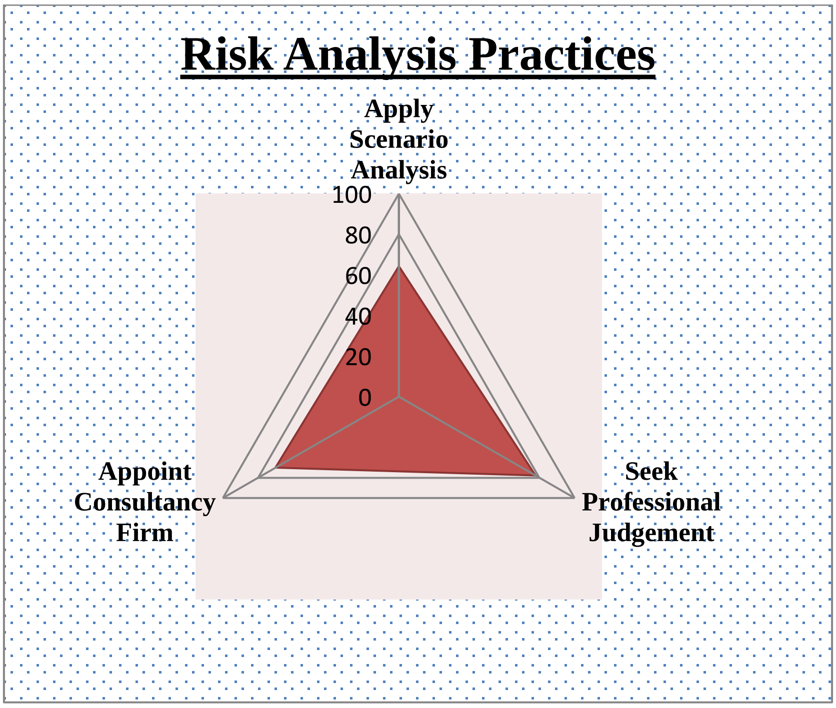

Figure 4.5: Radar Chart of Risk Analysis Techniques.

4.4.3 Risk Evaluation Practice

Analysis and evaluation process are inter-related and aided in prioritizing the critical risks according to impact and degree of seriousness. Pursuant to Table 4.6, the ranking of risk evaluation practices leads by evaluating risk in advise of professionals or experts (RII 75.56%), performing risk assessments (RII 63.76%) and lastly applying the quantitative analytical software (RII 55.56%).

In terms of standard deviation value comparison, use of analytical software has the largest standard deviation of 1.331, followed by the implementation of risk assessment (1.145) and the adoption of professional judgement (0.663). This finding agrees with Javed (2019). There is no universally accepted way to evaluate risk due to unique characteristic in each green building project (Javed, 2019). Hence, some developers tend to perform risk assessment to evaluate the risks, yet some of them reject to apply those assessments.

Table 4.6: Current Risk Evaluation Techniques Implemented by Malaysian Property Developers.

Risk Evaluation Practices	Mean	Std. Dev	RII (%)	Rank
Evaluate green risks using quantitative analytical software.	2.787	1.331	55.56	3
Perform risk assessments to quantify degree of seriousness of risk.	3.095	1.145	63.76	2
Adopt professional judgement to evaluate risk.	3.719	0.663	75.56	1

According to Figure 4.6, developers in green building projects prefer to seek for professional judgement while evaluating the risks. This is because there is still relatively low knowledge level in evaluating sustainability risks in Malaysian green building industry. Since there is still a gap of in-depth research in green risk analysis and evaluation, developers feel more feasible to apply less-complicated evaluation technique (Javed, 2019). Therefore, developers frequently consult experts to evaluate risk rather than applying the analytical software.

Besides of professional judgement, the results show that developers also perform different assessments (mean 3.095) such as Life-Cycle Assessment and Social Baseline Assessment to evaluate risks based on its impacts to community and environment. Life-Cycle assessment is performed on the green building materials such as insulated concrete form and straw bale. Developers consider the environmental impacts caused by construction materials during materials selection phase. They evaluate the risks according to the findings from Life-Cycle assessment.

