DEVELOPMENT OF BUILDING PROCUREMENT SUSTAINABILITY ASSESSMENT FRAMEWORK: A CASE STUDY IN MALAYSIA

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Development of Building Procurement Sustainability Assessment Framework: A Case Study in Malaysia

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A thesis submitted in partial fulfillment of the requirements

for the degree of Doctor of Philosophy

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CERTIFICATE OF ORIGINALITY

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Signature:

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Khairul Anuar Bin BAKHTIAR

To my lovely wife, Dr. Siti Hajar, my lovely daughter, Damia Zahra (2.5 years old) and my families, who gives me enduring love, patience and support throughout this Ph.D. study

ABSTRACT

Building procurement methods are defined as organizational systems that assign specific responsibilities and authorities to people and organizations. Previous studies have suggested that the performance of a construction project related to proper choices of building procurement methods. In the United Kingdom, the partnering method is believed as the most suitable method compatible with the sustainability followed by the design and build, and traditional methods. This research, however, identifies that there is a lack of studies conducted for assessing the sustainability performance of different building procurement methods in developing countries. Therefore, this research proposes a conceptual framework that based on sustainable construction and building procurement method to assess the sustainability performance when using different building procurement method.

This research takes the advantage of the Tenth Malaysian Plan to promote sustainable construction by improving building procurement method. Therefore, this research aims to develop a scoring framework as a decision support tool to assess the sustainability performance for different building procurement methods. There are two steps for data collection in this research. First, is through industry survey to identify an ‘integrated set of indicators’ for analyzing different building procurement methods. The Sustainable Procurement Decision Making (SuProDem) framework has been developed based on the identified integrated indicators. Second, the framework is used to evaluate the sustainability performances of different building procurement methods through a critical comparison of school construction projects in Malaysia. The school construction projects examined in this research involve two types of building procurement methods; the traditional and design and build procurement method. The outcome from the case studies was used to compare and validate the results of the industry survey.

This research identifies ten integrated indicators with relevant sub-indicators suitable for assessing sustainability performance when using different building procurement methods in developing countries. The research also recommends the SuProDem framework that provides decision makers with an objective references to choose effective and sustainable building procurement methods for their particular projects. The research finding supports that the design and build method makes the greatest contribution to the sustainable construction, if compared to the traditional methods. However, the findings of the industry survey and case study are not consistent. Therefore, wider application of the existing building procurement methods is needed to increase understanding of sustainable construction especially when dealing with complex construction projects. Finally, the overall findings fill the significant research gaps and demonstrate the relationship between sustainable construction and procurement methods for building projects in Malaysia.

PUBLICATIONS ARISING FROM THE THESIS

Journal papers

1. Bakhtiar, K.A.B., Shen, L.Y., and Misnan, S.H.B. (2008) A framework for comparison study on the major methods in promoting sustainable construction practice. *Jurnal Alam Bina*, **12**(3), 55-69. ISSN 1511-1369

2. Bakhtiar, K.A.B., Ann T.W. Yu, Misnan, S.H. (2016) An empirical survey of sustainable construction in Malaysia. (Ready for submission)

3. Bakhtiar, K.A.B., Ann T.W. Yu, Misnan, S.H. (2016) Sustainable Construction in Malaysia: A proper building procurement method. (Ready for submission)

Refereed conference papers

1. Bakhtiar, K.A.B. and Shen, L.Y. (2009) Challenges to sustainable construction in developing countries. In: *Proceedings of the 1st International Postgraduate Conference on Infrastructure and Environment*, 5-6 June 2009, Hong Kong, China: The Hong Kong Polytechnic University, 202-209.

2. Bakhtiar K.A.B. and Shen L.Y. (2009) Proper choice for construction procurement systems – A Key to sustainable construction in developing countries? In: *International Conference on Construction Industry 2009*, 30 July-1 August, 2009, Padang, West Sumatera, Indonesia: Universitas Bung Hatta, pp. 8.

3. Bakhtiar, K.A.B., Shen, L.Y. and Khalid A.G.B. (2009) Sustainable construction: An Empirical Findings between Hong Kong and Malaysia. In: *Proceedings of CRIOCM 2009 the 14th International Symposium on*

Advancement of Construction Management and Real Estate, Volume 1, 29-31 October, 2009, Nanjing, China: Southeast University, 219-227.

4. Bakhtiar, K.A.B., Shen, L.Y., Ann T.W. Yu, and Khalid A.G.B. (2010) Investigation on the contribution of procurement method to sustainable construction: A Malaysian Study. In *Proceedings of CRIOCM 2010 the 15th Annual Symposium on towards sustainable development of international metropolis*, 7-8 August, 2010, Johor Bahru, Johor, Malaysia, 34-42.

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CHAPTER 1 INTRODUCTION

1.1 Research background

1.2 Research problem statements

1.3 Research objectives

1.4 Research scope

1.5 Research significance

1.6 Structure of the thesis

1.7 Summary

CHAPTER 1

INTRODUCTION

This chapter provides general introduction to the research work on assessing sustainability performance when using different building procurement methods. It is comprised of research background, problem statements, research objectives, scope and its significance, and it ends with structure of the thesis.

1.1 Research background

Sustainable construction addresses human desire for development, while still maintaining the Earth's resources and ecological stability. Numerous studies have been conducted to develop sustainable construction principles (Shen, 1993; Kibert, 1994; Huovila and Koskela, 1998; Pearce, 2006; Kibert, 2007; Sev, 2009) and sustainable construction framework (Hill and Bowen, 1997; Ofori, 1998; Pearce, 2006; Shen *et al.*, 2006; Du Plessis, 2007; Bakhtiar *et al.*, 2008). Researchers have remarked that perspectives of sustainable construction differ between developed and developing countries (e.g. Du Plessis, 2001; A21 SCDC, 2002; Du Plessis, 2007). A developed country would strongly focus on the environmental agenda, with less consideration on the economic and social aspects. (Kibert, 1994; Huovila and Koskela, 1998; Carter, 2005; Shen *et al.*, 2006; Carter and Fortune, 2007; Carter and Fortune, 2008). On the contrary, a developing country would place significant focus on its economic and social agenda, and may not prioritize environmental concerns strictly (Ofori, 1998; Du Plessis, 2001; A21 SCDC, 2002; Gomes & Silva, 2005; Du Plessis, 2007; Bakhtiar and Shen, 2009). Nevertheless, environmental issues should be of serious concerns for both developed and developing countries. There is a growing interest in this topic, as there has been evidence from recent studies proposing sustainable construction concepts for developing countries (e.g. Du Plessis, 2001; A21 SCDC, 2002; Du Plessis, 2007; Bakhtiar and Shen, 2009b). Newly industrialized countries, including Malaysia, South Africa, Mexico, Brazil, China, India, Philippines, Thailand, and Turkey are considered having not reached developed country's status yet, but in macroeconomic sense, they outperform other developing countries (IMF World Economic Outlook Database, 2009).

In promoting sustainable construction, previous studies have indicated that numerous method which have been proposed and undertaken, such as education and training (Chan *et al.*, 2002; Gomes and Silva, 2005; Manoliadis *et al.*, 2006); environmental management system (BSI, 1994; Hill and Bowen, 1997; Kein *et al.*, 1999; Shen and Tam, 2002; Christini *et al.*, 2004; Ou *et al.*, 2006; Yao *et al.*, 2006); green building (Stum, 2000; Kibert, 2007; Kibert, 2008); green design (Al-Momani, 2000; Ekanayake and Ofori, 2000; Osmani *et al.*, 2008); green procurement (Spence and Mulligan, 1995; Ngowi, 1997; Ekanayake and Ofori, 2000; A21 SCDC, 2002; Sterner, 2002; Kibert, 2007; Kibert, 2008); green roof technologies (Nelms, 2007; Doshi, 2005); lean construction (Huovila and Koskela, 1998; Ballard *et al.*, 2003; Lapinski *et al.*, 2006); prefabrication (Tam *et al.*, 2007b; Jaillon *et al.*, 2008; Jaillon and Poon, 2008; Silva and

Vithana, 2008) and waste management (Bossink and Brouwers, 1996; Kein *et al.*, 1999; Teo and Loosemore, 2001; Kulatunga *et al.*, 2006; Begum *et al.*, 2007; Tam *et al.*, 2007a; Tam, 2008). However, little attention is paid to test the effectiveness of these methods.

Previous studies have also identified various sustainability indicators, including waste reduction (Kibert, 1994; Hill and Bowen, 1997; A21 SCDC, 2002; Reffat, 2004; Carter, 2005; Gomes and Silva, 2005; Manoliadis *et al.*, 2006; Shen *et al.*, 2006; Bakhtiar *et al.*, 2008; Kibert, 2008; Matar *et al.*, 2008; Bakhtiar *et al.*, 2009b); procurement material (Kibert, 1994; Hill and Bowen, 1997; A21 SCDC, 2002; Reffat, 2004; Carter, 2005; Gomes and Silva, 2005; Manoliadis *et al.*, 2006); employment (A21 SCDC, 2002; Reffat, 2004; Gomes and Silva, 2005; Bakhtiar and Shen, 2009); quality (Kibert, 1994; Hill and Bowen, 1997; A21 SCDC, 2002; Reffat, 2004; Carter, 2005; Manoliadis *et al.*, 2006; Shen *et al.*, 2006; Bakhtiar *et al.*, 2008; Kibert, 2008; Matar *et al.*, 2008; Bakhtiar *et al.*, 2009b) and environmental awareness (Kibert, 1994; Hill and Bowen, 1997; A21 SCDC, 2002; Reffat, 2004; Carter, 2005; Manoliadis *et al.*, 2006; Shen *et al.*, 2006; Kibert, 2008; Matar *et al.*, 2008; Bakhtiar *et al.*, 2009b). Moreover, other indicators should also be considered, including cost saving (Love *et al.*, 1998; Rwelamila and Meyer, 1998; Alhazmi and McCaffer, 2000; Chan *et al.*, 2001; Gomes and Silva, 2005; Bakhtiar *et al.*, 2008; Bakhtiar and Shen, 2009; Bakhtiar *et al.*, 2009b); time saving (Love *et al.*, 1998; Rwelamila and Meyer, 1998; Alhazmi and McCaffer, 2000; Chan *et al.*, 2001; Gomes and Silva, 2005; Bakhtiar *et al.*, 2008; Bakhtiar and Shen, 2009; Bakhtiar *et al.*, 2009b); design (Kibert, 1994; Hill and Bowen, 1997; A21 SCDC, 2002;

Reffat, 2004; Carter, 2005; Gomes and Silva, 2005; Manoliadis *et al.*, 2006; Shen *et al.*, 2006; Kibert, 2008; Matar *et al.*, 2008); and profitability (Kibert, 1994; Hill and Bowen, 1997; A21 SCDC, 2002; Reffat, 2004; Carter, 2005; Gomes and Silva, 2005; Manoliadis *et al.*, 2006; Shen *et al.*, 2006; Bakhtiar *et al.*, 2008; Kibert, 2008; Matar *et al.*, 2008; Bakhtiar and Shen, 2009; Bakhtiar *et al.*, 2009b).

Although there are many indicators mentioned in the literature, this study considers important and relevant indicators for developing countries. The selection of indicators to measure sustainability should consider factors, such as simplification and ease of understanding (Guy and Kibert, 1998). Ofori (2001) recommended methods for indicators measurement and compilation with the intention of formularization should be studied in detail to meet specific demands. Bakhtiar *et al.* (2009b) have found that cost and time saving could be a hindrance to sustainable construction, thus have suggested that both cost and time saving should be the significant indicators. Previous researches have suggested that high cost in implementing sustainable construction would be reimbursed by life-cycle cost-saving products, such as green buildings and green procurements (Halliday, 2008; Kibert, 2008). Cost and time are critical issues for developing countries as they sometimes require financial assistance and technology transfers from developed countries (e.g. Ofori, 1998; Du Plessis, 2001; A21 SCDC, 2002; Gomes & Silva, 2005; Du Plessis, 2007; Bakhtiar and Shen, 2009). Nevertheless, since each country could have different sustainability indicators (Shen, 1993; Ofori, 1998; Bakhtiar *et al.*, 2009b), this research focuses only on construction industry in Malaysia.

The increasing awareness on sustainability issues in construction industry calls for the formulation of proper building procurement methods. To date, however, there is a lack of studies conducted on this topic. This area of study is relatively under-researched. At present, there is a lack of knowledge in the impact of building procurement methods on sustainable construction. Love *et al.* (1998) defined building procurement methods as 'an organizational system that assigns specific responsibilities and authorities to people and organizations, and defines the relationships of various elements in the construction of the project'. Some studies have suggested that the performance of a construction project can be related to proper building procurement methods (e.g. Love *et al.*, 1998; Rwelamila and Meyer, 1998; Hashim, 1999; Alhazmi and McCaffer, 2000; Chan *et al.*, 2001). As noted by Ling and Kerh (2004), clients frequently prefer building procurement methods they are most familiar with or rely on professional advice. On the other hand, Rowlinson and McDermott (1999) highlighted the presumption of the choice of an appropriate building procurement method will lead to a successful project outcome. Ngowi (1998) claimed that the traditional, design and build procurement methods can fail to meet the expectation of users. Furthermore, Halliday (2008) suggested that there is no solid evidence to indicate that the adoption of sustainable construction has hindered any forms of building procurement methods. However, Rwelamila *et al.* (2000) found that the traditional procurement can be incompatible with sustainability parameters. Carter and Fortune (2007, 2008) had conducted comprehensive studies on the relationship between sustainability and building procurement methods, although their focus were in the project of a developed country. Carter (2005) found that building procurement method using partnering concept is the most suitable one which is compatible with the sustainable development of social housing project in the United Kingdom, followed by design and build, and traditional methods. Subsequently, Carter and Fortune (2007) have suggested that future study should focus to establish a linkage between building procurement methods and sustainability. Carter and Fortune (2008) have established a consensual sustainability model and decision support tool to promote 'sustainable' building procurement method.

In relation to this research, Ismail and Samad (1999) observed that building procurement methods used in construction industry in Malaysia are typically traditional (71%), design and build (21%), and management contracting (8%). Other procurement methods implemented in Malaysia including build operate transfer, private finance initiative, management contracting, construction management, package deal turnkey, and public-private partnerships are not popular in Malaysia (Zainuddin, 1999). The latest data from the Construction Industry Development Board (CIDB) of Malaysia in 2010 has shown that a selection of building procurement methods are traditional (96.54%), design and build (2.32%), turnkey (1.03%), build, operate and transfer (0.11%) (CIDB, 2010). These differences generate a unique anomaly when previous literature argues that partnering and design and build is the most suitable technique that is compatible with the sustainable development. Therefore, there is an urgent need to study the relationships and to assess the sustainability performance behind these differences.

1.2 Research Problem Statements

The sustainable concept was originally introduced to address the issues of environmental degradation. Since it is a global dilemma, both developed and developing countries should adopt sustainable construction concepts. Although the basis of the concept is similar, there are several differences on the implementation and focus of sustainability between developed and developing countries. In addition, rapid urbanizations in developing countries have made the issue of sustainability critical, which requiring solutions that are also capable of addressing the economic and social agendas.

Through extensive literature review on the above subject that has been carried out, this study has identified research gaps in building procurement methods and sustainable construction, in particular the impact of choices of different building procurement methods to sustainability. The major problem identified is that ‘there is a need to establish a decision support tool to assess sustainability performance when using different building procurement methods’. Furthermore, there are questions of the effectiveness of different building procurement methods to promote and achieve sustainable construction in Malaysia.

In Figure 1-1, the research gaps are identified between (1) sustainable construction; (2) developing countries; and (3) building procurement methods.

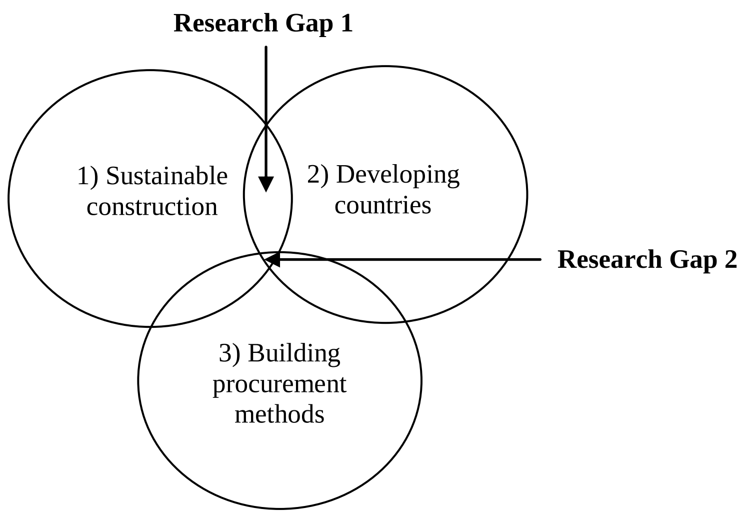

Figure 1-1 A diagram for identifying research gaps

1.2.1 Identification of Research Gap 1

There are only a handful of empirical studies on sustainable construction in Malaysia. At present, there exists a gap in this topic that requires in-depth studies to identify relevant sustainability indicators, including sustainable construction indicators for developing countries.

1.2.2 Identification of Research Gap 2

There is also a gap between sustainable construction and building procurement methods on integration between building procurement methods and sustainable construction. The identified gaps are then expanded and developed to add to the pool of knowledge in the area of 'sustainable' building procurement.

1.3 Research Objectives

Once the research problem statements and research gaps have been identified, broad concept of sustainable construction can then be narrowed down to define the specific objectives of this research. The aim of this research is '***to develop a framework as a decision support tool to assess sustainability performance for different building procurement method***'. The following are the specific objectives of this research:

1. To identify methods already developed for promoting sustainable construction, through a comprehensive literature reviews;

2. To establish integrated sustainability indicators for measuring the performance of different building procurement methods so as to promote sustainable construction;

3. To develop a scoring framework as a decision support tool for evaluating the sustainability performance of different building procurement methods in building projects;

4. To demonstrate the applicability of the scoring framework through case studies.

1.4 Research Scope

This study focuses on connection between sustainable construction, developing countries, and building procurement methods. Furthermore, it concentrates on sustainable construction concept as applied to developing countries, specifically to Malaysia as a newly industrialized country. Subsequent evaluations were made to recognize significant relationship between sustainability and building procurement methods in delivering a building project. Key stakeholders who involve in this study are the clients, contractors, and consultants in the industry.

1.5 Research Significance

Although the sustainable agenda is a global issue, past research had mostly focused on developed nations, overlooking the challenges faced by developing countries. This study is valuable to developing countries since these nations are undergoing rapid urbanizations. This research will significantly add to the existing body of knowledge with respect to:

1) Establishing a conceptual foundation based on sustainable development, sustainable construction and building procurement methods in developing countries to assess the sustainability performance when using different building procurement methods.

2) Establishing integrated indicators and sub-indicators suitable for accessing sustainability performance through an industry survey.

3) Recommending the Sustainable Procurement Decision-Making Framework (SuProDem) developed based on identified scoring techniques and integrated indicators.

4) Filling the significant research gaps and demonstrating the relationship between sustainable construction and building procurement methods for building projects in Malaysia.

The expected outcome of this research is the Sustainable Procurement Decision-Making Framework (SuProDem) as a decision support tool to assess sustainability performance when using different building procurement methods which may contribute to promote and increase sustainable construction performance especially to developing countries.

1.6 Structure of the Thesis

This thesis is organized into 8 chapters and structured according to research process. Figure 1-2 shows the structure.

Chapter 1 Introduction comprises a description of the research background, problem statements, objectives, scope, as well as its significance. The structure of the thesis and its summary are also described here.

Chapter 2 Literature Review summarizes the current literature to assess the current level of knowledge and research in the topic. The review includes the introduction of key relevant concepts of sustainable construction, sustainable construction practice in developing countries, and building procurement methods. The study establishes the fact that there is a lack of research on sustainable construction in developing countries, and building procurement methods. Thus, there exists a distinct gap of knowledge in this topic that this study attempts to address.

Chapter 3 Research Methodology which includes the introduction, research framework and methodology, literature review, a triangulation method, data collection, methods for data analysis, research planning, methodology framework, design, and summary.

Chapter 4 Scoring Framework for SuProDem Framework presents the development of the scoring framework which includes the introduction, conceptual framework, theoretical frameworks, developing of sustainable procurement decision-making framework for a building project, discussion of SuProDem framework, scoring, the Wittgenstein family-resemblance concept and summary.

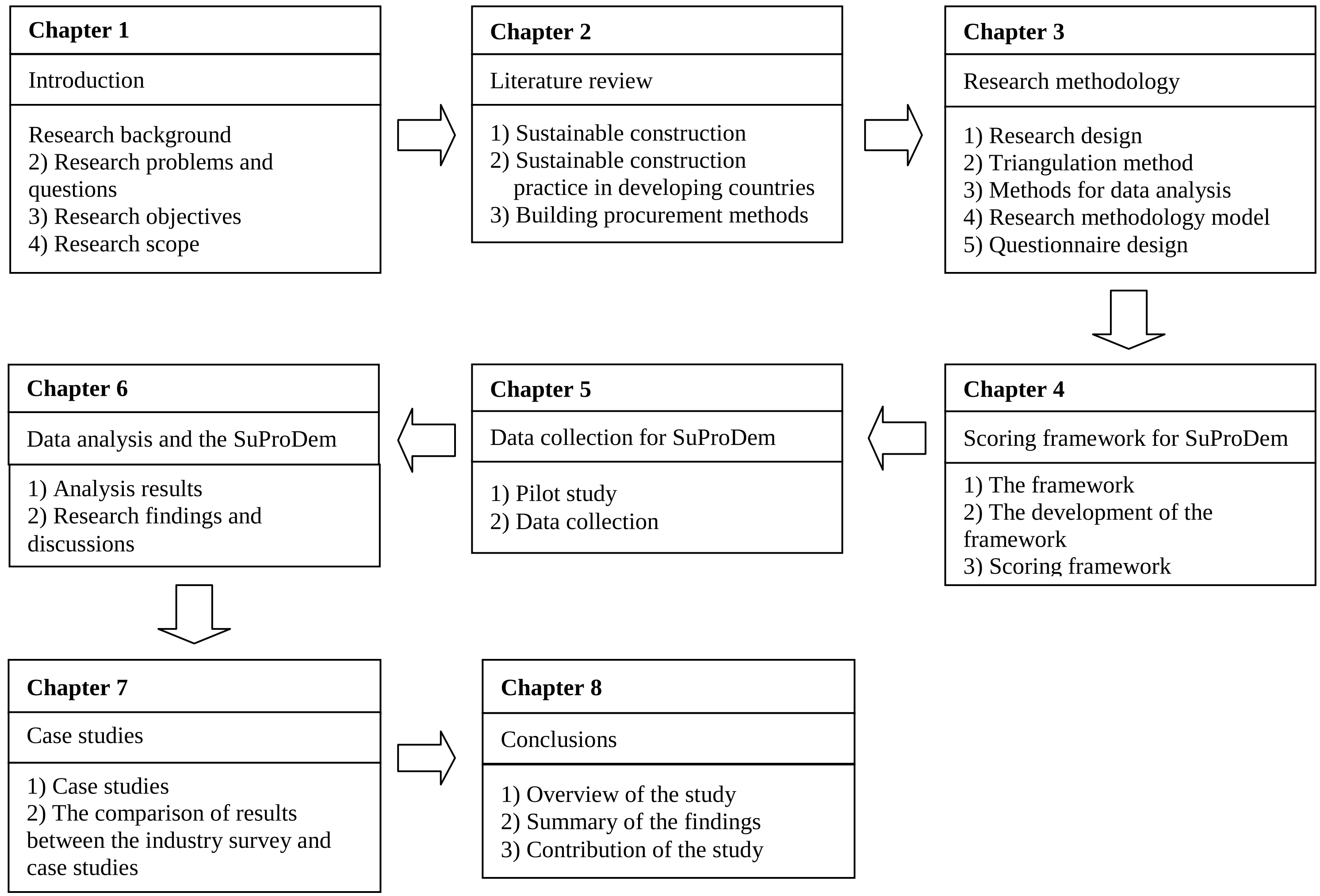

Figure 1-2 Structure of the thesis

Chapter 5 Data Collection for SuProDem Framework presents the data collection process, including introduction, pilot study, data collections, techniques for data collection, reliability, sampling validity and summary.

Chapter 6 Data Analysis and the SuProDem Framework illustrates the data analysis, which includes the introduction, analysis of results, research findings and discussions, the proposed framework and summary.

Chapter 7 Validation of SuProDem Framework by Case Studies presents the results of case studies, including the introduction, prepositional framework of sustainable procurement decision making conceptual framework(SuProDem) for a building project, case studies, qualitative results of identifying school project, and the comparison of results between industry survey and case studies, and its summary as well.

Chapter 8 Conclusion that includes introduction, overview of the study, summary of findings, contributions and limitations of the study, future research recommendations and personal attainment from this study.

1.7 Summary

This chapter lays the foundation of this research work. It firstly introduces the research background, highlighting several crucial obstacles in achieving sustainable construction especially in developing countries specifically through different building procurement methods. The related problems are presented together with the research objectives. Subsequently, the significance of the research is identified, and the research scopes are briefly discussed. Finally, the structure of the thesis is outlined, showing the overall research framework. On this background, the research proceeds with a detailed literature review in next chapter.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

2.2 Sustainable construction

2.3 Sustainable construction in developing countries

2.4 Building procurement methods

2.5 Research gaps

2.6 Summary

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews previous literature that is relevant to research objectives developed in previous chapter, which include: (1) overviews on sustainable construction; (2) sustainable construction in developing countries; (3) building procurement methods to identify research gaps, identifying relevant set of indicators and summarizing direction of this research. Figure 2-1 shows a diagram consisting of several sectors aimed at providing intensive reviews and connection between sustainable construction, developing countries, and building procurement methods.

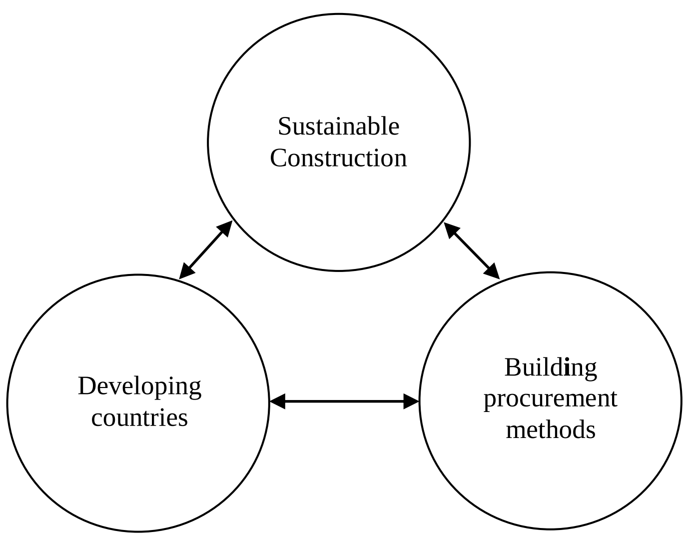

Figure 2-1 Diagram of the literature review conceptual foundation

2.2 Sustainable construction

2.2.1 Sustainable development

Over the last two decades, the concept of sustainable development has grown rapidly. Political and academic viewpoints on the concept have proliferated globally and supported by governments, non-governmental organizations, businesses, and scientific communities (Seidl, 2000). The concept has attracted the interest of researchers worldwide and has been adopted in various disciplines of studies, such as in policy-making, law, politics, and construction. Previously, the concept of sustainability relates heavily towards environmental degradation, with limited focus on economic and social issues. As mentioned by Huovila and Koskela (1998), buildings and infrastructure projects have been a major contributor to global environmental degradations. Nevertheless, current global pursuit of sustainable development has urged mankind to strive for sustainable life. This concept was well-described in the World Commission on Environment and Development (WCED) report, which defined it as:

> *development, which meets the needs of the present without compromising the ability of future generation to meet their own needs... the concepts of needs in particular the essential needs of the world's poor, to which overriding priority should be given... the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs* (WCED, 1987).

The definition above is often cited by researchers and has become a benchmark for governments, authorities, academicians, politicians, and businesses in making sustainability-focused decisions for mankind. The report was recognized as Brundtland report, named after its chairman, Gro Harlem Brundtland, a former Prime Minister of Norway. The report has highlighted that emphasizing only on environmental issues to achieve sustainable development is not sufficient. There is also a simultaneous need to address both economic and social agenda. Figure 2-2 shows the sustainable development pillars, as described by WCED (1987).

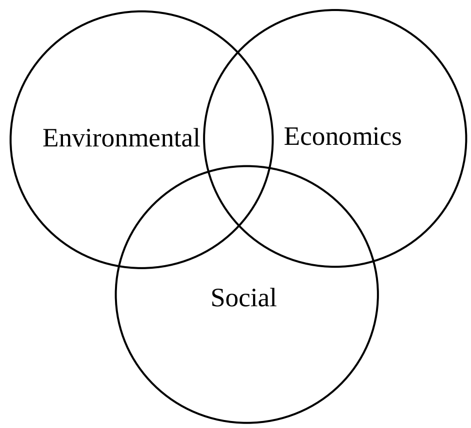

Figure 2-2 Sustainable development pillars
(Source: WCED, 1987)

These overlapping pillars describe the concept of sustainable development, urging mankind to appreciate the value of available resources and also improve their consumption efficiency (WCED, 1987). The concept expands into many ideas, frameworks and strategies. The Langkawi Declaration on the Environment (1989) has recommended several steps to address environmental issues, while promoting economic growth simultaneously, without overlooking: (1) poverty problems; (2) meeting human basic needs; and (3) enhancing quality of human life. Spence and Mulligan (1995) stated that most countries already have a legislative framework and fiscal controls set by the governments to mitigate environmental impacts related to construction activities. They mentioned that the environmental impacts in construction industry have resulted creation of many governmental policies and changes. Governments should have an active role in reducing the environmental impacts through various measures such as (1) regulations; (2) policy controls; (3) economic incentives; and (4) non-regulatory promotion activity. De Graaf *et al.* (1996) suggested a strategy for sustainable development to comprehensively address social, economic, cultural or ecological problems. They believe that the development is based not only on theoretical and ideological arguments, but also through experience gained. They proposed further studies on (1) management of negotiation process; (2) definition of socio-environmental systems which must develop in a sustainable way; (3) assessment of needs and demand people involved; and (4) assessment of possibilities of satisfying those needs and demands. Mitchell (1996) believed that greater benefit of sustainable development can be obtained by focusing on local context. He pointed out the importance of proper indicators to help decision-makers to monitor the progress and achievement of sustainability. Huovila and Koskela (1998) have studied lean construction principles to complement sustainable development. Their studies have revealed that in the European Union, buildings account for at least 40% of energy consumption and construction industry is estimated to generate 40% of wastage (see also CIB, 1999).

To promote sustainable development, the Department of the Environment, Transport and the Regions (DETR) in the United Kingdom, has identified four objectives, namely (1) social progress; (2) protection of the environment; (3) prudent use of natural resources; and (4) economic growth and employment (DETR, 1999). These objectives could address environmental degradations, without overlooking economic and social issues. Gutberlet (2000) commented that corporate world sustainability concept based on dematerialization, a tendency to use less material and energy inputs per unit output, to promote eco-efficiency. The construction industry has direct and indirect contributions towards micro and macro socio-economic aspect (Majdalani *et al.*, 2006). Pearce (2006) stated that sustainable means 'lasting or perpetual and there hardly seems any points to developing if the effort to do so is not sustained'. Pearce believe that the sustainability concept was too broad, and to some extent has failed to be narrowed down. Du Plessis (2007) described the essence of sustainable development as:

> *managing the relationship between the needs of humans and their environment (biophysical and social) in such a way that critical environment limits are not exceeded and modern ideals of social equity and basic human rights (including the 'right to development') are not obstructed.*

There are two factors determine the relationship between human beings and the environment, i.e. (1) Interpretation of 'quality of life' held by a particular community; and (2) choices made in terms of technological, political, economic and other systems adopted by mainstream society. These identified factors generated from a particular value system that a society adopts. Figure 2-3 shows a relational model of sustainable development, describing the connection between human needs and environmental limitations. The model has well described the human needs and environmental limits.

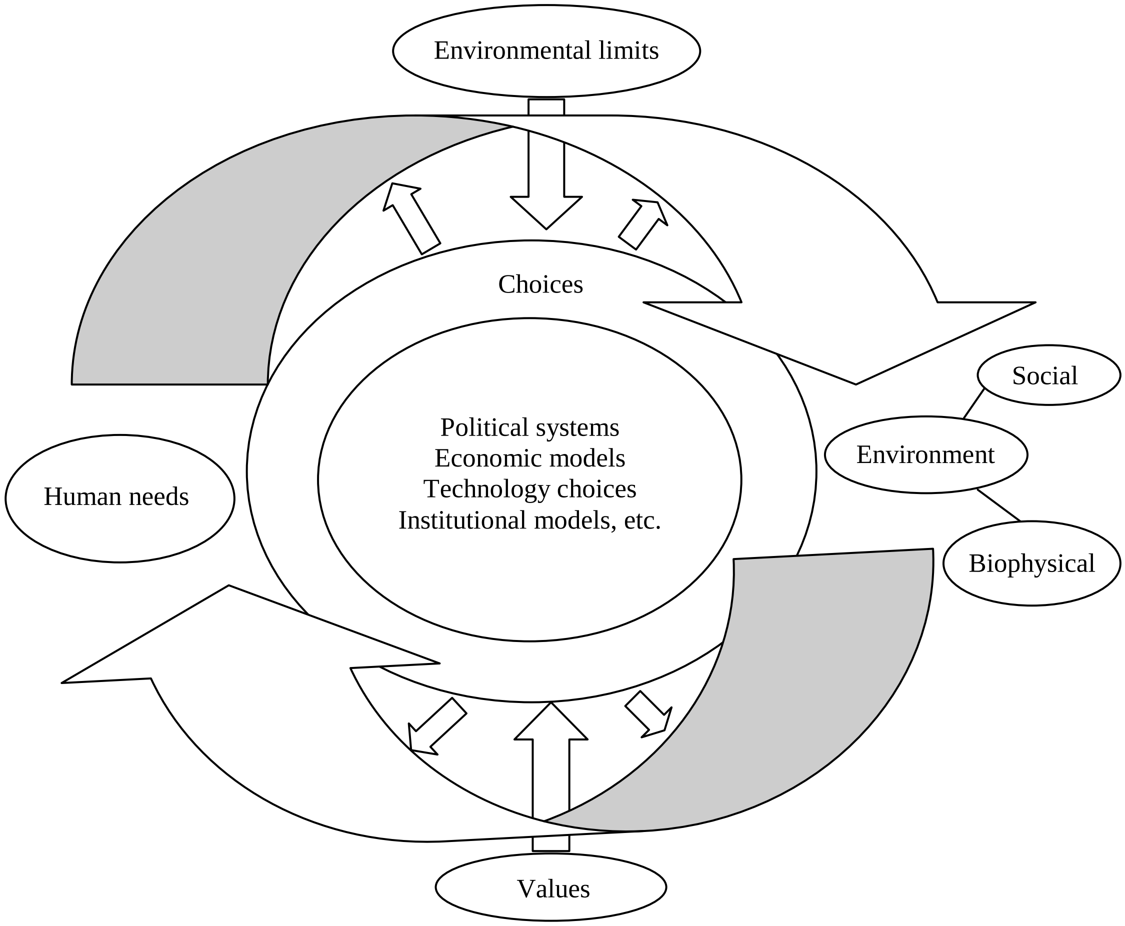

Figure 2-3 A relational model of sustainable development (Source: Du Plessis, 2007)

Table 2-1 shows the number of article links from a search made on two academic search engines, namely Scopus and Google Scholar, using the keywords “sustainable development” and “sustainable construction”.

Table 2-1 Links to sustainable development and sustainable construction research
(Source: Scopus, 2009 and Google Scholar, 2009)

Year		**2009**	
Search engine		**Scopus**	**Google Scholar**
Keywords	Sustainable development	49,080	1,140,000
	Sustainable construction	4,434	1,030,000

The table shows that this is one of the primary evidences in sustainability-related research which has gained its popularity in recent years. Sev (2009) suggested that achievement of sustainable development requires smart decisions, which include full consideration and knowledge of impacts associated with each alternative. Sustainable development can be seen from a macro perspective, yet still having direct connection with sustainable construction. Construction activities play an important role to meet sustainable development agenda (Huovila and Koskela, 1998) since the industry is a major contributor of economy in many countries (Cheung *et al.*, 2001). The literature review shows that the concept of sustainable development has evolved and steadily broadened its capacity, thus becoming more involved. Nevertheless, progress of application of sustainable development could be faster, but only if construction industry stakeholders can work together as a team (Waas *et al.*, 2014). In promoting sustainable development practically, there is a pressing need to guide construction professionals for their common interest.

2.2.2 Sustainable construction concept

Researches in sustainable construction have risen steadily over the past years. Initial concerns were raised by several researchers who have identified construction industry as a primary cause of environmental degradation (Spence and Mulligan, 1995; Ofori, 1998; Shen and Tam, 2002; Manoliadis *et al.*, 2006). One of the major reasons is due to the lack of environmental awareness of those involved in the industry (Hill and Bowen, 1997; Kein *et al.*, 1999; Shen *et al.*, 2006; Osmani *et al.*, 2008). Nevertheless, governments should have played active roles to reduce the environmental impact in the industry, such as through the establishment of regulation and controls, financial incentives, and a non-regulatory activity (Spence and Mulligan, 1995). Although sustainable construction is an exciting research topic, its implementation is still relatively new, and the improvement of its performance is difficult to measure (Kibert, 2007). It is a global trend to promote sustainable development that balances the environmental sustainability without compromising human needs for economic and social progress. Similarly, sustainable construction seeks to strike a balance between the environmental, social and economic progress. In developing countries, sustainable construction has been emphasized on economic and social agenda. Nevertheless, environmental degradation is a crucial issue in both developed and developing countries. Striking a balance between the three pillars for sustainable construction, namely the environmental, economic and social, would increase life quality and maintains the Earth's ecological system. Shen (1993) proposed a four-management dimension framework, namely, cost, time, quality and the environment, which are the essential management indicators. The environment is explicitly added since there has been a lack of attention for this factor. Figure 2-4 shows the construction management model of the four dimensions.

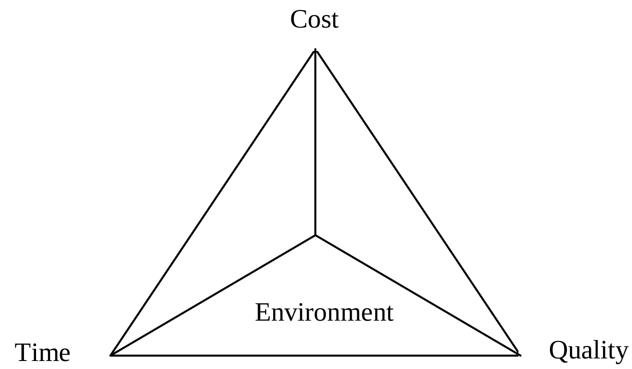

Figure 2-4 Construction management model with four dimensions
(Source: Shen, 1993)

The first international conference on sustainable construction in Tampa, United States of America, where Kibert (1994) introduced a famous definition of sustainable construction as 'creating a healthily-built environment using resource-efficient and ecologically-based principles'. The proposed principles attempt to deal with issues in sustainable construction such as (1) conserve; (2) reuse; (3) renew or recycle; (4) protect nature; (5) non-toxics; (6) economics; and (7) quality. The conference attracted much attention from researchers, and the principles presented during the event have become a guideline for research in sustainable construction. Figure 2-5 shows a framework for sustainable construction developed in 1994 by Task Group 16 (International Council for Research and Innovation in Building and Construction).

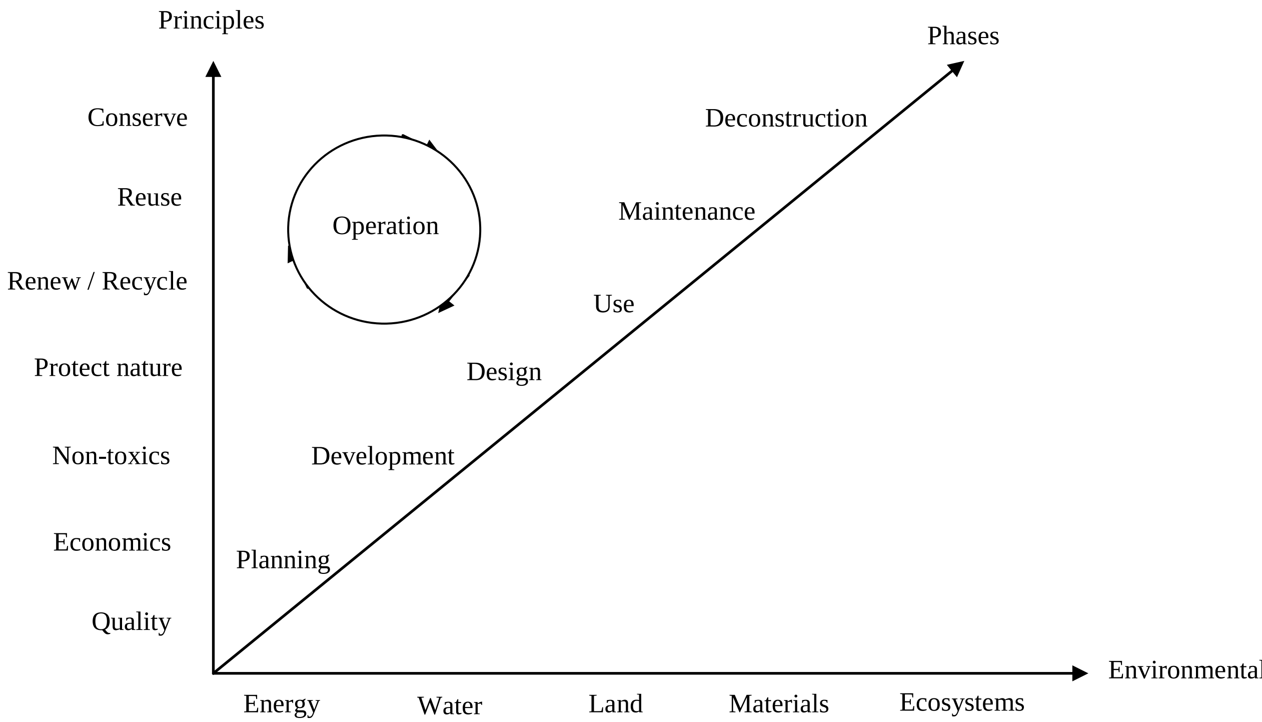

Figure 2-5 Framework for sustainable construction developed in 1994 by Task Group 16 (sustainable construction) of the International Council for Research and Innovation in Building and Construction *(Source: Kibert, 1994; Kibert, 2008)*

The proposed framework was designed to stimulate discussion. Since the economic and social issues have reached a notable achievement in developed countries, these issues are often overlooked. Furthermore, some researchers have perceived sustainable construction as an environmental matter only, undermining the economic and social aspects and seeing it in an unbalanced manner (e.g. Kibert, 1994; Huovila and Koskela, 1998; Shen *et al.*, 2006; Kibert, 2008). Hill and Bowen (1997) proposed the sustainable construction framework as four pillars, namely (1) social sustainability; (2) economic sustainability; (3) biophysical sustainability; and (4) technical sustainability. They proposed an extra pillar which is the technical sustainability. It was considered the first framework to address sustainability at fundamental level in construction sector. They suggested an application of Environmental Assessment and Environmental

Management to promote sustainable construction. The Environmental Assessment application should be used during planning and design stage of the project while the Environmental Management application is to be used within construction organization in operation and, where appropriate, even decommissioning. However, Ofori (1998) disagreed on the framework proposed by Hill and Bowen (1997) since it was only formulated from a developed country's point of view, and thus unsuitable from a developing country's perspective. He believed that the sustainable construction between developed and developing countries has some differences. He suggested that the technical pillar could be incorporated within economic sustainability and the two indicators proposed by Hill and Bowen, which include affordability and promoting employment under economic pillar, is applicable for developing countries. The role of different parties and collaboration towards sustainable construction are emphasized, with the government, as the largest construction client, being the principal agent. It is noted that developing countries are facing numerous challenges such as (1) lack of managerial experience; (2) financial resources; (3) legal and administrative systems for promotional activity; (4) formulating and enforcing regulations; and (5) giving incentives to encourage appropriate behavior. The implementation of environmental impact for developing countries may be difficult to achieve due to (1) financial constrains; (2) management difficulties; (3) rapid urbanization; (4) insufficient legal and administrative systems; and (5) lack of promotional and incentives activities.