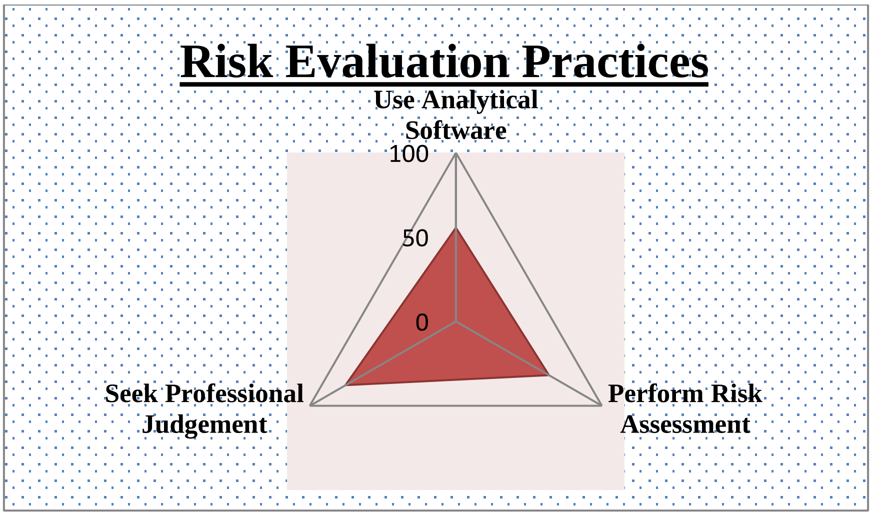

Figure 4.6: Radar Diagram for Risk Evaluation Techniques.

4.4.4 Risk Response Practice

There are 4 major types of risk response in green building projects, namely risk transfer, risk retention, risk acceptance and risk avoidance. Table 4.7 manifests current risk response methods applied by green building project developers. Risk transfers to manageable party through contract has the highest RII percentage (91.11%) and mean (4.556), followed by adoption of government financial aid program (RII 70.64%, mean 3.601), conducting workshop and trainings (RII 61.22%, mean 2.997). The least applied method is the adoption of risk avoidance policy with the lowest RII percentage of 57.96% and mean value of 2.778. Figure 4.7 presents radar diagram for risk responses.

Table 4.7: Current Risk Response Practices Implemented by Malaysian Property Developers.

Risk Response Practices	Mean	Std. Dev	RII (%)	Rank
Nominate party to manage risk through contractual means.	4.556	0.512	91.11	1
Opt for government financial aid.	3.601	0.959	70.64	2
Conduct workshops and training for workers on sustainable construction.	2.997	0.996	61.22	3
Adopt a "Total Avoidance of Risk" policy in green building project.	2.778	1.261	57.96	4

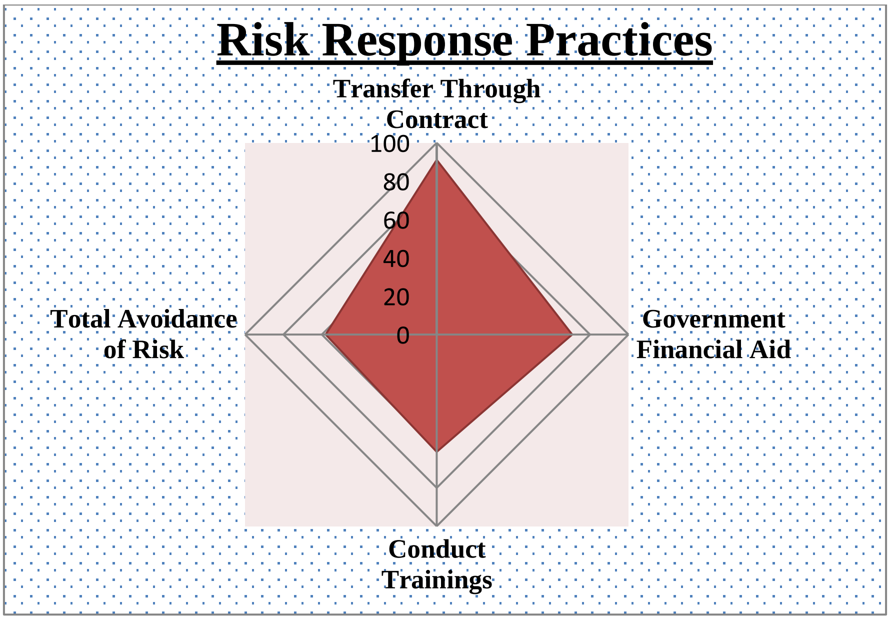

Figure 4.7: Radar Diagram for Risk Response.

Transferring risk to another party through contractual means has the highest RII percentage and lowest standard deviation value (0.512). It shows that most of the respondents manage risk by transferring risk to the party who can best manage the risk such as suppliers, contractors and clients. For instance, developers clearly allocate the risks and responsibilities regarding to GBI credits and product warranty period in the construction contracts between the stakeholders in green building projects.

Adoption of government financial aid program and incentives (risk retention) is ranked second. Malaysian government has launched a number of initiatives such as company tax exemption, investment tax allowance and GBI application fee allowance to promote green building projects (Aliagha, 2017). Developers are eager to opt for government financial incentives to reduce the likelihood of overrun of budget in green building projects.

Trainings, workshops and seminars on sustainable construction knowledge, information, technique and safety procedure are increasingly popular (RII 61.22%) to reduce risk of quality failure in green building projects.

On the other hand, developers do not find it suitable to apply “Total Avoidance of Risk” policy. Developers cannot omit risk because green building projects are required to comply with the regulations and standards of

GBI. This finding is supported by Berenger (2016). Extensive application of risk avoidance in green building projects deprives possible opportunities (Berenger, 2016). In short, developers believe that potential opportunities will be lost if they apply total avoidance policy in green building projects.

4.4.5 Risk Monitoring & Control Practices

Table 4.8 shows that risk monitoring through Design Assessment (DA) conducted by GBI certifier is ranked highest with a mean value (4.173). This is followed by work performance reporting and lastly by hiring independent third party.

Table 4.8: Current Risk Monitoring & Control Practices Implemented by Malaysian Property Developers.

Risk Monitoring & Control Practices	Mean	Std. Dev	RII (%)	Rank
Hire independent third party or experts to conduct inspections.	2.761	1.333	57.78	3
Monitor green risk through Design Assessment (DA) conducted by GBI certifier.	4.173	0.636	84.44	1
Carry out construction work performance reports to track green risk status.	3.803	1.174	77.78	2

In addition to conventional risk monitoring methods such as site meeting and documentation, green building project developers conduct the Design Assessment (DA) to monitor the risks. The GBI certifier undertakes Design Assessment to monitor green building project on site progress, site pollution impact and status of risks (Green Building Index, 2020).

Developers also conduct work performance report such as Green Concept Plan to monitor the risks and indirectly measure the project performance on achieving green standards. Some developers may hire independent third parties to conduct inspections on ventilation and fire-safety in addition to mandatory inspections by BOMBA, SYABAS, Tenaga Nasional

Berhad (TNB) and other local agencies. It is to ensure green building projects achieve local authority requirement and to obtain better green accreditation grade in the same time. Figure 4.8 illustrates frequency of risk monitoring practices based on collected responses.

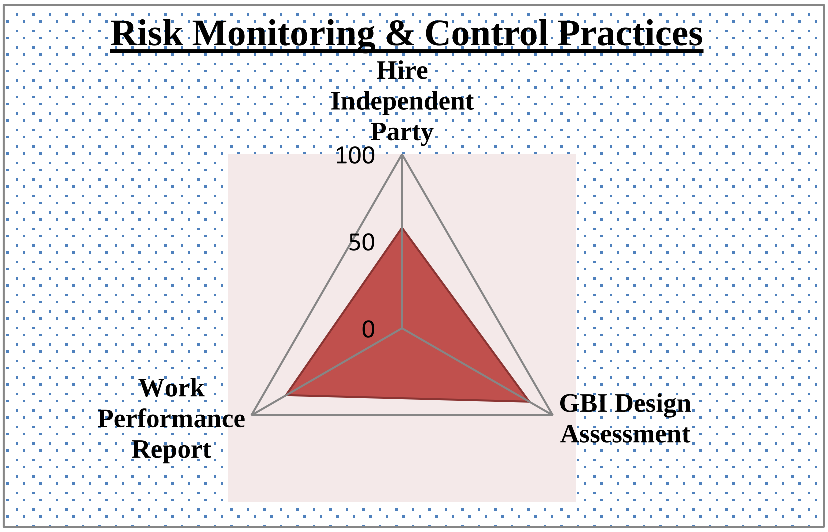

Figure 4.8: Radar Chart for Risk Monitoring & Control Techniques.

By shifting the perspective into the entire risk management process, the RII ranking test was conducted to measure the frequency of applying each risk management process. In overall, the results shown in Table 4.9 indicates that developers in green building projects frequently apply risk identification process (RII 74.17%), followed by risk monitoring & control (RII 73.33%), risk analysis (RII 70.73%), risk response (RII 70.23%) and lastly risk evaluation process possesses lowest RII of 64.96%.

Table 4.9: Risk Management Process in Green Building Projects.

Risk Management Stage	Mean	Std. Dev	RII (%)	Rank
Risk Identification	3.656	1.087	74.17	1
Risk Analysis	3.531	0.790	70.73	3
Risk Evaluation	3.200	1.116	64.96	5
Risk Response	3.483	0.932	70.23	4
Risk Monitoring & Control	3.579	1.048	73.33	2

Among the five risk management stages, risk identification seems to be the most common risk management process applied by green building project developers in Malaysia. This is due to the techniques of identifying risks in green building projects are often conducted during project initiation and planning phases. Green building projects always require complex and detailed pre-project planning on newer technology and material with less environmental impacts (Changwan, 2013). Hence, green building project developers tend to simultaneously conduct detailed project planning and risk identification process to register potential sustainability risks.

Furthermore, risk monitoring and control stage placed 2nd among 5 risk management stages with a mean value of 3.803. According to Green Building Index (2020), it is mandatory to implement Design Assessment (DA) in green building projects. In this way, developers adopt Design Assessment and respective work performance measures to monitor risks throughout the project cycle.