Sir John Egan has led a construction task force which presented a report entitled 'Rethinking Construction' to the government of the United Kingdom to improve quality and efficiency of construction sector in the country (Egan, 1998). The report recommended that construction industry should look into manufacturing and service industries to achieve radical changes including (1) committed leadership; (2) focus on customer; (3) integrating the process and the team around the product; (4) a quality driven agenda; and (5) commitment to people. It also proposed seven indicators covering a range of scope for sustained improvement in the UK's construction industry including (1) capital cost; (2) construction time; (3) predictability; (4) defects; (5) accidents; (6) productivity; and (7) turnover and profits. He suggested a rethink by approaching construction industry differently, to achieve both efficiency and quality. To increase the effectiveness in tackling environmental degradation, Kein (1999) suggested the use of environmental-friendly technology for sustainable construction.

The International Council for Research and Innovation in Building and Construction (CIB) in partnership with the United Nations Environment Program has commissioned preparation of the Agenda 21 for Sustainable Construction in Developing Countries (A21 SCDC) to promote sustainable construction in those countries. Thus, the agenda in those countries will be different from those of developed countries, which would also emphasize on both economic and social aspects (e.g. Ofori, 1998; Du Plessis, 2001; Ngowi, 2002; Du Plessis, 2007). Sustainable construction defined in the A21 SCDC agenda as:

> *a holistic process aiming to restore and maintain harmony between the natural and built environments, and create settlements that affirm human dignity and encourage economics equity... to imply holistic thinking as*

regards construction and management of the built environment, taking a lifecycle perspective... it implies to new environmentally orientated construction designs, but also new environmentally friendly operation and maintenance procedures (A21 SCDC, 2002, pp. 8-9)

A21 SCDC (2002) suggested that creating a clear understanding of sustainable construction in developing countries requires a flexible approach, which would incorporate knowledge and experience from developed countries (see also Gomes and Silva, 2005; Abu Bakar *et al.* (2011). It has outlined nine key points including sustainable construction in developing countries, namely: (1) internalizing sustainability; (2) making profit while achieving sustainability; (3) mobilization of resources; (4) promoting public awareness; (5) improving quality of construction process and its products; (6) reducing resource use; (7) innovation in building materials and methods; (8) environmental health and safety; and (9) finally procurement procedures (A21 SCDC, 2002). A proper sustainable construction framework for developing countries is thus essential. Ngowi (2002) explained that the construction industry in developing countries is facing serious challenges, such as urbanization problems, housing to accommodate rapid urbanization and adequate infrastructure requiring urgent attention among stakeholders in construction industry. Table 2-2 summarizes suggestions for the roles of construction industry stakeholder in promoting sustainable construction.

Table 2-2: Suggestions for construction industry stake holders' roles to promote sustainable construction.

Literatures	Suggestions
Shen (1993)	Protecting the environment can be obtained by full commitment and involvement of construction management team, including client, designer, contractor, and other construction related specialists.
Spence and Mulligan (1995)	Actions needed by governments worldwide to support the changes within construction industry and to control its environmental impacts.
Hill and Bowen (1997)	Interested and affected parties involved in a particular construction project can use sustainable construction framework and then seek consensus and compromises in reaching decisions to their chosen principles.
Ofori (1998)	Construction industry stakeholders can make progress in delivering sustainable construction practice by concerted effort and following good practice guidelines.
Ngowi (2002)	Construction industry has a major role to play in economic and social development strategy, and involve all stakeholders in construction industries to deal with it.
Reffat (2004)	Development of sustainable construction requires concerted action by all stakeholders involved in the creation of the built environment.
Gomes and Silva (2005)	Governments should lead by examples to championing sustainable building and construction, whilst the private sector also has a potential contribution.
Pearce (2006)	Construction industry stakeholders should focus on individual's needs, happiness, and well-being, not a rhetoric solution from theories, individual perception about SC concepts.
Du Plessis (2007)	Dialogue between different levels of government, broader construction industry, universities and research centers and civil society at regional, national and international levels.
Abu Bakar *et al.* (2011)	Most of developed countries have established their own assessment systems to evaluate building sustainability
Xia *et al.* (2014)	Owners, architects, engineers, and constructors must have an effective means of communicating to promote sustainability objectives for a green design-build projects

Researchers have highlighted significant roles of stakeholders in construction industry in the adoption of sustainable construction. For example, Gomes and Silva (2005) suggested (1) leading by examples by the government through enhancement of their own facilities and public tendering processes and procurement; (2) incorporation of sustainability recommendations into national building codes, laws and regulations; (3) development and implementation of subsidies and tax incentives; (4) public financing of more sustainable building and construction works; and (5) importation facilitation (short-term) and financing local, low-cost development of non-available or prohibitively high-cost products and technologies (medium-term). They believed that private sectors can contribute to sustainability without relying too much on their government. Manoliadis *et al.* (2006) discovered three major sustainable construction indicators contributing to driver of change in Greece, which are (1) energy conservation; (2) resource conservation; and (3) land use regulation and urban planning policies. They suggested a revision to the legislative framework to take into account on issues, such as urban development and integration of environmental studies in building construction and quality, and standardizing eco-labeling to support the overall process that can lead towards sustainability. Shen *et al.* (2006) extended the sustainable construction approach by proposing four strategies, namely: (1) regulation; (2) enabling and supporting mechanism; (3) incentives; and (4) example demonstration project and partnership. It recommended that the implementation should involve clients (owners, developers, investors, users); the authorities; the designers; the material suppliers; and the contractors. It is seen that sustainable construction discussions, which initially focused on the issue of limited natural resources, has shifted to material impacts on the environment, and is currently focusing on non-technical issues. Du Plessis (2007) suggested a paradigm shift in the industry, particularly on increasing research and development in areas of technology readiness. Figure 2-6 shows a proposed strategy to enable sustainable construction.

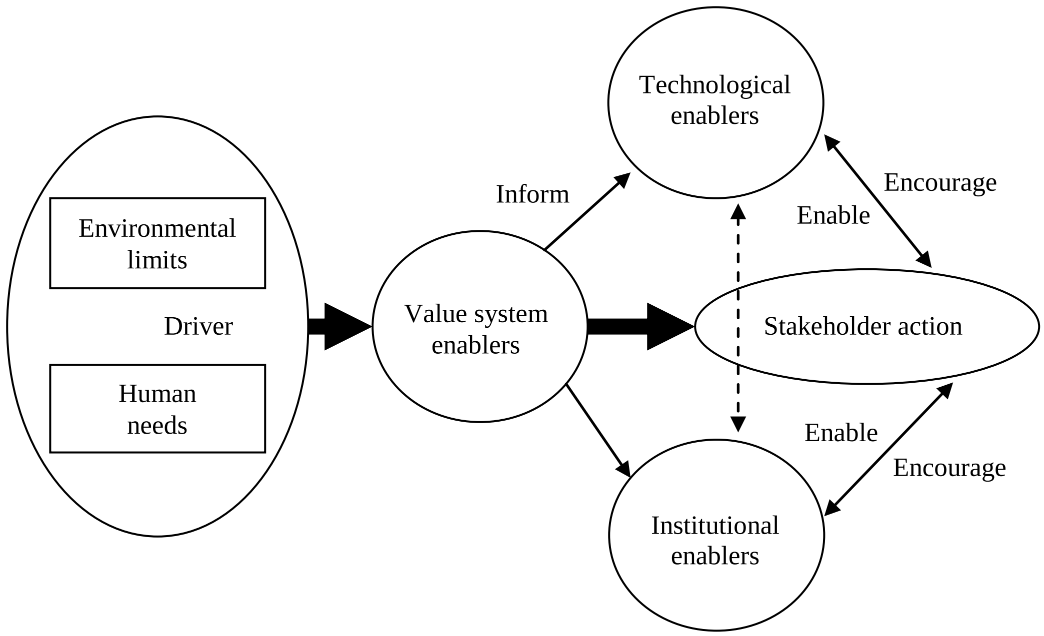

Figure 2-6 A strategy for enabling sustainable construction
(Source: Du Plessis, 2007)

The strategy, as shown in Figure 2-6, consists of value system enablers, technological enablers and institutional enablers. The proposed framework driven by the environmental limits and human needs and requires further action among the stakeholders in the construction industry. In addition, technology adopted from developed countries may not always be suitable and readily adaptable to the socio-economic and environmental conditions in developing countries (WCED, 1987; Ngowi, 2002). Although sustainable construction has become an important topic of research for the last two decades, the drive for implementation is still relatively new and lagging, and the progress of the performance is difficult to measure (Kibert, 2007). Kibert suggested that sustainable construction could be best defined as:

> *How the construction industry together with its product 'built environment', among many sectors of the economy and human activity, can contribute to the sustainability of the earth including its human and non-human inhabitants* (Kibert , 2007, p. 595)

Matar *et al*. (2008) analyzed a framework designed for sustainable construction management that uses Operational Context Space (OCS). The OCS framework consists of four parameters, which are: (1) resource consumption; (2) environmental loadings; (3) delivered facility; and (4) wider-scale issues. The OCS operating structure has two elements, i.e. (1) conceptual evaluation planes; and (2) metrics and measurement. The OCS used for environmental performance evaluation, and ranking system incorporated in the OCS platform. Concurrently, numerous international standards have been proposed by several organizations to define a standard of measurement for evaluating sustainability and the green indexes. For example, (1) ISO 14001 – Environmental Management Systems; (2) European Commission Mandate M350 – Integrated Environmental Performance of Buildings; (3) Green Globes; (4) BREEAM International; (5) LEED - Leadership in Energy and; (6) Green Star; (7) CASBEE – Comprehensive Assessment System for Building Environmental Efficiency; (8) World GBC – World Green Building Council; (9) UNEP – United Nations Environment Programme; (10) SBA – Sustainable Buildings Alliance; (11) SETAC – Society of Environmental Toxicology and Chemistry; (12) Supply chain management; (13) WWF One Planet Future; and (14) GRI – Global Reporting Initiative (Atkinson et al., 2009). Sev (2009) suggested that the sustainable construction must rely on three basic principles, i.e. (1) resource management; (2) life-cycle design; and (3) design for human. Figure 2-7 shows the framework for evaluating the construction industry sustainability.

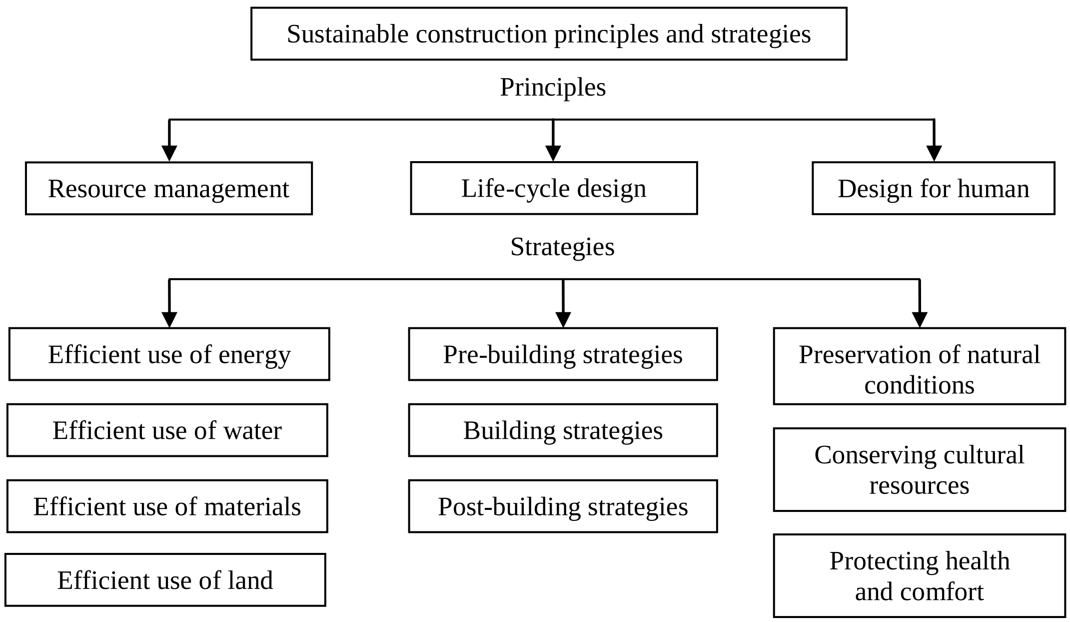

Figure 2-7 Frameworks for evaluating the construction industry sustainability
(Source: Sev, 2009)

2.2.3 Methods for promoting sustainable construction

Current literature has presented various types of methods in promoting sustainable construction. The growing number of proposed techniques has enabled researchers to have a wide range of methods to promote sustainability. Education and training in promoting sustainable construction practice is considered as one of the most important agendas. Manoliadis *et al.* (2006) believed that the education and training are major factors that facilitate sustainable construction, and its training programs should be upgraded to increase its understanding and skills. Gomes and Silva (2005) suggested that sustainability topics are seldom inserted in the undergraduate curricula at university level. About six strategies was proposed to initiate education and knowledge transfer to foster sustainable building and construction, which are (1) introducing concepts in program at all complexity and formality levels, raising awareness of market players, civil society and government spheres, promoting formation of professionals; (2) introducing sustainability assessment of built environment into regular design practice; (3) formatting and implementing training though close synergy between local and international experts; (4) reinforcing a regional research network by establishing centers of excellence and improving international collaboration; (5) creating demonstration projects; (6) creating and enhancing knowledge transfer opportunities by training architects and planners on one side and by adjusting developers and decision-makers towards sustainable building and construction on the other. The Environmental Management System, introduced in 1992 by the British Standard of Institution, is the world's first environmental management standard (BSI, 1994). Hill and Bowen (1997) suggested utilization of the Environmental Assessment and Environmental Management System to tackle the emerging environment issues in the construction industry. Environmental protective measures and Environmental Management System (EMS) commonly used in manufacturing and industrial industries, yet, only a small number of construction firms consider using EMS in their construction projects (Kein *et al.*, 1999; Christini *et al.*, 2004). The construction industry in Hong Kong has been promoting several measures to promote environmental awareness such as: (1) establishing waste management plans; (2) reducing and recycling construction and demolition waste; (3)

providing in-house training on environmental management; and (4) legal measures on environmental protection (Shen and Tam, 2002). However, barriers for implementing the environmental management exist, such as (1) increasing management cost; (2) lack of trained staffs and expertise; (3) lack of sub-contractor cooperation; and (4) lack of client support and lengthy duration for improving environmental performance (Shen and Tam, 2002). Yao *et al.* (2006) proposed a framework to improve project environmental performance such as (1) environmental policy; (2) planning; (3) implementation and operation; and (4) checking and corrective actions. At the same time, Ou *et al.* (2006) have developed indicators for measuring project environmental performance to analyze environmental performance in construction activities using a comprehensive computer-based scoring method.

The term "green building" is described as 'healthy facilities designed and built in a resource-efficient manner, using ecologically based principles' (Kibert, 2008). Stum (2000) defined green building as 'designed, constructed and used, in a way that minimizes negative environmental consequences from both economic and life cycle perspective, thus contributing to 'sustainable development'. A green building is characterized by features, such as minimal consumption of energy, materials, and water; provides healthy living and working environments, and greatly improve the quality of built environment (Kibert, 2007). One of the major challenges on green building is determining whether a building is green or not. The challenge has attracted numerous studies to develop suitable assessment methods. Examples of assessment methods in defining green building are CASBEE in Japan, LEED® in the United States of

America, LEED™ Canada in Canada, NABERS in Australia, and BREEAM in the United Kingdom (Kibert, 2007; Kibert, 2008; Halliday, 2008; Hussin *et al.*, 2013). Debates are still on-going on the economic reasoning of green building, since in general, its construction costs would be significantly higher than normal. Green building developers must ensure that the material can achieve life-cycle cost saving, higher quality and durability, and able to offer technical support and guarantee for their products. In addition, the materials used in green building should fulfill excellent energy saving criteria, non toxic and is environmentally-friendly as well.

The green building concept is less popular in developing countries because of high cost, lack of support from the government, and political issues. Thus, further research and development should be conducted for the concept to be applicable in developing countries. Green design plays an important role in promoting sustainable construction. Al-Momani (2000) remarked that design changes could result in significant consequences such as (1) extra energy consumption; (2) overruns in cost; and (3) longer construction time. Furthermore, a design change particularly in the construction stage could cause major waste generation because of unnecessary extra work during construction period and will contribute towards time delay (Ekanayake and Ofori, 2000). However, it is interesting to note that most architects in United Kingdom were reported to be reluctant in adopting waste design minimization strategies in their design practices (Osmani *et al.*, 2008). A designer is given an important role in pre-construction stage and is therefore able to proactively apply green design in early stage of construction. Osmani described the origins and causes of construction waste under design are due to (1) design changes; (2) design and detailing complexity; (3) design and construction detail errors; (4) unclear or unsuitable specifications; and (5) poor coordination and communication, such as late information, last-minute client requirements, slow drawing revision and distribution.

To improve energy efficiency, designers are encouraged to select appropriate materials and technologies in their designs that promote sustainable building (Spence and Mulligan, 1995). In green procurement process, the designers can consider using less material, low-energy materials, select recycled materials and design for recycling with long lifespan materials (Spence and Mulligan, 1995; Kibert, 2007; Kibert, 2008: Bratta *et al.*, 2013). Ekanayake and Ofori (2000) recommended an appropriate green procurement system which a client can use to mitigate construction wastage problem. Sterner (2002) promoted green procurement practice in Sweden, and was supported by positive survey results from both public and private building clients. Ngowi (1997) suggested the use of 'traditional' earth construction material because selected substance and resources from the earth can strengthen and increase the durability of the construction materials. A21 SCDC (2002) stated that sustainability criteria should be included into procurement policies and procedures of all clients (including government) to create a market for sustainable construction products. Walker and Brammer (2009) have found that costs were the leading barrier to sustainable procurement, while the leading facilitator is the presence of top management support. The subsequent analysis of both quantitative and qualitative surveys has shown that there is a significant variation across public sector's agencies in the nature of sustainable procurement practice. Geng and Doberstein (2008) suggested that in developing countries, green procurement by the government can have significant positive impacts.

Technology is one of the major issues in sustainable construction that can promote 'green' efficiency. One such example of the application of technology in construction was given by Nelms (2007) who proposed a green roof technology framework to improve service life and protection of roof membrane, reduction in space-conditioning requirement of building, improves storm water quality, and improves building marketability. He believed that the construction industry is interested in green roof technology because of potential and benefit across economics, environmental, and social aspects. There is a huge potential in technology, such as reduction in capital and life cycle costs that can be applied to all types of buildings and it has been proven to be a practical system. In addition, Doshi (2005) suggested that green roofs can also improve storm water management, combining sewer overflow control, air quality and reduction of energy consumption and its carbon dioxide reduction. He believed that the performance of green roof technology could noticeably increase, if the technology can increase its (1) depth and nature of growing and drainage medium; (2) percentage of roof greened; and (3) plant coverage on greened area. These aspects can also increase the benefits to the environment as well. However, the building construction cost would increase due to increasing building structural load ability to carry the weight of the green roof.

Lean construction principles can be utilized to eliminate material wastage and adds value for customers (Huovila and Koskela, 1998). To date, the research in lean construction has explored various methods of engineered-to-order, to evaluate which techniques is suitable to shorten lead times and achieve other performance improvements while minimizing waste (Ballard *et al.*, 2003). Lapinski *et al.* (2006) recommend adopting similar methods used in car industry and suggested that the construction industry can emulate the concepts used by Toyota production system in producing good quality vehicles. In construction industry, lean construction methodologies are commonly applied to prefabricated structural walls, beams, and columns and can be extended to other non-prefabricated components, such as plumbing, structural steel, curtain wall, and elevators.

Prefabrication is proposed to reduce construction waste of on-site activities as compared to conventional in-situ construction (Tam *et al.*, 2007b; Jaillon *et al.*, 2008; Silva and Vithana, 2008). Prefabrication offers a higher profit margin for contractors. Jaillon and Poon (2008) stated that prefabrication could contribute to sustainable construction aspect, in respect to economic, environmental and social. However, it is interesting to note that in some countries, such as Hong Kong, waste reduction is not a primary concern as compared to cost and time (Jaillon *et al.*, 2008). It could due to their construction industry being heavily market-oriented which values cost and time as more crucial than environmental benefits.

Waste management is an important measure in promoting sustainable construction. A large portion of purchased materials may end up as waste. Bossink and Brouwers (1996), in their study of construction industry in Netherlands, have found that around 9% of the total purchased construction materials end up as waste. Kein *et al.* (1999) have found in their study for Singapore market that reducing resource or energy wastage in a construction project is not a priority issue at project planning stage among contractors. Kulatunga *et al.* (2006), in evaluating construction industry in Sri Lanka, have pointed out that the amount of wastage at construction sites are much higher than the allowance given by the estimator in pre-construction stage for waste compensation. Tam *et al.* (2007a) discovered that a labor only sub-contracting produces the highest wastage as compared to direct labor and labor and material only. In Hong Kong construction industry using labor only sub-contracting arrangement, the highest level of wastage was for the formwork used, which accounts for an estimated 20% of the total waste of major materials.

However, the wastage can be reduced by 5% when a labor and material approach is used. Teo and Loosemore (2001) suggested evaluating the impact of procurement and contractual systems on generation of construction waste. They remarked that while cost savings could be the driving force to adopt waste reduction behavior, however, the current perception of the potential saving and rewards are considered low. Begum *et al.* (2007) claimed that waste minimization should be included into the construction development, and incorporated into early design and tendering stage. Since it is believed that sub-contractors can be a major contributor to waste problems, solutions such as trainings for on-site staffs on waste reduction has been proposed. Local authorities are positioned as significant drivers for the implementation of regulations on waste regulations. Tam (2008) explained that in implementing waste-management-plan, cost is considered as a major project factor while the environment is considered less important. He claimed that prefabrication of building components is an effective solution to reduce waste, and increases waste management effectiveness. Sustainability should perceive beyond technical approach and focuses on local needs. Researchers should be relatively open to discuss potential solutions for sustainability in other areas, such as the technical aspect of sustainability that is related to academic and industry as a whole. The integration of sustainability and technical aspects requires mutual understanding among construction industry stakeholders. The government of Malaysia, having committed itself to promoting sustainable construction in practice, needs to demonstrate sustainability, to compete with other countries engaged in the global sustainability agenda.

2.3 Sustainable Construction in Developing Countries

2.3.1 The definition of developing country

Shen (1993) remarked that developing countries could have different sustainability demand. For example， basic living facilities are more urgent than environmental needs. Shen believed that there isn’t any difference in the need for protecting the environment between developed and developing countries. The only difference is the standard of environmental procedures. A developed country is willing to spend more to support high quality of living and better care for the environment than a developing country. Thus, it is not surprising that a developed country would have higher level of environmental awareness. It is well known that developing countries would focus more on the need of their economic and social issues. Developing countries are characterized as having similar characteristics such as comparable climate, rich in cultural diversity, and equivalent economic conditions. A developing country is defined as a country with a per capita Gross National Product (GNP) of less than US$7,000 (A21 SCDC, 2002). GNP is defined as 'the value of all goods and services produced in the country in one year by its citizens, plus income earned by its citizens abroad, and minus income earned by foreigners in the country'.

2.3.2 Newly industrialized countries

The IMF World Economic Outlook Database (2009) has identified Malaysia as a newly industrialized country alongside South Africa, Mexico, Brazil, China, India, Philippines, Thailand, and Turkey. These newly industrialized countries have not reached developed country's status yet, but in macroeconomics sense, are outpacing their developing country counterparts. The construction industry constitutes an important element of the Malaysian economy and accounts for 2.5% of the GDP in 2007. Although the contribution is not significant in the GDP, the construction industry has direct and indirect effect on the overall economy such as in manufacturing, professional services, financial services, and education (CIMP, 2007). In addition, the industry in Malaysia provides around 800,000 employment opportunities, although most of the jobs are taken up by foreign labors. The Malaysian GDP experiences an average growth of 5.46% from 2000 to 2007, and the construction industry has been consistently contributing to its GDP on an average of 3% within that period.

2.3.3 Sustainable construction challenges between developed and developing countries

In general, for a developing country, social issues are more significant as compared to environmental and economic problems. A21 SCDC (2002) suggested that main issues of development in developing countries are (1) urbanization and rural development; (2) sustainable housing; (3) education; (4) gender equity; (5) financing and procurement; and (6) governance and management: institutional sustainability. Developing countries need affordable housing, yet at the same time reduce wastage and increase employment opportunities (A21 SCDC, 2002). A rapid development in Malaysia from early 1970s has made the country one of the most prominent among developing and newly industrialized countries. Du Plessis (2001) argued that present understanding of social and economics equity is based on the conditions in western countries and may not directly applicable to developing nations. To tackle environmental degradation, the responsibility should be shared between both developed and developing countries (Langkawi Declaration on the Environment, 1989). Sustainable construction in developing countries requires an approach that will also address economic and social context (Du Plessis, 2007). Nevertheless, creating an understanding and a proper sustainable construction implementation in developing countries requires the vast experience of developed countries (Ofori, 1998; A21 SCDC, 2002). Du Plessis (2001) further points out the definitions for sustainable construction derived from situations of western countries, emphasizing on resource efficiency. Ofori (1998) argued that the government, being the most important and largest construction client, should set an example in promoting sustainable construction. Many developing countries currently lack in managerial experience, financial resources, legal and administrative systems for promotional activities. Thus, it is important for these governments to find a solution to formulate and enforce regulations, and giving incentives to encourage appropriate sustainable behaviors (Ofori, 1998; Du Plessis, 2007).

In a recent study, Du Plessis (2007) proposed a strategy to enable sustainable construction by having value system enablers, technological enablers and institutional enablers. The structure is driven by environmental limits and human needs, as well as executive actions by stakeholders. However, technologies from industrialized countries are not always suitable or readily adaptable to the socio-economic and environmental conditions of developing countries (WCED, 1987; Ngowi, 2002). The framework proposed by Du Plessis (2007), although containing some points addressing economic and social issues, is still insufficient for developing countries since it focused more on technological matters and research and development. Developing countries are facing challenges in urbanization and rural development, which transpire people in rural areas migrate to seek employment in the city (A21 SCDC, 2002). In general, there is a wide gap in the value of land between those in the city and rural areas. In most developing countries, an affordable housing scheme is crucial to meet the demand of the large population, and in most cases there is a shortage of affordable housing in poor countries.

There has been an increasing public awareness in sustainability issues in developing countries. However, there is a lack in promotional activities for sustainable construction, whether in the industry or the education sectors. Current lectures delivered in institutions of higher learning lack of the components of sustainability in their syllabuses. In developing countries, the government should be the ‘mastermind’ for sustainable construction projects. Furthermore, the lack of financial support from the government is a major problem for poor countries. Moreover, these countries need good governance to support sustainable construction agenda. Although they are now facing many challenges to implement the sustainability agenda, it is hoped that this can be achieved with the formation of a reliable framework and efficient regulatory systems.

Cost, time and quality are important factors to evaluate the performance of construction projects (Barnes, 1988; Shen, 1993). Dalgliesh *et al.* (1997) highlighted relevant sustainable construction principles, which incorporate: minimization of resources used; maximization of reusing of resources; maximization of the use of renewable and recycled resources; use of non-toxic materials; protection of the nature; achievement of quality criteria; and promotion of labor-intensive methods, skills training and capacity enhancement of local people. Table 2-3 lists the sustainable construction challenges faced by both developed and developing countries. This list of sustainable construction challenges can be equally divided into typical sustainable construction pillars of environmental, economic and social aspects.

2.3.4 Construction industry in Malaysia and sustainability agenda

Vision 2020 of Malaysia charts the pathway for the nation to be a developed country with its identity by the year 2020 (Mohamad, 1991; Zainul Abidin, 2010). For the Ninth Malaysia Plan (9MP), the Malaysian government has allocated RM 200 billion for development activities (The Ninth Malaysia Plan, 2006). The concept of sustainability is well-described in the report of 9MP as:

> The fourth thrust of the National Mission is to improve the standard and sustainability of our quality of life. The Government will continue to provide basic needs such as water, energy, housing, transportation and other amenities but more emphasis must now be placed on addressing issues related to maintenance, upgrading and efficient usage of resources.

Table 2-3 Sustainable construction challenges between developed and developing countries

Developed countries			Developing countries		
Environmental	Economic	Social	Environmental	Economic	Social
Suggested high priority issues					
1) Reducing ecological footprints	1) Employment creation	1) Higher quality of living	1) Reducing construction material wastage	1) Employment creation	1) Affordable housing
2) Flora and fauna protection	2) Durability & maintenance	2) Health and safety	2) Reducing solid waste	2) Profitable in line by promoting sustainable construction	2) Combat poverty
3) Reducing deforestation impact	3) An uncertain economic environment		3) Reducing air pollution	3) Cost effective	3) Shortage of local labour
4) Reducing energy use			4) Reducing water pollution	4) An uncertain economic environment	4) Political stability
Suggested medium priority issues					
1) Material recycling	1) Profitable in line of promoting SC	1) Gender discrimination	1) Reducing energy use	1) Control rapid urbanization	1) Fighting corruptions
2) Reducing air pollution	2) Cost effective	2) Political stability	2) Material recycling	2) Adoption of incentive programs	2) Social inequity
3) Reducing water pollution			3) Reducing noise pollution	3) Durability & maintenance	3) Reduce unfair labour practice
4) Reducing noise pollution				4) Cheaper technology transfer	4) Health and safety
Suggested low priority issues					
1) Reducing construction material wastage			1) Flora and fauna protection	1) Inadequate Infrastructure	1) Education and training
			2) Reducing deforestation impact		2) Gender discrimination
			3) Reducing ecological footprints		3) Higher quality of living
Distribution of problematic issues (No.) (%)					
Developed countries			Developing countries		
Environmental	Economic	Social	Environmental	Economic	Social
(9) 50 %	(5) 28 %	(4) 22 %	(10) 33 %	(9) 30 %	(11) 37 %

Although the construction industry in Malaysia accounts for only 2.5% of the gross domestic product in the year 2007, the industry is important in the creation of national wealth and has multiplier effects to the economy (Construction Industry Master Plan, 2007). The 9MP outlines key areas such as (1) inefficient and ineffective methods and practices in contractor's registration and administration procedures; (2) procurement methods and practices; (3) contracting approaches; (4) construction methods; (5) planning submission; and (6) and building plan approval procedures (Construction Industry Master Plan, 2007). The primary thrust of the 9MP is to improve the standard, increase the quality of life, tackle maintenance issues, and efficient usage of resources (The Ninth Malaysian Plan, 2006), which are in line with the sustainability concept. Although Malaysia has had an impressive economic and human development progress, there is a growing concern on the lack of environmental awareness and sustainability of the nation (Hezri and Hasan, 2006). In recent years, various governmental and non-governmental agencies have actively begun to promote sustainability (Zainul Abidin, 2009). Although sustainability progress and adoption is still in its infancy and some of sustainability concepts have been introduced, such as the green building index Malaysia to assess green building in the nation (Zainul Abidin, 2010).

The government of Malaysia, having committed itself in promoting sustainable construction practice, but it needs to demonstrate sustainability, in order to compete with other countries engaged in global sustainability agenda. Further research is recommended for assessing linkages between sustainable construction and building procurement methods. It is needed to evaluate the construction industry stakeholders' perspective by exploring linkages between sustainable construction and building procurement methods.

2.4 Building Procurement Methods

Past studies have described building procurement methods' characteristics which included their advantages and disadvantages (Anumba and Evbuomwan, 1997; Cheung et al., 2001); benefits (Chan *et al.*, 2002; Hashim *et al.*, 2006); selections (Love *et al.*, 1998; Skitmore and Marsden, 1998; Hashim, 1999; Alhazmi and McCaffer, 2000; Cheung *et al.*, 2001; Chan *et al.*, 2001; Hashim *et al.*, 2006); and success factors (Zhang, 2005; Chan *et al.*, 2002). Suitable building procurement method should be selected carefully since each method has its own peculiarity that will affect the cost, time, and quality of the project (Love *et al.*, 1998; Rwelamila and Meyer, 1998; Skitmore and Marsden, 1998). Within an organizational project structure, 'procurement system' describes collective action required to acquire design, management, and installation inputs (Ngowi, 1998). Love *et al.* (1998) stated that the term 'contractual arrangement' and 'procurement systems' are usually used synonymously. In their studies, the definition used for procurement system is 'an organizational system that assigns specific responsibilities and authorities to people and organizations and defines the relationships of the various elements in construction project'. The procurement systems can be categorized as (1) traditional (design-tender-construct) methods; (2) design and construct methods; and (3) management methods. Some researchers have used the term 'procurement method' to describe the procurement system. Different project procurement systems can be categorized as (1) separated and cooperative system; (2) integrated; and (3) management oriented (Masterman, 1992). Figure 2-8 shows the category of building procurement system, describing different categories and sub-classifications in construction for a project procurement system. The figure discusses different categories and sub-classifications in construction for a project procurement system.

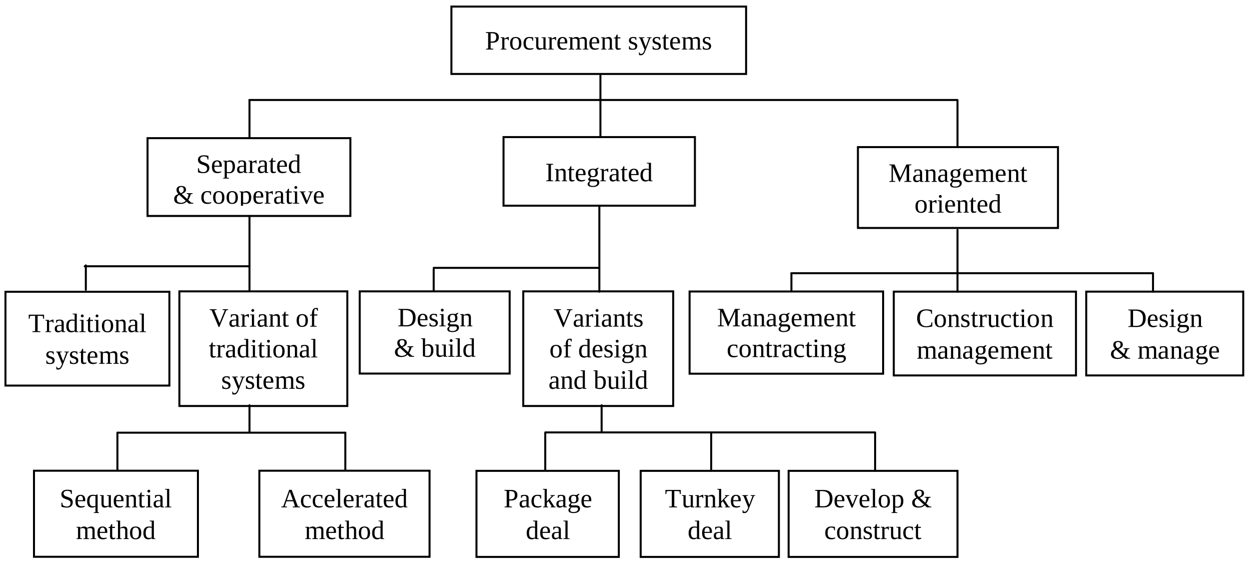

Figure 2-8 Category of building procurement system
(Source: Masterman, 1992)

Hashim (1999) described that in a traditional method, a client appoints design and cost consultants who produces a set of detailed drawings and a bill of quantities, detailed and quantified list of all categories of materials and labor in a job function. The client will enter into a separate contract with a main contractor who will carry out the construction work. The design and build method means that main contractor accepts responsibility for designing and building to meet the client's requirements. The management contracting method is a method whereby a specialist in planning and controlling construction work is appointed early in the project to ensure build ability or ease of construction, and then manages the actual construction done by several other contracting firms. Then the design and cost consultants will be appointed as in the traditional method. Love *et al.* (1998) suggested a simple set of criteria identified as adequate for procurement selection, and reasonable consensus on the appropriate weightings. They have listed nine indicators, namely: (1) speed; (2) certainty; (3) flexibility; (4) price completion; (5) risk allocation/avoidance; (6) responsibility; (7) quality; (8) arbitration and disputes; and (9) complexity.

2.4.1 Traditional procurement method

The traditional procurement is often adopted in Malaysia (Hashim, 1999; Abdul Rashid, 2002; Seng and Yusof, 2006). The main advantage of the method is that it allows project cost to be fixed, and the designer has full control on project design. However, the main disadvantage is lengthy period for project completion and miscommunication tends to occur among parties who involve in the design process. In general, in traditional method, the client, consultant and contractor would set up a project team. Rowlinson and McDermott (1999) stated that although traditional approach based on full drawings and bills of quantities would give the client firm, fixed price for construction, in reality this is not often realized. Figure 2-9 shows traditional procurement arrangement, outlining the employment of a consultant and the main contractor. After the contract is secured, the main contractor will appoint their sub-contractors.

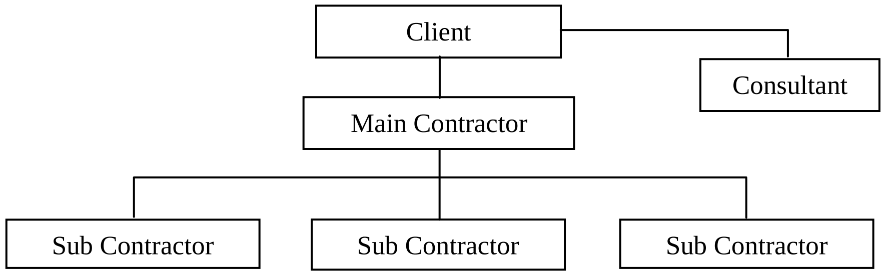

Figure 2-9 Traditional procurement *(Source: Hashim, 1999)*

Morledge *et al.* (2006) have discussed on the advantages and disadvantages of a traditional contract strategy. The advantages are: (1) competitive fairness, since all tendering contractors are bidden on the same basis; (2) design-led, with the client able to have direct influence, thus facilitating high level of functionality and quality in the design; and (3) reasonable price certainty at contract award based upon market forces (subjected to design changes or client-led changes which will have other cost implications). However, the disadvantages of the strategy include: (1) possibility of attempting to speed up the process by producing tender documents from an incomplete design, but this will usually result in less cost and time certainty and can be the cause of expensive disputes; (2) the overall project duration may be longer than other strategies as the strategy is sequential, where the construction cannot commence prior to completion of design; and (3) there is no input into the design or planning of the project by the contractor who is yet to be appointed at design stage.

2.4.2 Design and build procurement method

The design and build strategy is defined as 'the contractor accepts the whole responsibility for both design and construction of the building to meet the requirements or expectation of the client’ (CIOB, 1998). This approach can be divided into six techniques: (1) traditional design and build; (2) package deal (including turnkey contracts); (3) design and manage; (4) design, manage and construct; (5) innovation design and build; and (6) developed and construct. Figure 2-10 shows the general design and build characteristics.

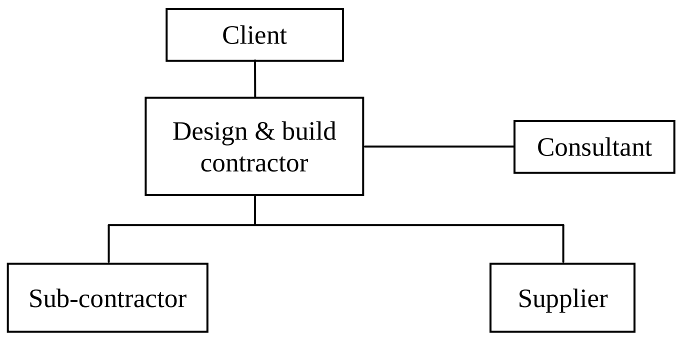

Figure 2-10 Design and build procurement *(Source: Hashim, 1999)*

One of the well-known strategies is Turnkey Method. Under this method, the payment is made upon completion and hand over of the building (Hashim, 1999). In contrast, for design and build method, payment would be made as work progresses – either based on fixed periodic valuations or by reference to the milestone achieved. The construction of 13 nucleus hospitals in peninsular Malaysia was procured by the turnkey method, which is quite similar to traditional method (Hashim *et al*., 2006).

2.4.3 Management contracting method

Clients can procure buildings using management contracting (Franks, 1998). The contracting is similar to traditional contracting, but with involvement of a manager to oversee the project. In Malaysia, management contracting methods are increasing in popularity on some construction projects (Mokhtar, 1993). In general, the contracting sets the client, consultant, and management contractor into one team with specific project targets. Figure 2-11 shows the management contracting procurement arrangement.

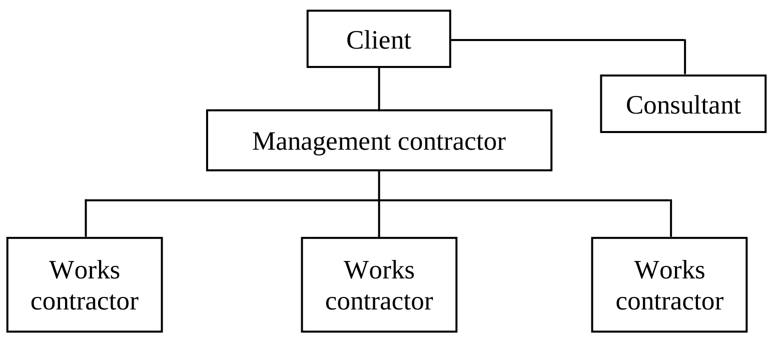

Figure 2-11 Management contracting procurement *(Source: Hashim, 1999)*

The management contracting is characterized by the employment of a consultant and a management contractor who distribute the work among work contractors. It is interesting to note that the contracting method has not been used in any governmental projects in Malaysia (Hashim et al., 2006). Rowlinson and McDermott (1999) have outlined the advantages and disadvantages of three different organizational strategies of (1) the traditional approach; (2) design and build approach; and (3) the management systems approach. The advantage of the traditional procurement method is the competitive tendering used. However, its disadvantages are decision processes are slow and convoluted. The advantage of design and build is a single-point responsibility. However, its disadvantages are the lack of independent advice. The advantage of the management systems is that it provides an early start to construction work. However, the disadvantages being no firm prices at the start of the construction project.

2.4.4 Other procurement methods

There are other procurement methods in construction industry such as: (1) partnering; (2) build-operate-transfer; (3) public-private partnership. These procurement methods are not considered in this study since they are rarely used in Malaysia and are unsuitable for the case studies of this research work. However, these methods are described here to complement the overall understanding of procurement methods that can be considered.

2.4.4.1 Partnering

Chan *et al.* (2003) described that partnering is a simple process on establishing a good working relationship between project parties. In a partnership arrangement, both clients and contractors are both responsible for procurement and development. The benefits of partnering projects are: (1) improved relationship amongst project participants; (2) improved communication amongst project participants; (3) more responsive to short-term emergency, changing of project or business needs; (4) reduction in dispute; and (5) better productivity.

2.4.4.2 Build-Operate-Transfer

The build-operate-transfer is an attractive procurement method in the construction industry involving huge capital flow, usually for development of mega construction projects. A construction firm that uses this method is usually part of a consortium. A similar strategy is called build-own-operate method. This type of procurement is less useful for small-scale projects.

2.4.4.3 Public-private partnership

Zhang (2005) suggested that different type of public-private partnership has been practiced in infrastructure development in both developed and developing countries with diverse results. The partnership has been used in numerous large construction projects in the world. It is well-delivered in developed countries and is gaining popularity in developing countries as well (A21 SCDC, 2002).

2.4.5 Selecting suitable building procurement methods

Common procurement systems in Malaysia are traditional, design and build; and management contracting (Hashim, 1999; Ismail and Samad, 1999). As in 2010, the data obtained from the Construction Industry Development Board (CIDB) of Malaysia shows that breakdown of building procurement methods are classified into traditional (96.54%), design and build (2.32%), turnkey (1.03%), built, operate and transfer (0.11%) (CIDB, 2010). Love *et al.* (1998) measured mean utility factors of criteria for procurement methods and listed down a set of criteria, including nine indicators to be analyzed, namely (1) speed; (2) certainty; (3) flexibility; (4) quality; (5) complexity; (6) risk allocation/avoidance; (7) responsibility; (8) arbitration/disputes; and (9) price competition. Variation in building procurement methods is a positive development, giving clients more choices to meet their needs. Since Malaysia belongs to the Commonwealth nations, the country's choice of procurement methods is largely influenced by the British system of tendering and contracting procedures (Hashim, 1999).