The minor difference between the RII percentages for risk analysis (RII 70.73%) and risk response (RII 70.23%) stages indicates that developers are willing to perform analysis process regardless of qualitative (expert consultation) or quantitative analysis (software application). Developers establish relevant risk responses on mitigating or reducing the identified risks to achieve favourable outcome in projects.

Risk evaluation process ranks at the last place among the 5 stages with a large standard deviation value (1.116). This finding indicates that developers in Malaysia have different opinions in choosing evaluation practices. Quantitative evaluation method is usually applied to prioritize critical risks based on the quantitative records (Javed, 2019). However, due to insufficient of historical data in green building projects, developers in Malaysia are unfamiliar with quantitative risk evaluation technique. The result is supported by Byung (2015) as stating that risk evaluation in Malaysian construction industry is still at initial stage (Byung, 2015). Therefore, developers tend to neglect the risk evaluation process in green building projects in Malaysia.

4.5 Impact of Risk Management Process on Green Building Project Performance

Chi-square test was applied to determine whether there exists an association between risk management practices and green building project performance. Table 4.10 presents the chi-square value and p-value obtained from questionnaire responses. The null hypothesis (H_o) and alternative hypothesis (H_1) are defined as follows:

H_o: Risk management practices have no effect and influence to the project performance of green building projects.
H_1: Risk management practices affect the project performance of green building projects.

Table 4.10: Results of Chi-Square Test of Risk Management Statements.

Risk Management Process	Degree of Freedom (df)	Chi-Square value (x^2)	Asy. Sig. (p-value)
Risk Identification	2	90.704	2.013×10^{-20}
Risk Analysis		26.348	1.899×10^{-6}
Risk Evaluation		27.706	9.637×10^{-7}
Risk Response		79.772	4.976×10^{-18}
Risk Monitoring & Control		43.739	3.177×10^{-10}

The degree of freedom was determined as 2 and a significance level of $\propto = 0.05$ was chosen. Based on Table 4.10, the chi-square values for 5 risk management stages are ranged between 26.348 (lowest) to 90.704 (highest). The large values of chi-square obtained are due to the significant difference between the observed data (respondent choices) and expected data (based on null hypothesis).

All p-values obtained are much smaller than chosen significance level ($\propto = 0.05$), thus the null hypothesis is rejected. Hence, there is a relationship between risk management practices and green building project performance. The relatively small p-values obtained are due to the large chi-square values in the test. In conclusion, risk management practices positively affect the performance of green building projects.

4.5.1 Risk Identification

Based on Table 4.11, respondents strongly agree with statement S1 (RII 82.22%) as risk identifying process helps managers to ensure compliance of quality requirement of green building projects. Developers believe that the risk identification process helps to establish corresponding treatments to manage the risks in green building projects. The identified risks are analysed based on seriousness and established corresponding contingency plan to minimize impact on project performance (Javed, 2019).

Results show that respondents agree with risk identification offers effective control on both OPEX and CAPEX to ensure favourable cost performance. However, statement R5 has the least RII percentage (69.71%) implying high level of agreement among respondents that project managers tend to overestimate project budget due to lack of information or data in green building projects. This finding shows similar trend with Shealy (2018). Over-estimating project budget is caused by inadequate information on projects (Shealy, 2018). In short, application of risk identification practices improves green building project performance subjected to cost and quality aspects.

Table 4.11: Statements Regarding Risk Identification Impact on Project Performance.

Code	**Statements**	**RII (%)**	**Rank**
S1	Risk identification for green building projects provides efficient control on project operational expenditure (OPEX).	79.22	3
S2	Risk identification in green building projects provides effective control on project capital expenditure (CAPEX).	79.04	4
S3	Risk identification ensures design of building complies with current green construction standards.	81.96	2
S4	Risks identifying help managers to meet quality requirements of green building projects.	82.22	1
R5	Project managers tend to overestimate project budget for green building projects.	69.71	5

*R indicates reverse worded statements.

4.5.2 Risk Analysis

In term of risk analysis, the developers in Malaysia believe that risk analysis improves green building project delivery time possessed highest RII of 88.42% (S10). It is followed by S6 (RII 86.67%), S7 (RII 84.54%), R11 (RII 80.50%), R9 (RII 71.11%) and lastly R8 (RII 68.39%) as shown in Table 4.12. Developers agree on practising risk analysis throughout green building project lifecycle helps achieve quality and time performances (S3).

Table 4.12: Statements Regarding Risk Analysis Impact on Project Performance.

Code	Statements	RII (%)	Rank
S6	Risk analysis improves selection of sustainable products and materials that meet green project requirements.	86.67	2
S7	Feedback from stakeholders throughout project lifecycle is an essential part of risk analysis in green building projects.	84.54	3
R8	Cost for mitigating measures in risks management is proportional to the likelihood of risk occurrence in green building projects.	68.39	6
R9	Feedback from stakeholders is only critical at planning stage when risks are first identified for analysis.	71.11	5
S10	Managing risks in green building projects improves project delivery time.	88.42	1
R11	Selectively managing critical risks help managers to meet quality requirements of green building projects.	80.50	4

*R indicates reverse worded statements.

4.5.3 Risk Evaluation

Table 4.13 illustrates ranking of statements related to impact of risk evaluation on project performance. S14 possess largest RII value of 85.16%, whereas S12 is ranked third place with 71.31% of RII. Green building projects developers strongly agree that smooth project activities flow are achieved through applying risk evaluation practices such as consultation with experts in sustainable construction. Furthermore, the respondents agree that risk evaluating activity reduces overall project duration as reversed worded R13 possess RII of 81.97%. This is because the risk evaluation helps to prioritize the critical risks without delaying the work progress. Risk evaluation process prioritizes critical risks and implies control measures to minimize the impacts in construction projects (Adekele, 2020). As result, risk evaluation process positively affects the project performance of green building projects.

Table 4.13: Statements Regarding Risk Evaluation Impact on Project Performance.

Code	Statements	RII (%)	Rank
S12	Risk evaluation provides information that facilitates educated decision-making throughout the green building projects.	71.31	3
R13	Processes involved in evaluating risks for green building projects increase overall project duration.	81.97	2
S14	Evaluating risks in green building projects results in smooth implementation of project activities.	85.16	1

*R indicates reverse worded statements.

4.5.4 Risk Response

Statements S19 and S18 have 86.61% and 83.71% of RII values as ranked at first and second place respectively. Risk transfer in green building projects helps reduce project costs and prevent unnecessary disputes between stakeholders. An unambiguous contract and clearly stated condition of contract minimize the occurrence of contractual disputes in green building projects (Anete, 2016).

Results from S15, R16 and S17 show that risk mitigation techniques such as “implementing structural design control measures” ensure compliance of green certification and avoid overrun of project budget. Application of different risk response strategies enhances green building project performance on aspects of cost, time and quality. Table 4.14 presents the ranking of each statement with regard to risk response impacts on green building project performance.

Table 4.14: Statements Regarding Risk Response Impact on Project Performance.

Code	Statements	RII (%)	Rank
S15	Compliance to green certification requirements helps mitigate risks throughout project lifecycle.	82.66	3
R16	Implementation of structural control measures such as design measures as part of risk response will increase project cost.	82.11	4
S17	Implementation of structural control measures as part of risk response is cost-effective during planning and design stages.	80.34	5
S18	Risk transfer in green building projects helps reduce project cost.	83.71	2
S19	Risk transfer in green building projects reduces contractual disputes related to procurement and installation of green products / materials / services.	86.61	1
S20	Risk transfer in green building projects reduces severity of impact due to improper installation of green building materials / products.	79.55	6

*R indicates reverse worded statements.

4.5.5 Risk Monitoring & Control

Table 4.15 indicated that S21 is ranked highest with a RII value of 83.33%, followed by S22 with a value of 81.46%. Developers in green building projects agree that monitoring risks through GBI Design Assessment and work performance report provides effective quality control over construction and operation of green buildings.

According to Green Building Index (2020), Design Assessment (DA) conducted by project team and GBI certifier enhances awareness and provide clarity on regulatory requirements during construction. Thus, risk monitoring and control techniques maximize the achievement on time, cost and quality performance in green building projects. Risk monitoring and control process therefore has a positive influence on green building project performance.

Table 4.15: Statements Regarding Risk Monitoring and Control Impact on Project Performance.

Code	Statements	RII (%)	Rank
S21	Risk monitoring improves project planning and execution of green construction designs.	81.46	2
S22	Monitoring risks in green building projects helps managers to achieve better quality control during construction and operation phases.	83.33	1

*R indicates reverse worded statements.

4.6 Risk Management Model for Green Building Projects

Based on the findings above, the risk management model for green building projects shown in Figure 4.9 established to provide a practical methodology for green building project developers in Malaysia to select and apply the appropriate risk management techniques to ensure project success is thus validated.