Procurement is defined as 'collective action required for acquiring design, management, and installation inputs' (Ngowi, 1998). Thus the procurement system, as defined by Love *et al.* (1998) as 'an organizational system that assigns specific responsibilities and authorities to people and organizations, and defines the relationships of various elements in the construction project'. They suggested that a similar client may have varying needs in their procurement objectives, depending on the nature of individual project. Hashim *et al.* (2006) suggested that the client's choice of procurement could be affected by various government policies, and would follow government's procedures (via Treasury's instruction) in choosing a particular procurement route for government projects. For example, in 1998, the Education Ministry of Malaysia instructed that all school projects should be procured by the design and build method, because during that time Malaysia needed more schools with creative and innovative designs (Hashim *et al.*, 2006). However, Hashim *et al.* (2006) stated that this directive was terminated in 2006 because numerous schools were constructed haphazardly using inferior quality materials and poor workmanship. Morledge et al. (2006) suggested some factors in selecting a procurement strategy, namely (1) factors outside the control of the project team; (2) client resources; (3) project characteristics; (4) ability to make changes; (5) risk management; (6) cost issues; (7) timing; and (8) quality and performance. They suggested that the decision makers should prioritize significant factors during the selection of these strategies. An appropriate strategy will ensure that the client will prioritize certain factors. Hashim (1999) listed sixteen factors for the improvement of construction procurement as the following: (1) confidence in principal contractor; (2) confidence in design; (3) buildings fits its purpose; (4) high-workmanship quality; (5) high aesthetic quality; (6) low operational cost; (7) low-maintenance cost; (8) value for money; (9) lowest possible cost; (10) minimum construction time; (11) minimum overall time of building; (12) reliable construction cost; (13) reliable construction time; (14) reliable design time; (15) building regulation approval; and (16) detailed planning permission. These factors were proposed to accelerate the procurement method agenda. Further research is recommended for assessing linkages between sustainable construction and building procurement methods. So far, only a limited number of studies have assessed the contribution of building procurement methods towards sustainable construction. This study attempts to fill the gap identified by addressing various sustainable construction methods available in literature.

2.5 Research Gaps

2.5.1 Identification of the research gap

There are many studies in sustainable construction areas, such as in the development of principles and framework, sustainable construction in developing countries, assessment and tools, techniques and strategies (Kibert, 2007). However, from the literature review that has been conducted, there is an enormous research gap between sustainable construction and building procurement methods. Some studies suggested that the sustainability could be linked with proper building procurement methods (Ngowi, 1998; Rwelamila *et al.*, 2000; Carter and Fortune, 2007). Many studies have attempted to establish a connection between building procurement methods and the sustainability. Nevertheless, some failed to provide sufficient evidence to support their studies. In theory, sustainable construction is often focused on three aspects of the environmental, economic and social agenda; with less focus on technical aspect (see also Hill and Bowen, 1997). This study proposed the incorporation of technical capability in building procurement methods to contribute to sustainable construction. Furthermore, some building procurement method indicators, such as time, cost, quality, and other relevant factors, could be connected with sustainable construction.

Many studies on sustainable building procurement have been conducted, such as those by Ngowi (1998); Pollington (1999); Rwelamila *et al*. (2000); Sterner (2002); Carter (2005); Carter and Fortune (2007 and 2008). Hashim (1999) believed that procurement methods should address the challenges on economic, social and environmental sustainability, but also needs to fulfill individual project objectives on cost, time and quality. Ogunlana (1999) believed that the choice of building procurement methods is influenced by construction projects outcome and thus sustainability could also be addressed. Walker and Brammer (2009) suggested that the cost is a leading barrier to sustainable procurement. The construction industry in Malaysia has been facing issues related to poor delivery of building projects using traditional procurement system and design and build procurement method.

Thus, alternative methods have been proposed, such as build-operate-transfer, private finance initiative, management contracting, construction management, package deal turnkey, and public-private partnerships (Hashim, 1999). However, these alternatives may not be suitable if inappropriately chosen. An example on the failure of using inappropriate procurement method is a private national sewerage project using build-operate-transfer scheme (Abdul-Aziz, 2001). Halliday (2008) suggested building procurement methods have little relationship with sustainable construction practice; and yet there isn't any solid evidence indicating that sustainable construction implementation has hindered any forms of building procurement methods. Over the last decade, there has been an increase in awareness among construction stakeholders to adopt 'sustainable' construction practice. The general adoption of the sustainability concept is yet to be realized, and only a handful of construction professionals can fully appreciate the differences in various building procurement methods (Ngowi, 1998; Rwelamila *et al.*, 2000). In general, there is still a lack in capability in making good judgment on which building procurement method is more suitable for a specific construction project (Ling and Kerh, 2004).

A21 SCDC (2002) suggested that most governments in developing countries favor large turnkey projects and 'build, operate, and transfer' projects. These types of building procurement methods are typically designed for large scale projects. Moreover, most large companies are able to participate effectively in projects of this size, especially a foreign company having financial and expert resources, is capable of winning the tender for such projects. These situations will create unstable economic opportunities for local construction players in both short and long term. The industry in Malaysia is typically divided into traditional (71%), followed by design and build (21%), and management contracting (8%), (Ismail and Samad, 1999). Hashim (1999) and Abdul Rashid (2002) have also considered those procurement systems in a research study in Malaysia. It is well appreciated that cost, time and quality are significant in evaluating procurement system performance on the construction project as reviewed by e.g. Love *et al.*, 1998; Rwelamila and Meyer, 1998; Alhazmi and McCaffer, 2000; Chan *et al.*, 2001.

Rwelamila and Meyer (1998) had recommended the selection of appropriate procurement system for different projects and suggested that each procurement system must be tailored to meet different project needs. Ngowi (1998) conducted a survey and discovered that traditional procurement and "design and build" method do not meet the expectation of users in Botswana construction industry. Lam *et al.* (2007) found that the design and build has tight schedule, frequent changes by various end-users, stress from clients, frequent changes by various clients, and conflict of interest between design members and contractor. Moreover, the clients' requirements and their project scope are hard to understand and often ill-defined. Rwelamila *et al*. (2000) believed that traditional procurement systems are unable to deal with the sustainability parameters, and thus suggested a paradigm shift in its choice of construction procurement system, reducing the reliance on using the traditional method as the 'default system' choice. Rwelamila and Meyer (1998) discovered the bill of quantities in contract documents in the Botswana public sector were prepared from incomplete design, as a result of time constraints and other uncertainties. Ngowi (2000) has suggested the adoption of concurrent engineering principles, which has been successful deployed in manufacturing industry, to improve the delivery of the procurement system. Moreover, integrated contracts can lead to more sustainable infrastructure development (Lenferink *et al.*, 2013).

Construction industry stakeholders may also consider a 'hybrid' building procurement method which combines 'basic' procurement process and with other types of procurements, or incorporated with concurrent engineering principles, and other relevant techniques. There are comprehensive studies about the building procurement methods and sustainability by Carter, 2005; Carter and Fortune, 2007 and 2008. Carter (2005) has suggested two different aspects of sustainability in procurement systems. First, the process involved in procuring the product and secondly, the product itself. Both aspects are equally important to achieve sustainability. They discovered partnering approach is an appropriate building procurement method to implement sustainable development in the United Kingdom’s social housing as compared to “traditional” and “design and build”.

Carter and Fortune (2007) also suggested further studies could focus in establishing a linkage between building procurement method and sustainability. They suggested a procurement system, such as partnering to provide a useful insight of perceptions for sustainability and it can be best delivered in social-owned housing projects. Normally in construction industry, contractor and developer are less inclined to promote sustainability due to safeguarding their profit margins. The contractor would be reluctant to implement sustainability approach without any extra fund allocation or profit. Eventually, the extra cost will be passed on to end users. Appropriate methodologies can promote sustainable construction without compromising the industry stakeholders’ interest such as profit, finishing the project on time, and delivered quality works.

For this reason, sustainability should be included early in procurement system decision process. Carter and Fortune (2008) demonstrated a consensual sustainability model. The model is a decision support tool for ‘sustainable’ building procurement method. In a study by Carter (2005), one of the major ideas is to integrate sustainable development and building procurement methods for social housing project in the United Kingdom. The model has limitations because its sustainability aspect has focused only on social factor. It proposed reflecting a developed country's perspective, in this case for the United Kingdom, and may not be suitable for a developing country. Furthermore, the model did not address which type of building procurement methods can deliver sustainability, but instead it proposed a new sustainable building procurement methods model. Carter (2005) developed a *consensual sustainable model (ConSus)*. The ConSus shows various types of sustainability indicators and a wide perception about sustainability. Hashim (1999) showed a comparison between traditional, design and build, and management contracting. The traditional model is suitable for use in a medium sized project with low to medium complexity. The design and build are suitable for use in medium sized projects with low to medium complexity whereas the management contracting is suitable in large and expensive projects, and with high complexity. He elaborated the characteristics of traditional methods (single-lump sum; provisional quantities; cost reimbursement), design and build (contractor design and build; turnkey and package deals), management contracting (construction management; management contracting; design and manage) (Love *et al*., 1998).

A typical study on a building procurement method will include discussion on traditional (sequential; accelerated), competitive (design and build; turnkey), management contracting (management contracting; construction management) (Cheung *et al*., 2001). Hashim (1999) listed eight-performance indicators for building procurement methods indicators. They are: (1) pre-construction time; (2) construction time; (3) total project duration; (4) speed of construction; (5) cost of construction; (6) time overrun; (7) cost overrun; (8) subjective measures of client satisfaction on time, cost and quality. Chan *et al*. (2002) stated that to evaluate the success of a project, it must be divided into objective and subjective measurements. Chan divided a framework of assessment for the project success into three categories with time-horizon which are: (i) pre-construction phase – the 'past'; (ii) construction phase – the 'present'; (iii) post-construction phase – the 'future'. The objective measurements are hard, and tangible, whereas the subjective measurement described as soft, intangible, and less quantifiable measures. Chua *et al.* (2002) stated that the project success will be related to project objective (budget; schedule; and quality). Walker (1996) described the construction as a whole project life-cycle, beginning at initial inception of the project towards final realization and use.

Partnering is an attractive concept in developed countries, such as in the United Kingdom. However, the concept is relatively new for newly industrialized countries such as Malaysia, and would mostly be applicable for large project costing more than RM 40 million (Adnan *et al.*, 2008). Many stakeholders in the construction industry are involved in the construction process and its management. Although the relationship is considered complex, there are available tools, standards and guidance which can be used to increase efficiency (Atkinson *et al.*, 2009). Atkinson *et al.* (2009) suggested that the driver of change needs to target specific stakeholder while also considering the impacts on others less affected directly. Rowlinson and McDermott (1999) believed that there has been little work within the published work of the International Council for Research and Innovation in Building and Construction (CIB) W92 – Procurement Systems of the International Council for Building Research Studies and Documentation on concept of environmental sustainability and procurement. In the process of identifying the research gap, there exists significant research gap in the integration of sustainability into building procurement methods. This research attempts to fill this gap by developing a decision-making support tool for the construction industry stakeholders to integrate sustainable construction into building procurement methods.

2.5.2 Identification of features to fill the research gap

Figure 2-12 shows the integration of construction procurement with cost, time and quality which is developed to relate sustainability concepts and procurement methods.

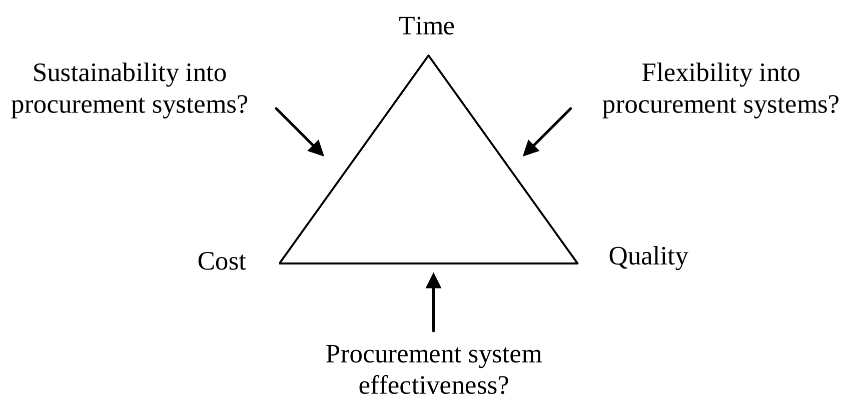

Figure 2-12 Integration of construction procurement with cost, time and quality

Figure 2-13 shows the preliminary concept between building procurement methods and sustainable construction. An extensive literature review has been undertaken, and the integration features is the acknowledgement and findings in this review.

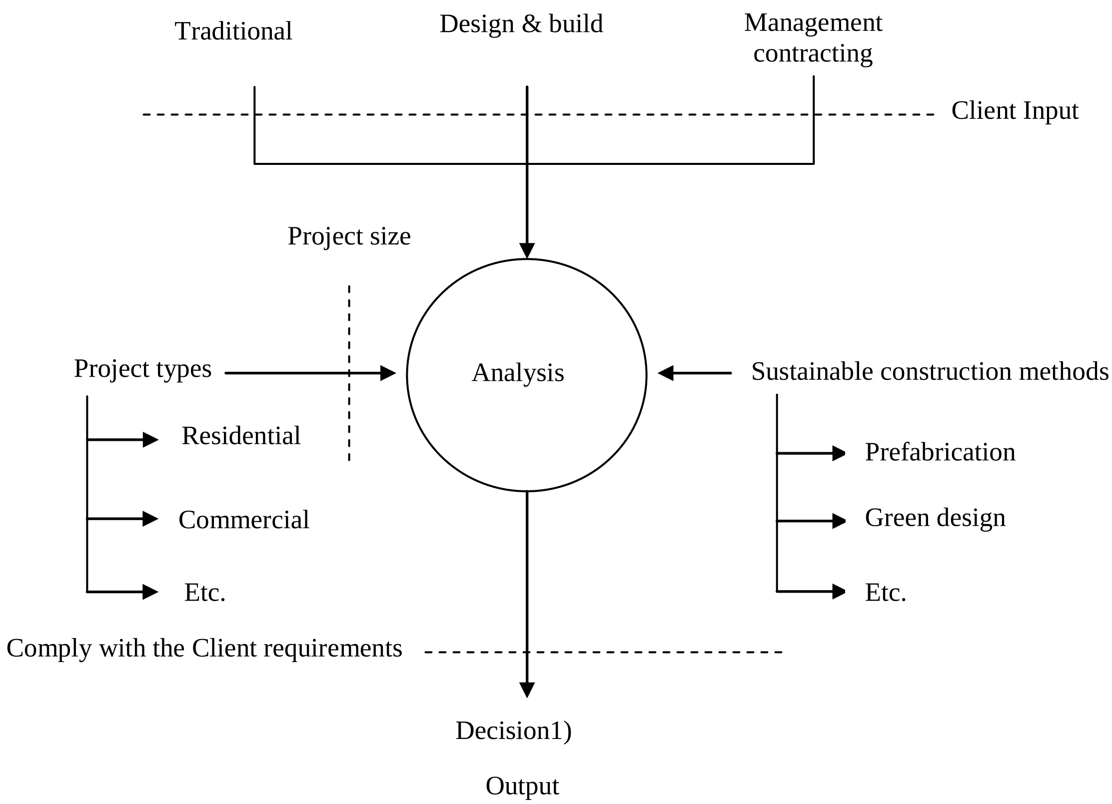

Figure 2-13 Preliminary concepts between building procurement methods and sustainable construction

The traditional procurement, design and build, and management contracting will be analyzed for different types of buildings, such as residential, commercial, and others. It has been extensively reviewed, in particular for developing countries in the suggested conceptual framework above. Building procurement methods has sustainable construction intrinsic capability, which could intensify a capability as a sustainability delivery mechanism, and the potential has not been fully appreciated by construction stakeholders.

2.6 Summary

An extensive literature review has been conducted in this chapter which focuses on sustainable construction in developing countries and building procurement methods. This study focuses on the contribution of building procurement methods towards sustainable construction. From the findings of literature reviews, the research gap was underlined between building procurement methods and sustainable construction. The term “sustainability” may not be frequently used in building procurement methods, but issues such as waste reduction, quality, cost saving, time saving, profitability, etc. are considered essential. Sustainable construction should perceive beyond vague ideas and adopt technical approach while focusing on local needs. Due to increasing sustainability awareness, choosing an efficient building procurement method is necessary for success of project. Next chapter explains in detail how related data have been collected and analyzed.

CHAPTER 3 RESEARCH METHODOLOGY

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research methodology which consists of five sub-topics, i.e. (1) literature review; (2) data collection; (3) triangulation method; (4) data analysis; and (5) final product. This research study has adopted a triangulation or 'mixed-method' designed to integrate both quantitative and qualitative approaches. In construction industry, stakeholders are recognized as: (1) clients – owners, developers, investors, users; (2) contractors; (3) authorities; (4) designers; and (5) materials suppliers (Shen *et al.*, 2006). In general, the choice of respondents for any research should cover whole spectrum of stakeholders. In this research, it gains the response from clients, contractors, and consultants, with some inputs from the perspective of academia in preliminary survey. Vogt (2007) described the process of planning research question consists of three steps: (1) design, that focus on methods of 'collecting' evidence and addressing the question such as the way to conduct the study; (2) measurement, that typically involves procedures for 'recording' and handling evidence, answering questions such as how to sort, count, and assign numbers to variables; and (3) analysis, that includes methods for 'interpreting' the evidence, answering questions such as 'how to produce, evaluate, and make sense of the results. Figure 3-1 shows a strong connection between the process of design, measurement, and analysis.

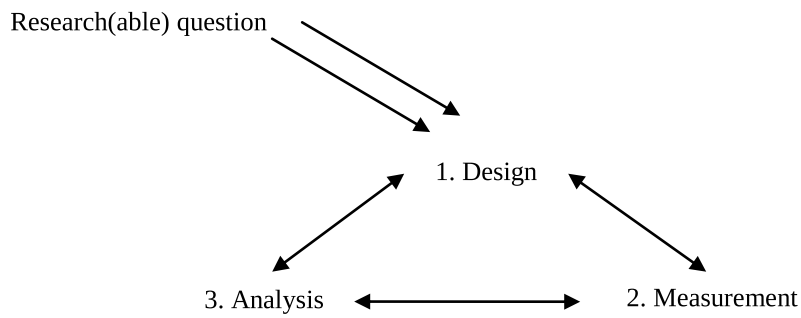

Figure 3-1 Design, measurement, and analysis (Vogt, 2007)

A well-made research design does ensure the whole process and output generated are correct and acceptable.

3.2 Research Methodology

The research methodology is a major component of research design. A ‘hard’ and a ‘soft’ components are identified in the research design. The ‘hard’ issue is the building procurement methods on technical capabilities while the ‘soft’ issue is the sustainability aspects. The methodology can be broken down into 4 main stages, as shown in Figure 3-2, to enable stimulation of ideas for design of a robust approach in achieving the objectives.

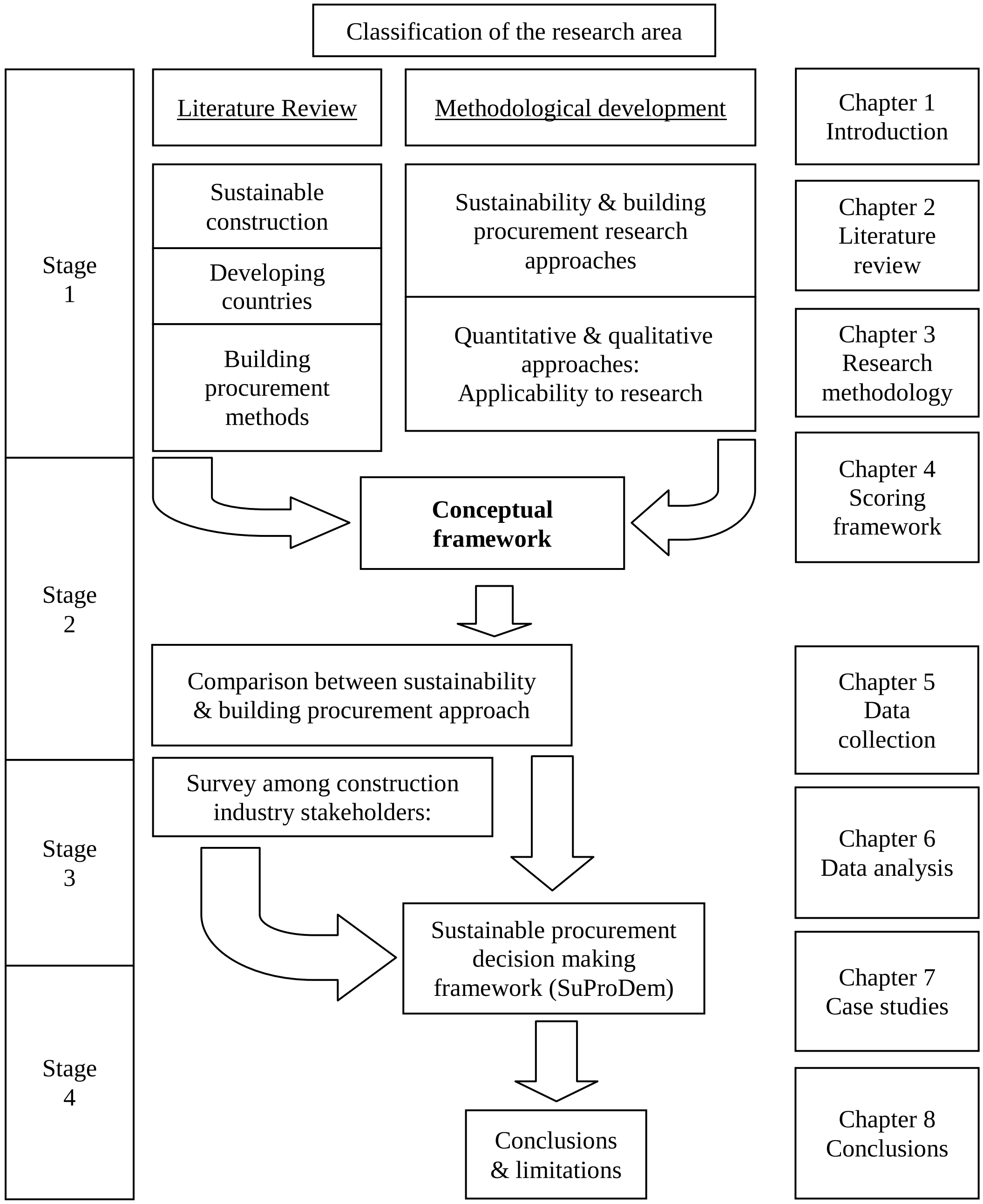

Figure 3-2 Research methodology

3.2.1 Four Stages in Research Methodology

1) Stage 1

At Stage 1, a preliminary conceptual framework has been developed which aims to identify research gaps. Initially, a large number of indicators were proposed. A process was then designed to link methodological development, sustainability and procurement research approaches, quantitative and qualitative approaches. Furthermore, this stage involves literature review of sustainable construction, developing countries, and procurement methods.

2) Stage 2

Stage 2 serves to compare sustainability and building procurement approaches and explore possible linkages. This stage is important for development of a suitable framework for both sustainable construction and building procurement methods. The output was adopted to analyze the suggested indicators.

3) Stage 3

At Stage 3, a survey process comprising of a scoring framework called SuProDem was developed. The framework has been subsequently used in case studies. The framework was developed from the results of survey among construction industry stakeholders. It could be used to identify possible improved process for building procurement methods.

4) Stage 4

Stage 4 discusses conclusions of the research (Chapter 7). At this stage, a case study was proposed, and it was described as an overall study. Moreover, it also elaborated the research findings and drew reasonable conclusions.

3.2.2 Data collection

A targeted group for data collection was identified to ensure respondents' participation, and a thorough selection was made to select suitable respondents. Data collection included a wide range of data to provide a comprehensive understanding of sustainability topics. A secondary set of data was also adopted, such as information from the Construction Industry Development Board (CIDB) of Malaysia to complement primary collected data. A measuring tool was developed as part of the research design, and a case study was conducted to validate the data.

3.2.3 Data measuring tools

A data measuring tool was used to verify the collected data. The data was then analyzed and discussed and it was analyzed in four stages using Excel spreadsheet. The software has been used because it is convenient, user friendly and cost effective. A customized algorithm and formula were incorporated to analyze the four stages of objectives.

3.3 Literature Review Process

The literature review process has collected reliable information from various sources, such as journals, books, magazines, and websites. The process is necessary to establish framework of the research and to identify relevant indicators for sustainable construction.

3.3.1 Selection of literatures

The literatures were collected from published articles in research journals listed in reputable publication databases, such as Web of Science, Google Scholar and Scopus. A review of the literature has enabled the establishment of current scenario and to identify possible research gaps.

3.3.2 Literatures organization

Literature organization was conducted to categorize quality and relevancy of the information and data. Research information has been collected from primary and secondary questionnaire survey. The research articles were arranged in chronological order to review development of research topics over the years.

A comprehensive set of the identified indicators was selected to meet sustainable construction principles. Some of the indicators have contributed to each pillar of sustainable construction. The identification of indicators is important for development of conceptual framework and is discussed in detail in Chapter 4.

3.3.3 Comparison between sustainability research approach and procurement research approach

3.3.3.1 Sustainability research

Sustainability research was proposed as the main theme of this study. Carter (2005) mentioned that the interest in sustainability first appeared in construction management research in the 1990s during a debate on paradigmatic trends. He also stated the changes in construction management research were pioneered by a small number of active researchers, whereas trends in sustainability research are mainly the results of enormous pressure from governments and global legislation.

3.3.3.2 Building procurement methods research

Building procurement methods research is considered a subjective topic. However, it can be objectively viewed provided a wide range of reliable indicators are available. At present, there is a lack in research data on building procurement practices, especially those related to sustainability.

3.4 Triangulation Method

Quantitative and qualitative methods can be integrated and used in developing a conceptual framework for sustainable construction. Stecker *et al.* (1992) summarized four ways that qualitative and quantitative methods can be combined in a triangulation method, namely:

Model 1: Qualitative methods are used to develop quantitative measures.

Model 2: Qualitative methods are used to explain quantitative findings.

Model 3: Quantitative methods are used to embellish a primary qualitative study.

Model 4: Qualitative and quantitative methods are used in parallel.

In this study, model 4 was chosen since both qualitative and quantitative methods are used in parallel. Figure 3-3 shows the model of triangulation, comprising a questionnaire survey for the quantitative approach and qualitative method by some interviews with experts.

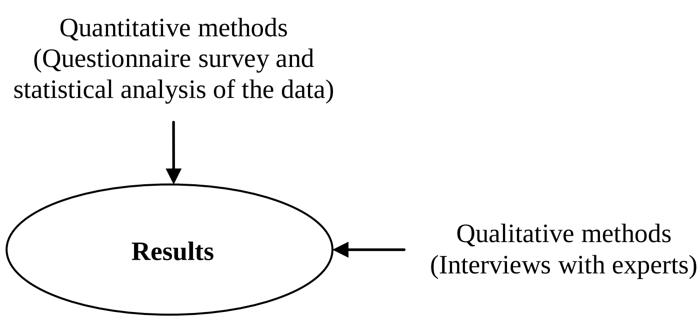

Figure 3-3 Model of triangulation (Source: Stecker *et al.*, 1992)

Carter (2005) adopted a soft system methodology in which qualitative analysis is conducted to complement quantitative technique. Figure 3-4 shows the methodological approach for the basis of a mixed methodology utilized by him. Walker and Brammer (2009) used both quantitative and qualitative surveys to identify significant variations on sustainable procurement practices among public sectors.

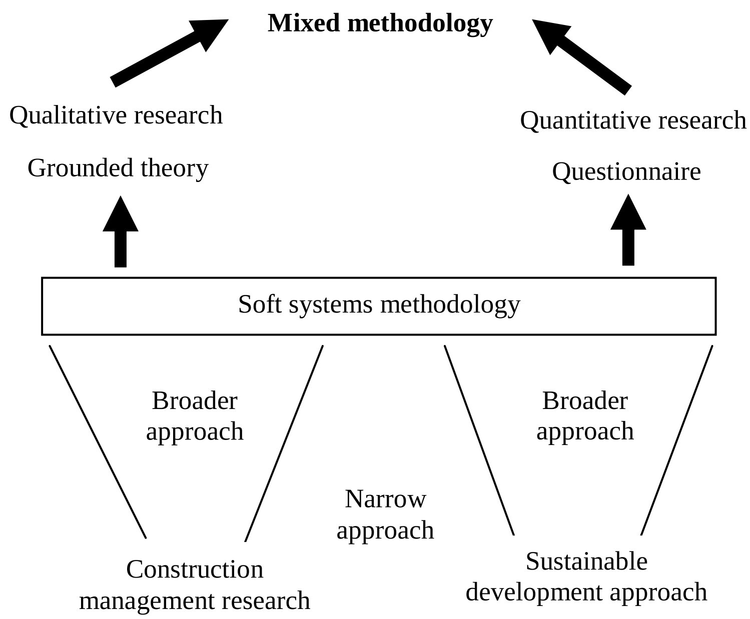

Figure 3-4 Methodological approach emerging research agenda
(Source: Carter, 2005)

3.4.1 Quantitative method

Quantitative research method is primarily used for this study. Vogt (2007) stated that the quantitative method is popular due to increasing use of specialized software. Mathematically-intensive statistical evaluations can be effectively conducted with the software. The utilization of computer has made the analysis exponentially faster than manual calculations, although researchers should be knowledgeable to use the wide range of complex mathematical calculation tools.

3.4.2 Qualitative method

In implementing a qualitative research approach, Richards and Morse (2007) stated the importance of understanding various available methods, questions, and desired results. Knight and Ruddock (2008) suggested a grounded theory as a method, derived in a structured data form with or without preliminary research questions. Moreover, it involves systematic gathering and analyzing sets of data, evolve theory based upon data. On the other hand, Douglas (2003) described grounded theory research would comprise three main categories of data such as (1) field data (notes); (2) interview data (notes, recordings, transcripts); and (3) any other existing literatures. Nevertheless, the interview approach is considered sufficient for a qualitative method. Qualitative research is a common technique among researchers and is designed to reveal the range of behaviors of respondents and the perceptions that drive it, with respect to a particular topic being studied. Figure 3-5 shows the process of qualitative methods, where conceptual framework is developed to evaluate perception among construction stakeholders on sustainable construction methods. In this study, a triangulation method was adopted. The data from the survey would be analyzed with reference to the four objectives. Subjective evaluations would be incorporated into the process to complement quantitative results. It is expected that the analysis process would result in two proposed preliminary framework 1 and 2. Figure 3-5 shows the methodology framework utilized for this study.

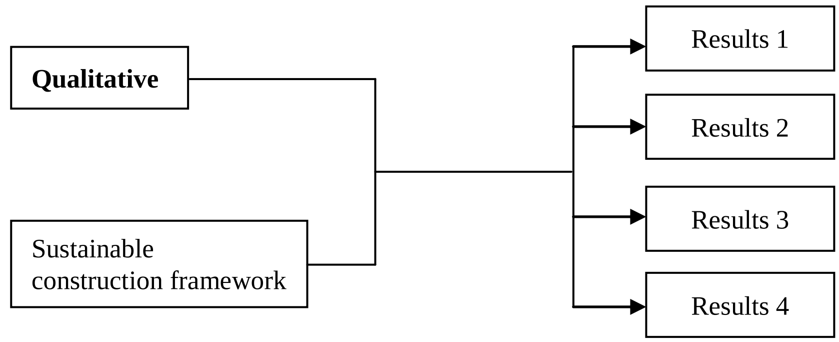

Figure 3-5 Process of qualitative methods

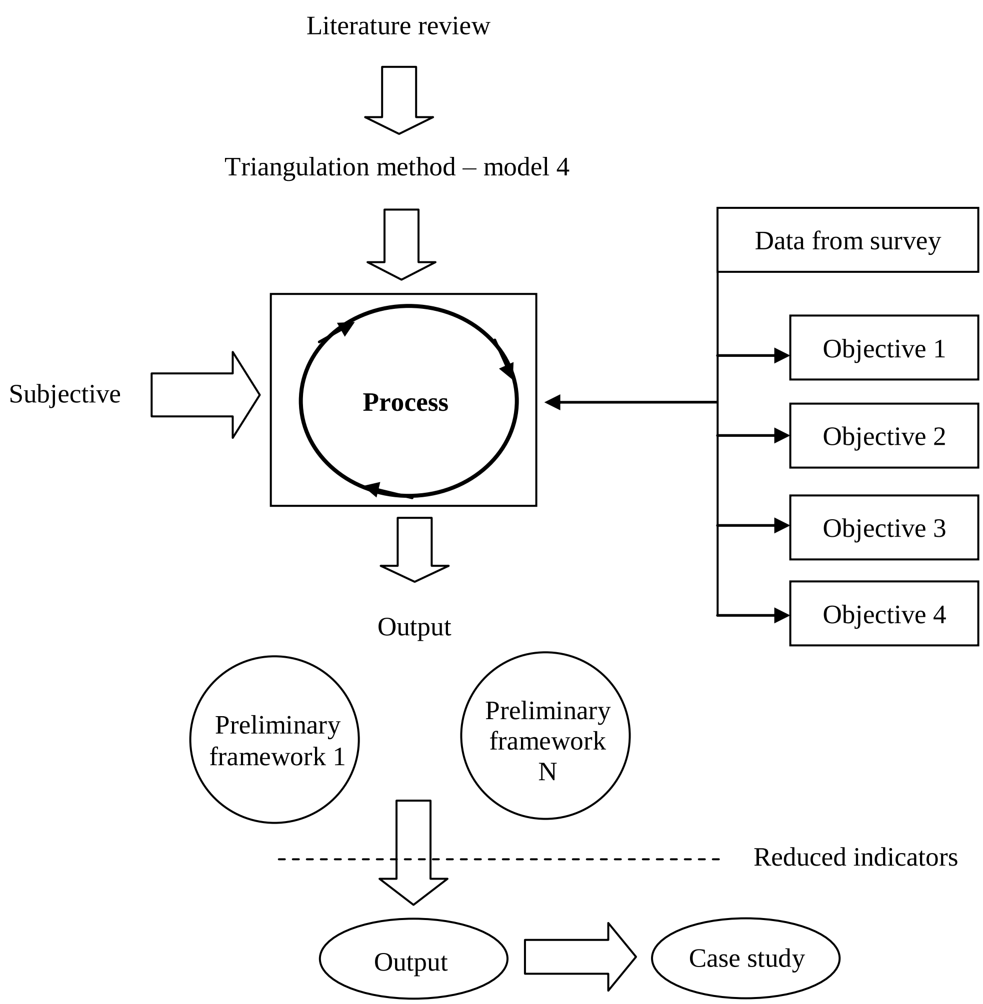

Figure 3-6 Methodology frameworks

3.5 Research Planning

Research planning is important to define the framework of the study (Naoum, 1998; Fellows and Liu, 2008). The planning should outline scheduled work, execution process and timeline. A good research plan should ensure that the study to be focused and is well conducted.

3.6 Research Design

A research design supports technical aspect of research and will discuss in-depth understanding for positive feedback in a group of targeted respondents.

3.6.1 Research design for sustainable construction methods

The questionnaire was designed to achieve the objectives of this research, based on past literature on construction methods. Figure 3-7 shows the operational framework undertaken to fulfill the research objectives.

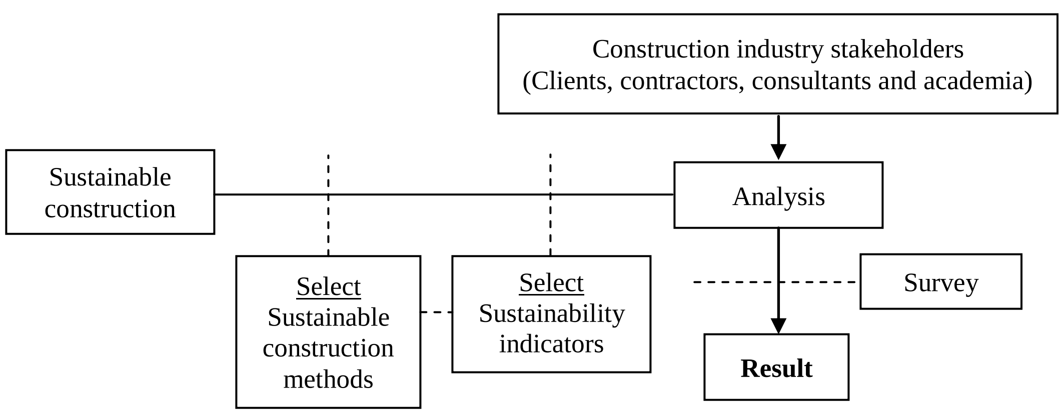

Figure 3-7 Operational frameworks

3.6.1.1 Sustainable construction methods

In this study, sustainable construction methods were suggested, namely (1) education and training; (2) environmental management systems; (3) green building; (4) green design; (5) green procurement; (6) green roof technology; (7) lean construction; (8) prefabrication; and (9) waste management. Figure 3-8 shows the outline of sustainable construction methods which are used for this study.

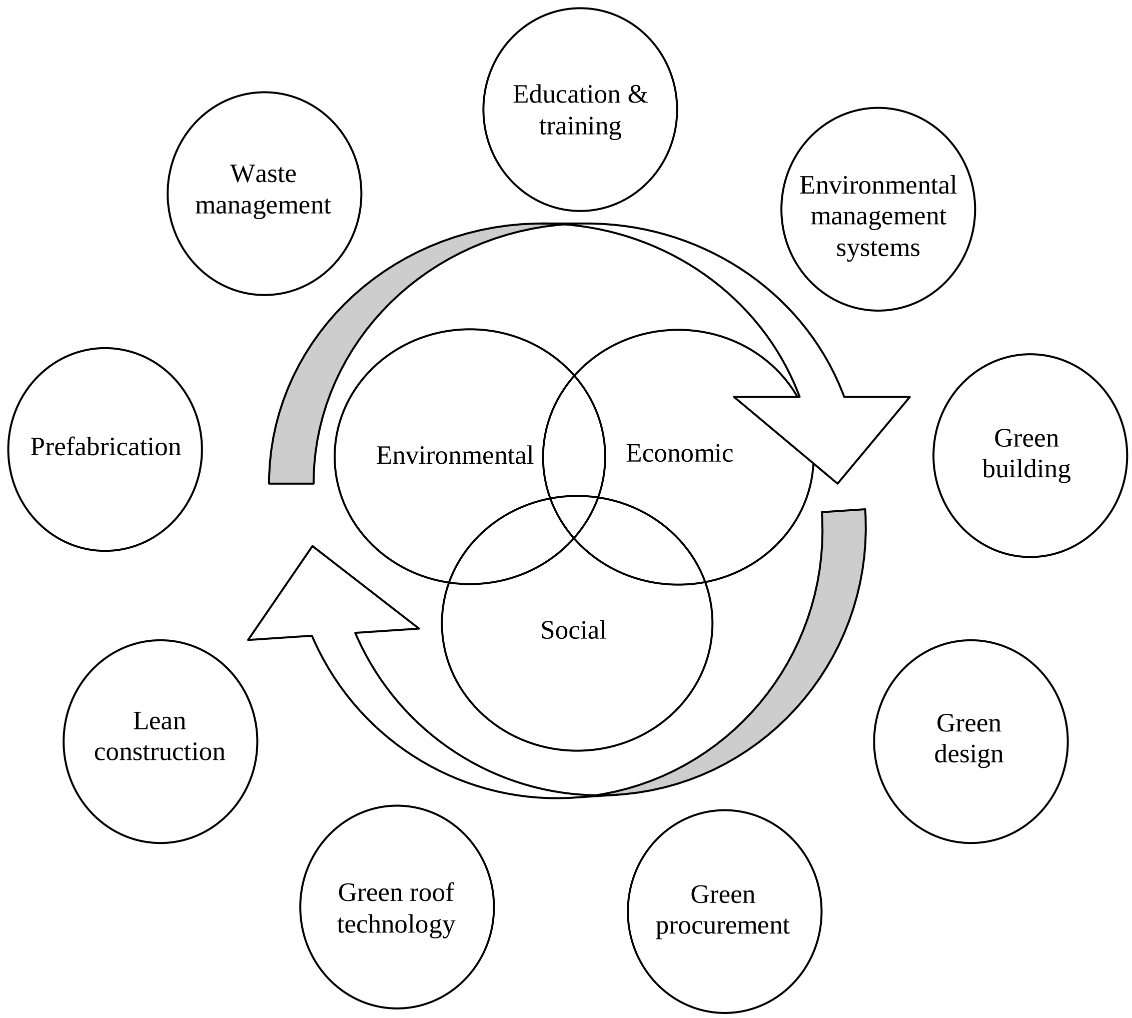

Figure 3-8 Sustainable construction methods

Since methods for sustainable construction have gained popularity, there is a need to understand their characteristics. Characteristics that are described as innovative indicators would be the most useful one to improve sustainable constructions. These characteristics should be prioritized by both practitioners and researchers. A significant framework can be developed by involving construction industry stakeholders.

3.6.1.2 The proposed sustainability indicators

This study proposed a range of indicators extracted from literature reviews related to sustainability. They were subsequently used in scoring framework and case studies. The selected indicators were waste reduction, cost saving, time saving, quality, material recycling, flora and fauna protection, noise pollution control, air pollution control, water pollution control, and energy saving.

3.6.2 Research design for sustainability indicators

Construction stakeholders such as clients, contractors, and consultants (the respondents) were invited to select sustainability indicators that match procurement methods performance indicators. Adjustment was made to suit the indicators between sustainability and procurement methods.

3.6.2.1 Preliminary conceptual framework

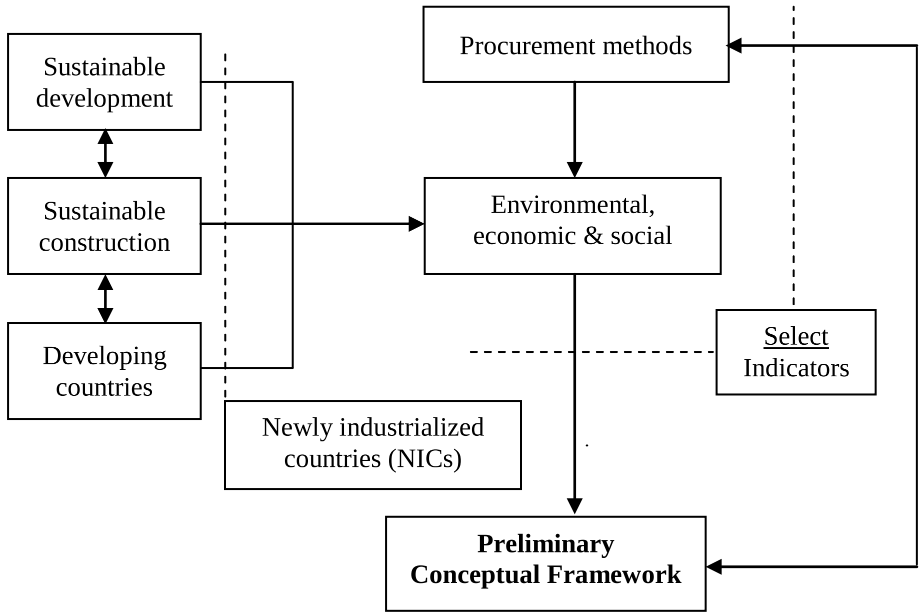

Figure 3-9 Flow of preliminary conceptual framework

3.6.2.2 The concept and theoretical framework for identified indicators

Figure 3-10 shows the concept of sustainable procurement methods between sustainability and procurement methods.

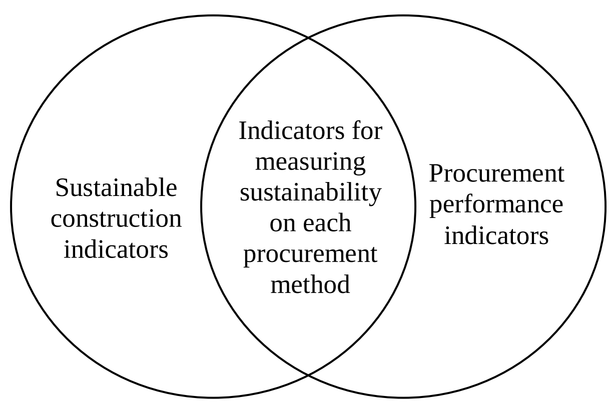

Figure 3-10 Concepts of sustainable procurement methods between sustainability and procurement methods

3.6.2.3 The proposed sustainability indicators

The proposed indicators were identified from review of literature on sustainable construction and procurement methods. Shortlisted indicators were evaluated for its relative importance with relation to this study.

3.6.3 Research design for scoring framework

A scoring framework presents a priority rating scale and utility factor to reflect sustainability performance for a specific building procurement method. A ranking scheme was adopted to develop the scoring framework to be applicable for subsequent case studies. The score was then summarized to generate value and the ranking for each indicator and then was calculated to reflect sustainability performance when a specific building procurement method is applied. The framework indicates whether there is a difference between industry survey and case studies if any, and it can then be calculated.

3.6.4 Research design for case studies

3.6.4.1 Comparison study

A comparison was made between results obtained from industry survey with case studies. It serves as a verification of the results from industry survey, and any discrepancies are discussed and justified in Chapter 6.