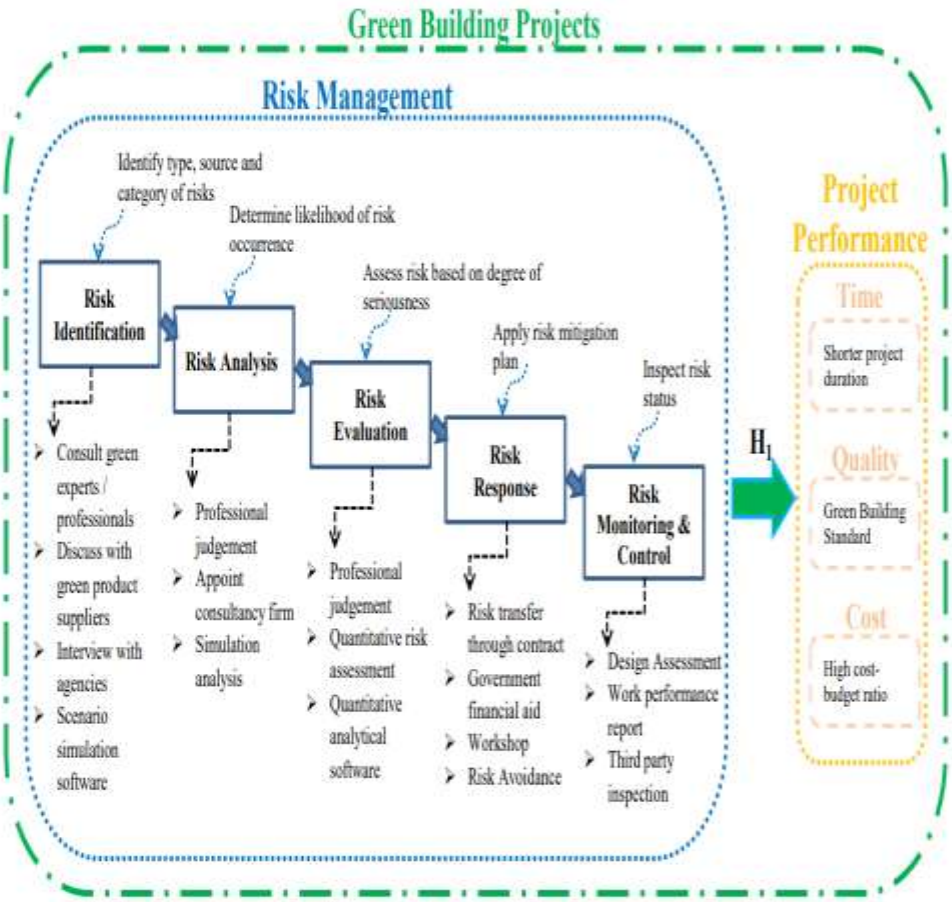

Figure 4.9: Proposed Risk Management Model for Green Building Projects.

Application of risk management process is considered as the input, whereas the project performance on time, quality and cost aspects is defined as the output from this model. At first, risk identification process is performed to identify the types, factors and sources of the risks in green building projects. Based on the survey, the applied risk identification techniques are consulting with experts and professionals, discussing with green material suppliers, conducting interview with local agencies and using scenario simulation software. According to Baccarini (2001), interview session is helpful in identifying unnoticed sustainability risks. Hence, the consultation, discussion and interview sessions are suggested as the appropriate risk identification practices in green building projects.

Next, the identified risks are analysed regarding probability of risk occurrences. Due to insufficient historical data of green building projects, developers are recommended to make consultation and appointment of consultancy firm rather than applying software analysis methods.

Risk evaluation based on professional judgement is recommended to prioritize critical risks in green building projects. To evaluate the likelihood and impact of sustainability risks, risk assessment such as Life-Cycle Assessment is suggested to evaluate reliability and productivity of green materials.

There exist a significant difference in applying risk response strategy in green building and conventional building projects. The model suggests the techniques such as risk transferring through contract condition, government financial incentives and preparing trainings or workshops to educate workers on sustainable construction to treat the risks. These risk response techniques aim to minimize the impact of risk as well as exploit potential opportunities in green building projects.

In terms of risk monitoring and control process, the Design Assessment conducted by GBI authority and work performance report are recommended to observe the status of risks. Relevant strategies regardless of additional treatment action or closing of risk should be made depending on the observed risk status. This model also illustrates that risk management should be applied as a loop and continuous process within the green building project life cycle until the risks are prevented or reduced.

The output from risk management process is the improvement of project performance on time, cost and quality. In this model, the alternative hypothesis (H_1) connects risk management practices and project performance by stating that risk management practices do positively affect the project performance of green building projects. Based on findings in Chapter 4.5, implementation of risk management practices have positive influence on project performance by shortening the project duration (time), promoting achievement of green certification (quality) and reducing overrun of project budget (cost). In conclusion, the proposed risk management model offers the sequence of applying risk management stages and selection of appropriate risk management practices to ensure achievement on favourable performance in green building projects.

4.7 Summary

Risk management practices adopted by Malaysian green building project developers are slightly different with those applied in conventional building projects. Conducting interviews, discussions and consultations were commonly used by developers during risk identification, analysis and evaluation processes in green building projects. Risk transfer through contract and adoption of government financial allowances are favoured by developers to mitigate risks in green building projects. GBI design assessment is frequently used by developers to ensure GBI accreditation.