3.6.4.2 Measurement tools

3.6.4.2.1 Scoring framework

A reliable statistical method was adopted to develop a scoring framework for assessing sustainability performance and building procurement methods. This framework is thoroughly evaluated in Chapter 4 and is subsequently used in evaluation of case studies on school building projects in Chapter 6.

A scoring framework was developed to integrate the analysis and to form decision-making tool that could be used by researchers and the industry. Sev (2009) recommended a framework that included principles, strategies and methods; offers tools for construction industry stakeholders (urban designer, architect, planners, contractors and supplier); aims to help when developing the most appropriate assessment tool based on the priorities of critical conditions. It was designed to complement framework 1, and subsequent scoring method was developed from qualitative results generated by a series of interview among clients, contractors, and consultants. The SuProDem framework was finally proposed as a decision tool that can be utilized for the selection process of sustainability-compliant building procurement methods.

<u>Priority rating</u>

A priority rating was used to describe the perspective of respondents. The respondents gave a rating from 1-10 and 1-5 depending on which particular indicator from two questionnaires. The rating gives a view regarding the respondents' perception on the indicators.

<u>Utility factor</u>

A utility factor score on a scale of 10-110 was adopted to avoid zeros output (Love *et al.*, 1998). As shown in past studies, the values of the criteria weights may vary, although typically the relative importance of each criterion is usually in the range on a scale of 1-20 (Love *et al.*, 1998).

3.7 Data Collection Process

Data collection is an integral part of the research process. For this study, relevant data was collected for each of the four objectives. To ensure good quality data, proper sampling and identification of respondents are necessary. The advantages of sampling methods are reduced cost and faster than a complete census of the whole population. It is not practical to conduct a survey in the whole population because it involves a large number of respondents, extra cost and time. A small population is more suitable to reduce cost and having a good respectable sampling (Fellows and Liu, 2008).

The data collection process in this study was perfectly designed to meet each objective. It was assigned to test the validity of the survey. A number of research findings could be drawn from the questionnaire survey.

3.7.1 Scaling

A five-point Likert scale was used to capture respondent's perception in answering the questions of the survey. The range of scale was from 1 (totally disagree) to 5 (totally agree). The scale from 1 to 5 was chosen because it is easy to be understood by respondents. On the other hand, the Likert scale also range from 1 to 7; 1 to 10; and others, and also including the wording that will be used (for example: totally disagree to totally agree) depends on researcher's requirements. It is widely used in previous studies for similar research area (e.g. Naoum, 1998; Chan *et al.*, 2003; Kulatunga *et al.* 2006; Osmani *et al.*, 2008). Mulder (2006) outlined that the indicators required a gradient in different forms such as (1) nominal scales, consisting only two values and provide very little information, but are easy to agree in case of the controversial themes; (2) ordinal scales that based on a hierarchy of qualitative states, e.g. the quality of personnel training, transparency of decision-making processes or possibilities for public participation; and (3) cardinal scales that gives quantitative information. He also suggested that researchers use cardinal scales particularly in quantitative research, and the scale was more preferred. Nevertheless, it must meet the four criteria of (1) general; (2) indicative; (3) sensitive; and (4) robust.

3.7.2 Sampling

Fellows and Liu (2008) described that the objective of sampling is to provide a practical mean for data collection and the processing component of research to be conducted, whilst ensuring the sample provides good representation of the population; i.e. the sample is representative. If the population is small, a full population 'sample' may be conducted. Table 3-1 shows a methodological approach emerging from the research agenda.

Table 3-1 Methodological approach emerging from research agenda

Population size → N	Sample size → n
Population mean → μ	Sample mean → $\bar{x}$
Population standard deviation → σ	Sample standard deviation → s

Generally, a normal survey involves a large amount of data from a substantial number of respondents. In normal practice, it is usually impractical to conduct the survey of whole population since it would incur tremendous costs and time, instead a sampling is utilized. Fellows and Liu (2008) described that a sampling is '*to provide a practical means of enabling the data collection and processing components of research to be carried out whilst ensuring that the sample provides a good representation of the population; i.e. the sample is representative*' Levine *et al.*, (2008) gave three benefits of using a sample population, which are (1) selecting a sample is less time-consuming than entire population; (2) selecting a sample is less costly than entire population; and (3) an analysis of a sample is less cumbersome and more practical. For this research work, the respondents were selected from a list of (1) clients; (2) contractors; and (3) consultants. Respondents from academia were also selected to fulfill the first-research objective. The questionnaire was delivered to recipients in Malaysia via email and post, and they were given sufficient time to return the completed questionnaire.

3.7.2.1 Simple random sampling

A set of data was collected, and simple random sampling was adopted to meet the targeted criteria of the questionnaire. The sampling was adopted because of low cost, time saving (Levine *et al.*, 1998), ease of analyses and it is aimed to achieve objective 1 to 3.

3.7.2.2 Cluster sampling

A cluster sampling method was adopted for data collection focusing in Klang Valley, Malaysia. The sampling technique was based on strategic data collection by Levine et al (1998). It is a sampling technique where the entire population is divided into clusters and a random sample of these clusters is selected. It is typically used when a researcher is unable to get a complete list of members of the population he/she wishes to study, but can get a complete list of groups or 'clusters' of the population. This method can be more cost effective than simple random sampling, enhancing the sampling effectiveness and was adopted to achieve objective 1 to 3.

3.7.2.3 Pertubuhan Akitek Malaysia (PAM) / Malaysian Institute of Architects directory

The respondents' addresses were obtained from the directory of the Pertubuhan Akitek Malaysia (PAM) or the Malaysian Institute of Architects (PAM directory, 2010). The directory provides a list of information on major local authorities, housing developers, contractors (Class A or G7), specialist contractors, architects' firms, quantity surveyor firms, consulting engineers' firms, and others. Local contractors are categorized to classes according to the sizes and costs of their projects. For example, a class A or G7 contractor are those managing construction project of more than RM 10,000,000 (Pertubuhan Akitek Malaysia, 2010). A total of 3608 firms were registered under the PAM directory.

3.7.2.4 Case studies

The case studies focused on investigation for school projects in Malaysia, with data obtained from survey involving several school projects in Klang Valley (Kuala Lumpur, Selangor, and Putrajaya). A total of 109 school projects using either traditional or design and build methods were investigated. The project-oriented questionnaire was administrated by mail, and a similar questionnaire was used as an industry survey.

3.7.3 Respondent selection and background

Chan et al. (2003) proposed that based on the nature of a project, the respondents can be divided into three groups for analysis which comprising (1) client's group; (2)

contractor’s group; (3) and consultant’s group (see also Majdalani et al., 2006). The client can be further divided into two groups, i.e. (1) public authorities, and (2) private organizations (Newcombe, 1994). Various resources (books, website directories and journals) were searched to identify and shortlist potential respondents. In addition, a group of experts was selected to participate in the survey.

3.7.4 Pilot study

The questionnaire was administered to a small group of respondents, who were as similar as possible to target population. A pilot study would ensure that the questionnaire developed works practically, and to identify and amend problematic questions and refine the questionnaire. Comments from respondents were taken into consideration to complete final questionnaire.

3.7.5 Questionnaire survey

The questionnaire survey is used as a mechanism to capture respondents’ opinions and perception on the topic being surveyed. It is a quick and relatively low cost method to obtain response from a large population (Fellow and Liu, 2008; Knight and Ruddock, 2008). Past studies on construction industries have described the usage of questionnaire surveys for data collection. Sanvido et al. (1992) developed a questionnaire to facilitate data collection and ensure consistency in the elements examined. Chan et al. (2003) suggested that based on the nature of project participants, respondents can be divided into three groups for analysis, namely (1) the client’s group; (2) contractor’s group; and

(3) consultant's group (see also Majdalani et al., 2006). The client's group can be further divided into two categories: (1) public authorities, and (2) private organizations (Newcombe, 1994). The survey was chosen to capture the respondents' perceptions about sustainable construction in Malaysia.

Once the pilot study was completed, any necessary modifications and improvements were implemented in the final version of the questionnaire. Major study was then conducted using finalized questionnaire to collect sufficient empirical data from them. The questionnaire was delivered by post to the participants, and a sufficient time frame from two to four weeks was allocated for them to respond.

3.8 Methods for Data Analysis

3.8.1 Likert's scale

The Likert's scale is widely used in past studies to capture respondent's perspective on a particular subject (e.g. Naoum, 1998; Chan *et al.*, 2003; Kulatunga *et al.* 2006; Osmani *et al.*, 2008). Suitable rated scale would be in the range of 1-9; or 1-7; or 1-5. For a five-point Likert scale, the scale points can range from 1 (totally disagree) to 5 (totally agree), and 0 (no idea). Other variations to the scale points descriptions are: (1) no contribution; (2) less contributable; (3) medium contributable; (4) contributable; (5) major contribution; and (0) not adopted. Others have also been described as (1) not effective; (2) less effective; (3) medium effective (4) effective; (5) totally effective; and (0) no idea. In this study, a five-point Likert scale was utilized for the survey. The respondents were requested to rate their degree of agreement for each question on a five-point Likert scale, from (1) totally disagree to (5) totally agree. In addition, a ten-point Likert scale was also adopted.

3.8.2 Mean (μ) and ranking

Descriptive statistics such as mean and standard deviations were generated to determine and compare the range and variance of the score. The mean formula is widely known, and typically used in many studies, as shown by Chan et al. (2003); Jaillon *et al*. (2008). Typically, a ranking scheme is adopted in many studies, for example by Ahadzi and Bowles (2004); Kulatunga *et al*. (2006); Tam (2008). In this study, the mean was used to calculate the score in each sub-indicator and the mean ranking was generated from the data collected. The ranking method used is to evaluate the perception of respondents and is not presented as an objective assessment (Chan *et al.*, 2003). It was ordered from the most important to the least important. Result shows a significant scale among the respondents. The ranking of these groups was associated with their perceptions.

3.8.3 Standard deviation

The standard deviation was calculated for each mean generated to determine and compare the range and variance of scores (Levine, 2008). A high standard deviation signifies that it allowed for the possibility that the answers could be between agreed and disagreed, and is also considered uncertain. Zhang (2005) and Chua et al. (1999)

adopted a significance indexes formula to calculate the ranking among different parties. It is practical to analyze the relative significance indicators and sub-factors. The relative significance was placed on a scale of 0-5 (with “0” being “not applicable,” “1” being “not significant”, “2” being “fairly significant,” “3” being “significant, “4” being “very significant,” and “5” means “extremely significant”). The significance indexes are simply mathematical calculations that used to calculate indexes, and a tool that calculates reliability from respondents. The relative significance indexes are calculated for each sub-indicator. A formula is used to convert linearly 0-5 scale adopted in the questionnaire survey to 0-100 scale with “0” representing the lowest and “100” the highest significance; this means that “5”, “4”, “3”, “2”, “1”, and “0” have significance indexes of 100, 80, 60, 40, 20, and 0, respectively (Zhang, 2005).

3.8.4 Significance indexes

Figure 3-11 shows the relative significance indexes of the nine proposed framework and those of successful sub-factors (the sub-indicators) are calculated separately.

$$\frac{Ri0 \times 0 + Ri1 \times 20 + Ri2 \times 40 + Ri3 \times 60 + Ri4 \times 80 + Ri5 \times 100}{Ri0+Ri1+Ri2+Ri3+Ri4+Ri5} = \frac{20Ri1 + 40Ri2 + 60Ri3 + 80Ri4 + 100Ri5}{Ri0+Ri1+Ri2+Ri3+Ri4+Ri5}$$

where S*i* = significance index for the ith factor or sub factor;
R*i*0 = number of response as “0” for the ith factor or sub factor;
R*i*1 = number of response as “1” for the ith factor or sub factor;
R*i*2 = number of response as “2” for the ith factor or sub factor;
R*i*3 = number of response as “3” for the ith factor or sub factor;
R*i*4 = number of response as “4” for the ith factor or sub factor;

R*i*5 = number of response as “5” for the *i*th factor or sub factor.

Figure 3-11 Significance indexes (Source: Zhang, 2005)

3.8.5 Normality test

If two populations are to be compared using T-Test, it should follow a normal distribution. To check on this, a normality test such as the *Shapiro-Wilk*, *Kolmogorov-Smirnov*, *Lilliefors* and *Anderson-Darling* tests can be used (Razali and Wah, 2011). For this study, *Shapiro-Wilk* test is used. It was published in 1965 by Samuel Sanford Shapiro and Martin Bradbury Wilk (Shapiro and Wilk, 1965). *Shapiro-Wilk* test is used because it is the most powerful test to assess normality for a data distribution (Razali and Wah, 2011). To understand the *p*-value, one needs to set-up the null hypothesis. The null hypothesis is that the population is normally distributed.

3.8.6 Primary hypothesis

A basic hypothesis is adopted to compare the mean and ranking of different respondents. The following null hypotheses (Ho) are proposed for substantiation and are forwarded for validation, and also to compare the pattern of ranking of importance by the respondents. A significance level of 0.05 was chosen, equivalent to 95-% level of confidence, which is interpreted as a 5 chances in every 100 of being mistaken (Levine, 2008; Hashim 1999). Statistical tests of (1) t-test; and (2) spearman rank-order correlation coefficient (r) were used to test hypotheses for the survey. A significance level of 0.05 was chosen, equivalent to 95-% level of confidence (Levine, 2008; Hashim 1999).

3.8.7 The t-test

The *t-test* calculation is based from previous studies such as Jaillon and Poon (2008); Yip and Poon (2009); Jaillon *et al.* (2008); Yip and Poon (2009). The technique is used to determine whether a respondent is in agreement. Hypothesis Ho, a null hypothesis, was proposed for the analysis to test the indicators that were identified. The *t-test* was applied to study comparison between (1) clients and contractors, (2) clients and consultants, and (3) contractors and consultants.

3.8.7.1 Hypothesis to t-test

The *t-test* is used to compare the mean scores of each individual problem between any two populations. It was used to determine whether a respondent is in agreement. Ho: U1 = U2 or U1 – U2 = 0 and H1: U1 ≠ U2 or U1 – U2 ≠ 0 (e.g. Levine, 2008). The Ho states that there is no significant disagreement on the means of A-B; A-C; and B-C. The U1 is the number one respondent and the U2 are the number two respondent.

Null hypothesis (Ho)

There is no significant difference in the pattern of ranking of individual mean among respondents. Rating of the mean ranking of the respondents is unrelated to each other.

3.8.8 Spearmen rank-order correlation coefficient

A Spearman correlation calculation is based on several past studies such as Chan and Yeong (1995); Chan et al. (2003); Assaf and Al-Hejji (2006). The Spearman rank-order correlation coefficient (r) and the hypothesis between clients, contractors, and consultants are suggested. The aim of this technique is to determine whether the respondents have the same agreement of ranking. The correlation is a non-parametric, distribution-free test (Assaf and Al-Hejji, 2006). The hypothesis Ho is proposed for the analysis.

3.8.8.1 Hypothesis for the Spearman rank-order correlation coefficient

The aim of this technique is to determine whether respondents have the same ranking or not. Ho: no significant disagreement on the ranking among respondents; and

H1: significant disagreement on the ranking among respondents.

Null hypothesis (Ho)

The null hypothesis states that there is no significant disagreement on the mean ranking among respondents. The harmony between any of the two parties on the rankings can be measured by the Spearman rank-order correlation coefficient. These techniques are typically conducted to cross-compare the relative importance of the problems from different perceptions from different groups of respondents. A value of +1 indicates a perfect linear correlation while negative values indicate negative correlations (Vogt, 2007).

3.8.9 The overall research methodology process

The overall research methodology process consists in-depth understanding for future study and consistency. The process involves research elements, as shown in Figure 3-11.

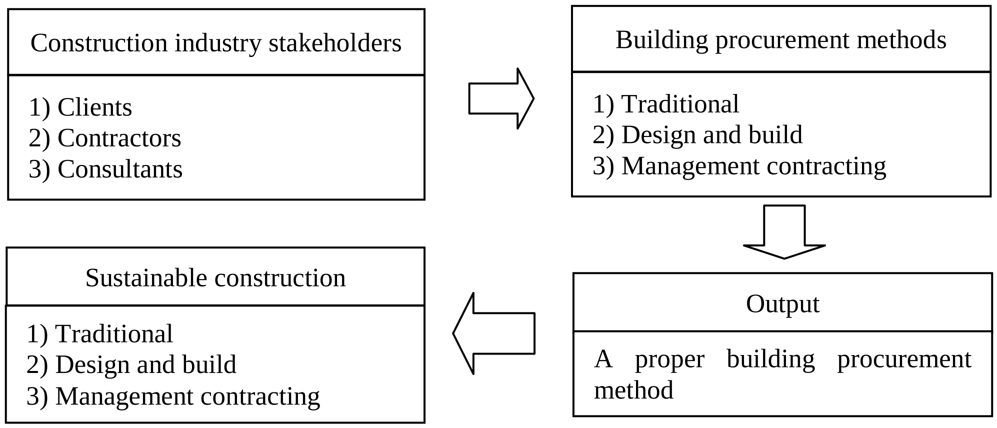

Figure 3-12 Process of methodology

The process involves four stages, including (1) construction industry stakeholders; (2) building procurement methods; (3) sustainable construction; and (4) output.

3.9 Summary

This chapter addresses relevant methodological issues and describes a particular appropriate methodology used in this research. Here, a scoring framework determines respondent criteria for a proper building procurement method. The methodology was carefully designed to establish a decision support tool to promote sustainability in building projects. Next chapter gives details of the development of scoring framework as a platform to develop comprehensive decision support tool for evaluating the sustainability performance of different building procurement methods in building projects.

CHAPTER 4 SCORING FRAMEWORK FOR SUSTAINABLE PROCUREMENT DECISION MAKING FRAMEWORK

CHAPTER 4

SCORING FRAMEWORK FOR SUSTAINABLE PROCUREMENT DECISION MAKING FRAMEWORK

4.1 Introduction

This chapter explains in detail about the process of developing sustainable procurement decision making framework through setting up scoring framework as a research foundation. To achieve objectives 1 and 2, first, it is important to study conceptual foundation based on sustainable development, sustainable construction and procurement method and identify their interrelated indicators and sub-indicators through intensive literature reviews. The research continues by listing selected indicators and sub-indicators suitable for developing countries. The scoring framework is then proposed at the end of this chapter for accessing sustainability performance of different types of procurement methods in next chapter. Summary is given at the end of the chapter.

4.2 Identification of Related Indicators

4.2.1 Sustainable Development Indicator

This section summarizes the related sustainable development indicator that will be incorporated into decision making framework. Sustainability indicators are identified from literature reviews and are summarized in Figure 4-1. The identified indicators are : (1) waste reduction; (2) cost saving; (3) time saving; (4) quality; (5) material recycling;

(6) flora and fauna protection; (7) noise pollution control; (8) air pollution control; (9) water pollution control; and (10) energy saving. They correspond to the needs of developing countries as well as newly industrialized nations such as Malaysia. The figure also shows the relationship between the sustainability indicators with the environmental, economic and social aspects of newly industrialized countries.

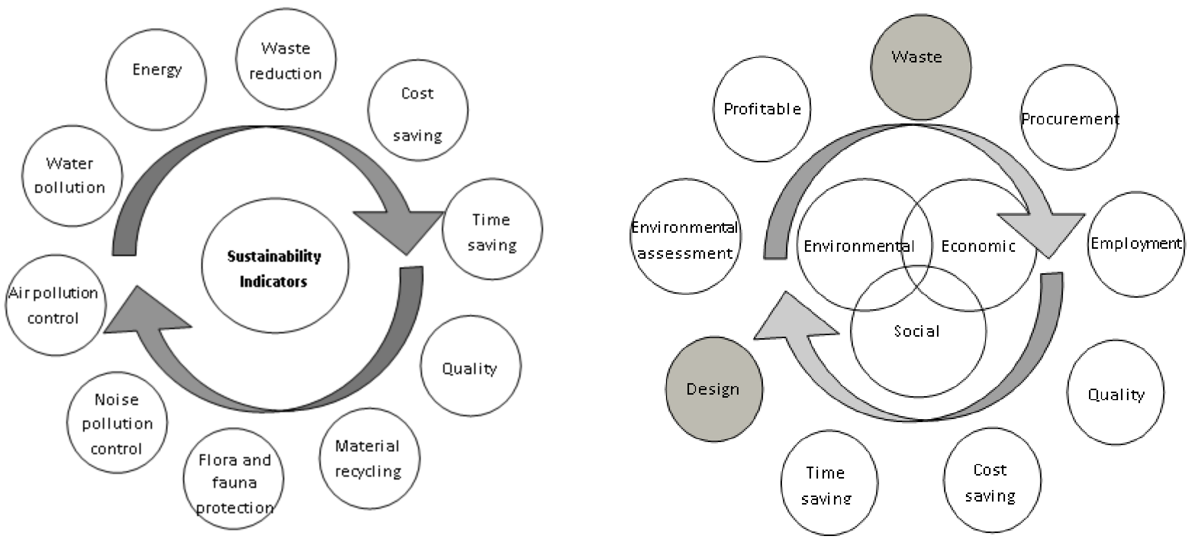

Figure 4-1 Typical Sustainability Indicators and
Newly Industrialized Countries Sustainability Indicators

4.2.2 Sustainable Construction Method and Indicator

This section also further explains the identification of related indicator specifically from sustainable construction literatures. Although there are many indicators related to sustainable construction, the most suitable identified indicators are waste reduction, quality, material recycling, flora and fauna protection, air pollution control, noise pollution control, water pollution control and energy saving. In addition, cost and time are also considered as significant indicators. In previous studies, there was little consideration to account for cost and time saving and they represent technical barriers in promoting sustainable construction (Dalgliesh *et al.*, 1997; Majdalani *et al.*, 2006; Manoliadis *et al.*, 2006; Halliday, 2008). Suitable indicators are identified and categorized, as shown in Table 4-1 below.

Table 4-1 Sustainable construction methods and contribution towards sustainability

METHODS	**INDICATORS**									
	Waste reduction	Cost saving	Time saving	Quality	Material recycling	Flora and fauna protection	Air pollution control	Noise pollution control	Water pollution control	Energy saving
Education and training	○	○	Δ	○	○	○	○	○	○	○
Environmental management system	○	Δ	Δ	Δ	○	○	○	○	○	Δ
Green building	○	○	Δ	○	○	○	○	Δ	Δ	○
Green design	○	○	○	○	○	○	Δ	Δ	Δ	○
Green procurement	○	○	○	○	○	○	○	○	○	○
Green roof technologies	Δ	○	Δ	○	Δ	○	○	○	Δ	○
Lean construction	○	○	○	○	Δ	○	Δ	Δ	Δ	Δ
Prefabrication	○	Δ	○	○	Δ	Δ	○	○	Δ	Δ
Waste management	○	○	Δ	Δ	○	○	○	○	○	Δ
Notes: ○ – Adopted Δ - Not adopted										

Figure 4-2 below illustrates three dimensions of construction management model. The model is accepted by many researchers, and it is quite well described. Morledge *et al.* (2006) suggested a relative importance between cost, time and performance in relation to any project would affect the choice of the most suitable procurement strategy for the project. Furthermore, there is also a client's need in each project's characteristics.

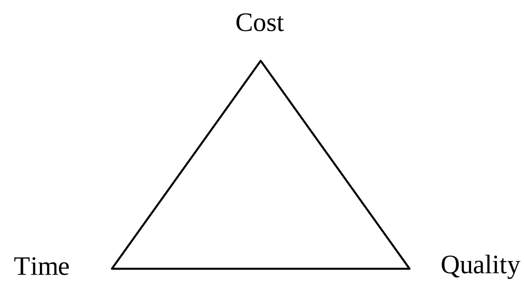

Figure 4-2 Three Dimensions of Construction Management Model
(Source: Barnes, 1998)

Figure 4-3 below shows the interrelationship of the client's needs. The relationship provides a decision support tool and references for the construction industry stakeholders.

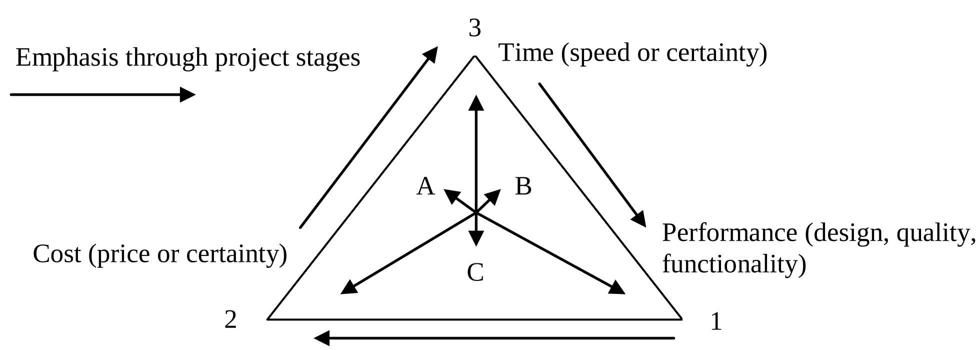

Figure 4-3 The Interrelationship of Client's Needs
(Source: Morledge et al., 2006)

If a client emphasizes on a particular need, it does affect other criteria as well. Furthermore, different clients differ in their expectations. Owner-occupier clients might focus on function and price certainty; developers would focus on cost and speed; while investor clients would focus on design and speed. A decision taken at this early stage of the project would drive future decisions and strategies.

There are numerous sustainability indicator described in the literature relating to the 'green' agenda. However, for sustainable construction, there is also a need to address both economic and social agenda as well. Figure 4-4 shows the selection of indicators within sustainable construction pillars that overlap the environmental, economic and social agenda. The proposed framework is designed to complement the pillars and without overlooking sustainable construction as an environmental matter only. It is useful for scholars as well as practitioners in making their decisions towards sustainable construction.

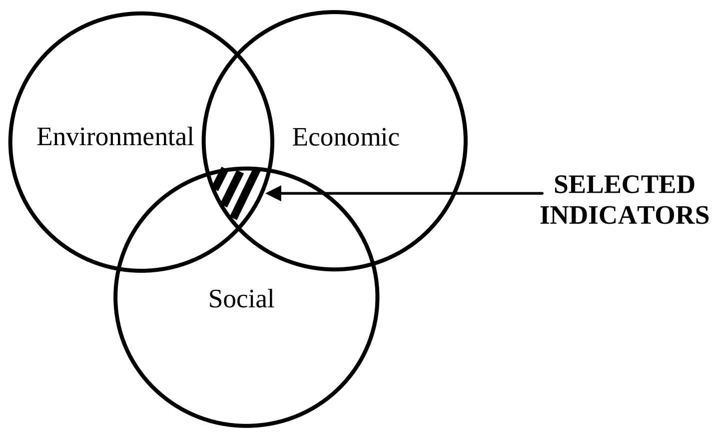

Figure 4-4 Selected Indicators within Sustainable Construction Pillars

Figure 4-5 illustrates the similarities on environmental aspect in both developed and developing countries. This information could be improved by incorporating knowledge of sustainability and selecting relevant indicators. In developing the framework, perspective of construction industry stakeholders should be taken into consideration. Since the issues on sustainability are locally and globally applicable, a solid foundation on which framework is built is necessary.

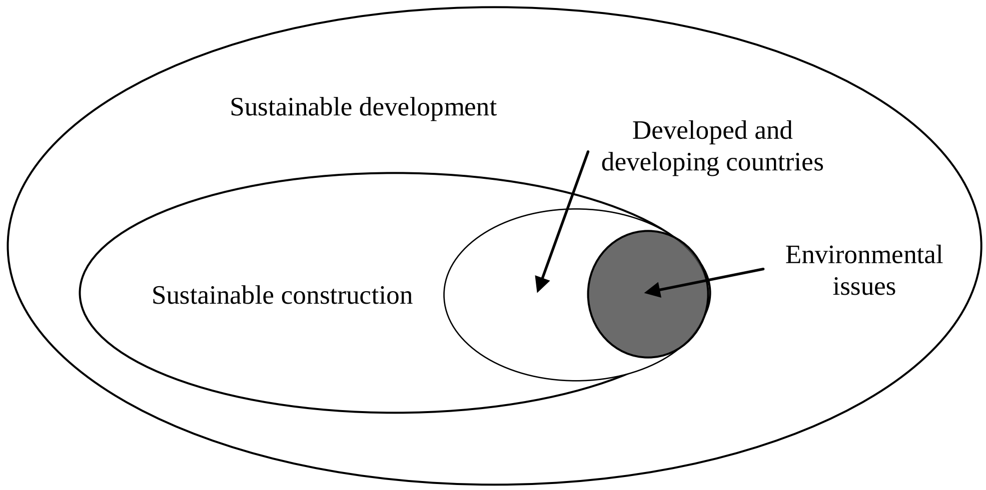

Figure 4-5 Illustration of the Environmental Similarities between Developed and Developing Countries

Significant sustainable construction challenges in developing countries are the economic and social issues. There is a need to close the gap between developing and developed countries in addressing the challenges of the environment, economic and social agenda. This can be achieved by knowledge sharing and transfer of technology as shown in Figure 4-6. The relationship and challenges highlighted may contribute to the environmental, economic, and social development; and ensuring an equal distribution between the sustainable construction pillars. Furthermore, it could be promoted for construction industry stakeholders at various stages of technical competencies.

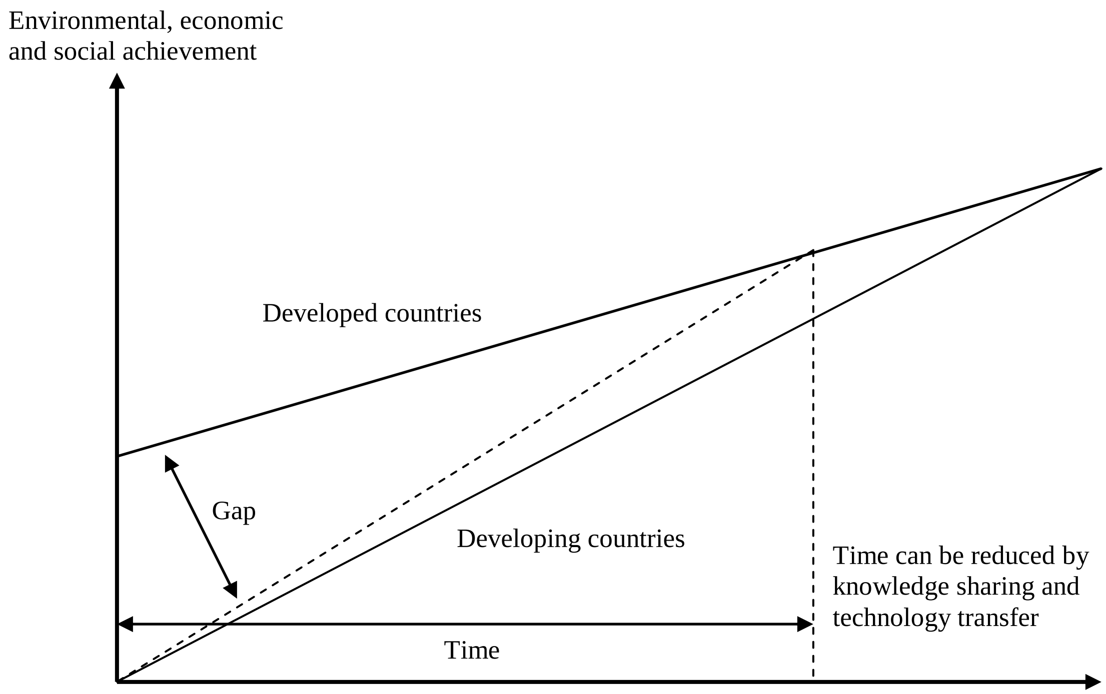

Figure 4-6 Sustainable construction challenges to fill the gap for economics, social and environmental achievement between developed and developing countries

An example of environmental benefits is the waste reduction. An improved waste reduction brings significant advantages to the overall benefits of sustainable construction. It is essential for the construction industry to understand the importance of the environment. The environmental benefits could spread widely and can be the most desirable decision to be considered in a construction project. The economic benefit, such as employment, will significantly improve the economy. This benefit is seen as a major benefit in developing countries. Social benefits, such as health and safety, are important for human needs involving in the industry and should be a significant agenda for the industry stakeholders.

Furthermore, there are many indicators related to sustainable construction and the most suitable identified indicators are waste reduction, quality, material recycling, flora and fauna protection, air pollution control, noise pollution control, water pollution control and energy saving. In addition, cost and time are also considered as significant indicators. In previous studies, there was little consideration to account for cost and time saving and that represents technical barriers to promote sustainable construction.

Table 4-2 summarizes the identified sustainable construction indicators from review of past literature from 1994 to 2010. It includes the research done by Kibert (1994) who conducted a pioneering study on sustainability, in which ten sustainable construction indicators were identified and expanded into 85 sub-indicators related to building procurement methods. Those sub-indicators have been selected as performance indicators in several subsequent studies on building procurement methods (see Love *et al.*, 1998; Skitmore and Marsden, 1998; Alhazmi and McCaffer, 2000; Chan *et al.*, 2003). Thus, a proper sustainable construction framework for building procurement method is needed.

Table 4-2 Comprehensive summary of literature and sustainable construction indicators

Literatures	**Indicators**										
	Group	1) Quality	2) Cost saving	3) Design	4) Time saving	5) Waste reduction	6) Procurement - materials	7) Health and safety	8) Employment	9) Profitability	10) Application of advanced management method and technology
Kibert (1994)	TSCI	√		√		√	√	√			
Mitchell (1996)	TSCI	√	√				√	√	√		√
Hill and Bowen (1997)	TSCI	√	√	√	√	√	√	√	√	√	√
Guy and Kibert (1998)	TSCI	√	√		√	√	√	√			
Ofori (1998)	DCSCI	√	√	√	√	√	√	√	√	√	√
A21 SCDC (2002)	DCSCI	√	√	√	√	√	√	√	√	√	√
Reffat (2004)	DCSCI	√	√	√	√	√	√	√	√	√	√
Carter (2005)	TSCI	√	√	√	√	√	√	√		√	√
Gomes and Silva (2005)	DCSCI	√	√	√		√	√	√	√	√	√
Manoliadis *et al.* (2006)	TSCI	√	√	√	√	√	√	√		√	√
Shen *et al.* (2006)	TSCI	√		√		√	√	√		√	√
Carter and Fortune (2007)	TSCI	√	√	√	√	√	√	√		√	√
Du Plessis (2007)	DCSCI	√		√	√	√	√	√	√	√	√
Kibert (2007)	TSCI	√	√	√	√	√	√	√			√
Carter and Fortune (2008)	TSCI	√	√	√	√	√	√	√		√	√
Jaillon and Poon (2008)	TSCI	√	√	√	√	√	√	√	√	√	√
Halliday (2008)	TSCI	√		√		√	√	√			√

Kibert (2008)	TSCI	√	√	√		√	√	√			√
Matar *et al.* (2008)	TSCI	√				√	√	√		√	√
Sev (2009)	TSCI	√		√		√	√	√	√		
Zainul Abidin (2010)	DCSCI	√	√	√			√	√	√	√	√
Abu Bakar *et al.* (2011)	TSCI	√		√		√	√	√			√
Total		22	15	19	12	20	23	23	10	14	19

Note 1: **TSCI** = typical sustainable construction indicators; **DCSCI** = developing countries sustainable construction indicators;
Note 2: the literatures in year and alphabetical order

Table 4-3 Comprehensive summary of selection of procurement indicators

Literatures	Speed / time	Certainty (cost saving)	Flexibility	Quality	Complexity	Risk (allocation/ avoidance)	Price competition / total cost	Responsibility	Competent contractor	Clear user's requirement	Familiarity	Arbitration and dispute	General needs	Design innovation
Skitmore and Marsden (1998)	√	√	√	√	√	√	√	√						
Love *et al.* (1998)	√	√	√	√	√	√	√	√				√		
Hashim (1999)	√	√		√	√		√				√		√	√
Alhazmi and McCaffer (2000)	√		√	√			√						√	√
Cheung *et al.* (2001)	√	√	√	√	√	√	√	√						
Chan *et al.* (2001)	√	√	√	√	√	√	√	√	√	√	√			
Hashim *et al.* (2006)	√	√	√	√	√	√	√	√	√		√		√	

Note: These studies are ranked in chronological order followed by the alphabetical order of the authors

4.2.3 Building Procurement Method and Indicator

The process of developing decision making framework for this research has been enhanced by reviewing and identifying related procurement methods and its indicators. A conceptual idea, as shown in Figure 4-7 below, was formulated to link sustainable construction, related strategy, and building procurement methods.

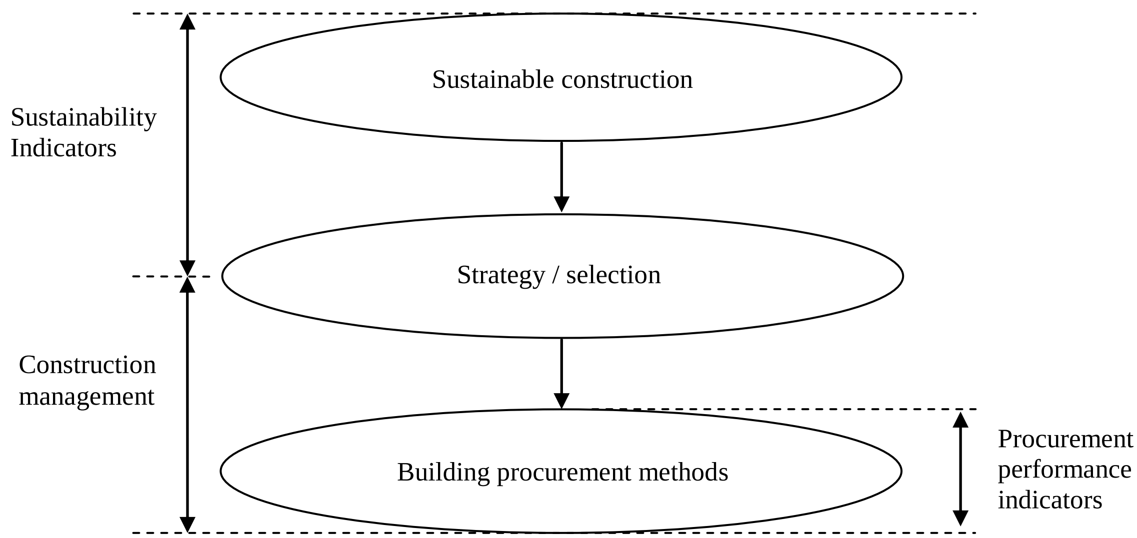

Figure 4-7 A conceptual idea

Mitchell (1996) argued that many typical sustainable indicators developed in the past could not fulfil both local and global needs. Furthermore, he also revealed that some indicators were formulated without necessary feedback and consultations from the public. It was suggested that proper selection of sustainability indicators would also encourage local sustainability agenda. Thus, it is recommended that researchers should consider variation in population and geographical relations (e.g. different country, different culture) in the use of relevant sustainability indicators.

The well-known indicators of sustainable constructions, as presented by Kibert (1994) are: (1) conserve; (2) reuse; (3) renew or recycle; (4) protect the nature; (5) non-toxic; (6) economics; and (7) quality. Time and cost are two additional indicators that should also be taken into consideration (see also Halliday, 2008). These indicators are important and useful in promoting sustainable building practice provided they are designed with care and used properly, and not be used to mislead or misinform (Mitchell, 1996). Indicators should be simplified and understandable in measuring sustainability (Guy and Kibert, 1998), and should be useful to construction industries (Ofori, 2001). Ofori believes that the methods for indicators measurement and compilation with the intention of formularisation should meet specific demands, such as local suitability.

Manoliadis *et al.* (2006) proposed a set of indicators, i.e. (1) energy conservation; (2) waste reduction; (3) indoor environmental quality; (4) environmental-friendly energy technologies; (5) resource conservation; (6) incentive programmes; (7) performance-based standards; (8) land use regulations and urban policies; (9) education and training; (10) re-engineering the design process; (11) sustainable construction materials; (12) new cost metrics based on economic and ecological value systems; (13) new kinds of partnerships and project stakeholders; (14) product innovation and/or certification; and (15) recognition of commercial buildings as productivity assets. A21 SCDC (2002) has outlined nine key points on challenges of sustainable construction in developing countries, which are (1) internalizing sustainability; (2) profitable while meets sustainability requirement; (3) mobilization of resources; (4) public awareness; (5)

improving the quality of construction process and its products; (6) reducing resource use; (7) innovation in building materials and methods; (8) environmental health and safety; and (9) procurement procedures. Brown *et al.* (2001) suggested that the construction sector performance improvement in the United Kingdom consist of (1) capital cost; (2) construction time; (3) predictability; (4) defects; (5) accidents; (6) productivity; (7) turnover and profits. Manoliadis *et al.* (2006) argued that achieving sustainable built environment requires a shift in the way of approaching the time, cost and quality constraints. Table 4-3 shows a comprehensive summary of the selection of procurement methods extracted from past literatures from 1998 to 2013. Skitmore and Marsden (1998), is among the earliest research on sustainable construction which discussed the importance of building procurement methods. Table 4-4 shows the details of the identified indicators.

Table 4-4 Summary of the identified indicators

SUSTAINABILITY INDICATORS	PROCUREMENT PERFORMANCE INDICATORS
Waste reduction	Speed / time
Procurement	Certainty (cost saving)
Employment	Flexibility
Quality	Quality
Cost saving	Complexity
Time saving	Risk (allocation /avoidance)
Design	Price competition / total cost
Environmental assessment	Responsibility
Profitability	Competent contractor
Energy efficiency	Explicit user’s requirement
Transportation	Familiarity
Site selection	Arbitration and dispute
Solid waste management	General needs
Health and safety	Design innovation
Durability and maintenance	

Recycling	
Non-toxic	
Protecting health and comfort	
Flora and fauna protection	
Noise pollution control	
Air pollution control	
Water pollution control	

The relationships of the indicators are recognized, and the framework of argument and future direction for building procurement methods are developed, as shown in Figure 4-8.

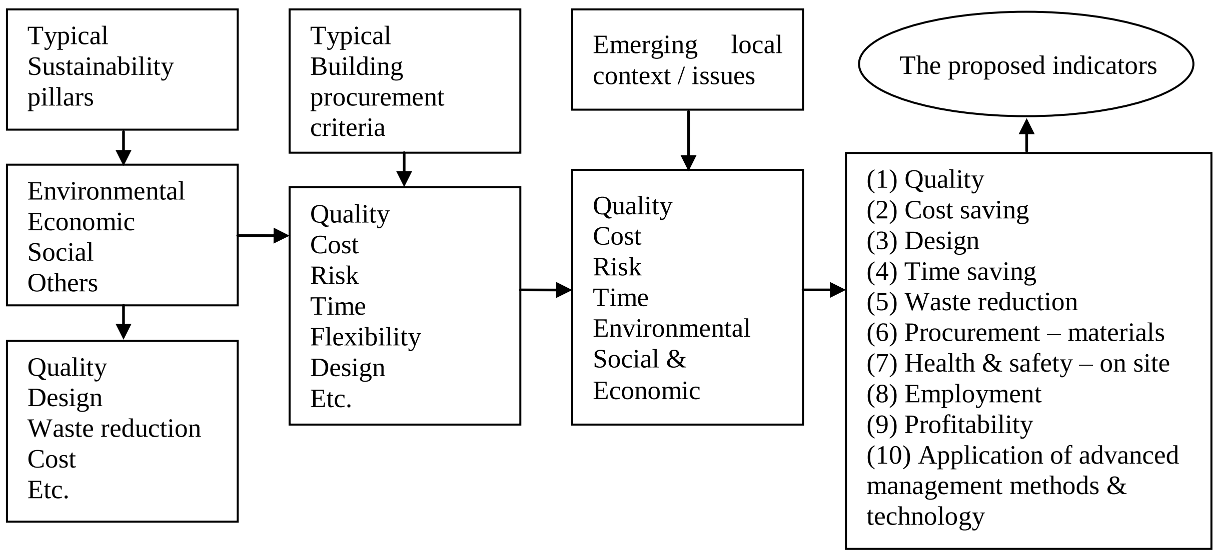

Figure 4-8 Frameworks of the argument and future direction for building procurement methods

The framework outlines the process to match typical indicators of sustainable construction with indicators for building procurement methods. These are then linked to emerging local context and issues. Finally, the proposed indicators are then established. The first step in the framework is the identification of sustainable construction indicators.

4.3 Scoring Framework for Sustainable Procurement Decision Making Framework

Having understood and conducted comprehensive literature reviews on sustainable development, sustainable construction and various building procurement methods, this section discusses the way to integrate all related indicators to develop a scoring framework for Sustainable Procurement Decision Making. About ten (10) relevant indicators were selected and proposed including: (1) quality; (2) cost saving; (3) design; (4) time saving; (5) waste reduction; (6) procurement – materials; (7) on-site health and safety (8) employment; (9) profitability; and (10) application of advanced management methods and technology. Figure 4-9 illustrates the proposed set of indicators. Selected indicator is used as a starting point in generating the entire comprehensive framework. Therefore, the structure of the framework is divided into ten indicators.

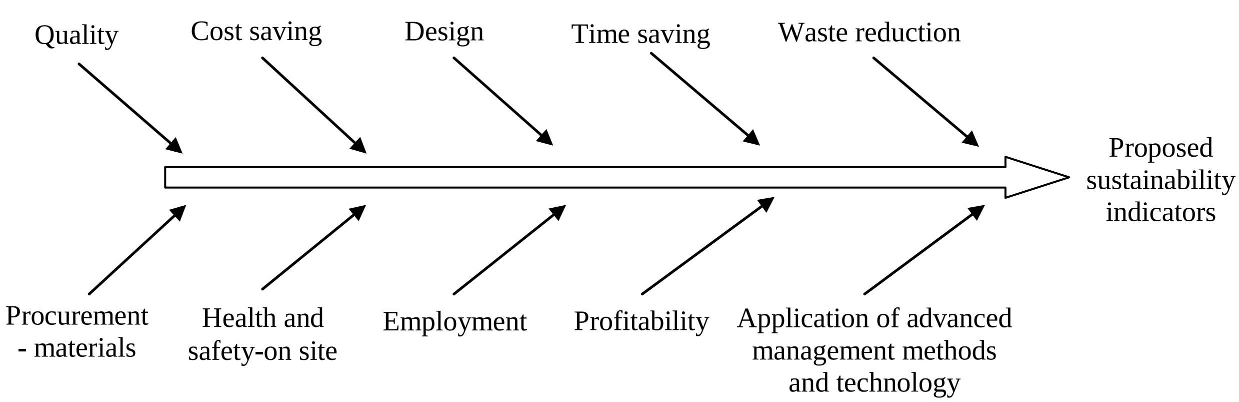

Figure 4-9 Proposed 10 sets of indicators for decision making framework

The proposed scoring framework for developing Sustainable Procurement Decision Making was then named as SuProDem Framework. It is developed to expand the knowledge and integrate the empirical and theoretical knowledge between sustainable development, sustainable construction and building procurement method in promoting sustainable procurement.

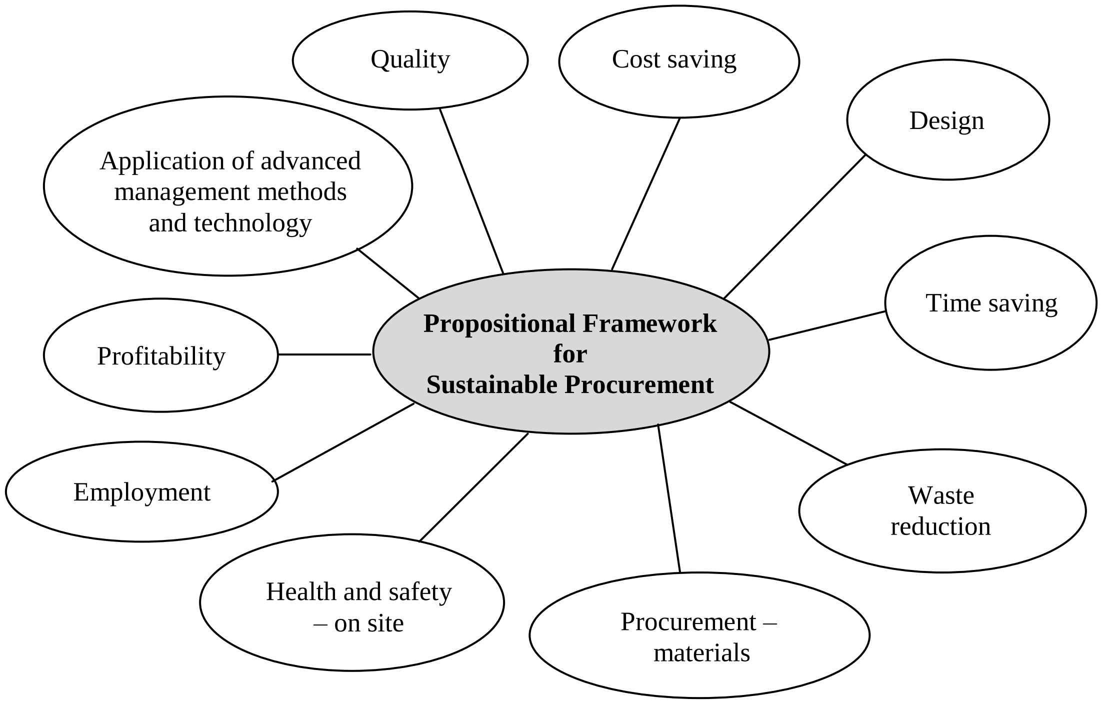

Figure 4-10 Scoring Frameworks for SuProDem Framework (Stage 1)

The framework is then expanded to include sub-indicators. The indicators and sub-indicators from literatures are elaborated as follows:

<u>1) Quality</u>

Kibert (1994) emphasized quality as one of major sustainable construction principles. Dalgliesh et al. (1997) suggested that the pursuit of quality for built environment would relate to environmental and social sustainability. Hill and Bowen (1997) explained that the quality of the built environment is essential to promote sustainable construction. Egan (1998) promoted a quality-driven agenda by working together with all professionals. The measurement of quality is well-recognised in sustainable construction and can provide good fundamental indicators for assessment (Kibert, 1994; Hill and Bowen, 1997; A21 SCDC, 2002). Hashim et al. (2006) considered that the quality level is not radically affected by the building procurement methods arrangement used, but depend on clients' experience and detailed information of contract documentation provided by consultants.

2) Cost saving

Cost is an important factor for the performance evaluation of construction projects (Barnes, 1988; Shen, 1993; Chan et al., 2003; Jakaitis, 2008). One of the major issues of sustainable construction in developing countries is the high cost (Dalgliesh *et al.*, 1997; Majdalani *et al.*, 2006; Du Plessis, 2007). Egan (1998) suggested specific actions should be considered for construction industry to obtain value for money. The Langkawi Declaration on the Environment (1989) pledged to take immediate actions to thoroughly tackle environment issues by identifying suitable techniques to incorporate environmental issues in economic decision-making.

3) Design

A hastily made design could neglect sustainable construction concepts (Rwelamila *et al.*, 2000). Design can be related to the contractors' reputation, aesthetics and confidence (Love *et al.*, 1998). Al-Momani (2000) suggested design changes could lead to consequences such as extra energy consumptions, cost overruns, and prolonged construction time. Design changes, particularly at construction stage, can cause construction wastage and time delays (Ekanayake and Ofori, 2000; Osmani *et al*. (2008).

4) Time saving

Time provides the measurement capability and feedback over sustainability performance (Guy and Kibert, 1998). Typical perception is that the sustainable construction would increase the amount of professional work required (Majdalani *et al*., 2006). The advancement of research in exploring various types of engineered-to-order methods help reducing lead times (Ballard et al., 2003). The delays in construction projects affect the client's profit margins (Mohanty, 1992; Cheung *et al.*, 2001). Longer time means higher investment cost and affects sustainable product achievement (Sterner, 2002).

5) Waste reduction

On-site wastage problem consists of both tangible and intangible waste due to incomplete drawing and insufficient design (Bossink and Brouwers, 1996; Ekanayake and Ofori, 2000; A21 SCDC, 2002; Saunders and Wynn, 2004). Begum et al. (2007) suggested waste minimization should be well planned in the early stage of design and tendering stage with adequate training for on-site staffs (see also Saunders and Wynn, 2004). A21 SCDC (2002) stated that a reduction of building material wastage could reduce construction costs. Kulatunga et al. (2006) pointed out that the amounts of waste in actual site operations are much higher than the allowance given by estimator in pre-construction stage. Poon (2007) suggested the use of technologies can contribute to waste reduction significantly.

6) The procurement – material

Sterner (2002) promoted green procurement in construction procurement practice (see also Ekanayake and Ofori, 2000). Gardiner (2007) discussed sustainable procurement action plan in improving sustainability. A choice of high-quality material is important for sustainable construction (A21 SCDC, 2002). A designer should consider using less material, low-energy materials, selecting recycled materials and designing for recycling with long lifespan materials (Spence and Mulligan, 1995; Kibert, 2007; Kibert, 2008).

7) Health and safety

Health and safety are defined as promoting health and general safety of workers at construction site and eliminating major accidents (Bubshait and Almohawis, 1994). They would benefit the workers socially and set a good benchmark for construction industry (A21 SCDC, 2002). Chan (2000) suggested that one vital performance of procurement method is the safety. Zou and Sunindijo (2010) suggested that a safety climate refers to employee's perceptions and attitudes towards safety in the organization or at their workplace at a certain point of time.

8) Employment

It is well understood that construction industry provides employment opportunities (Ngowi, 2002). Dalgliesh *et al*. (1997) stated that one of sustainable construction principles is the training and capacity enhancement of local staffs. Hill and Bowen (1997) suggested that employment opportunities are the social benefits derived from construction activities. Rowlinson and McDermott (1999) believed that the involvement of foreign contractors and consultants in developing countries could affect the employment opportunities for the locals.

9) Profitability

It is well understood that the parties who involve in the construction industry are interested in obtaining high-profit margins (Cheng and Li, 2005; Kulatunga *et al.*, 2006; Majdalani *et al.*, 2006; Zainul Abidin, 2010). Profitable projects could generate sustainable business environments and promote growth of employments (Akintoye *et al.*, 2003; Halliday, 2008). Zainul Abidin and Pasquire (2007) believed that an efficient use of resources such as manpower, materials, financing could contribute to increasing profitability and economic sustainability.

10) Application of advanced management methods and technology

Tonn *et al.* (2000) suggested that the use of an environmental decision-making process would incorporate sustainability concerns. Technology gives construction industry numerous advantages that support sustainable construction (Du Plessis, 2007). Information technology is important for rapid advancement in the construction industry (Rowlinson and McDermott, 1999) and value management can improve sustainability and increase efficiency (Zainul Abidin and Pasquire, 2005; Zainul Abidin and Pasquire, 2007). Promoting partnering is a new approach and useful in construction industry

(Carter, 2005). Information technology is a benefit to construction industry (Ali *et al.*, 2002; Li *et al.*, 2005). Lean construction can promote sustainability by reducing material wastage, and increase value for clients (Huovila and Koskela, 1998).

From the above reviews on relevant literature, the scoring framework at Stage 1 was then expanded to include relevant sub-indicators as shown in Table 4-5.

Table 4-5 Frameworks for SuProDem Framework (Stage 2)

1) Quality	2) Cost saving	3) Design
Better quality control and quality assurance of the project	Better value for money	Better integrated design and construction
Better quality of service and advice from project team	Better price competition from the bidding process	Better cost-effective design
Better quality of client's brief	Better budget control	Better flow of information on design (reduction of insufficient or incorrect information, others)
Meeting clients' needs	Controllable variation in cost	Better control of the design and supervision of the work
Meeting users' satisfaction	Improving contractor's resources utilization efficiency	Enhanced aesthetic appearance of the building
Meeting project team satisfaction	Reduction of cost overrun (project)	Promoting green design (energy conservation, others)
Reduction of inadequate supervision of the project	Reduction of incorrect cost estimation	Promoting design innovation (prefabrication, others)
Reduction of error in the contract documents	Reduction of maintenance cost (life-cycle)	Reduction of conflict of interests among parties involved in design process
Reduction of engineering rework	Reduction of monetary claims	Reduction of design changes (in general)
		Reduction of delays due to drawing revision and distribution
4) Time saving	**5) Waste reduction**	**6) Procurement – materials**
Better early start to implement a construction project	Better waste management	Better client involvement in choice of materials
Better planning and designing time	Better site communication to avoid abortive works	Better choice of materials (project)
Better detailing and coherent work program (project)	Better site planning to avoid travel distance	Better quality materials specification
Better cooperation amongst project team	Promoting education and training	Better value for money (material)
Completing works by dates agreed	Promoting green technologies	Promoting green procurement – material (environmentally friendly products)
Minimization of activities interference (general)	Reduction of insufficient or incorrect information	Reduction of ordering error (not in compliance with specification)
Reduction of overall project duration	Reduction of changes due to client's requirements	Reduction of quantities error – material (over ordering and under ordering)
Reduction of changes (construction)	Reduction of unused materials and products	Reduction of unused materials and products
Rapid response to client needs	Reduction of paperwork (e.g. using less paper)	Reduction of unclear specification

(project)		
7) Health and safety – one site	**8) Employment**	**9) Profitability**
Better decision on health and safety issues	Better allocation of responsibilities amongst staff	Better financial control
Better attitude and culture towards health and safety issues	Better working relationship in the project team (reduction of conflicts, others)	Better risk management
Improving safety performance on site	Better knowledge sharing	Better cash flow
Increasing awareness on health and safety issues	Improving level of empathy within the project team	Better project risks sharing amongst project participants
Reduction of professional negligence	Improving performance and motivation amongst project members	Improving profit margin
Reduction of accident rate	Increasing productivity	Reduction of cost, such as loan interest.
	Job creation and empowerment	Reduction of construction and design risk to client
	Promoting local professional employees	General reduction of administrative cost
	Promoting gender equity and community empowerment	
	Reduction of stressful working environment	
10) Application of advanced management methods and technology		
Better use of information technology (IT)		
Better concern for environmental issues (in general)		
Improving accountability of contractors		
Promoting value management		
Promoting lean construction		
Promoting partnering		

4.3.1 Propositional scoring framework with detailed priority rating

Base on the above discussion and data analysis from respondent feedback, Figure 11 and Table 4-6 shows the propositional – final stage of scoring framework for SuProDem Framework which becomes a fundamental platform in this research. Sev (2009) recommended a framework that included principles, strategies and methods; offers tools for construction industry stakeholders (urban designer, architect, planners, contractors and supplier); aims to help when developing the most appropriate assessment tool based on the priorities of critical conditions. The framework was designed to complement framework at stage 1, and the subsequent scoring method was developed from the qualitative result generated by a series of interview among clients, contractors, and consultants. The scoring framework for SuProDem framework is finally proposed as a decision tool that can be utilized for the selection process of sustainability-compliant building procurement methods in next chapters.

4.3.2 The Wittgenstein family-resemblance concept

This research applies the Wittgenstein family-resemblance concept. It is a 'sun-flower theory' to present a unique approach for range of data analysis. The concept was used in many studies on construction industry (Nystrom, 2005; Yeung, 2007). An idea of family-resemblance was used to structure an indicator. The concept was adopted and started by Ludwig Wittgenstein, a German philosopher (Nystrom, 2005).

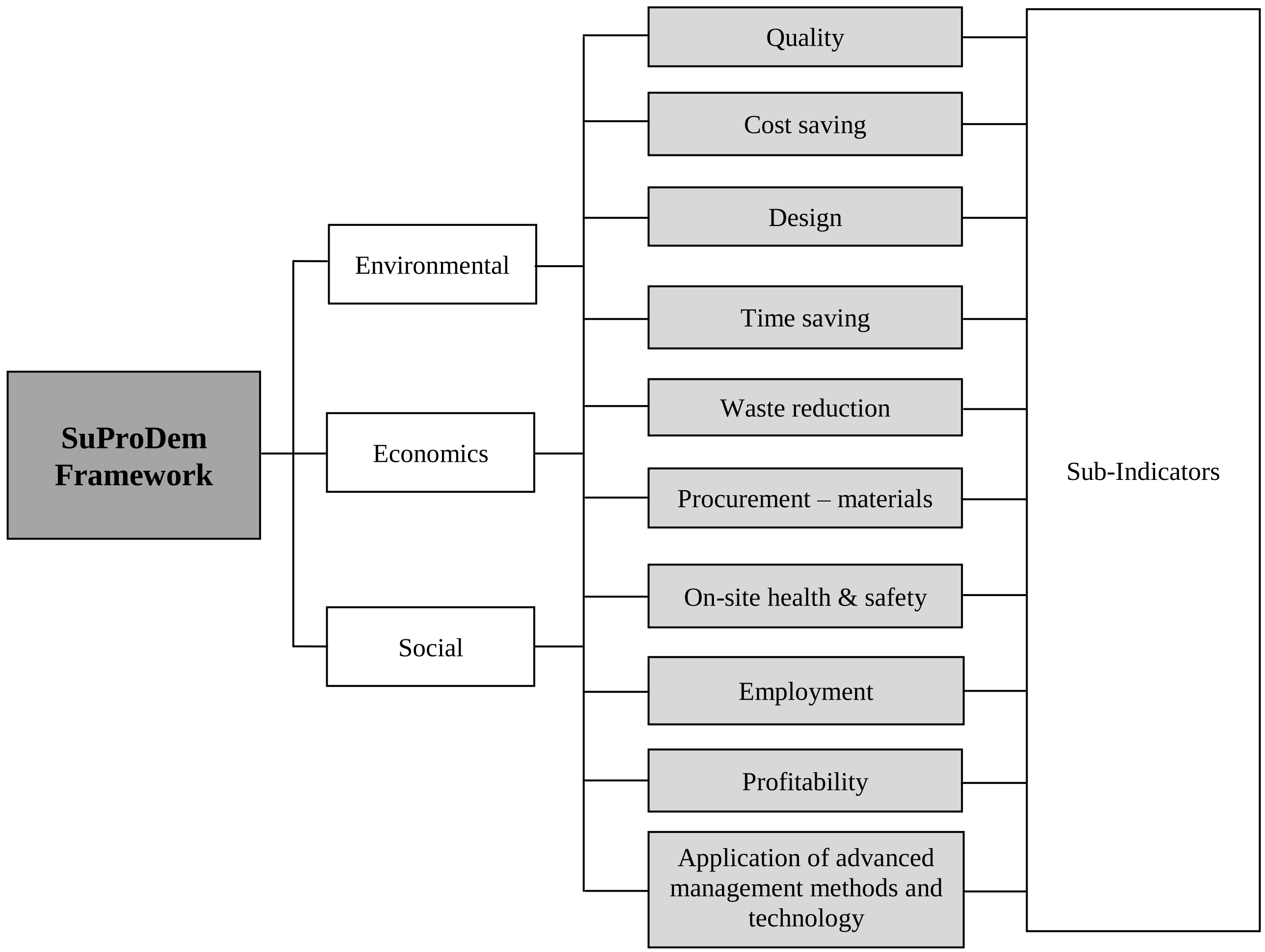

Figure 4-11 Scoring Frameworks of SuProDem Framework

Table 4-6 Indicator and Sub-Indicator in the Scoring Framework of SuProDem Framework: – Final Stage

1) Quality	**2) Cost saving**	**3) Design**
Better quality control and assurance of project	Better value for money	Better integrated design and construction
Better quality service and advice from project team	Reduction of maintenance cost (life-cycle)	Promoting green design (energy conservation)
Meeting user's satisfaction	Improving contractor's resources utilization efficiency	Better cost-effective design
Better quality of client's brief	Better budget control	Promoting design innovation (prefabrication, others)
Meeting the client's needs	Reduction of cost overrun (project)	Better flow of information on design (reduction of insufficient or incorrect information)
Reduction of engineering rework		Better control of the design & supervision of the work
Reduction of error in the contract documents		
Reduction of inadequate supervision of the project		
4) Time saving	**5) Waste reduction**	**6) Procurement – materials**
Better planning and designing time	Better waste management	Promoting green procurement – material (environmentally-friendly products)
Better cooperation amongst project team	Promoting green technologies	Better quality materials specification
Better detailing and coherent work program	Better site communication to avoid abortive works	Better value for money (material)
	Reduction of unused materials and products	Better choice of materials (project)
7) Health and safety – one site	**8) Employment**	**9) Profitability**
Better attitude and culture towards health and	Better knowledge sharing	Better financial control

safety issues		
Increasing awareness on health and safety issues	Increasing productivity	Better risk management
Improving on-site safety performance	Better allocation of responsibilities amongst staffs	Optimal control of cash flow
Enforcing on health and safety issues	Improving performance and motivation amongst project members	
Reduction of professional negligence	Better working relationship in project team (harmonious negotiation , reduction of conflicts, etc)	
Elimination of accidents		
10) Application of advanced management methods and technology		
Better concern for environmental issues (general)		
Better use of information technology		
Promoting value management		
Enforcing accountability of contractors		
Promoting lean construction		

A priority questionnaire and rationalized priority rating was also discussed. Table 4-7 shows a framework of sustainability and building procurement methods.

Table 4-7 A framework of sustainability and building procurement methods

Priority questions	Priority question	Rationalized priority rating	Procurement options					
			Traditional method		Integrated method / Design and Build		Management method	
			U.F.	Score	U.F.	Score	U.F.	Score
1) Indicators		Client Type / Project Type						
2) Indicators		A framework of the procurement methods and sustainability						
3) Indicators								
4) N								
Totals								
Rank order								

Note: U.F. = Utility factor; Score = Scoring

In general, there is a complex network in sustainable construction within construction industry. Nystrom (2005) suggested that the Wittgenstein method is flexible as it does not restrict the meaning of a concept to a small number of simple characteristics.

The sustainability flower concept is adopted in the networking and with overlapping results. It is an important criterion to determine the importance of sustainability and also for future reference. An application of a scoring framework is useful for researchers, making it easy to link various sustainability indicators. Firstly, the preliminary scoring framework arranges relevant sustainability indicators for building procurement methods. A strategy that overlaps many features has been suggested between sustainability and building procurement method. An application of this concept can be found in Chapter 7.

4.4 Summary

This chapter presents the results of data analysis derived from extensive literature reviews to achieve Objectives 1 and 2. Specifically, it combines empirical and theoretical knowledge between sustainable development, sustainable construction and building procurement methods. Finally, a scoring framework, i.e. the SuProDem framework was developed as a fundamental platform in this research. The following chapter continue with detailed explanation on how data collection was conducted to validate the scoring framework that has been developed.

CHAPTER 5 DATA COLLECTION FOR SuProDem FRAMEWORK

CHAPTER 5

DATA COLLECTION FOR SuProDem FRAMEWORK

5.1 Introduction

This chapter describes detail explanation on how data collection been conducted in order to validate the scoring framework that has been developed in the previous chapter including the data collection methodology used in this thesis. This research adopted a mixed mode research design involving quantitative and qualitative methods. A quantitative approach was used to generate reliable research findings, whilst the qualitative approach was used to collect in-depth research findings. Because of quantitative data being numerical (Keith, 1998), a set of reliable data was required. Quantitative methods are essential for empirical research and are considered to be 'objective' in nature (Naoum, 1998). Questionnaire surveys were thus developed based on the research objectives for this research. Questionnaire surveys provide a quick and relatively low cost method of obtaining responses from a large population (Vogt, 2007; Fellows and Liu, 2008; Knight and Ruddock, 2008). The survey questions were based on the key issues identified in the literature and scoring framework. Pilot studies were also conducted to develop robust survey instruments.

Construction professionals, including clients, contractors, and consultants, was selected to obtain reliable data on the knowledge and expertise of the respondents. The questionnaire was specifically designed to allow comparison of the perceptions of two groups of construction industry stakeholders, namely, contractors and consultants. The survey design was based on the best practices established from the literature review, and was tested in a pilot survey. The main empirical study, which involved several industry-wide surveys, was conducted in Malaysia between 2009 and 2011. The respondents were requested to rate their agreement on each of the identified indicators according to a Likert Scale ranging, for example, from 1 = not significant to 5 = extremely significant.

5.2 Techniques for Data Collection

The data collection technique used in the survey involved questionnaire surveys and personal interviews. Case studies were also conducted to verify the findings, which are described and discussed in chapter 7. The case studies used postal questionnaires, which are widely used in research and are one of the best solutions for conducting major surveys. The postal survey also provided a simple and easy way to handle the large amounts of data. Personal interviews were conducted to supplement the quantitative survey data.

5.3 The Pilot Studies

A pilot study was conducted for each of the individual industry-wide surveys using a small group of respondents. A pilot study is normally conducted before a major survey (Naoum, 1998) to improve the standard of the survey instrument. The pilot studies generated numerous spontaneous answers from the respondents. The respondents were given a stipulated period in which to complete the questionnaires. The results of the pilot studies were used to clarify the questions in the main surveys. The pilot studies highlighted some difficult questions that were clarified according to the responses. The profiles of the respondents were also used to develop further questions and for future reference. The assessments obtained from the pilot studies ensured that high-quality questionnaires were used in the major surveys.

5.4 Data Collection

The data were collected in relation to four objectives, and the data collection processes were divided into four corresponding stages. The first-stage involved collecting data on a questionnaire regarding sustainable construction methods. The second stage collected data on sustainability indicators. In the third stage, data were collected for the scoring framework. In the fourth stage, data were collected for the case study that is discussed in chapter seven. The responses were collected in both soft and hard format. The collected data were then analyzed using the selected methodological approaches. Each body of data was collected from a group of potential respondents. Before each major survey, research data were initially collected in a pilot study. The data collection in each stage allowed the flow of data to be examined. The surveys aimed to measure the respondents' perceptions on a range of questions. A Likert scale was used to determine the strength of the respondents' views on each questionnaire item. Table 5-1 shows the framework of the Likert scales used for the different questions posed for objectives one to four.

Table 5-1 Framework of the Likert scales used for the different questions asked in relation to objectives one to four

Objective / questions	Questions 1	Questions 2	Questions 3	Questions 4	Questions 5
Objective number 1	(1) totally disagree; (2) disagree; (3) neutral; (4) agree; (5) totally agree; and (0) no idea.	(1) not significant; (2) less significant; (3) medium significant; (4) significant; (5) totally significant; and (0) not applicable.	(1) no contribution; (2) less contributable; (3) medium contributable; (4) contributable; (5) major contribution; and (0) not adopted.	(1) strongly disagree; (2) disagree; (3) neutral; (4) agree; (5) strongly agree; and (0) no idea.	(1) not effective; (2) less effective; (3) medium effective; (4) effective; (5) totally effective; and (0) no idea.
Objective number 2	(1) not familiar; (2) less familiar; (3) neutral; (4) familiar; (5) very familiar.	(1) not familiar; (2) less familiar; (3) neutral; (4) familiar; (5) very familiar.	(1) no contribution; (2) less contributable; (3) medium contributable; (4) contributable; (5) major contribution.	(1) not significant; (2) less significant; (3) medium significant; (4) significant; (5) very significant; and (0) not applicable.	
Objective number 3	(1) no contribution; (2) less contributable; (3) medium contributable; (4) contributable; (5) major contribution.	(1) no contribution; (2) less contributable; (3) medium contributable; (4) contributable; (5) major contribution.	(1) not significant; (2) less significant; (3) medium significance; (4) significant; (5) very significant	(1) not significant; (2) less significant; (3) medium significance; (4) significant; (5) very significant	
Objective number 4 (Case study)	(1) not significant; (2) less significant; (3) medium significance; (4) significant; (5) very significant	(1) not significant; (2) less significant; (3) medium significance; (4) significant; (5) very significant			

A Likert scale was used to determine the respondents' perceptions of specific issues. The rating scale was designed to determine the reliability of the different questions and to capture the overall perspectives of the different respondents.

Further tests were conducted to ensure the reliability of the survey instruments and to validate the range of data that were collected from the respondents.

5.4.1 Reliability

Reliability is important as it determines the significance of the relevant data and analyses. The reliability of the most significance features was considered, and the tests verified the reliability of the revised versions of the survey instruments and the corresponding analyses. The measurements were also revised to improve the reliability of the findings and to ensure the clarity of the underlying concepts.

5.4.2 Validity

Validity is essential to clarify the relevance of the data obtained and the research framework. It is also important to establish a validity to counter any problems relating to insufficient data and to identify any problems with the research questions.

5.5 Verification Process on Selected Indicators and Sub-indicators for SuProDem Framework

In this section, the research continues by explaining the verification process over selected indicators and sub-indicators through questionnaires which were distributed to various construction players in Malaysia. The first-stage, it involved conduction of survey through questionnaire for verifying sustainable construction methods. It was then followed by the second stage conducting survey through questionnaire for verifying selected sustainability indicators. The questionnaire surveys aimed to measure the respondents' perceptions on a range of questions. A Likert scale was used to determine the strength of the respondents' views on each questionnaire item.

5.5.1 Verification Process on Sustainable Construction Methods

A questionnaire survey targeting construction professionals was conducted in Malaysia between January and March 2009. The respondents comprised (1) clients; (2) contractors; (3) consultants; and (4) academics. The questionnaire survey was piloted with a number of small groups of construction professionals and academics in early January 2009. The questionnaire was divided into four parts, namely, (1) company and personal particulars; (2) sustainable construction and the construction industry; (3) sustainable construction and procurement methods; and (4) comments or suggestions. The objective of the survey was to validate Sustainable Construction Methods and evaluate the respondents' perception of the willingness of construction industry stakeholders to implement sustainable construction methods. Four hundred questionnaires were delivered via mail and email to potential respondents in Malaysia. The industry-wide survey explored the prevailing perceptions toward sustainable construction and different building procurement methods. Due to time limitations, the respondents were given only three weeks to complete and return the questionnaires. Table 5-2 shows a detailed breakdown of the numbers of questionnaires sent and received.

Table 5-2 Detailed breakdown of the numbers of sent and received questionnaires

Item	Total
Total number of questionnaires sent by mail	300
Total number of questionnaires sent by email	100
Total number of questionnaires sent	400
Total number of complete questionnaires received	44
Total number of incomplete questionnaires received	15
Ratio of complete replies to total sent	**11.00%**
Ratio of total replies to total sent	**14.75%**

The 15 incomplete questionnaires were accompanied by letters stating that:

1. The firm did not have enough time to fill out the questionnaire;
2. The firm did not understand the topics; or
3. The questionnaire only partially completed.

Forty-four completed questionnaires were returned and used for analysis, giving a response rate for this survey of 11.00%. However, 15 questionnaires were received that were incomplete, making the overall response rate including incomplete responses 14.75%. Although the response rate was fairly low, it is typical for modern surveys and provides an appropriate and representative sample of the construction industry in Malaysia and provides sufficient data to draw reasonable conclusions. Table 5-3 and Figure 5-1 show the numbers of returned questionnaires from the client, contractor, consultant, and academic groups.

Table 5-3 Number of questionnaires returned by each respondent group

Item	Sub-total
Clients (owners, developers, government)	12
Contractors	14
Consultants	10
Academia	8
Total	44

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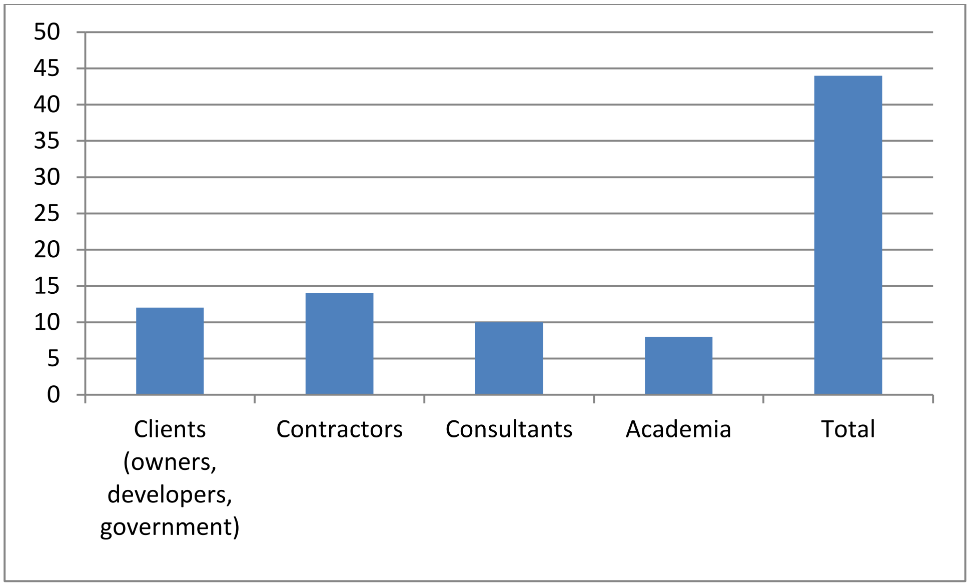

Figure 5-1 Number of questionnaires returned by each respondent group

Among the different respondent groups, the contractors returned the most questionnaires (14), followed by clients (12), consultants (10), and academics (8). Overall, these figures are considered acceptable for this thesis. The respondents were also asked to state their official designation in the questionnaire. Table 5-4 and Figure 5-2 show the official designations of the respondents.

Table 5-4 Official designations of the respondents

Item	Sub-total
Managing Director / Director / Principal	10
CEO / General Manager / Head	8
Manager	7
Professional	6
Executive	5
Academic	8
Total	44

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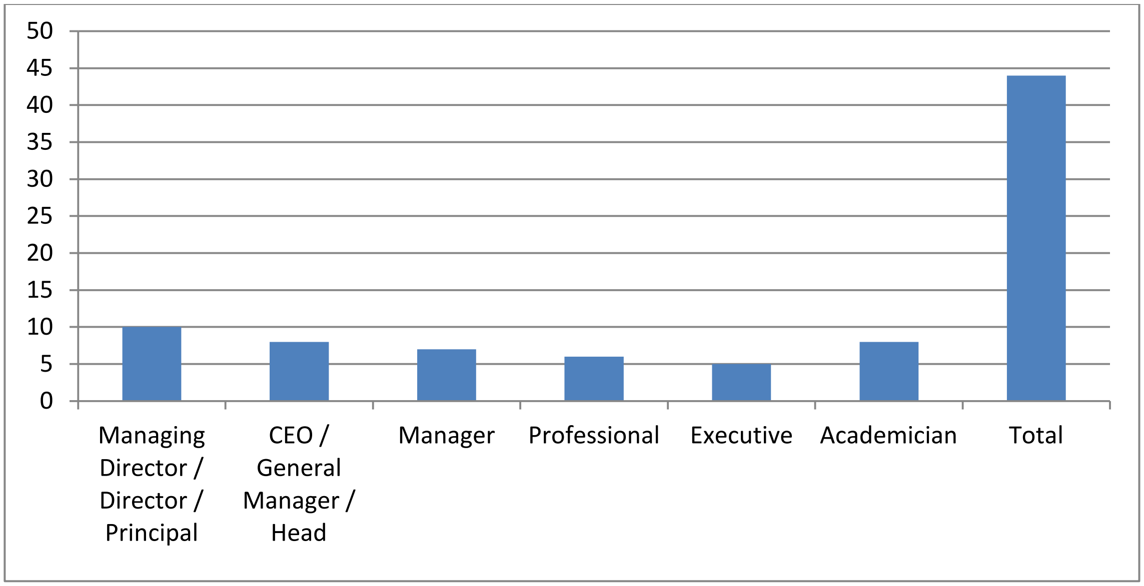

Figure 5-2 Official designations of the respondents

More than 50% of the respondents were identified as managers or above, with around 23% of the respondents being in the top management level of the organization (e.g., managing director, director, or principal). Accordingly, a large percentage of the survey respondents were top executives, which could have influenced the perceptions of the respondents.

5.5.2 Verification on Sustainability Indicators

To select suitable sustainability indicators, this research also undertook another survey in Malaysia between March and June 2010. The questionnaire was divided into four parts: (1) general information; (2) general questions; (3) significance of the indicators; and (4) further comments. The questionnaire survey was first piloted with a small group of construction professionals and academics in March 2010. The main questionnaire survey was designed to capture the perceptions of the respondents. Eight hundred and fifteen firms were selected from the 3,608 firms registered in the Pertubuhan Akitek Malaysia (2010) directory. Questionnaires were sent to each company that had an address in Malaysia. Overall, a reasonable rate of completed questionnaires was returned. Table 5-5 shows a detailed breakdown of the numbers of questionnaires sent and received.

Table 5-5 Detailed breakdown of the numbers of sent and received questionnaires

Item	Total
Total number of questionnaires sent	815
Total number of complete questionnaires received	97
Total number of incomplete questionnaires received	8
Ratio of complete replies received to total sent	11.90%
Ratio of total replies to total sent	12.90%

Eight questionnaires were returned incomplete because:

1. The firm did not have enough time to fill out the questionnaire;
2. The firm found it hard to understand the topic;
3. The questionnaire was partially completed; or
4. The firm had closed or moved.

The respondents were asked to complete the questionnaire within a stipulated period. Table 5-6 and Figure 5-3 shows the number of returned questionnaires from each respondent group.

Table 5-6 Returned questionnaires from each respondent group

Item	Sub-total
Clients (owners, developers, government)	30
Contractors	23
Consultants	44
Other	0
Total	97

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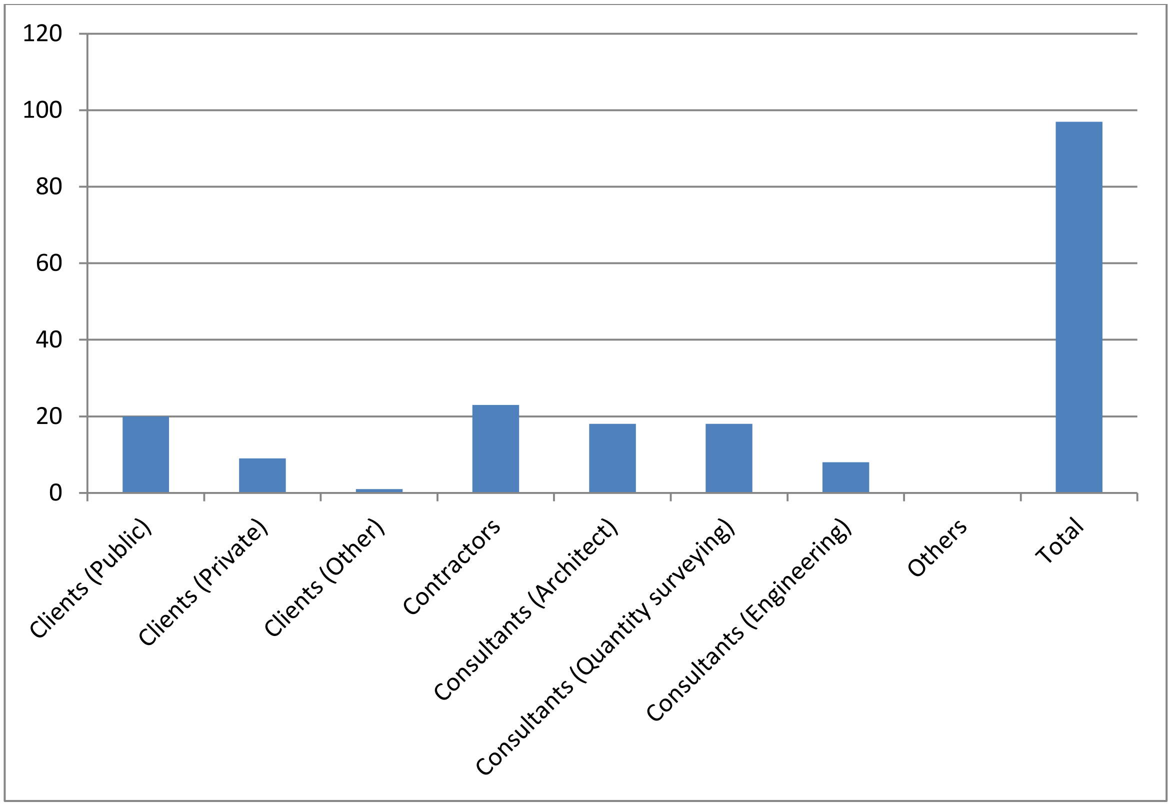

Figure 5-3 Returned questionnaires from each respondent group

Of the 815 questionnaires sent, 97 completed questionnaires were returned (30 from clients, 23 from contractors, and 44 from consultants), giving an overall response rate of 11.90%. Although the response rate was fairly low, it is typical for modern surveys and provides an appropriate and representative sample of the construction industry in Malaysia. The questionnaire also provided data on the designation of the respondents. Table 5-7 and Figure 5-4 shows the official designations of the respondents.

Table 5-7 Official designations of the respondents

Designation	Total	Percentage
Managing Director / Director / Principal / Associates	43	44.33%
CEO / General Manager	6	6.19%
Manager (Project Manager, etc.)	10	10.31%
Professional (Architect, QS, Engineer)	13	13.40%
Executive (Project, Contract, etc.)	11	11.34%
Others	1	1.03%
Not specified	13	13.40%
Total	97	100.00%

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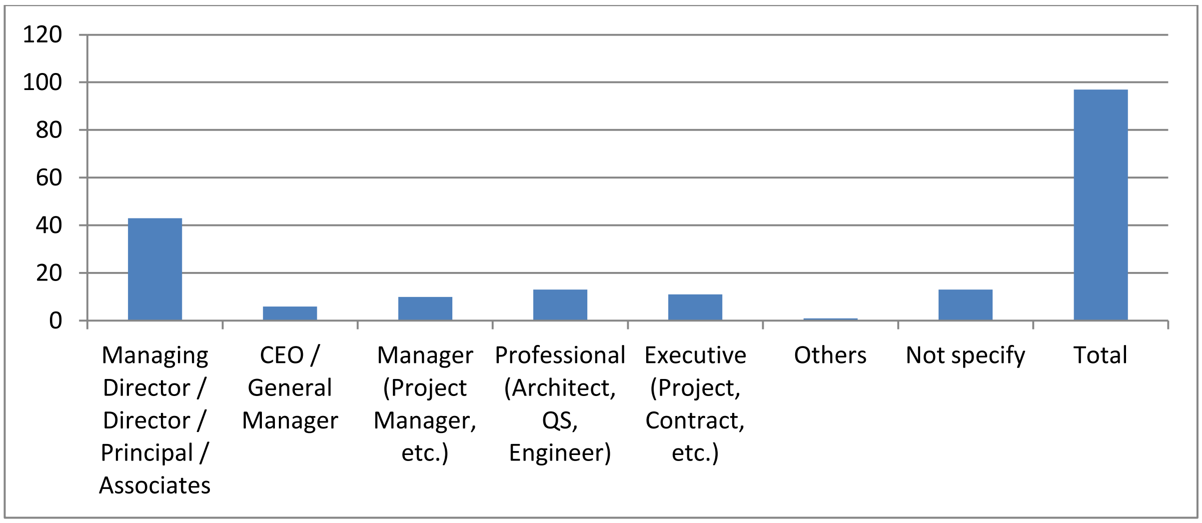

Figure 5-4 Designations of the respondents

Forty-three respondents held a top position in their organization (e.g., managing director, director, principal, associate). Overall, 74.23% of the respondents were managers or above. The range of designations of the respondents is considered sufficient. The survey also collected data on the respondents' work experience. Table 5-8 and figure 5-5 show the number of years the respondents had worked in their respective industries.

Table 5-8 Years' of experience of the respondents in their industry

Years	Sub-total	Percentage
< 5 Years	11	11.34%
5 - 10 Years	12	12.37%
10 - 15 Years	11	11.34%
15 - 20 Years	18	18.56%
20 - 25 Years	12	12.37%
> 25 Years	31	31.96%
Not specified	2	2.06%
Total	**97**	**100.00%**

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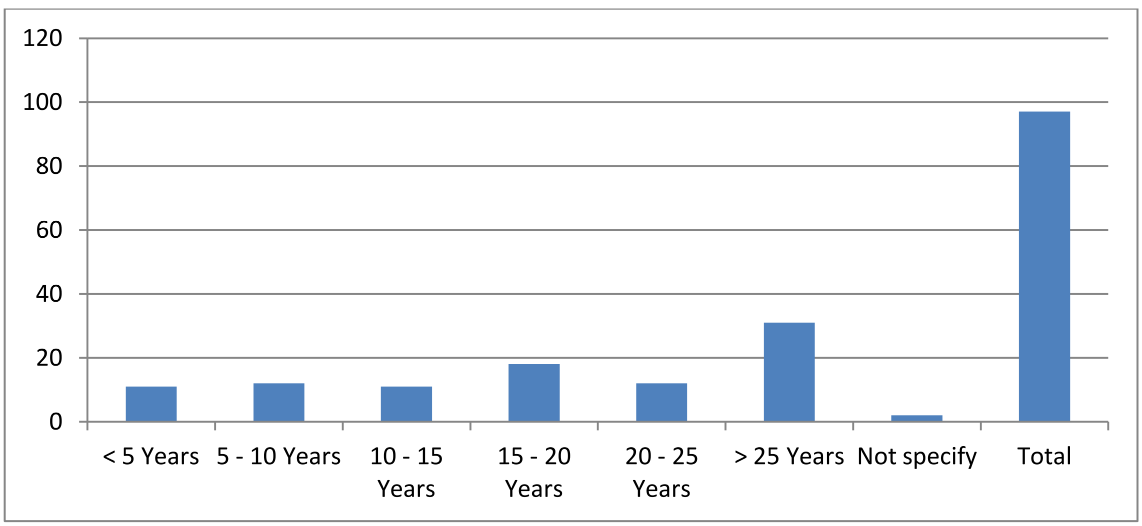

Figure 5-5 The years of experience of the respondents

Over 31% of the respondents had more than 25 years of experience and over 74% of the respondents had more than 10 years of experience in their industry. Overall, the response rates indicate that the respondents were highly qualified and experienced. The respondents were also asked to rate their familiarity with building projects, the concept of sustainable construction, and the sustainability pillars. Table 5-9 shows the respondents' familiarity with building projects, the concept of sustainable construction, and the environmental, economic, and social effects of sustainable construction.