Data collected also revealed that risk management practices can affect project performance in a positive manner.

The validated risk management model for green building projects will thus provide a practical approach for green building project developers when carrying out the 5 phases in risk management.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes and concludes the findings from previous chapters. Conclusion related to objectives of this research is presented in this chapter. In the following section, a number of recommendations are presented for future research purpose.

5.2 Conclusions

Owing to the increasing incident of project cost overrun in green building projects, this study probed into the risk management practices in green building projects in Malaysia. Risk management process in green building projects is divided into 5 stages, namely risk identification, risk analysis, risk evaluation, risk response and risk monitoring & control. During risk identification process, green building project developers in Malaysia consult professionals, experts, suppliers and local agencies on green products and construction methods. It indicates that there is a lacking of knowledge on green technologies, green construction methods and green building regulations among workers in green building projects.

Risk analysis based on professional judgement and consultations are favoured by developers in green building projects due to insufficient historical data in green building projects. The most significant risk evaluation practice applied by green building project developers is the adoption of professional judgement due to slow adoption of Information Technology in Malaysian construction industry. Developers also transfer risk through contract conditions and reduce risk by opting for government financial incentives as strategies for risk response. GBI Design Assessment significantly applies by developers in green building projects to monitor and control risks.

The risk management model provides a practical approach for green building project developers in Malaysia to understand the complete risk management process, to select the appropriate risk management practices and to improve their project performance.

5.3 Recommendations for Future Work

This study shows some limitations regarding selection of research population and research method. In this way, there are some recommendations to be proposed for future studies.

First and foremost, this study is focused on developers that involved in green building projects in Malaysia to identify the risk management practices applied within their organizations. The future research could expand the research population to other construction stakeholders such as consultants and contractors.

Furthermore, this study is focused on risk management practices applied by green building project developers during construction and execution phase. For future research, a study could be made to identify and evaluate the risk management practices applied throughout the entire life cycle of green building projects, especially maintenance and operation phase. In other words, the future study could probe into the risk management practices applied in both construction and building operation phases.

In addition, the closed-ended questionnaire is utilized in this study to identify the adopted risk management practices and evaluate the impact of risk management process on project performance in green building projects. Therefore, it is recommended to apply mixed methods including quantitative and qualitative research methods. Future studies look into factors that drive the implementation of risk management practices by adopting the questionnaire survey and interviews as research tools.

Last but not least, the findings in this study shows that developers identify, analyse and evaluate risks based on professional judgement in green building projects due to slow adoption of Information Technology in Malaysian construction industry. The research topic on barriers of adopting Information Technology (IT) in green building projects could be conducted for future studies to understand the barriers and to provide solutions for enhancing the adoption of IT such as application of Building Information Modelling (BIM) in green building projects.

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APPENDICES

APPENDIX A: Online Survey Questionnaire

Dear Respondents,

I am a final year undergraduate student pursuing Bachelor of Engineering (Honours) Civil Engineering from Universiti Tunku Abdul Rahman (UTAR). I am currently conducting a questionnaire for my Final Year Project (FYP), entitled **"Risk Management Practices in Green Building Project".**

Project budget overrun is one of the major problems faced by green building construction stakeholders caused due to a lacking of understanding of the project risks involved. This questionnaire is to study the risk management practices applied in green building projects adopted by Malaysian construction developers and the effects on project performance.

This questionnaire consists of **THREE (3) sections.** Kindly answer **ALL** questions.

Your co-operation in answering this questionnaire is highly appreciated and vital for completing my research. I would appreciate if you would participate in this questionnaire survey. All of your information is **CONFIDENTIAL** and your responses will be remained private. This information is solely for academic research purposes.

I deeply appreciate your help in participating in this questionnaire. If you have any enquiry, please do not hesitate to contact me by email: **darentan98@1utar.my.**

Yours, sincerely,

If you agree to be part of the research study, you will be asked to complete an online survey. This will take less than 20 minutes to complete. At the end of the survey, please click SUBMIT to complete the survey.

- Yes, I agree.
- No, I disagree.

Section 1: Demographic Information

1) Work Experience:

- Less than 5 years
- 5 – 10 years
- 11 – 20 years
- More than 20 years

2) Company / Organization:

____

3) Involvement in Green Building Projects:

- Less than 5 years
- 5 – 10 years
- 11 – 20 years
- More than 20 years

4) Position in Organization:

- Project Manager or Above
- Engineer
- Supervisor / Inspector
- Other (please specify): ______________

Section 2: Risk Management Practices in Green Building Projects

Risk management in green building projects is aimed at maximizing opportunities and reducing impacts of risk events. This section explores the risk management practices adopted by Malaysian developers in green building projects.

The following statements seek to identify the current risks management practices adopted by organizations to manage risks in green building projects. Please rate the frequency of use of following activities in risk management process within your organization or departments.