Table 5-9 Respondents' familiarity with building projects, the concept of sustainable construction, and the environmental, economic, and social effects of sustainable construction

	ALL	Client	Contractor	Consultant
(1) Familiarity with building projects	4.34	4.14	4.35	4.48
(2) Familiarity with the sustainable construction concept	3.67	3.79	3.78	3.52
(3) The effects of sustainable construction on the:				
(i) Environment	4.11	4.13	4.04	4.12
(ii) Economy	3.83	3.97	3.83	3.74
(iii) Society	3.72	3.86	3.30	3.86

The average mean score for the respondent's familiarity with building projects was 4.34, while that for the respondent's familiarity with the concept of sustainable construction was 3.67. The environmental, economic, and social effects of sustainable construction also showed consistent results. Overall, these results indicate that the respondents largely believed the environment to be a typical indicator of sustainable construction.

5.5.3 Verification of the overall Scoring Framework

An empirical study was undertaken in Malaysia between October 2010 and February 2011. The questionnaire was developed from the key issues identified in the literature and a pilot study. Of the 3,608 firms registered in the PAM (2010) directory, questionnaires were sent to the 815 firms that had an address in Malaysia. The questionnaires were divided into four parts: (1) general information; (2) general questions; (3) significance of the indicators; and (4) further comments. The respondents were asked to complete the questionnaire within a stipulated period. Table 5-10 shows a summary of the survey responses.

Table 5-10 Summary of the survey questionnaires

Item	Total
Total number of questionnaires sent by mail	815
Total number of completed questionnaires received	72
Total number of incomplete questionnaires received	15
Ratio of completed replies received to total sent	**8.83%**
Ratio of total replies to total sent	**10.67%**

Fifteen questionnaires were returned incomplete because:

1. The firm did not have enough time to fill out the questionnaire; or
2. The questionnaire was only partially completed.

In general, around 9% of the respondents completed the questionnaires. This response rate is considered adequate for this thesis. Table 5-11 and figure 5-6 show the response rates for the different types of organization.

Table 5-11 Responses from different organizations

Types of organization / firm	Sub-total	Percentage
Clients		
Clients (Public)	14	19.44%
Clients (Private)	9	12.50%
Clients (Other)	1	1.39%
Contractors	14	19.44%
Consultants		
Consultants (Architect)	7	9.72%
Consultants (Quantity surveying)	17	23.61%
Consultants (Engineering)	9	12.50%
Other	1	1.39%
Total	72	100%

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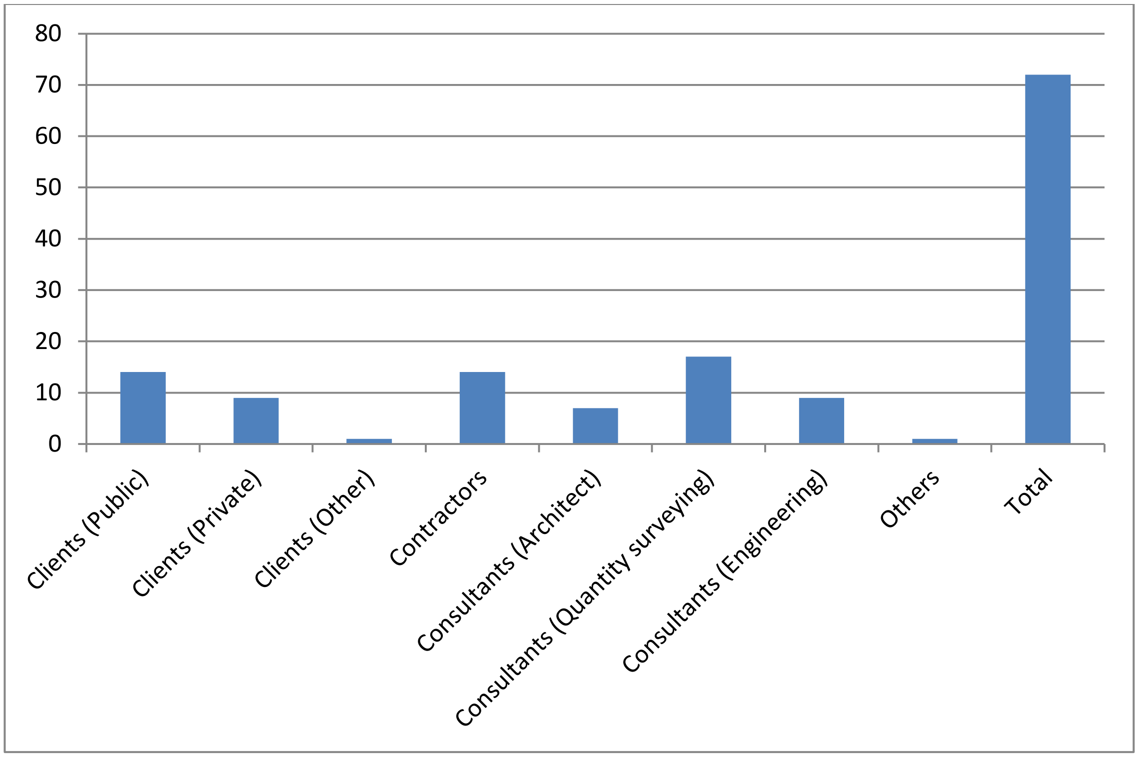

Figure 5-6 Responses from different types of organization

A total of 72 completed questionnaires were returned (24 from clients, 14 from contractors, 33 from consultants, and 1 from other industries), giving a positive response rate of 8.883% for this survey. Although the response rate was fairly low, it is typical for modern surveys and provides an appropriate and representative sample of the construction industry in Malaysia. The survey also achieved an appropriate level of distribution in terms of the different respondent groups. The questionnaires collected information on the respondents' official designation. Twenty-three respondents held top positions in their organizations (e.g., managing director, director, principal, associate). Overall, around 55% of the respondents were managers or above, while around 76% of the respondents had more than ten years, and around 21% had more than 25 years of experience. In general, the results showed that the respondents were highly qualified and experienced. The respondents believed that procurement methods contribute to sustainable construction, with this item receiving an average mean response of about 4.03. The respondents also believed that design and building procurement methods contribute to sustainable construction, with a mean average response for this item being about 3.71. The mean averages for management contracting and tradition were about 3.65 and 3.51, respectively. The mean for each indicator was calculated based on a five-point scale Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

The Likert scale is widely used in studies of this kind (e.g., Naoum, 1998; Chan *et al.*, 2003; Kulatunga *et al.* 2006; Osmani *et al.*, 2008). The questionnaire was specifically devised to allow comparison between the client, contractor, and consultant groups. Descriptive statistics such as the mean and standard deviation were generated to determine and compare the range and variance of the scores. Table 5-12 and figure 5-7 show the designations of the respondents.

Table 5-12 Designations of the respondents

Designation	**Total**	**Percentage**
Managing Director / Director / Principal / Associates	23	31.94%
CEO / General Manager	5	6.94%
Manager (Head, Project Manager, Manager, etc.)	11	15.28%
Professional (Architect, QS, Engineer)	11	15.28%
Executive (Project, Contract, etc.)	11	15.28%
Others	5	6.94%
Not specified	6	8.33%
Total	72	100.00%

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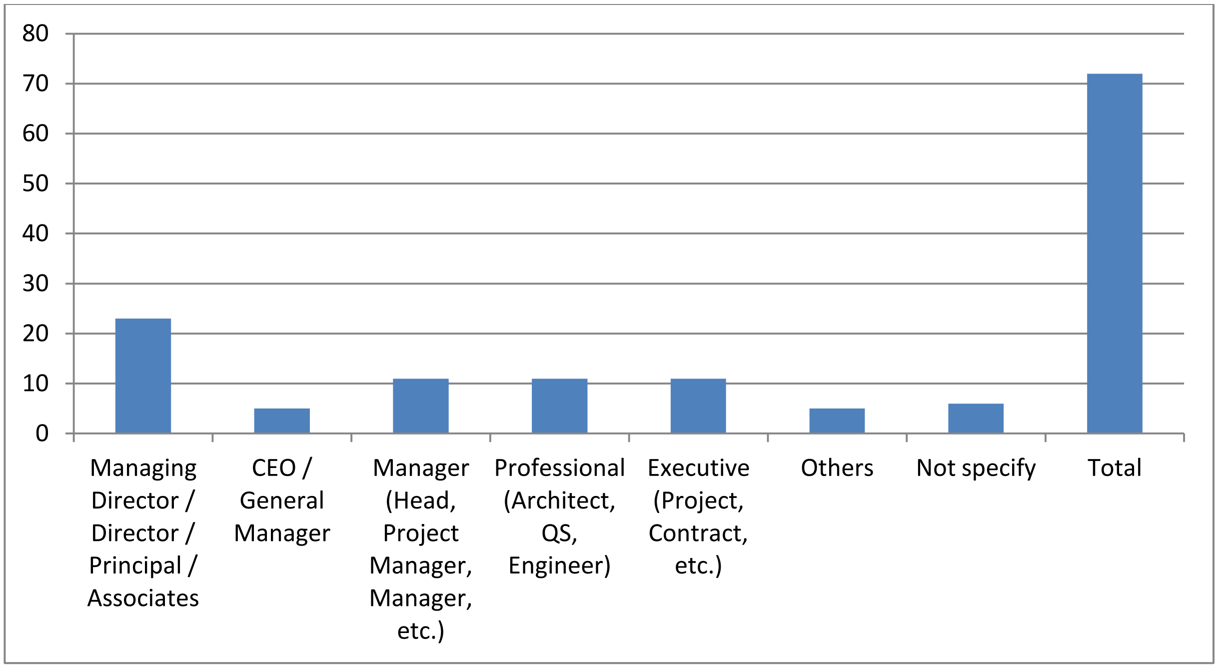

Figure 5-7 Designations of the respondents

Table 5-12 shows that 23 respondents, or around 32% of the total, held top positions in their organizations (e.g., managing director, director, principal). Around 54% of the respondents held a managerial or professional post. Table 5-13 and figure 5-8 show the respondents' total years of experience in the construction industry (personal).

Table 5-13 Total years of experience in the construction industry (personal)

Years	**Sub-total**	**Percentage**
< 5 Years	6	8.33%
5 - 10 Years	10	13.89%
10 - 15 Years	12	16.67%
15 - 20 Years	23	31.94%
20 - 25 Years	5	6.94%
> 25 Years	15	20.83%
Not specify	1	1.39%
Total	72	100.00%

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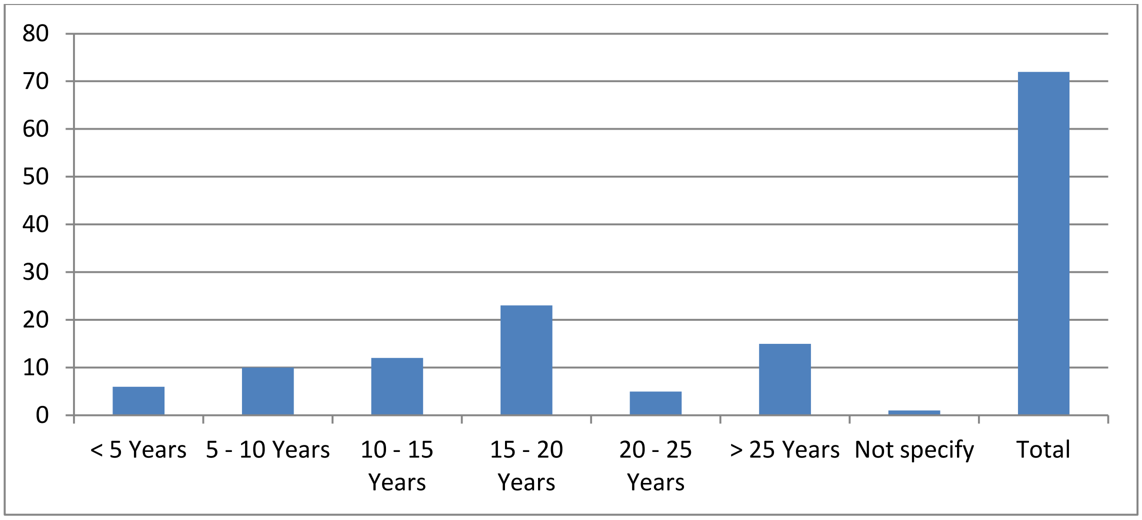

Figure 5-8 Total years of experience in the construction industry (personal)

The respondents' total years of experience ranged from less than 5 to more than 25 years. Table 5-14 shows the general questions on the contribution of procurement methods.

Table 5-14 General questions on the contribution of building procurement methods

	ALL	Client	Contractor	Consultant
(1) Procurement methods contribute to sustainable construction	4.04	4.21	4.00	3.91
(2) Which procurement methods contribute to sustainable construction?				
(a) Traditional	3.50	3.71	3.21	3.45
(b) Design and Build	3.69	3.63	4.00	3.61
(c) Management Contracting	3.64	3.83	3.57	3.52

The results for the general questions suggest that building procurement methods can contribute to sustainable construction because there were similarities in terms of the responses to these indicators from the clients, contractors, and consultants. The general questions were significant, as they determined the respondents' perception of the contribution of building procurement methods to sustainable construction.

5.6 Discussion over Proposition of Sustainability Indicators

Result from questionnaire shows that the proposed sustainability indicators supposedly should address the sustainable construction pillars of environmental, economic and social aspects. Respondent also agrees that the government should improve the law and regulation, and to improve the education system to incorporate knowledge of sustainability in the teaching curriculum. Some of the related comment from respondent as stated as below:

“The governmental rules and regulations and educational system play a very vital role in promoting sustainability in the construction industry”.

“The local industry still lacks from the green or sustainable issues. They just simply produce (construct). Design and build and management contracting may work for big and high profile project only but overall in Malaysia still big failure compared to the United Kingdom and others, for examples, overpriced. Apart from that, the health and safety is still not much improvement although getting slightly better”.

5.6.1 Propositional Indicators and Sub-Indicators

A propositional framework was then discussed for each sub-indicator, and the levels of relationships between sustainability and procurement methods were also determined.

1) Quality

Quality is a major indicator for sustainable construction. However, it depends on many features, for example, specifications. The quality specification is a feature suggested by the following comments from the respondents.

> *"The traditional method can achieve a better quality compared to design and build. This is because in design and build, the contractor tends to maximize their profit because they tend to give low quality product for the construction project".*

The traditional procurement method is important to improve sustainable construction:

> *"The reason why traditional method can contribute to quality is because the client and consultant already at the beginning of the project indicated and specified the specification"*
>
> *"However, if supervision is weak, the quality will be much lower"*

There are also other reasons contributing to the low quality of a construction project. One of the reasons is a lack of supervision from the supervisor.

2) Cost saving

The specification in the cost saving is a feature suggested by the following comment;

> "The traditional procurement method frequently will create many variation orders, which could lengthen the construction period."

3) Design

The specification of design is a range of feature suggested by the following comment:

> "Due to the implication of green building index (still optional) to the construction project recently, I believe this green building index is already creating awareness in sustainable construction to everyone and most project clients apply this green building index to any of the procurement methods. So, I think any procurement method as long as there is a green building index there will be some contribution to sustainable construction"

The sub-indicators are (1) better integrated design and construction; (2) better cost-effective design; (3) better flow of information on design (reduction of insufficient or incorrect information, others; (4) better control of the design and supervision of the work; (5) enhanced aesthetic appearance of the building; (6) promoting green design (energy conservation, others); (7) promoting design innovation (prefabrication, others); (8) reduction of conflict of interests among the parties involved in the design process; (9) reduction of design changes (general); and (10) reduction of delays due to drawing revision and distribution.

4) Time saving

The sub-indicators are (1) better early start to implement a construction project; (2) better planning and designing time; (3) better detailing and coherent work program (project); (4) better cooperation amongst a project team; (5) completing works by dates agreed; (6) minimization of activity interference (general); (7) reducing of overall project duration; (8) reduction of changes (construction); and (9) rapid response to client needs (project).

5) Waste reduction

The specification of the waste reduction is a feature suggested by the following comment:

> "I believe that the design and build has a better waste management practice"

The sub-indicators are (1) better waste management; (2) better site communication to avoid abortive works; (3) better site planning to avoid travel distance; (4) promoting education and training; (5) promoting green technologies; (6) reduction of insufficient or incorrect information; (7) reduction of changes due to client's requirements; (8) reduction of unused materials and products; and (9) reduction of paperwork (using less paper).

6) Procurement – materials

The specification of the procurement – materials is a feature suggested by the following comments:

> "Depending on a location of a project, the consultant's involvement should ensure a minimization (more like optimization) of reduction of carbon footprints. In any case, an increase in expenditure for a landscaping or tree planting is a small step towards this goal"
>
> "The integrity of a contractor is important. A material used should be as in (complied) the spec and no inferior quality. People at a construction site

> are considered important to deliver and respond. They (people at site) must be honest and (act as) a professional in their work ethic. Only people with relevant skills should be employed as the workers at site"

The sub-indicators are (1) better client involvement in choice of materials; (2) better choice of materials (project); (3) better quality materials specification; (4) better value for money (material); (5) promoting green procurement – material (environmentally friendly products); (6) reduction of ordering error (not in compliance with specification); (7) reduction of quantities error – material (over-ordering and under ordering); (8) reduction of unused materials and products; and (9) reduction of unclear specification.

7) Health and safety – on site

The specification of the health and safety – on site is the feature suggested by the following comment:

> "Both procurement methods have less significance on this issue and it depend on site management."

The sub-indicators are (1) better decision on health and safety issues; (2) better attitude and culture towards health and safety issues; (3) improving safety performance on site; (4) increasing awareness on health and safety issues; (5) reduction of negligence (professional); and (6) reduction of accident rate.

8) Employment

The specification of the employment is a feature suggested by the following comment:

> "Regarding employment, there is no significant difference between both procurement methods, probably more the less is the same. Moreover, both methods can create jobs. The traditional procurement method could provide construction professionals an excellent learning experience in a construction project. Both procurement processes could contribute to productivity"

The sub-indicators are (1) better allocation of responsibilities amongst staff; (2) better working relationship with the project team (reduction of conflicts, others); (3) better knowledge sharing; (4) improving the level of empathy within the project team; (5) improving performance and motivation amongst project members; (6) increasing productivity; (7) job creation and empowerment; (8) promoting local employees (professional); (9) promoting gender equity & community empowerment; and (10) reduction of stressful working environment.

9) Profitability

The specification of the profitability is a feature suggested by the following comment:

> "Design and build is more profitable than the traditional method."

The sub-indicators are (1) better financial control; (2) better risk management; (3) better cash flow; (4) better project risks sharing amongst project participants; (5)

improving profit margin; (6) reduction of cost (loan interest, others); (7) reduction of construction and design risk to client; and (8) reduction of administrative cost (general).

10) Application of advanced management methods and technology

The specification in the application of advanced management methods and technology is a feature suggested by the following comments:

> "The administrative cost does not apply in procurement method. It relied on how much the firm used"
>
> "The traditional method is a far much better used of the information technology. Moreover, it is much better concern on the environmental issues. And also the design and build need to follow the client and has a tight monitoring system"
>
> "The accountability of the contractor is much better if adopted design and build"

The sub-indicators for this feature are (1) better use of information technology; (2) better concern for environmental issues (general); (3) improving accountability of contractors; (4) promoting value management; (5) promoting lean construction; and (6) better use of information technology (IT).

5.6.2 Relationship between Sustainable Construction and Building Procurement Methods

This research received various comments and responses from the construction industry stakeholders which highlighted how important to understand the scenario and the challenges in the implementation of sustainability in procurement methods. One respondent commented:

> "Procurement method contributes to sustainable construction only if the players are professional and honest in their respective roles. A procurement method should be based on contractors' capabilities and not on a political influence"

Some respondents do not agree that procurement methods could contribute to sustainable construction. They argued that other factors are more significant, as exemplified in the following comment:

> "In my opinion there is not much of the procurement method that could contribute to sustainable construction. It is much more towards the design, material used, technologies and specifications of material, workmanship should be more specific"

However, it is believed that building procurement method will have an impact on the sustainability provided all parties are professional in their conduct. Thus, it can be a motivating factor for these groups of people to improve their level of thinking and professionalism in their work ethics. A reminder for all parties to be professional is given by the following comment by one of the respondents:

> "Procurement method can contribute to sustainable construction only if the players are professionals and honest in their respective roles. Procurement method should be based on contractors' capabilities and not on political influence"

The sustainability standard in a building project includes various requirements that set a high standard for compliance, ensuring a high quality for a building project.

> "Some sustainability indicators mentioned do not necessarily co-relate to the procurement methods as there is a statutory requirements for the contractors to comply with e.g. safety & health, pollution, cost and time saving applied to the contractor's commercial wisdom. Quality should be part of any construction project, irrespective of procurement methods; it should be approved and agreed among consultants and client. It looks that the Green Building Index encompasses all (almost) indicator mentioned"

The respondents commented that the industry standard is set at a high level, expecting more than the average level required. In addition, uncertainty remains on some building procurement adopted. The following comments highlight this issue:

> "In this kind industry no matter how a method of contracting adopted, the most are the procurement - cost control, and quality of finishes. The building process is not much of a concern to the client .The industry needs the most return on investment, and profit. There are major renovation based on '*Feng Shui*' or other element involved in their life"

“A proposed procurement method which combines both traditional and design and build procurement has to improve the design in procurement stage to make the process fast in the tendering stage. The contractor has to take liability when the building or project finished especially with a defect item in building such as leaking in a toilet (because not enough waterproofing), roof leaking, and others”.

“If design and build contracts are carried out in a transparent manner it will be more effective than other contract for. The way management contract do will determine the level of sustainability that can be achieved”

“The design and build contractor normally can understand and undertake traditional method. Contractors normally employ staff with qualified academic background, staffs has capabilities handling task and company overall have a stronger financial background.”

“The design in a design and build contract is typically made by the contractor, however it would be better if it is designed by the consultant (refer to traditional methods)”

“The traditional method is (normally) handled by the consultant, and there is a tendency for a large variance in the traditional method that could create many variation orders”

“The design & build projects has proven itself to be a wrongful method of procurement. Practically, the spirit of the contractor's to take the risk is no more applicable, as in the end the government (or client) will have to pay for any flaw (fault) in design. The contractors, especially the large players in the industry will offer various excuses for design flaws, and may place the blame on the clients for not opting to pay more for upgraded design. Although in reality, there are already inherent flaws in the original design that has caused problems, both in term of cost and social impact"

"The design and build system in Malaysia for building projects has weakness which result in poor quality buildings (which are being constructed at higher cost). However, they (the design and build) are delivering faster than others. Moreover, the public sector procurement system is not transparent. The management contracting for a building project is not commonly practiced, because of the fear of not getting enough value for money"

5.7 Summary

This chapter explained in detail how data collection been conducted through industry surveys and validation process over scoring framework that has been developed in Chapter 4. The next chapter presents the results from the data collected in this chapter and analyzed it through scoring framework.

CHAPTER 6 DATA ANALYSIS AND SuProDem FRAMEWORK

CHAPTER 6

DATA ANALYSIS AND SuProDem FRAMEWORK

6.1 Introduction

This chapter discusses the data analysis and it was divided into four main stages: (1) the analytical results; (2) research findings and discussion; (3) the proposed framework; and (4) summary. A triangulation method comprising quantitative and qualitative methods was adopted for the data analysis. The method was selected because of a holistic approach for the analysis consideration.

6.2 Analytical Results

The four-research objectives were analyzed in different stages. Descriptive statistics such as the mean and standard deviation were used to compare the range and variance of the scores and for complex calculations. Ranking was used as one of the main tools for the data analysis. A number of statistical tools, namely, (1) significance indices; (2) the *Spearman correlation* (regression); and (3) the *t-test*, were also adopted.

6.2.1 Mean, ranking, and standard deviation

6.2.1.1 Sustainable construction practices in public and private projects

The mean and standard deviation were calculated for the respondents' perspectives on sustainable construction in public and private projects. Table 6-1 shows the results for public projects and sustainable construction practices in Malaysia.

Table 6-1 Public projects and sustainable construction practices in Malaysia

N	Mean	Standard deviation
44	3.20	0.95

The results show that the respondents agreed that public projects comply with sustainable construction practices, with an average mean of 3.20. However, the average mean of 2.95 for private projects indicates that the respondents did not agree that private projects in Malaysia comply with sustainable construction principles. Table 6-2 shows the results for private projects and sustainable construction practices in Malaysia.

Table 6-2 Private projects and sustainable construction practices in Malaysia

N	Mean	Standard deviation
44	2.95	1.12

However, the higher standard deviation for private projects suggests that many of the respondents either agreed or disagreed on this matter and that the group as a whole was uncertain. However, the respondents were also asked to judge the appropriate sustainability indicators. The respondents perceived quality, cost, and energy saving as the top sustainability indicators. These indicators have also been identified as major indicators in the literature. Table 6-3 shows the mean ranking of the sustainability indicators.

Table 6-3 Mean ranking of the sustainability indicators

No.	Indicators	Mean	Rank
4	Quality	4.11	1
2	Cost saving	3.93	2
10	Energy saving	3.86	3
3	Time saving	3.84	4
7	Air pollution control	3.75	5
1	Waste reduction	3.68	6
9	Water pollution control	3.64	7
8	Noise pollution control	3.57	8
5	Material recycling	3.43	9
6	Flora and fauna protection	3.41	10

The mean ranking was calculated for quality, cost saving, energy saving, time saving, air pollution control, waste reduction, water pollution control, noise pollution control, material recycling, and flora and fauna protection. Surprisingly, flora and fauna protection was the lowest scoring indicator, although it is considered an essential part of sustainability in the literature. The respondents were also asked to rate the performance indicators along with their perceptions of particular sustainable construction practices. Table 6-4 shows the respondents' perceptions of sustainable construction methods in Malaysia.

The results show that education and training, lean construction, prefabrication, and waste management were perceived to contribute to waste reduction and environmental management systems to add to air pollution control. Sustainable construction methods such as green building, green design, green procurement, and green roof technologies were perceived to be related to energy saving. Cost and time were considered to be less significant for environmental management systems, green building, green design, green procurement, and green roof technologies, although they constitute critical issues in implementing sustainable construction.

Table 6-4 Perception of sustainable construction methods in Malaysia

Methods		Performance Indicators									
		Waste reduction	Cost saving	Time saving	Quality	Material recycling	Flora and fauna protection	Noise pollution control	Air pollution control	Water pollution control	Energy saving
(1) Education and training	Mean	4.02	3.50	3.41	4.14	3.68	3.68	3.75	3.57	3.82	3.82
	SD	1.09	1.28	1.28	0.80	1.27	1.12	1.14	1.30	1.13	1.21
(2) Environmental management systems	Mean	3.86	2.95	2.70	3.50	3.59	3.93	4.20	4.02	4.02	3.64
	SD	1.29	1.14	1.13	1.02	1.21	1.13	0.98	0.98	0.90	1.16
(3) Green building	Mean	3.20	2.64	2.50	3.36	3.11	3.50	3.70	3.23	3.45	3.93
	SD	1.42	1.16	1.17	1.26	1.28	1.19	1.21	1.34	1.39	1.35
(4) Green design	Mean	3.27	2.77	2.55	3.57	3.23	3.73	3.82	3.34	3.55	4.14
	SD	1.40	1.10	1.21	1.26	1.22	1.19	1.11	1.16	1.19	1.11
(5) Green procurement	Mean	3.07	2.66	2.61	3.32	3.18	3.18	3.16	2.84	3.00	3.32
	SD	1.45	1.12	1.17	1.22	1.33	1.54	1.49	1.38	1.45	1.38
(6) Green roof technologies	Mean	2.84	2.48	2.34	2.89	2.70	3.39	3.57	3.07	3.11	3.95
	SD	1.57	1.19	1.22	1.37	1.41	1.48	1.52	1.42	1.42	1.28
(7) Lean construction	Mean	3.86	3.77	3.70	3.64	3.14	2.64	2.77	2.66	2.66	2.93
	SD	1.21	1.01	1.09	1.14	1.39	1.24	1.33	1.38	1.35	1.42
(8) Prefabrication	Mean	4.02	3.55	4.05	3.93	3.11	2.52	2.95	2.91	2.86	2.86
	SD	0.98	1.09	0.94	1.02	1.32	1.28	1.35	1.33	1.30	1.30
(9) Waste management	Mean	4.27	3.14	2.89	3.27	4.00	3.52	3.61	3.05	3.66	3.16
	SD	0.97	1.25	1.06	1.19	1.14	1.34	1.22	1.33	1.24	1.35

Notes: ☼ – Most Significant ◊ – Significant □ - Adopted Δ - Not adopted

Lean construction and prefabrication are the only methods considered contributing to both cost and time saving, although they made the least contribution to the sustainability indicators. The perceptions of the various construction industry stakeholders were also analyzed with regard to sustainable construction methods. Table 6-5 shows that the construction industry stakeholders' willingness to use the different sustainable construction methods.

Table 6-5 Sustainable construction methods and construction industry stakeholders

Methods / construction industry stakeholders	Government	Clients	Contractors	Designers	Material Suppliers
Education and training	4.32	3.41	2.75	3.66	2.98
Environmental management systems	4.16	3.45	2.84	3.61	2.80
Green building	4.07	3.59	2.80	3.77	2.89
Green design	4.09	3.57	2.82	3.95	3.09
Green procurement	3.84	3.55	2.82	3.77	3.11
Green roof technologies	3.75	3.43	2.64	3.64	3.09
Lean construction	4.00	3.64	3.18	3.57	3.14
Prefabrication	4.20	3.84	3.16	3.75	3.27
Waste management	4.23	3.64	3.11	3.70	3.05
Total mean average	**4.07**	**3.57**	**2.90**	**3.71**	**3.05**

The results indicate that the government is perceived to play an important role in sustainable construction practices, with an average mean score of 4.07, followed by the designers, clients, material suppliers, and contractors. The respondents were also asked to judge the connection between sustainable construction methods and various construction procurement methods. Table 6-6 shows the results for the respondents' perception of the relationship between sustainable construction methods and different construction procurement methods.

Table 6-6 Sustainable construction methods and construction procurement methods

	Traditional	Design and build	Management contracting
Education and training	3.34	3.77	3.66
Environmental management system	3.18	3.75	3.59
Green building	3.14	3.68	3.39
Green design	3.09	3.77	3.32
Green procurement	3.09	3.66	3.34
Green roof technologies	3.02	3.55	3.30
Lean construction	3.09	3.73	3.39
Prefabrication	3.36	3.93	3.61
Waste management	3.11	3.70	3.50
Total mean average	**3.16**	**3.73**	**3.45**

The results suggest that the respondents' agreed that all of the building procurement methods promote sustainable construction. The results also indicate that design and build was perceived to increase the effectiveness of delivering sustainable construction, with an average mean score of 3.73, compared with management contracting at 3.45 and traditional methods at 3.16.

6.2.1.2 Building projects and sustainable construction in Malaysia

The mean and standard deviation were calculated to show the respondents' familiarity with building projects and sustainable construction. This section discusses the respondents' familiarity with (1) building projects; (2) the concept of sustainable construction; (3) the environmental, economic, and social sustainable construction pillars within the Malaysian context; and (4) the types of procurement methods that were frequently used.

a) Familiarity with building projects

The familiarity of clients, contractors, and consultants with building projects was analyzed. Table 6-7 shows the different respondents' level of familiarity with building projects.

Table 6-7 Familiarity with building projects.

	All	Clients	Contractors	Consultants
Familiarity with building projects	4.34	4.14	4.35	4.48

The clients, contractors, and consultants' familiarity with building projects was assessed. The average mean score for all respondents is 4.34, while the scores for clients, contractors, and consultants are 4.14, 4.35, and 4.48, respectively.

b) Familiarity with the concept of sustainable construction

Table 6-8 shows the results for the respondents' familiarity with the concept of sustainable construction.

Table 6-8 Familiarity with the concept of sustainable construction

	All	Clients	Contractors	Consultants
Familiarity with the sustainable construction concept	3.67	3.79	3.78	3.52

The results show an overall average mean for the respondents' familiarity with sustainable construction is 3.67. The clients had the highest mean at 3.79, followed by the contractors at 3.78 and the consultants at 3.52. Although the respondents' level of familiarity is above 3.00 (neutral), the results are still below 4.00 (familiar). This could indicate that various construction industry stakeholders have different project demands and are less aware of the concept of sustainable construction.

c) Environmental, economic, and social nature of sustainability in the Malaysian context

Table 6-9 shows the results for the respondents' perceptions of the environmental, economic, and social dimensions of sustainability in the Malaysian context.

Table 6-9 Environmental, economic, and social dimensions of sustainability in Malaysia

Environmental, economic, and social dimensions of sustainability in Malaysia	**All**	**Clients**	**Contractors**	**Consultants**
(i) environmental	4.11	4.13	4.04	4.12
(ii) economic	3.83	3.97	3.83	3.74
(iii) social	3.72	3.86	3.30	3.86

Analysis of the respondents' perceptions of the environmental, economic, and social contributions of sustainable construction shows that the average mean contribution to the environment is 4.11, while the corresponding figures are 3.83 for the economic and 3.72 for the social contributions.

d) Most frequently used types of procurement method

Table 6-10 Types of procurement method most frequently used

Building type	**Traditional**	**Design and Build**	**Management Contracting**
1) Residential	66.9%	18.6%	14.4%
2) Commercial (office, shop, hotel, etc.)	47.3%	31.3%	21.4%
3) Industrial (factory, mill, etc.)	38.1%	47.6%	14.3%
4) Government (parliament, police station, etc.)	39.3%	43.6%	17.1%
5) Health (hospital, clinic, etc.)	27.3%	52.5%	20.1%
6) Educational (school, university, etc.)	41.8%	42.5%	15.7%
7) Military (barracks, tower, etc.)	28.8%	51.2%	20.0%
8) Transit stations (airport, bus, etc.)	20.8%	52.0%	27.2%
9) Religious (mosque, church, etc.)	64.6%	28.3%	7.1%

6.2.1.3 Sustainable construction and procurement methods

The mean was calculated to show the respondents' perceptions of how different procurement methods contribute to sustainable construction. This section discusses (1) how procurement methods contribute to sustainable construction and (2) which procurement methods contribute to sustainable construction.

a) <u>Contribution of procurement methods to sustainable construction</u>

Table 6-11 shows the results for the respondents' views on how much procurement methods contribute to sustainable construction.

Table 6-11 (10) Contribution of procurement methods to sustainable construction

Contribution of procurement methods to sustainable construction	All	Clients	Contractors	Consultants	Other
	4.04	4.21	4.00	3.91	5.00

<u>b) Which procurement methods contribute to sustainable construction</u>

Table 6-12 shows the results for the respondents' views on which procurement methods contribute to sustainable construction.

Table 6-12 Contribution of particular procurement methods to sustainable construction

Contribution of particular procurement methods to sustainable construction	All	Clients	Contractors	Consultants	Other
(i) Traditional	3.50	3.71	3.21	3.45	4.00
(ii) Design and Build	3.69	3.63	4.00	3.61	4.00
(iii) Management Contracting	3.64	3.83	3.57	3.52	4.00

6.2.2 Significance indices

Three statistical tests, namely, (1) *significance indices*; (2) *the Spearman rank-order correlation coefficient (r)*; and (3) *t-tests*, were used to test the hypotheses. To compare the 'pattern of ranking' in the respondents' views in relation to public building projects, a null hypothesis (Ho) was used to validate the results. The results show that there is significant 'agreement' among the respondents. The responses were ranked from the most important to the least important. The significance indices indicate that if indices of 70.00 points are used, 49 sub-indicators are selected. However, if the significance indices are more than 75.00 points, 22 sub-indicators are selected. The ranking of these groups associated with the respondents' perceptions of (1) quality; (2) cost saving; (3) design; (4) time saving; (5) waste reduction; (6) procurement – materials; (7) health and safety – on-site; (8) employment; (9) profitability; and (10) the application of advanced management methods and technology. These indicators were identified previously in chapter 4 (Scoring framework). Figure 6-1 shows the calculation of the relative significance indexes:

$$\frac{Ri0 \times 0 + Ri1 \times 20 + Ri2 \times 40 + Ri3 \times 60 + Ri4 \times 80 + Ri5 \times 100}{Ri0+Ri1+Ri2+Ri3+Ri4+Ri5} = \frac{20Ri1 + 40Ri2 + 60Ri3 + 80Ri4 + 100Ri5}{Ri0+Ri1+Ri2+Ri3+Ri4+Ri5}$$

where S*i* = significance index for the ith factor or sub factor;
R*i*0 = number of response as "0" for the ith factor or sub factor;
R*i*1 = number of response as "1" for the ith factor or sub factor;
R*i*2 = number of response as "2" for the ith factor or sub factor;
R*i*3 = number of response as "3" for the ith factor or sub factor;
R*i*4 = number of response as "4" for the ith factor or sub factor;
R*i*5 = number of response as "5" for the *i*th factor or sub factor.

Figure 6-1 Significance indexes (Source: Zhang, 2005)

6.2.2.1 Results

Significance indices were used to assess the significance of the indicators and to rank the responses. Table 6-13 shows the results for no. (1) quality.

Table 6-13 (1) Quality results

(1) Quality	Number of responses						Significance indices	Rank
	0	1	2	3	4	5		
Better quality control and assurance of the project	0	0	3	17	34	43	84.12	1
Better quality of service and advice from the project team	0	0	5	16	45	31	81.03	2
Meeting the user's satisfaction	0	2	7	19	47	22	76.49	3
Better quality of client's brief	0	4	8	20	36	29	76.08	4
Meeting the client's needs	0	3	8	26	42	18	73.20	5
Reduction in the amount of engineering rework	2	1	10	21	44	19	73.20	5
Reduction of errors in the contract documents	1	5	11	24	33	23	71.34	7
Reduction in the inadequate supervision of the project	1	6	8	27	38	17	70.10	8
Meeting the project team's satisfaction	1	4	7	28	48	9	69.90	9

It is not surprising 'better quality control and assurance of the project' was the most important indicator of quality among all respondents. The second most important indicator was 'better quality of service and advice from the project team,' while 'meeting the user's satisfaction' was also perceived to be important. However, 'meeting the project team's satisfaction' was seen as the least important indicator. These results are not surprising because the 'nature' of quality driven by the perceptions and expectations of the clients. Because quality is accessed as a subjective judgment by professionals, other parties may have different priorities in regard to each indicator. The results indicate that the majority of respondents favored adopting quality control and assurance for their projects. Moreover, the analysis focused on identifying the range of perceptions among the respondents to establish the 'pattern of the rankings' among the indicators. Cost saving was also important. Table 6-14 shows the results for no. (2) cost saving.

Table 6-14 (2) Cost saving results

(2) Cost saving	Number of responses						Significance indices	Rank
	0	1	2	3	4	5		
Better value for money	0	1	5	14	45	32	81.03	1
Reduction of maintenance costs (life-cycle)	0	2	9	14	47	25	77.32	2
Improving the utilization efficiency of the contractor's resources	0	2	7	19	51	16	73.61	3
Better budget control	2	3	10	20	41	21	72.58	4
Reduction of cost overrun (project)	4	3	7	25	40	18	70.52	5
Controllable variation in cost	4	3	9	22	45	14	69.48	6
Better price competition from the bidding process	0	4	11	28	39	14	69.28	7
Reduction of incorrect cost estimation	2	4	8	33	33	17	69.28	7
Reduction of monetary claims	2	4	13	32	37	9	65.77	9

With regard to cost saving, 'better value for money' was considered to be the most important, followed by 'reduction of maintenance costs (life-cycle).' 'Improving the utilization efficiency of the contractor's resources' was considered important for cost saving. The respondents appreciated that getting value for money is important for gaining economic advantages, which could also be linked to the environmental and social effects of sustainable construction (A21 SCDC, 2002). Cost criteria are always an issue in the construction industry and this is confirmed by the literature (Bakhtiar *et al.*, 2009b). Studies have also stressed that cost saving is a critical issue affecting sustainable construction. The respondents indicated that cost saving is not only the sole responsibility of the government as they believed that contractors need to share responsibility in this area together with the government. It is noted that the ranking played a significant role in determining the appropriate results. Design was also found to play an important role in sustainable building. Table 6-15 shows the results for no. (3) design.

Table 6-15 (3) Design results

(3) Design	Number of responses						Significance indices	Rank
	0	1	2	3	4	5		
Better integration of design and construction	1	0	5	14	39	38	82.06	1
Promoting green design (energy conservation, etc.)	0	0	4	20	40	33	81.03	2
Better cost-effective design	0	0	3	22	42	30	80.41	3
Promoting design innovation (prefabrication, etc.)	2	0	6	20	46	23	76.49	4
Better flow of information on design (reduction of insufficient or incorrect information, etc.)	1	1	7	26	41	21	74.64	5
Better control of the design and supervision of the work	2	1	8	25	42	19	73.20	6
Reduction of design changes (general)	3	4	10	30	44	6	65.98	7
Reduction of delays due to revising and redistributing the drawings	4	4	9	34	35	11	65.77	8
Reduction of conflict of interests among parties involved in the design process	4	5	14	28	35	11	64.33	9
Enhanced aesthetic appearance of the building	3	2	17	40	29	6	62.27	10

With regard to design, the respondents agreed ‘better integrated design and construction’ is needed in the construction industry. ‘Promoting green design’ was also seen to be important for energy conservation, and ‘better cost-effective design’ was important in the design. An improved design process could promote sustainable construction over a long period and lead to more efficient sustainable construction, thereby promoting sustainable construction in the long term. The results indicate that the respondents did not perceive design to be the sole responsibility of the client or the design team, as they believed that other construction industry stakeholders should be involved in the design process. Although the findings suggest that these indicators are the most important, other indicators, such as time saving, are also considered to be important. Table 6-16 shows the results for no. (4) time saving.

Table 6-16 (4) Time saving results

(4) Time saving	Number of responses							
	0	1	2	3	4	5	Significance indices	Rank
Better planning and designing time	2	2	8	22	35	28	75.05	1
Better cooperation among the project team	1	2	7	29	34	24	74.02	2
Better detailing and more coherent work program	1	3	7	25	39	22	73.81	3
Completing works by the dates agreed	3	5	10	22	37	20	69.90	4
Reduction of changes (construction)	2	6	8	27	44	10	67.84	5
Rapid response to client needs (project)	0	6	11	30	41	9	67.42	6
Early start to implementing a construction project	5	5	7	30	37	13	66.39	7
Minimization of interference to activities (general)	3	6	9	30	40	9	65.77	8
Reduction of the overall project duration	3	7	12	33	36	6	62.68	9

The respondents perceived ‘better planning and designing time’ to be the most important contributor to time saving, followed by ‘better cooperation among the project team’ and ‘better detailing and more coherent work program.’ Time saving increases the efficiency of sustainable construction and is also important for decision makers in the long term. Time saving can also increase the appreciation of the value of construction. The results indicate that time saving requires team work among the construction industry stakeholders. The respondents also considered waste reduction to be a major contributor to sustainable building. Table 6-17 shows the results for no. (5) waste reduction.

Table 6-17 (5) Waste reduction results

(5) Waste reduction	Number of responses							
	0	1	2	3	4	5	Significance indices	Rank
Better waste management	0	1	7	13	49	27	79.38	1
Promoting green technologies	0	2	4	23	43	25	77.53	2
Better site communication to avoid abortive works	0	4	5	19	43	26	76.91	3
Reduction of unused materials and products	0	4	8	27	45	13	71.34	4
Promoting education and training	1	3	5	41	34	13	69.48	5
Reduction of insufficient or incorrect information	2	2	11	30	39	13	69.07	6
Better site planning to avoid long travel distances	1	7	8	33	36	12	67.22	7
Reduction of changes due to client's requirements	2	7	9	34	33	12	65.77	8
Reduction of paperwork (using less paper)	2	9	8	38	26	14	64.54	9

'Better waste management' was perceived to be the most important contributor to waste reduction, followed by 'promoting green technologies' and 'better site communication to avoid abortive works.' 'Reduction of paperwork (using less paper)' was considered to be the least important. Procurement – materials was also considered to be an important factor in sustainable construction. Table 6-18 shows the results for no. (6) procurement – materials.

Table 6-18 (6) Procurement – materials results

(6) Procurement – materials	Number of responses							
	0	1	2	3	4	5	Significance indices	Rank
Promoting green procurement – materials (environmentally friendly products)	0	0	3	32	39	23	76.91	1
Better quality materials specification	0	2	3	27	48	17	75.46	2
Better value for money (materials)	1	0	8	23	50	15	74.23	3
Better choice of materials (project)	0	1	6	31	44	15	73.61	4
Reduction of unused materials and products	1	4	8	33	39	12	69.07	5
Better client involvement in the choice of materials	1	5	12	34	31	14	67.01	6

Reduction of unclear specifications	2	5	10	34	36	10	66.19	7
Reduction of quantities errors – materials (over ordering and under ordering)	3	5	12	33	35	9	64.54	8
Reduction of ordering errors (not in compliance with specifications)	3	5	13	35	33	8	63.51	9

'Promoting green procurement of materials,' such as environmentally friendly products, was perceived to be the most important procurement (materials) factor in promoting sustainable construction, followed by 'better quality materials specification' and 'better value for money (materials).' 'Reduction of ordering error (not in compliance with specifications)' was considered to be the least important. While this result is not surprising, it indicates that sustainable procurement materials need to be promoted among the construction industry stakeholders to increase the efficiency of sustainable construction. Health and safety on site was also considered to be an important contributor to sustainable construction. Table 6-19 shows the results for no. (7) health and safety on site.

Table 6-19 (7) Health and safety – on-site results

(7) Health and safety – on-site	Number of responses							
	0	1	2	3	4	5	Significance indices	Rank
Better attitude and culture with regard to health and safety issues	0	3	5	26	36	27	76.29	1
Increasing awareness on health and safety issues	0	2	7	23	41	24	76.08	2
Improving safety performance on-site	0	4	5	23	41	24	75.67	3
Better decisions on health and safety issues	0	5	6	24	37	25	74.64	4
Reduced negligence (professional)	0	5	8	28	39	17	71.34	5
Reduced accident rate	1	8	6	25	34	23	71.34	5

'Better attitude and culture in regard to health and safety issues' was considered to be the most important factor for health and safety, followed by 'increasing awareness on health and safety issues' and 'improving safety performance on-site.' 'Reduced accident rate' was perceived to be the least important contributor, which is a surprising finding. Employment was also considered to be an important contributor to health and safety. Table 6-20 shows the results for no. (8) employment.

Table 6-20 (8) Employment results

(8) Employment	Number of responses						Significance indices	Rank
	0	1	2	3	4	5		
Better knowledge sharing	0	2	5	27	48	15	74.23	1
Increasing productivity	3	2	7	25	38	22	72.78	2
Better allocation of responsibilities among staff	0	5	6	29	37	20	72.58	3
Improved performance and motivation among project members	1	3	8	28	37	20	72.37	4
Better working relationship among the project team (reduction of conflicts, etc.)	1	5	8	27	39	17	70.72	5
Improved level of empathy within the project team	2	3	9	37	36	10	67.22	6
Job creation and empowerment	2	1	14	33	41	6	66.39	7
Reduction of the stress of the working environment	4	5	16	27	36	9	63.30	8
Promoting local employees (professional)	4	3	14	39	28	9	62.89	9
Promoting gender equity and community empowerment	4	7	20	37	26	3	57.11	10

'Better knowledge sharing' was considered to be the most important contributor to employment, followed by 'increasing productivity' and 'better allocation of responsibilities among staff.' 'Promoting gender equity and community empowerment' are considered to be the least important factors for increasing employment. It is surprising that 'promoting local employees' was one of the least important contributors to employment. Profitability was considered to be an important contributor to sustainable construction. Table 6-21 shows the results for no. (9) profitability.

Table 6-21 (9) Profitability

(9) Profitability	Number of responses						Significance indices	Rank
	0	1	2	3	4	5		
Better financial control	0	2	9	20	41	25	76.08	1
Better risk management	1	3	6	21	45	21	74.85	2
Better cash flow	2	3	10	25	35	22	71.75	3
Reduction of construction and design risk for clients	1	4	12	31	33	16	68.66	4
Better project risk sharing among project participants	1	5	7	36	36	12	68.25	5
Improved profit margin	1	3	14	34	30	15	67.63	6
Reduction in costs (loan interest, etc.)	2	5	11	37	28	14	65.98	7
Reduction in administrative costs (general)	4	2	13	35	31	12	65.36	8

'Better financial control' was considered to be the most important contributor to profitability, followed by 'better risk management' and 'better cash flow.' 'Reduction in administration costs (general)' was considered to be the least important contributor to profitability. The use of advanced management methods and technology was considered to be a major contributor to sustainable construction. Table 6-22 shows the results for no. (10) the application of advanced management methods and technology.

Table 6-22 (10) Application of advanced management methods and technology (10)

(10) Application of advanced management methods and technology	Number of responses						Significance indices	Rank
	0	1	2	3	4	5		
Increased concern for environmental issues (general)	0	0	2	24	44	27	79.79	1
Better use of information technology (IT)	0	0	6	23	51	17	76.29	2
Promoting value management	0	1	7	30	36	23	75.05	3
Improving the accountability of contractors	3	2	6	22	46	18	72.99	4
Promoting lean construction	0	1	6	38	37	15	72.16	5
Promoting partnering	1	3	16	36	31	10	65.36	6

‘Increased concern for environmental issues’ was considered to be the most important contributor to advanced management methods and technology, followed by ‘better use of information technology’ and ‘promoting value management.’ The least important contributor was ‘promoting partnering.’ Theoretically, the research framework can be divided between clients, contractors, and consultants to measure the views of the individual stakeholders with regards to a proper practice for meeting the requirements for sustainable building.

6.2.2.2 Statistical tools

a) Spearman Pearson analysis

Spearman Pearson analysis was conducted on the results for (1) quality; (2) cost saving; (3) design; (4) time saving; (5) waste reduction; (6) procurement – materials; (7) health and safety – on-site; (8) employment; (9) profitability; and (10) the application of advance management methods and technology indicators. The analysis compared the (i) client ranking versus contractor ranking; (ii) client ranking versus consultant ranking; and (iii) contractor ranking versus consultant ranking. The objective of the analysis was to compare the survey results for the various groups of respondents. Table 6-23 shows the results for the quality sub-indicators.

Table 6-23 Quality sub-indicators

Comparison	R	Significance	Conclusion
Client ranking versus contractor ranking	0.6546	0.0557	Reject Ho
Client ranking versus consultant ranking	0.5819	0.1001	Reject Ho
Contractor ranking versus consultant ranking	0.8075	0.0084	Accept Ho

The results show that the contractor ranking versus consultant ranking supports the significance of the sub-indicators. This result indicates that the respondents considered the quality of a building to be important. One of most important considerations for quality is the collaboration between the parties involved. Table 6-24 shows the results for the cost saving sub-indicators.

Table 6-24 (2) Cost saving sub-indicators

Comparison	R	Significance	Conclusion
Client ranking versus contractor ranking	0.5030	0.1674	Reject Ho
Client ranking versus consultant ranking	0.4156	0.2658	Reject Ho
Contractor ranking versus consultant ranking	0.8712	0.0022	Accept Ho

The results show that the null hypothesis (Ho) for contractor ranking versus consultant ranking is accepted and that contractor ranking versus consultant ranking is significant and has the highest correlation value, which indicates that the contractors and consultants have the best relationship. Table 6-25 shows the results for the design sub-indicators.

Table 6-25 (3) Design sub-indicators

Comparison	R	Significance	Conclusion
Client ranking versus contractor ranking	0.8463	0.0020	Accept Ho
Client ranking versus consultant ranking	0.8304	0.0029	Accept Ho
Contractor ranking versus consultant ranking	0.8914	0.0005	Accept Ho

The results show that the null hypothesis (Ho) for ‘contractor ranking versus consultant ranking’ is accepted. Overall, the results indicate that there is a good relationship between the respondents for all the indicators for design because many of the respondents emphasized the respective correlations that were generated. Table 6-26 shows the results for the time saving sub-indicators.

Table 6-26 (4) Time saving sub-indicators

Comparison	R	Significance	Conclusion
Client ranking versus contractor ranking	0.7299	0.0255	Accept Ho
Client ranking versus consultant ranking	0.9193	0.0004	Accept Ho
Contractor ranking versus consultant ranking	0.7591	0.0176	Accept Ho

The results show that the null hypothesis (Ho) for client ranking versus consultant ranking is accepted. The respondents agreed that time saving contributes to sustainable construction with respect to all of the suggested indicators. However, further analysis is needed to determine whether time saving follows the logic of the research findings. Table 6-27 shows the results for the waste reduction sub-indicators.

Table 6-27 (5) Waste reduction sub-indicators

Comparison	R	Significance	Conclusion
Client ranking versus contractor ranking	0.5378	0.1352	Reject Ho
Client ranking versus consultant ranking	0.6833	0.0424	Accept Ho
Contractor ranking versus consultant ranking	0.8167	0.0072	Accept Ho

The results show that the null hypothesis (Ho) for ‘contractor ranking versus consultant ranking’ is accepted. Waste reduction was also deemed to be a significant contributor to the development of sustainable construction. Table 6-28 shows the results for the procurement – materials sub-indicators.

Table 6-28 (6) Procurement – materials sub-indicators

Comparison	R	Significance	Conclusion
Client ranking versus contractor ranking	0.4392	0.2368	Reject Ho
Client ranking versus consultant ranking	0.9293	0.0002	Accept Ho
Contractor ranking versus consultant ranking	0.5443	0.1296	Reject Ho

The results show that the client ranking versus consultant ranking has the most significance. This finding shows that the respondents agreed that clients can work together with consultants and that it is necessary to focus on procurement – materials for sustainable construction. Table 6-29 shows the results for the health and safety – on-site sub-indicators.

Table 6-29 (7) Health and safety – on-site sub-indicators

Comparison	R	Significance	Conclusion
Client ranking versus contractor ranking	0.2253	0.6677	Reject Ho
Client ranking versus consultant ranking	0.3105	0.5491	Reject Ho
Contractor ranking versus consultant ranking	0.8612	0.0275	Accept Ho

The results show that the contractor ranking versus consultant ranking is significant for on-site health and safety. However, most of the rankings are not significant. This indicates that the respondents agreed that contractors can work closely with consultants. Table 6-30 shows the results for the employment sub-indicators.

Table 6-30 (8) Employment sub-indicators

Comparison	R	Significance	Conclusion
Client ranking versus contractor ranking	0.8708	0.0010	Accept Ho
Client ranking versus consultant ranking	0.7519	0.0121	Accept Ho
Contractor ranking versus consultant ranking	0.8796	0.0007	Accept Ho

The results show that the null hypotheses (Ho) for all of the comparisons are accepted. The result for client ranking versus contractor ranking is almost the same as that for contractor ranking versus consultant ranking. Table 6-31 shows the results for the profitability sub-indicators.

Table 6-31 (9) Profitability sub-indicators

Comparison	R	Significance	Conclusion
Client ranking versus contractor ranking	0.8375	0.0094	Accept Ho
Client ranking versus consultant ranking	0.9403	0.0005	Accept Ho
Contractor ranking versus consultant ranking	0.9151	0.0014	Accept Ho

The results show that the null hypotheses (Ho) for all of the comparisons are accepted. These results are understandable because all parties involved in the construction process focus on increasing profitability. The results could also indicate that profitability supports sustainable construction. Table 6-32 shows the results for the application of advanced management methods sub-indicators.

Table 6-32 (10) Application of advanced management methods and technology sub-indicators

Comparison	R	Significance	Conclusion
Client ranking versus contractor ranking	0.9760	0.0008	Accept Ho
Client ranking versus consultant ranking	0.9428	0.0048	Accept Ho
Contractor ranking versus consultant ranking	0.8612	0.0275	Accept Ho

The results show that the null hypotheses (Ho) for all of the comparisons are accepted. These results are understandable because all parties involved in the construction process are particularly interested in the application of advanced management methods and technology. In general, the analyses show that sustainable construction is supported by the construction industry.

6.2.2.3 T-test

a) Hypotheses

To compare the pattern of ranking for the respondents' views on the different sub-indicators, the null hypotheses (Ho) illustrated in Figure 6-2 were put forward for substantiation.

Ho: U1 = U2 or U1 – U2 = 0 H1: U1 ≠ U2 or U1 – U2 ≠ 0

Figure 6-2 The null hypotheses (Ho)

U1 refers to the number one respondents and U2 the number two respondents. The testing was conducted between the 10 indicators. The tests conducted on the relationships between (1) client and contractor; (2) client and consultant; and (3) contractor and consultant. The groups were tested in relation to the sub-indicators of the major identified indicators. The testing tools used were the significance, conclusion, and *t-critical* (2-tail test) from the *t-tests*. The results are different for the sub-indicators of each major indicator and between the groups.

Results included in the Appendices

The full-calculation results shown in Tables 6-55, 6-56 and 6-57 of Appendix C. Table 6-55 of Appendix C shows the results for the relationship between (1) client and contractor. The results indicate that most of the respondents accepted the null hypothesis. Table 6-56 shows the results for the relationship between (2) client and consultant. The results indicate that the respondents largely accepted the null hypothesis, although the relationship is not as strong. Finally, table 6-57 shows the results for the relationship between (3) contractor and consultant. The results indicate that most of the respondents accepted the null hypothesis. In summary, the results indicate that clients and contractors and contractors and consultants are most likely to work together, compared with clients and consultants. The results may also indicate that clients and consultants have different views and perceptions of the building process.

6.2.3 Priority rating and utility factor

6.2.3.1 Results

The priority rating and utility factor of the significance weighting of the respondents' views were examined. The results of these two measures determine the significance of the findings. The priority rating and utility factor results are further discussed in the results section.

a) Priority rating

The priority rating was calculated by creating an input scale of the ratings from the respondents. The ratings based on the results of the structured questionnaire survey of the construction industry stakeholders.

b) Utility factor

The utility factor was calculated to determine the level of significance of the scoring from the respondents.

c) Full priority rating and utility factor results

The results generated from the priority rating, and the utility factor determines the significance of the findings among the respondents. Table 6-33 shows the priority rating scales (mean) for all of the respondents and the individual client, contractor, and consultant groups.

Table 6-33 Priority rating scale for all respondents,
and the client, contractor, and consultant groups (mean)

Indicators	ALL	Clients	Contractors	Consultants	Others
1) Quality	8.33	8.75	8.00	8.18	8.00
2) Cost saving	8.36	8.38	8.29	8.39	8.00
3) Design	7.90	8.25	7.50	7.82	8.00
4) Time saving	7.93	8.04	7.43	8.06	8.00
5) Waste reduction	7.47	7.38	7.93	7.33	8.00
6) Procurement – materials	7.53	7.67	7.43	7.45	8.00
7) Health and safety – on-site	7.35	7.58	7.71	7.00	8.00
8) Employment	6.61	6.67	6.79	6.45	8.00
9) Profitability	7.63	7.46	7.50	7.79	8.00
10) Application of advanced management methods and technology	7.29	7.50	7.14	7.21	7.00

Note: Clients include public and private sector institutions.

The rank order is important for determining the significance of the findings among the different respondents. Table 6-34 shows the rank order of the priority rating scale for all respondents, and the clients, contractors, consultants, and others.

Table 6-34 Rank order of the priority rating scale for all respondents, clients, contractors, consultants, and others

Indicators	ALL	Clients				Contractors	Consultants				
		ALL	Public	Private	Others		ALL	Architects	Quantity surveyors	Engineers	Others
1) Quality	2	1	1	1	1	2	2	4	2	2	2
2) Cost saving	1	2	3	2	1	1	1	3	1	1	8
3) Design	4	3	2	5	6	5	4	1	4	6	8
4) Time saving	3	4	4	4	8	7	3	2	3	4	4
5) Waste reduction	7	9	8	7	1	3	7	8	5	8	4
6) Procurement – materials	6	5	5	9	1	7	5	7	6	6	10
7) Health and safety – on-site	8	6	7	6	1	4	8	6	8	9	6
8) Employment	10	10	10	10	10	10	10	10	9	10	6
9) Profitability	5	8	9	3	6	5	5	9	7	3	1
10) Application of advanced management methods and technology	9	7	6	7	8	9	9	4	10	5	2

The rank order is important for determining the significance of the findings among the different respondents. Table 6-35 shows the summary points and rank for traditional, design and build, and management contracting.

Table 6-35 Summary of points and rank for traditional, design and build, and management contracting

Indicators / Procurement methods	Traditional			Design and Build			Management Contracting		
	Rank			Rank			Rank		
	1	2	3	1	2	3	1	2	3
1) Quality			√		√		√		
2) Cost saving			√	√				√	
3) Design			√	√				√	
4) Time saving			√	√				√	
5) Waste reduction			√	√				√	
6) Procurement – materials			√		√		√		
7) Health and safety – on-site			√		√		√		
8) Employment			√	√				√	
9) Profitability			√	√				√	
10) Application of advanced management methods and technology			√	√				√	
Points	0	0	10	18	8	0	12	12	0
Total	10			26			24		
Rank	3			1			2		

Note: rank 1 = 3 points; rank 2 = 2 points; rank 3 = 1 point

ALL respondents

1) All respondents

Table 6-36 shows the ranking summary for all respondents (clients, contractors, and consultants)

Table 6-36 Ranking summary for all respondents (clients, contractors, and consultants)

Indicators	Traditional	Design and Build	Management Contracting
1) Quality	18	16	13
2) Cost saving	17	12	14
3) Design	23	10	14
4) Time saving	19	9	16
5) Waste reduction	21	9	15
6) Procurement – materials	18	15	12
7) Health and safety	22	12	13
8) Employment	22	11	14
9) Profitability	19	14	12
10) Application of advanced management methods and technology	21	12	12
Total	200	120	135
Ranking (lowest ranking)	3	1	2

2) All respondents (clients, contractors, and consultants)

Table 6-37 shows the ranking summary for all respondents (clients, contractors, and consultants)

Table 6-37 Ranking summary for all respondents (clients, contractors, and consultants)

Indicators	Traditional	Design and build	Management contracting
1) Quality	3	2	1
2) Cost saving	3	1	2
3) Design	3	1	2
4) Time saving	3	1	2
5) Waste reduction	3	1	2
6) Procurement – materials	3	2	1
7) Health and safety – on-site	3	2	1
8) Employment	3	1	2
9) Profitability	3	1	2

10) Application of advanced management methods and technology	3	1	2

The results indicate that design and build was considered to be the most appropriate building procurement method, followed by management contracting and traditional building procurement. The indicators are listed according to the previously established rankings. The summary suggests the appropriate use of the results generated. The full results for the ranking calculation listed in the following table 6-38, table 6-39, table 6-40, table 6-41, table 6-42, table 6-43, table 6-44, table 6-45, table 6-46, and table 6-47.

Results of the ranking calculations

Table 6-38 Summary of the ranking of all respondents for quality

1) Quality	Priority rating	Rationalized priority rating	Traditional		Design and Build		Management contracting	
			Utility factor	Results	Utility factor	Results	Utility factor	Results
Better quality control and assurance of the project	8.333	0.022	7.24	0.16	7.15	0.16	7.61	0.17
Better quality of service and advice from the project team	8.333	0.022	7.29	0.16	7.28	0.16	7.53	0.17
Meeting user's satisfaction	8.333	0.022	7.36	0.16	7.28	0.16	7.60	0.17
Better quality of client's brief	8.333	0.022	7.49	0.17	7.10	0.16	7.58	0.17
Meeting the client's needs	8.333	0.022	7.71	0.17	7.44	0.16	7.67	0.17
Reduction of engineering reworking	8.333	0.022	6.57	0.15	7.44	0.16	7.00	0.16
Reduction of errors in the contract documents	8.333	0.022	6.97	0.15	7.49	0.17	7.47	0.17
Reduction of inadequate supervision of the project	8.333	0.022	6.75	0.15	7.26	0.16	7.39	0.16
Total			1.27		1.29		1.33	
Rank order			3		2		1	

Table 6-39 Summary of the ranking of all respondents for cost saving

2) Cost saving	Priority rating	Rationalized priority rating	Traditional		Design and Build		Management contracting	
			Utility factor	Results	Utility factor	Results	Utility factor	Results
Better value for money	8.361	0.022	7.35	0.16	7.38	0.16	7.46	0.17
Reduction of maintenance costs (life-cycle)	8.361	0.022	6.93	0.15	7.06	0.16	7.38	0.16
Improving utilization efficiency of contractor's resources	8.361	0.022	6.58	0.15	7.79	0.17	7.29	0.16
Better budget control	8.361	0.022	7.22	0.16	7.47	0.17	7.47	0.17
Reduction of cost overrun (project)	8.361	0.022	6.96	0.15	7.50	0.17	7.44	0.17
Total				0.78		0.827		0.823
Rank order				3		1		2

Table 6-40 Summary of the ranking of all respondents for design

3) Design	Priority rating	Rationalized priority rating	Traditional		Design and Build		Management contracting	
			Utility factor	Results	Utility factor	Results	Utility factor	Results
Better integrated design and construction	7.903	0.021	6.76	0.14	8.01	0.17	7.17	0.15
Promoting green design (energy conservation, etc.)	7.903	0.021	6.94	0.15	7.42	0.16	7.26	0.15
Better cost-effective design	7.903	0.021	6.71	0.14	7.89	0.17	7.26	0.15
Promoting design innovation (prefabrication, etc.)	7.903	0.021	6.32	0.13	8.00	0.17	7.18	0.15
Better flow of information on design	7.903	0.021	6.61	0.14	7.68	0.16	7.40	0.16
Better control of the design and supervision of the work	7.903	0.021	7.08	0.15	7.44	0.16	7.42	0.16
Total				0.85		0.98		0.92
Rank order				3		1		2

Table 6-41 Summary of the ranking of all respondents for time saving

4) Time saving	Priority rating	Rationalized priority rating	Traditional		Design and Build		Management contracting	
			Utility factor	Results	Utility factor	Results	Utility factor	Results
Better planning and designing time	7.931	0.021	6.92	0.15	7.81	0.16	7.47	0.16
Better cooperation among the project team	7.931	0.021	7.11	0.15	7.69	0.16	7.47	0.16
Better detailing and coherent work program	7.931	0.021	7.15	0.15	7.74	0.16	7.50	0.16
Total				0.45		0.490		0.473
Rank order				3		1		2

Table 6-42 Summary of the ranking of all respondents for waste reduction

5) Waste reduction	Priority rating	Rationalized priority rating	Traditional		Design and Build		Management contracting	
			Utility factor	Results	Utility factor	Results	Utility factor	Results
Better waste management	7.472	0.020	6.40	0.13	7.46	0.15	7.03	0.14
Promoting green technologies	7.472	0.020	6.61	0.13	7.19	0.14	7.07	0.14
Better site communication to avoid abortive works	7.472	0.020	6.65	0.13	7.72	0.15	7.26	0.14
Reduction of unused materials and products	7.472	0.020	6.35	0.13	7.51	0.15	7.06	0.14
Total				0.52		0.594		0.564
Rank order				3		1		2

Table 6-43 Summary of the ranking of all respondents for procurement – materials

6) Procurement – materials	Priority rating	Rationalized priority rating	Traditional		Design and Build		Management contracting	
			Utility factor	Results	Utility factor	Results	Utility factor	Results
Promoting green procurement – materials	7.528	0.020	6.83	0.14	7.31	0.15	7.43	0.15
Better quality materials specification	7.528	0.020	7.21	0.14	7.11	0.14	7.43	0.15
Better value for money (materials)	7.528	0.020	7.06	0.14	7.36	0.15	7.10	0.14
Better choice of materials (project)	7.528	0.020	7.13	0.14	7.28	0.15	7.38	0.15
Total				0.56		0.581		0.587
Rank order				3		2		1

Table 6-44 Summary of the ranking of all respondents for health and safety – on-site

7) Health and safety – on-site	Priority rating	Rationalized priority rating	Traditional		Design and Build		Management contracting	
			Utility factor	Results	Utility factor	Results	Utility factor	Results
Better attitude and culture towards health and safety	7.347	0.020	6.90	0.13	7.21	0.14	7.57	0.15
Increased awareness of health and safety issues	7.347	0.020	6.93	0.14	7.28	0.14	7.35	0.14
Improved safety performance on-site	7.347	0.020	6.85	0.13	7.21	0.14	7.39	0.14
Better decisions on health and safety issues	7.347	0.020	6.81	0.13	7.21	0.14	7.28	0.14
Reduced negligence (professional)	7.347	0.020	7.00	0.14	7.29	0.14	7.40	0.14
Reduced accident rate	7.347	0.020	6.75	0.13	7.10	0.14	7.24	0.14
Total				0.805		0.846		0.86
Rank order				3		2		1

Table 6-45 Summary of the ranking of all respondents for employment

8) Employment	Priority rating	Rationalized priority rating	Traditional		Design and Build		Management contracting	
			Utility factor	Results	Utility factor	Results	Utility factor	Results
Better knowledge sharing	6.611	0.018	7.03	0.12	7.47	0.13	7.36	0.13
Increasing productivity	6.611	0.018	6.76	0.12	7.65	0.13	7.25	0.13
Better allocation of responsibilities amongst staff	6.611	0.018	6.92	0.12	7.42	0.13	7.35	0.13
Improved performance and motivation among project members	6.611	0.018	6.71	0.12	7.50	0.13	7.28	0.13
Better working relationships among the project team	6.611	0.018	6.86	0.12	7.60	0.13	7.43	0.13
Total				0.602		0.662		0.644
Rank order				3		1		2

Table 6-46 Summary of the ranking of all respondents for profitability

9) Profitability	Priority rating	Rationalized priority rating	Traditional		Design and Build		Management contracting	
			Utility factor	Results	Utility factor	Results	Utility factor	Results
Better financial control	7.625	0.020	6.79	0.14	7.75	0.16	7.54	0.15
Better risk management	7.625	0.020	6.61	0.13	7.67	0.16	7.57	0.15
Better cash flow	7.625	0.020	6.54	0.13	7.46	0.15	7.22	0.15
Total				0.404		0.46		0.453
Rank order				3		1		2

Table 6-47 Summary of the ranking of all respondents for the application of advanced management methods and technology

10) Application of advanced management methods and technology	Priority rating	Rationalized priority rating	Traditional		Design and Build		Management contracting	
			Utility factor	Results	Utility factor	Results	Utility factor	Results
Better concern for environmental issues (general)	7.292	0.019	6.92	0.13	7.25	0.14	7.35	0.14
Better use of information technology (IT)	7.292	0.019	6.79	0.13	7.57	0.15	7.68	0.15
Promoting value management	7.292	0.019	6.75	0.13	7.58	0.15	7.67	0.15
Improving the accountability of contractors	7.292	0.019	6.86	0.13	7.68	0.15	7.57	0.15
Promoting lean construction	7.292	0.019	6.51	0.13	7.43	0.14	7.17	0.14
Total				0.66		0.727		0.726
Rank order				3		1		2

6.3 Research Findings and Discussion

6.3.1 Research findings

In this section, the results of the data analysis are examined to highlight the relevant findings and to select appropriate indicators. The findings for suitable indicators are summarized first, followed by those for the *Spearman* rank-order, the *t-test*, and the overall results. The organization of these indicators is organized carefully from the most important indicator to the least important indicator.

6.3.1.1 Suitable indicators

It is important to identify suitable indicators which enable construction industry stakeholders to select the most appropriate indicators for sustainable construction. The selection of suitable indicators is a unique characteristic of the proposed framework. The analysis is divided into the three stages. It is an important task to collect a suitable and reliable indicator.

a) Stage one – selecting appropriate indicators

The findings from the data analysis suggest that the respondents considered quality to be the top indicator, followed by cost saving and energy saving. These results are not surprising because quality is essential to construction industry stakeholders. The lowest ranking was for flora and fauna protection. This result is unexpected and suggests that there is a lack of understanding of this issue among construction industry stakeholders. Similarly, a low ranking for material recycling suggests that there is a lack of understanding of sustainability among construction industry stakeholders. Table 6-48 shows the ranking of the indicators for Objective 1.

Table 6-48 Indicators for Objective 1

Indicators	Rank
Quality	1
Cost saving	2
Energy saving	3
Time saving	4
Air pollution control	5
Waste reduction	6
Water pollution control	7
Noise pollution control	8
Material recycling	9
Flora and fauna protection	10

The suitable indicators selected by the respondents can expanded into a range of reliable indicators, which represents an important research finding of this thesis.

b) Stage two – developing a sustainability indicator

For the second stage of the indicator selection process, significance indices of more than **75** were selected to ensure that only the highest quality indicators were adopted. The indicators were selected by the respondents for their own future reference. Table 6-49 shows the selected suitable indicators for Objective 2.

Table 6-49 Suitable indicators for Objective 2

	Quality
a)	Better quality control and assurance of the project
b)	Better quality of service and advice from the project team
c)	Meeting user’s satisfaction
d)	Better quality of client’s brief
	Cost saving
a)	Better value for money
b)	Reduction of maintenance costs (life-cycle)
	Design
a)	Better integration of design and construction
b)	Promoting green design (energy conservation, etc.)
c)	More cost-effective design
d)	Promoting design innovation (prefabrication, etc.)
	Time saving
a)	Better planning and designing time
	Waste reduction
a)	Better waste management
b)	Promoting green technologies
c)	Better site communication to avoid abortive works
	Procurement – materials
a)	Promoting green procurement – materials
b)	Better quality material specification
	Health and safety – on-site
a)	Better attitude and culture towards health and safety
b)	Increased awareness of health and safety issues
c)	Improved safety performance on-site
	Profitability
a)	Better financial control
	Application of advanced management methods and technology
a)	Better concern for environmental issues (general)
b)	Better use of information technology (IT)
c)	Promoting value management

c) Stage three – developing a ranking indicator

After modified previous findings, the ranking of the most suitable indicators can be suggested using indicators from the previous stage. The rankings determine the selection of the appropriate indicators and play an important role in determining the factors that need to be considered in promoting sustainable construction. Table 6-50 shows the ranking of the indicators for objective 3 or the third stage of the analysis.

Table 6-50 Ranking of the indicators for Objective 3

	Indicators
1)	Cost saving
2)	Quality
3)	Time saving
4)	Design
5)	Profitability
6)	Procurement – materials
7)	Waste reduction
8)	Health and safety
9)	Application of advanced management methods and technology
10)	Employment

The suitable indicators which were selected from the results of the various questionnaire surveys, can then be used to determine the most important factors for developing the framework.

6.3.1.2 Summary of the Spearman rank-order correlation coefficient (r) results

The Spearman rank-order correlation coefficient (*r*) was tested with the null hypotheses (Ho) and the results are summarized in Table 6-51, along with a comparison of the assessments of the indicators of the client, contractor, and consultant groups.

Table 6-51 Summary of the Spearman rank-order correlation coefficient (*r*)

	Client ranking versus contractor ranking	Client ranking versus consultant ranking	Contractor ranking versus consultant ranking
1) Quality	Reject Ho	Reject Ho	Accept Ho
2) Cost saving	Reject Ho	Reject Ho	Accept Ho
3) Design	Accept Ho	Accept Ho	Accept Ho
4) Time saving	Accept Ho	Accept Ho	Accept Ho
5) Waste reduction	Reject Ho	Accept Ho	Accept Ho
6) Procurement – materials	Reject Ho	Accept Ho	Reject Ho
7) Health and safety – on-site	Reject Ho	Reject Ho	Accept Ho
8) Employment	Accept Ho	Accept Ho	Accept Ho
9) Profitability	Accept Ho	Accept Ho	Accept Ho
10) Application of advanced management methods and technology	Accept Ho	Accept Ho	Accept Ho
% Hypotheses Ho accepted	**50%**	**70%**	**90%**

6.3.1.2.1 Relationship between clients and contractors

The results for clients and contractors show a 50% agreement that both parties benefit from a mutual relationship, which suggests that the respondents had a neutral or moderate view of their relationship. This result is understandable because the client has an indirect relationship with the contractor during most of the construction process.

6.3.1.2.2 Relationship between clients and consultants

The results for clients and consultants show that there is 70-% agreement that both parties benefit from their mutual relationship, which suggests that the respondents believe that their relationship is improving. This result may be because clients have a good relationship with consultants.

6.3.1.2.3 Relationship between contractors and consultants

The results for contractors and consultants show a 90-% agreement that both parties benefit from their mutual relationship, which suggests that the respondents believed that contractors have a very good relationship with consultants. This result maybe because contractors and consultants have a direct relationship during the building process.

6.3.1.3 Summary of the t-test results

T-tests were conducted to test the significance of the relationships between the clients, contractors, and consultants. Table 6-52 shows the *t-test* results for the relationships between the respective groups.

Table 6-52 *T-test* results for the client-contractor, client-consultant, and contractor-consultant relationships

	i) Client and contractor		ii) Client and consultant		iii) Contractor and consultant	
Indicators	Accept	Reject	Accept	Reject	Accept	Reject
(1) Quality	9	0	8	1	9	0
(2) Cost saving	9	0	6	3	8	1
(3) Design	10	0	8	2	10	0
(4) Time saving	9	0	7	2	9	0
(5) Waste reduction	9	0	7	2	7	2
(6) Procurement – materials	7	2	7	2	8	1
(7) Health and safety – on-site	2	4	2	4	6	0
(8) Employment	7	3	2	8	10	0
(9) Profitability	6	2	4	4	8	0
(10) Application of advanced management methods and technology	6	0	6	0	6	0
Sub-Total	4	11	57	28	81	4
Total	**85**		**85**		**85**	

The indicators were then analyzed to identify any similarities among the groups.

Although the concept was well appreciated by the respondents, the results differed for the different groups of construction professionals.

6.3.1.3.1 Relationship between clients and contractors

The results suggest that clients and contractors have a good understanding on many of the indicators. However, they could have a little relationship towards sustainable construction practice.

6.3.1.3.2 Relationship between clients and consultants

The results suggest that clients and consultants have a relatively good relationship and that the two parties have less understanding on many of the indicators. Moreover, the relationship could consider a little bit complex.

6.3.1.3.3 Relationship between contractors and consultants

The results suggest that clients and contractors have an extremely very good relationship and that the two parties have a good understanding on many of the indicators. It also indicates that they have establishing a good working relationship.

6.3.1.4 Normality test results

Assume that the null hypothesis is that the population is normally distributed. The chosen alpha level is 0.05. The *p*-value of 0.26 accepts the null hypothesis that the data is from a normally distributed population. In other words, the population is normally distributed. If the *p*-value is less than the chosen alpha level, the null hypothesis is rejected.

6.3.1.5 Summary of the findings

Overall, the survey findings suggest that construction industry stakeholders perceive that building procurement methods are likely to contribute toward sustainable construction.

6.3.2 Discussions

In this section, the results are discussed using a systematic framework and tools to support the research analysis. The tools are important for this research.

6.3.2.1 Sustainable construction in Malaysia

Public projects are perceived to comply with the principle and practice of sustainable construction more than private projects. The results suggest that the government has the greatest willingness to implement sustainable construction, followed by designers, clients, material suppliers, and contractors. This result is not surprising because the public sector has sufficient money to invest in sustainable building projects. Moreover, the respondents perceived a lack of awareness of sustainable construction practices in the private sector in Malaysia. The private sector is possibly less willing to engage in sustainable construction because it is more profit-oriented. This is supported by existing research, which suggests that the government should play a major role in sustainable construction (e.g., Spence and Mulligan, 1995; Ofori, 1998; A21 SCDC, 2002; Du Plessis, 2007). However, the results may also indicate that construction industry stakeholders in Malaysia are less willing to promote sustainable construction (Zainul

Abidin, 2010). With private projects, clients normally follow market demand (Majdalani *et al.*, 2006; Zainul Abidin, 2010). It is also likely that the private sector perceives sustainable construction to involve higher construction costs (Zainul Abidin, 2010), which in turn mean higher costs to the client and the user.

A recent study showed that the sustainable construction in Malaysia is mostly driven by the government rather than public and private partnerships (Majdalani *et al.*, 2006). This is not surprising, because the government has sufficient funds to promote and support sustainable construction (A21 SCDC, 2002). However, it could also indicate that public projects promote sustainable building. Moreover, it is not surprising that the findings show that contractors are the least willing to implement sustainable construction because the nature of contracting firms is to increase profits, reduce costs, and finish construction projects on time. Therefore, contractors are less willing to invest resources in sustainable construction as the contracting business is driven by profit margins. The respondents suggested that the promotion of sustainable construction among contractors must be based on win-win principles. In this respect, the government could be in the best position to create a favorable environment for involving both the public and private sectors in sustainable construction practices. Sustainable construction is typically perceived as a form of environmental protection, and the respondents' perceptions of sustainable construction tended to relate to the environment in general. While all of the respondents perceived the environment to be important, progress in tackling the environmental effects of the construction industry is slow, mainly because of the profit driven nature of the construction industry (Majdalani *et al.*, 2006; Zainul Abidin, 2010). Balancing the pillars of sustainable construction is important to ensure the benefits of sustainability flow to people and the construction industry (Zainul Abidin, 2010). The survey results are in line with many existing sustainable construction studies that argue that the environment is the main issue facing the construction industry (e.g., Carter and Fortune, 2007; Zainul Abidin, 2010). Although the survey findings suggest that sustainable construction is delivering sustainability in a harmonious way, the contribution is rather limited for some indicators, possibly because many of the respondents lacked understanding of the environmental agenda.

The respondents agreed that design and building procurement methods can deliver sustainable construction practices. The different building procurement methods have strengths and weaknesses with respect to sustainability issues. The respondents believed that traditional procurement methods make the least contribution to sustainable construction. A number of other studies have shown that traditional procurement methods have weaknesses in dealing with sustainability (e.g., Ngowi, 1998; Rwelamila and Meyer, 1998; Ngowi, 2000; Rwelamila *et al.*, 2000; Carter, 2005; Carter and Fortune, 2008; Bakhtiar *et al.*, 2009a). Thus, more research on integrating procurement and sustainability is needed. For example, new procurement methods could be suggested to improve an innovative strategy to achieve sustainable construction. In this respect, the respondents' views need to be interpreted in relation to identifying potential solutions to the problems arising within the construction industry. The change in sustainable construction also needs to be reflected in the various practices of construction participants due to their different roles in building design, development, and construction (Yip and Poon, 2009).

6.3.2.2 Sunflower Model

In this section, a sunflower model is used to show the significance indices obtained in the data analysis. The model serves as a mechanism and benchmark for the development of this research. The first diagram shows the significant index of quality. To develop a model, a significance index with a value of more than (**>70.00**) was selected. The subsequent diagrams consider the other indicators discussed in the results section.

(1) Quality

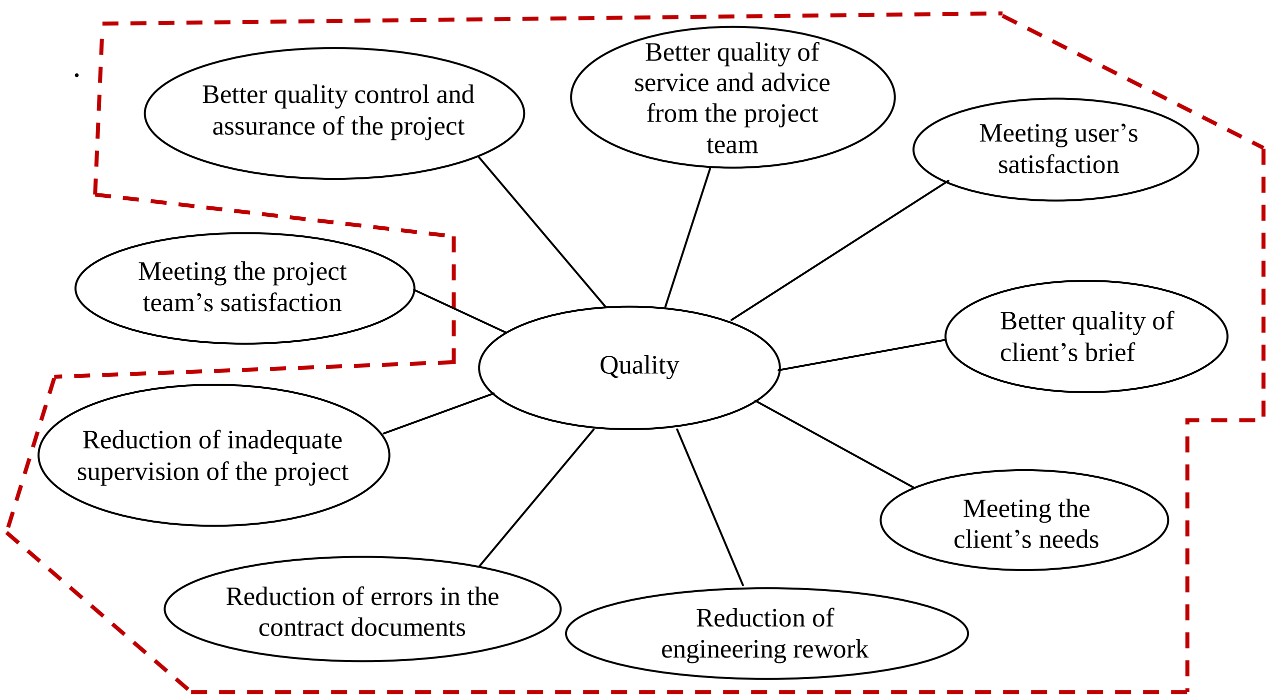

Figure 6-3 Diagram of quality

The diagram in figure 6-3 depicts the important indicators of quality. Quality can provide a good fundamental indicator for sustainability assessment (Kibert, 1994; Hill and Bowen, 1997; A21 SCDC, 2002). Most of the sub-indicators were well appreciated and discussed by the respondents. It is interesting to note that ‘meeting the project team’s satisfaction’ was not considered to be important for quality. The results might reflect a need for raising project team’s satisfaction. From the findings, it seems that construction industry stakeholders have little understanding regarding team spirit and do not necessarily indicate they have limited sustainability knowledge.

2) Cost saving

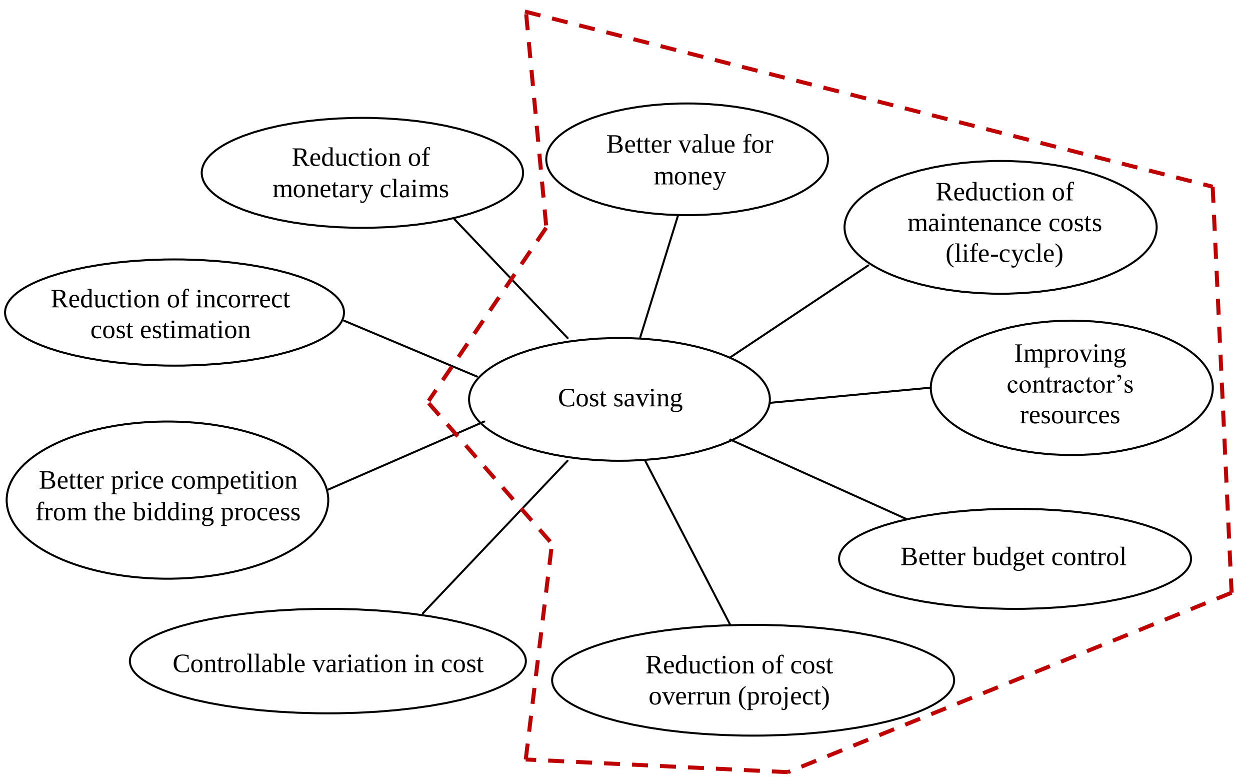

Figure 6-4 Diagram of cost saving

The diagram in figure 6-4 depicts the important indicators of cost saving. It is interesting to note that ‘better value for money’ and ‘better budget control’ was considered important for cost saving. Today, sustainable construction focuses on vibrant issues such as energy saving, cost saving, value for money, return on investment, and others. One of the major issues of SC in developing countries is the higher cost of its implementation, and limited scholars (Dalgliesh *et al.*, 1997; Du Plessis, 2007; Bakhtiar *et al.*, 2009b). Bakhtiar *et al.* (2009b) found that a higher cost could hinder sustainability progress in developing countries. Predominantly, there is consensus that the construction industry should support sustainable construction. However, there are many sustainable construction hindrances such as lack of regulation, funding, research and development. One reason is that sustainable construction research to date offers few indicators that can measure progress of its implementation.