1: Not at all 2: Rarely 3: Sometimes 4: Often 5: Always

No	Statements	1	2	3	4	5
1.	Consult professionals / experts regarding green construction technique, equipment & materials.	○	○	○	○	○
2.	Discuss with green equipment or product suppliers on potential green risks.	○	○	○	○	○
3.	Conduct interview with local agencies (e.g. Malaysian Green Technology Corporation) to identify sustainability risks regarding compliance of regulations.	○	○	○	○	○
4.	Apply scenario simulation software (e.g. BIM) to identify & forecast potential risks related to green element performances.	○	○	○	○	○
5.	Forecast likelihood of risk occurrences based on simulation & scenario analysis software (e.g. S-Frame software).	○	○	○	○	○
6.	Analyse risk based on professional judgement & scientific data on green elements	○	○	○	○	○
7.	Appoint consultancy company to assess green risks.	○	○	○	○	○
8.	Evaluate green risk using quantitative analytical software (e.g. commercially available or in-house software).	○	○	○	○	○

9.	Perform quantitative risk assessments (e.g. Life-Cycle Assessment, Social Baseline Assessment, etc) to quantify degree of seriousness of green risk.	○	○	○	○	○
10.	Adopt professional judgement to evaluate green risks.	○	○	○	○	○
11.	Nominate party to manage risks through contractual means.	○	○	○	○	○
12.	Opt for government financial aid program (e.g. company tax exemptions, application fee allowance).	○	○	○	○	○
13.	Conduct workshops and trainings for workers on sustainable construction.	○	○	○	○	○
14.	Adopt a "Total Avoidance of Risk" policy in green building projects.	○	○	○	○	○
15.	Hire independent third party / experts to conduct inspections (e.g. ventilation inspection) and to verify achievement of green standards.	○	○	○	○	○
16.	Monitor green risks through Design Assessment (DA) conducted by GBI certifier.	○	○	○	○	○
17.	Carry out construction work performance reports (e.g. Green Concept Plan) to track green risk status during construction phase.	○	○	○	○	○

Section 3: Productivity, efficiency, works quality, time of completion and cost of project are keys to the success of a green building project.

This section intends to evaluate the effectiveness of risk management practices on the performance of green building projects, in terms of cost, time and quality.

The following statements seek to investigate the impact of risk management measures when they are implemented in the green building projects. Kindly select your level of agreement on impact of risk management in green building projects.

No	Statements	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.	Risk management for green buildings provides efficient & effective control on project operational expenditure (OPEX).	○	○	○	○	○
2.	Risk management in green buildings provides efficient & effective control on project capital expenditure (CAPEX).	○	○	○	○	○
3.	Risk management provides information that facilitates educated decision-making throughout the green building projects.	○	○	○	○	○
4.	Project managers tend to overestimate project budget for green building projects.	○	○	○	○	○
5.	Risk management improves selection of green / sustainable products and materials that meet green project requirements.	○	○	○	○	○

6.	Risk management ensures design of building complies with current green building standards and guidelines.	○	○	○	○	○
7.	Feedback / input from stakeholders is only critical at planning stage when risks are first identified for analysis.	○	○	○	○	○
8.	Feedback from stakeholders throughout project lifecycle is an essential part of risk management in green building projects.	○	○	○	○	○
9.	Compliance to green certification requirements helps mitigate risks throughout project lifecycle.	○	○	○	○	○
10.	Cost for control and mitigating measures in risks management is proportional to the likelihood of risk occurrence in green building projects.	○	○	○	○	○
11.	Processes involved in managing risks for green building projects increase overall project duration.	○	○	○	○	○
12.	Managing risks in green building projects improves project delivery time.	○	○	○	○	○
13.	Evaluating and controlling risks in green building projects results in smooth implementation of project activities.	○	○	○	○	○
14.	Risks identified in building projects help managers to meet quality requirements of green building projects.	○	○	○	○	○

15.	Selectively managing critical risks help managers to meet quality requirements of green building projects.	○	○	○	○	○
16.	Implementation of structural control measures such as design measures as part of risk management will increase project cost.	○	○	○	○	○
17.	Implementation of structural control measures as part of risk management is cost-effective during planning and design stages.	○	○	○	○	○
18.	Risk transfer in green building projects helps reduce project cost.	○	○	○	○	○
19.	Risk transfer in green building projects reduces or eliminates contractual disputes related to procurement & installation of green products / materials / services.	○	○	○	○	○
20.	Risk transfer in green building projects reduces or eliminates the severity of impact due to improper installation of green building materials / products.	○	○	○	○	○
21.	Risk management improves project planning and execution of green construction designs.	○	○	○	○	○
22.	Monitoring risks in green building projects helps managers to achieve better quality control during construction and operation phases.	○	○	○	○	○