3) Design

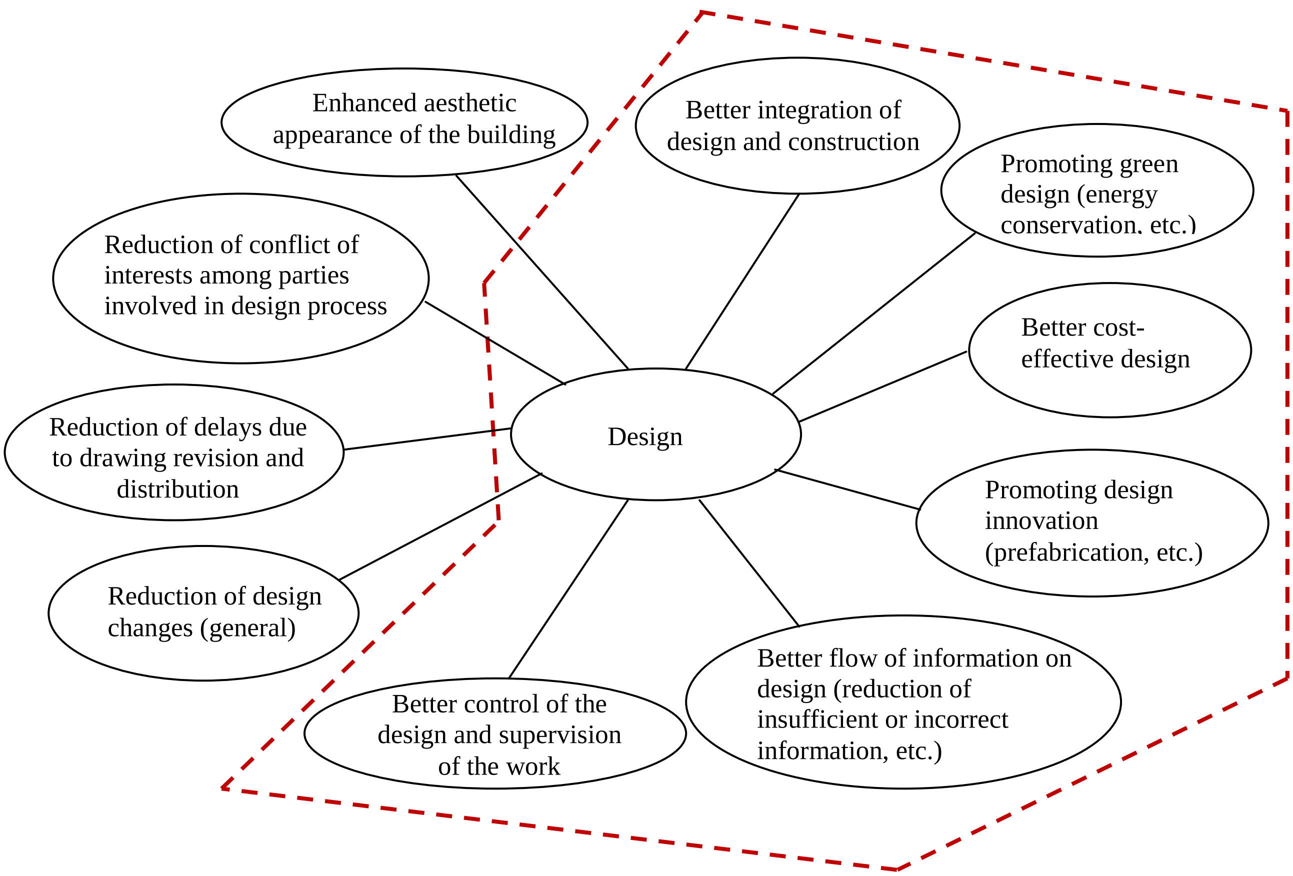

Figure 6-5 Diagram of design

The diagram in figure 6-5 depicts the important indicators of design. It is interesting to note that 'better cost-effective design', 'better integration of design and construction' was considered contribute to design. A hasty design could lead to undesirable neglected of the concept of sustainable construction (Rwelamila *et al.*, 2000). Design can be related to the contractors' reputation, aesthetics and confidence (Love *et al.*, 1998). Al-Momani (2000) suggests that design changes can lead to consequences such as extra energy consumption, cost overruns, and time delays. The design changes, particularly in the construction stage, can cause construction wastage and time delays (Osmani *et al.*, 2008).

4) Time saving

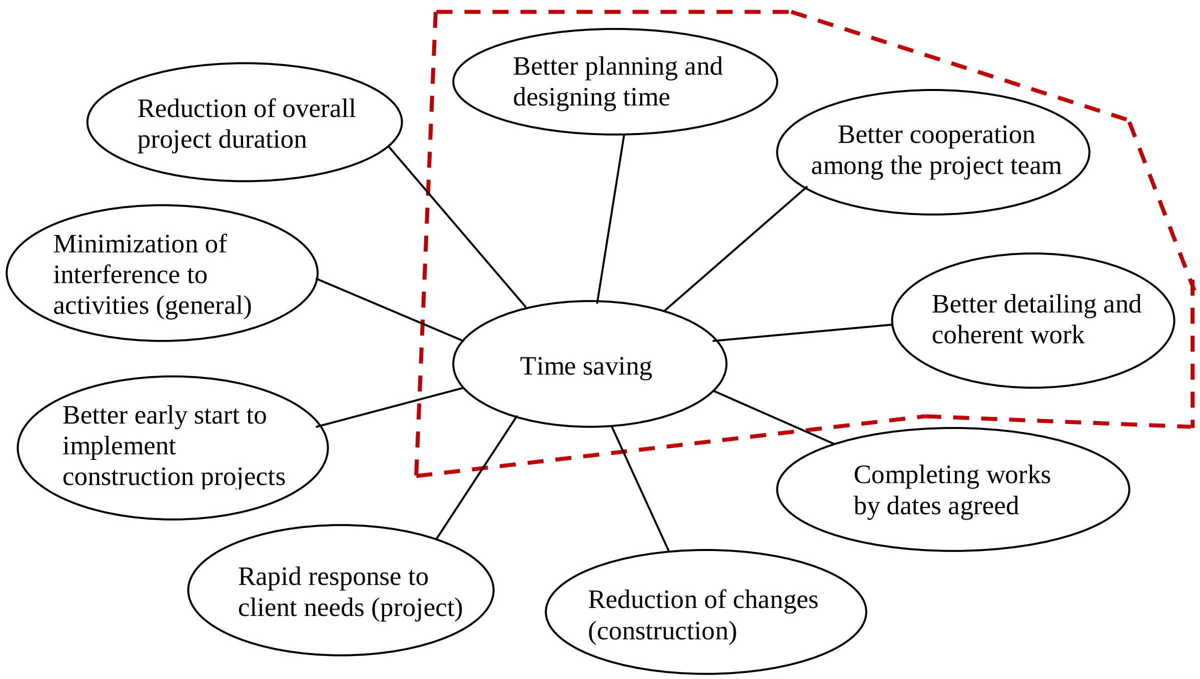

Figure 6-6 Diagram of time saving

The diagram in figure 6-6 depicts the important indicators of time saving. It is interesting to note that 'better detailing and coherent work', 'better cooperation among the project team', and 'better planning and designing time' can save time. Time saving contributes efficiency to sustainable construction and is important to the decision makers in respected in implementing sustainable construction. Time saving leads to value appreciation, thus contributes to sustainable construction. Time could provide the measurement capability and feedback over sustainability performance (Guy and Kibert, 1998). Time saving is one of significance sustainable construction indicators (Bakhtiar *et al.*, 2009b).

5) Waste reduction

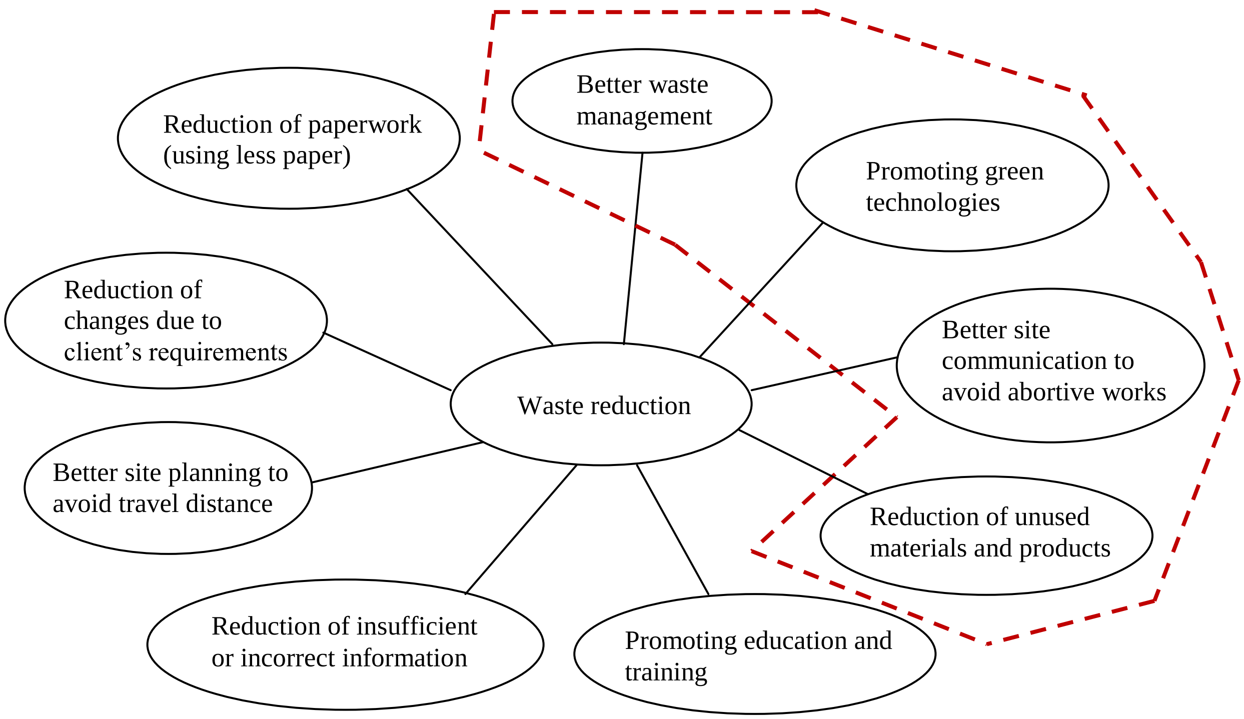

Figure 6-7 Diagram of waste reduction

The diagram in figure 6-7 depicts the important indicators of waste reduction. It is interesting to note that 'promoting green technologies', 'reduction of unused materials and products' was considered important for waste reduction. Waste reduction is unnecessary work including incomplete, over the drawing, and poor design that can produce wastage problem on site both tangible and intangible manner (Bossink and Brouwers, 1996; A21 SCDC, 2002).

6) Procurement – materials

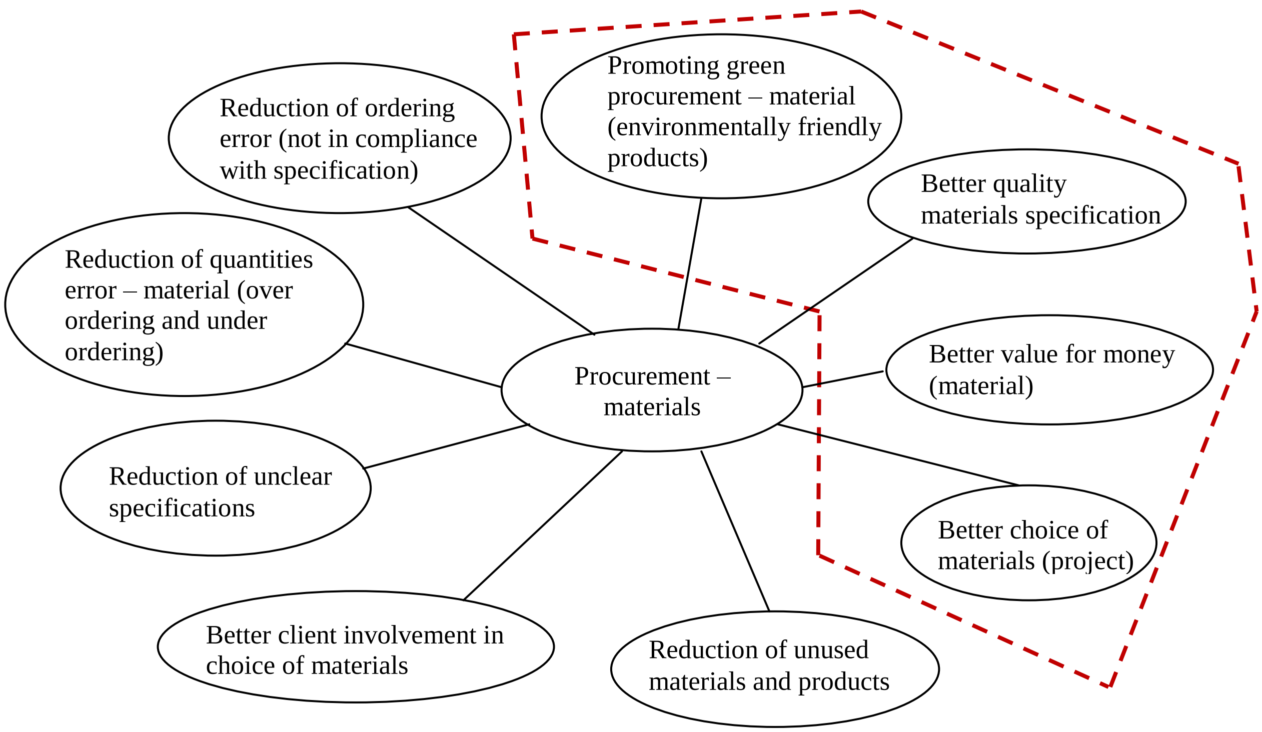

Figure 6-8 Diagram of procurement – materials

The diagram in figure 6-8 depicts the important indicators of procurement – materials. It is interesting to note that 'better choice of materials (project)' and 'better value for money (material)' was considered important for procurement – materials. The designer should consider using less material, low-energy materials, select recycled materials and design for recycling with long lifespan materials (Spence and Mulligan, 1995; Kibert, 2007).

(7) Health and safety – on-site

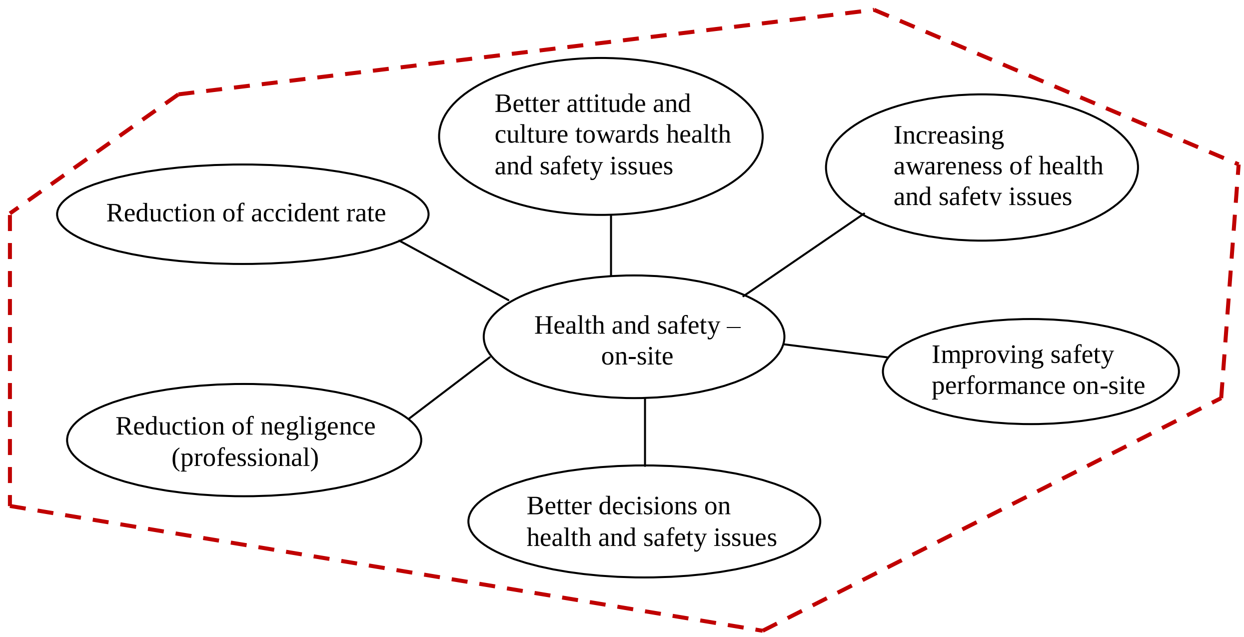

Figure 6-9 Diagram of health and safety – on-site

The diagram in figure 6-9 depicts the important indicators of health and safety – on-site. It is interesting to note that all sub-indicator for health and safety – on site was considered important. These indicators point to a better life for workers in the built environment. Health and safety is defined as promoting health and general safety of workers in the construction site without a major accident (Bubshait and Almohawis, 1994). Health and safety promote social benefits to the workers (Chan, 2000; A21 SCDC, 2002).

(8) Employment

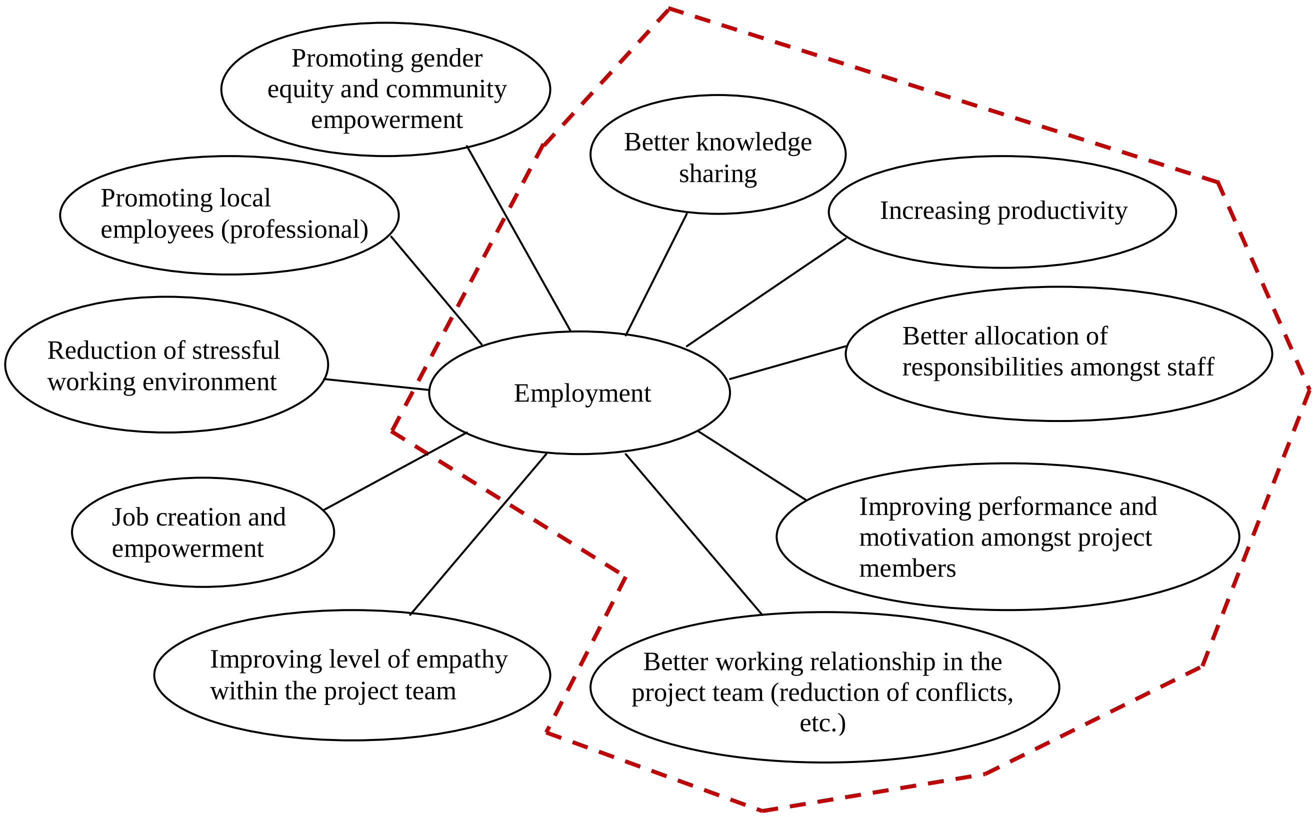

Figure 6-10 Diagram of employment

The diagram in figure 6-10 depicts the important indicators of employment. It is interesting to note that 'better knowledge sharing' and 'increasing productivity' was considered important for employment. The institution of higher education needs to promote SC in their syllabus to enhance their value in employment market. Creating a 'sustainable' employment market is also essential to 'sustain' a local employee, rather than using non-local workers. It is well appreciated that the construction industry provides employment opportunities (Ngowi, 2002). Hill and Bowen (1997) suggest employment opportunities seek equitable social benefits from implementing construction activities.

(9) Profitability

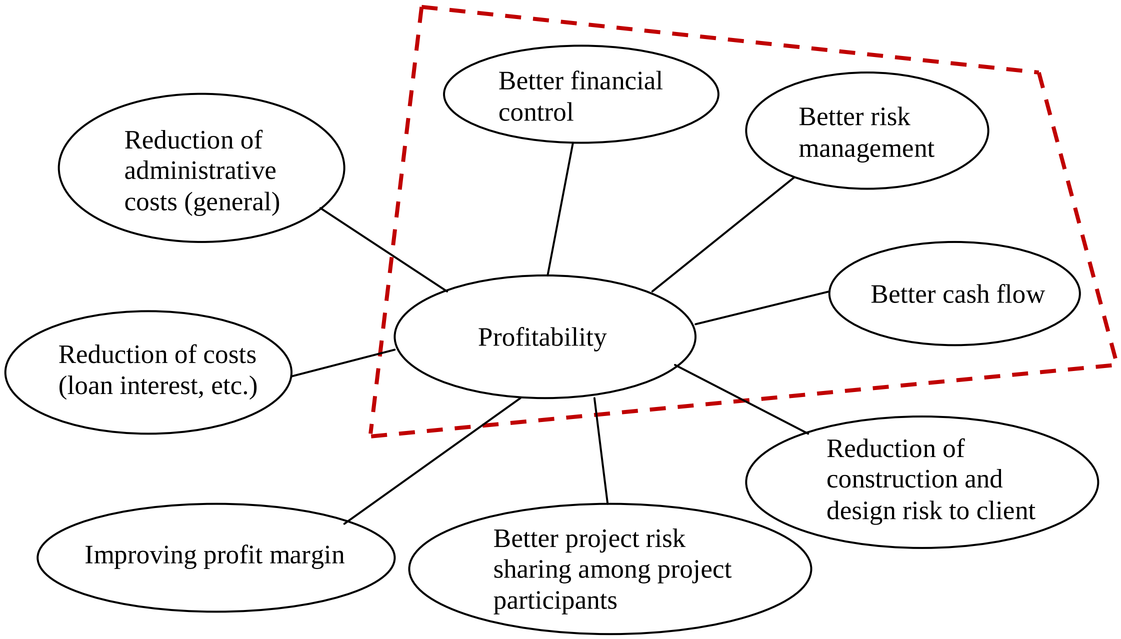

Figure 6-11 Diagram of profitability

The diagram in figure 6-11 depicts the important indicators of profitability. It is interesting to note that 'better cash flow', 'better risk management' and 'better financial control' was considered important for profitability. Contracting firms are primarily motivated by profit (see also Love *et al.*, 1998; Skitmore and Marsden, 1998). It is well addressed that parties involved in the construction industry have an interest for a higher profit margin (Cheng and Li, 2005; Majdalani *et al.*, 2006). Profitable businesses could generate a sustainable business environment and promote employment growth (Akintoye *et al.*, 2003).

(10) Application of advanced management methods and technology

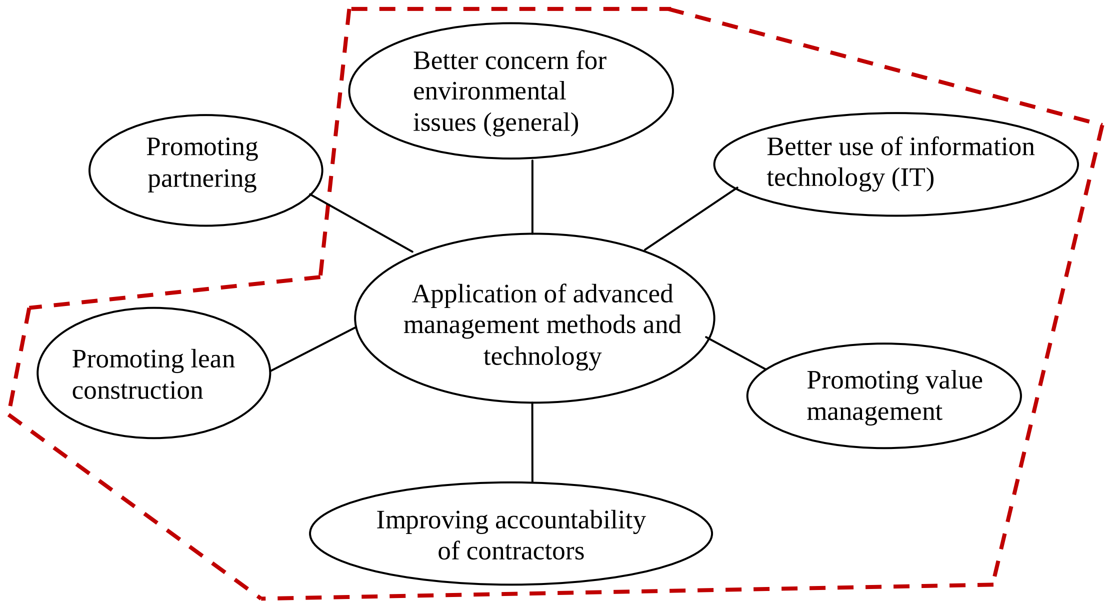

Figure 6-12 Diagram of the application of
advanced management methods and technology

The diagram in figure 6-12 depicts the important indicators of the application of advanced management methods and technology. It is interesting to note that 'promoting partnering' was not considered to be important for promoting partnering. The use of information technology is benefiting the construction industry (Ali *et al.*, 2002; Li *et al.*, 2005). Value management can improve sustainability and increase efficiency (Zainul Abidin and Pasquire, 2005; Zainul Abidin and Pasquire, 2007). Promoting partnering is a new approach and useful in the construction industry (Carter, 2005). A current technology in the market could further enhance the sustainable construction viability.

6.3.2.3 Perception differences among clients, contractors, and consultants

In this section, the means of the priority rating scale are used to explore the differences among the client, contractor, and consultant groups. From the statistical table, the critical *t-test* values are 2.008 and -2.008 for clients and contractors; 1.993 and -1.993 for clients and consultants; and 1.997 and -1.997 for contractors and consultants. If a *t-value* is within the critical values, there is no significant disagreement between the means of the two groups. The significance level of the *t-test* is 0.05 for a two-tailed test. The different means for the different groups of respondents suggest that their perceptions and knowledge varied. It indicates that the highest agreement of means is between contractors and consultants at around the 95% level. This result is probably because contractors are driven by profit margins and will promote sustainable construction if clients cover the extra costs because it is in their interests. The mean between clients and contractors is slightly lower at around 87% agreement. The lowest among the groups is the mean between clients and consultants of around 67%. This result indicates that clients may have less interest in sustainability than contractors and consultants and that client have limited knowledge of construction. The results also suggest that sustainable construction should be carried out by clients, as well documented that the clients tend to focus on quality, cost, and time.

Consultants normally offer their professional advice to clients and contractors. However, from all of the indicators studied, the clients and consultants had fewer accepted hypotheses and the highest rejection rates in the *t-test* analysis for ‘employment.’ One of the reasons for this is that clients do not deal with the workers on-site, unlike consultants, who tend to have more professional employees. Besides, clients have limited knowledge of construction and need to seek advice from consultants. The second highest rejected *t-test* is for ‘health and safety’ between clients and consultants and clients and contractors. The results indicate that the relationships of contractors and consultants are quite consistent for each indicator. It is also clear that the findings support the argument that procurement methods contribute to sustainable construction.

The ranking method used in this thesis based on the perceptions of the respondents and does not represent an objective assessment (Chan *et al.*, 2003). Nevertheless, the results show significant agreement among the respondents. The ranking is in the order of the most important to the least important. If significance indices of 70.00 points are used, 49 sub-indicators are selected, while if the significance indices are more than 75.00 points, 22 sub-indicators are selected. Again, the ranking of these groups is associated with their perceptions. The indicators determined in this thesis are ranked in the following order: (1) quality; (2) cost saving; (3) design; (4) time saving; (5) waste reduction; (6) procurement – materials; (7) health and safety – on-site; (8) employment; (9) profitability; and (10) the application of advanced management methods and technology.

6.4 The Proposed Integrated Indicators for SuProDem framework

Table 6-53 shows the pattern of perception (POP) framework proposed for the Malaysian context.

Table 6-53 Pattern of perception (POP) framework for Malaysia

Methods		Performance Indicators									
		P1) Waste reduction	P2) Cost saving	P3) Time saving	P4) Quality	P5) Material recycling	P6) Flora and fauna • protection	P8) Noise pollution control	P7) Air pollution control	P9) Water pollution control	P10) Energy saving
M1) Education and training	MAL	4.02	3.50	3.41	4.14	3.68	3.68	3.75	3.57	3.82	3.82
	POP	◊	□	□	☼	□	□	□	□	◊	◊
M2) Environmental management system	MAL	3.86	2.95	2.70	3.50	3.59	3.93	4.20	4.02	4.02	3.64
	POP	□	Δ	Δ	□	□	◊	☼	◊	◊	□
M3) Green building	MAL	3.20	2.64	2.50	3.36	3.11	3.50	3.70	3.23	3.45	3.93
	POP	□	Δ	Δ	□	□	◊	◊	□	□	☼
M4) Green design	MAL	3.27	2.77	2.55	3.57	3.23	3.73	3.82	3.34	3.55	4.14
	POP	□	Δ	Δ	□	□	◊	◊	□	□	☼
M5) Green procurement	MAL	3.07	2.66	2.61	3.32	3.18	3.18	3.16	2.84	3.00	3.32
	POP	□	Δ	Δ	☼	◊	◊	□	□	□	☼
M6) Green roof technologies	MAL	2.84	2.48	2.34	2.89	2.70	3.39	3.57	3.07	3.11	3.95
	POP	Δ	Δ	Δ	Δ	Δ	◊	◊	□	□	☼
M7) Lean construction	MAL	3.86	3.77	3.70	3.64	3.14	2.64	2.77	2.66	2.66	2.93
	POP	☼	◊	◊	□	□	Δ	Δ	Δ	Δ	Δ
M8) Prefabrication	MAL	4.02	3.55	4.05	3.93	3.11	2.52	2.95	2.91	2.86	2.86
	POP	◊	□	☼	◊	□	Δ	Δ	Δ	Δ	Δ
M9) Waste management	MAL	4.27	3.14	2.89	3.27	4.00	3.52	3.61	3.05	3.66	3.16
	POP	☼	□	Δ							

Notes: ☼ – Most Significant ◊ – Significant □ - Adopted Δ - Not adopted

Mean value from 0-5 (1) No contribution; (2) Less contributable; (3) Medium contributable; (4) Contributable; (5) Major contribution; (0) Not adopted

The POP is defined as the perception of Malaysia respondents towards sustainability, and their perception create a sustainability pattern. The pattern is between sustainable construction method and the sustainability performance indicators.

Table 6-54 shows the second propositional framework. The framework is also based on the results of the case study and presents the final findings from the series of analyses presented in this chapter.

Table 6-54 Propositional framework 2

1) Quality	**2) Cost saving**	**3) Design**
Better quality control and assurance of the project	Better value for money	Better integration of design and construction
Better quality of service and advice from the project team	Reduction of maintenance cost (life-cycle)	Promoting green design (energy conservation, etc.)
Meeting user's satisfaction	Improving utilization efficiency of contractor's resources	Better cost-effective design
Better quality of client's brief	Better budget control	Promoting design innovation (prefabrication, etc.)
Meeting the client's needs	Reduction of cost overrun (project)	Better flow of information on design (reduction of insufficient or incorrect information, etc.)
Reduction of engineering rework		Better control of the design and supervision of the work
Reduction of error in the contract documents		
Reduction of inadequate supervision of the project		
4) Time saving	**5) Waste reduction**	**6) Procurement – materials**
Better planning and designing time	Better waste management	Promoting green procurement – materials (environmentally friendly products)
Better cooperation amongst project team	Promoting green technologies	Better quality materials specification
Better detailing and coherent work program	Better site communication to avoid abortive works	Better value for money (material)
	Reduction of unused materials and products	Better choice of materials (project)
7) Health and safety – on-site	**8) Employment**	**9) Profitability**
Better attitude and culture toward health and safety issues	Better knowledge sharing	Better financial control
Increasing awareness of health and safety issues	Increasing productivity	Better risk management

Improving safety performance on-site	Better allocation of responsibilities among staff	Better cash flow
Better decisions on health and safety issues	Improving performance and motivation among project members	
Reduction of negligence (professional)	Better working relationship among the project team (reduction of conflicts, etc.)	
Reduction of accident rate		
10) Application of advanced management methods and technology		
Better concern for environmental issues (general)		
Better use of information technology (IT)		
Promoting value management		
Improving accountability of contractors		
Promoting lean construction		

Definition and characteristics of the identified indicators

Each indicator should not be considered the 'ultimate' indicator for measuring the environmental, economic, and social pillars of sustainable construction. Rather, the indicators should be distributed equally among the pillars in a balanced manner because some of the indicators only relate to one pillar. Moreover, some of the proposed indicators need to be further analyzed because they were considered 'vague' by the respondents. Waste reduction is defined as the avoidance of unnecessary work, such as overdrawing and incomplete designs that produce both tangible and intangible wastage issues. A tangible issue of incomplete design is the production of on-site wastage such as excess cement and concrete, ceramic blocks, reinforcement-bars, formwork, and other materials (A21 SCDC, 2002). However, the issue of waste reduction is only discussed in the design stage and is mainly approached on from an intangible perspective. Procurement contributes to intangible forms of waste reduction such as choosing an appropriate procurement method to reduce design error, design changes, unsuitable specifications, and other factors. Osmani *et al.* (2008) found that last minute changes due to the clients' requirements and design changes are likely to contribute to waste during the design stage. In addition, the amounts of waste in actual site operations were found to be much higher than the allowance given in the pre-construction estimates for waste compensation in Sri Lanka (Kulatunga *et al.*, 2006). The reduction in building material wastage is believed to reduce construction costs, make housing more affordable, and reduce global material consumption in the long term (A21 SCDC, 2002). In line with this, management, design, and cultural practices are considered to have a great influence on wastage rates.

Procurement defined as a system for procuring materials for a construction project. The selection of a proper procurement system can enhance sustainability in general. The choice of materials is important for sustainability, and proper procurement method can contribute to the selection of high-quality materials. Due to the workload involved, the speed of construction can limit the capability of designers (architectural and engineering). For example, the design and build method requires faster decision making compared with the traditional methods. Thus, the choice of building method could have an intangible effect on the delivery of construction materials. Moreover, inappropriate design details could result in unused materials and product and, therefore, negatively affect the procurement system.

Employment defined as the work opportunities created by a construction project. However, the parties involved in the construction process also have to integrate with other project team members. Open communication among the parties involved is considered to be very important for project efficiency. Rowlinson and McDermott (1999) stated that most developing countries adopt foreign consultants and contractors for their construction projects, including major developments, thus reducing job growth and affecting local professionals. Local employment indicates that a building project creates job opportunities for the people living in the area that is being developed (A21 SCDC, 2002).

Quality defined as a project that is completed according to the required level of quality and meets the client's expectations (public or private). In this respect, quality is related to the contractor's reputation, aesthetics, and confidence in design (Love *et al.*, 1998). Hashim *et al.* (2006) showed that the level of quality was not radically affected by the procurement arrangements, but depended on the client's experience of using different procurement methods and the details included in the contract documentation provided by the consultants.

Cost saving defined as the savings from using a suitable procurement method. Cost saving is also associated with the interest rates provided by financial institutions. A current issue in sustainable building is the increased cost of building associated with finance. As a result, the costs incurred in constructing a green building are often different in different countries. Another major reason for cost differences is the level of advancement of technologies. While the respondents raised some issues with regard to whether building procurement systems contribute to sustainable building, some procurement methods are known to deliver advantages in terms of cost savings.

Time saving defined as the reduction of the building period (Hashim, 1999). A shortened construction time can reduce the financial burden for a client, especially in the private sector. However, normally time is not crucial for public clients in Malaysia, as quality is considered much more important in this case. Time saving is important for some sustainable construction methods, especially in the Malaysian construction industry. Overall, time saving is crucial for sustainability as rising costs can affect all stakeholders.

Design defined as the design efficiency in enhancing the creative responses of the various parties involved in a construction project. Moreover, the design of a construction project can require specific procurement systems, which could affect the performance of the construction process. According to Hashim *et al.* (2006), in 1998 the Malaysian Education Minister instructed that all school projects should be procured by the design and build method because Malaysia needed more schools with creative and innovative designs, instead of the standard design.

Environmental awareness is defined as the degree to which the adopted procurement method can be used to control the pollution generated from the building process. Different procurement methods have different priorities for environmental assessment as faster construction; for instance, can undermine the environmental performance of a project.

Profitability defined as the profits generated from construction activities. Most of the parties involved in the construction industry seek a higher profit margin. Profitability can also enhance the sustainability of a project. For example, the sustainability of a company can be maintained if it achieves a certain profit target. The profits a company makes can also be used for research and development. Thus, profitability is a major factor in construction (Cheng and Li, 2005), as greater profitability can generate a sustainable business environment and promote employment growth.

The application of advanced management methods and technology defined as the use of management and technology to obtain efficiencies (Huovila and Koskela, 1998). Tonn *et al.* (2000) suggest that the decision-making process should be adapted to incorporate environmental and sustainability concerns. Technological advances can help the construction industry support sustainable construction (Du Plessis, 2007). Information technology is also important for the rapid advancement of the construction industry (Rowlinson and McDermott, 1999; Ali *et al.*, 2002; Li *et al.*, 2005).

Value management tools, for example, can improve sustainability and increase efficiency (Zainul Abidin and Pasquire, 2005, 2007). The promotion of partnering is a new approach that can enhance the sustainability of the construction industry (Carter, 2005). Lean construction methods can also promote sustainability by helping to eliminate material wastage and thus increase the value for the client (Huovila and Koskela, 1998).

Application of Sunflower model for comparing the traditional, design and build, and management contracting construction approaches

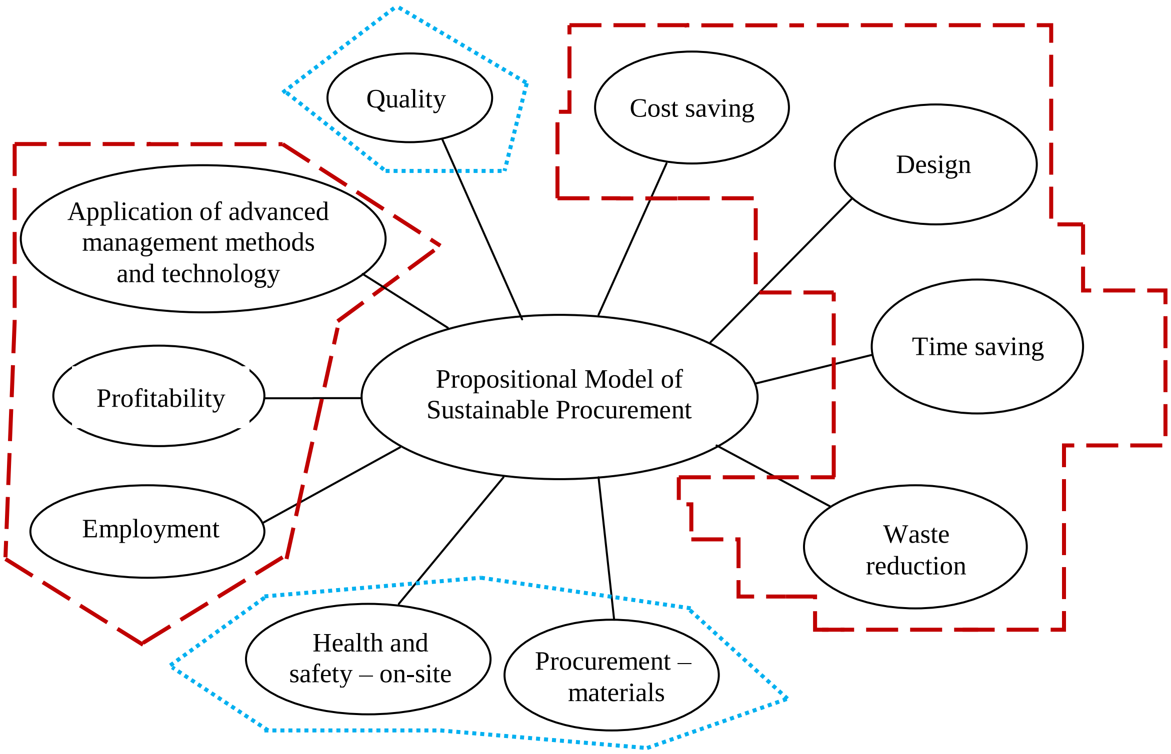

Figure 6-13 Diagram of the propositional model of sustainable procurement methods

The sunflower model comprises (please refer to page ***Table 6-35*** *for clarification):*

(1) Traditional procurement method;

(2) Design and build method; and

(3) Management contracting method

No.	Indicators	Building procurement methods
1)	———	Traditional procurement method
2)	— — — —	Design and build method
3)	··············	Management contracting

Figure 6-14 Indicators line

Figure 6-13 shows that the design and build method makes the greatest contribution to the suggested sustainability indicators, followed by management contracting. However, traditional procurement method contributes very little to the sustainability indicators and therefore not appears in the diagram.

6.5 Summary

Sustainable construction focuses mainly on the environmental, social, and economic effects of a building project and less on technical factors, such as the procurement method used (Hill and Bowen, 1997). The research findings presented in this chapter contribute to the knowledge of sustainable construction about the effects of different building procurement methods. Moreover, the findings show that the sustainability can improve if the construction stakeholders work together. However, a proper set of sustainable construction indicators needs to be identified to fulfill the common interests of all parties. The effectiveness of specific building procurement methods in relation to factors such as quality, cost, time, and design can also be linked to sustainable construction. The integration of sustainable construction and building procurement methods requires direct or indirect mutual understanding and participation among constructions industries stakeholders. In this respect, the government should lead the way by promoting sustainable construction by implementing a suitable public tendering process and promoting sustainable procurement practices. Moreover, the relevant government bodies should carefully examine the sustainability of existing public procurement methods and make the results available to the public. A measure of the importance of sustainable construction needs to be promoted to meet the demand for a new approach to sustainable construction. The results would provide important information for decision-makers in the construction industry that could be applied to any project. Researchers should also be relatively open to discussing their findings on 'sustainable procurement.' The next chapter validates the SuProDem framework developed in this chapter through case studies in Malaysia.

CHAPTER 7 VALIDATION OF THE SuProDem FRAMEWORK BY CASE STUDIES

CHAPTER 7

VALIDATION OF THE SuProDem FRAMEWORK BY CASE STUDIES

7.1 Introduction

This chapter presents the Sustainable Procurement Decision Making (SuProDem) framework for building projects, validation through the case studies, the qualitative results on school construction projects in Malaysia and finally comparison of the results of the industry survey and the case study and a summary. The case studies compare the technical characteristics of the traditional method and design and build method adopted to school project in Malaysia. The studies also examine the sustainability of the two-building procurement methods. The results of the case studies suggest that existing building procurement methods have the necessary technical capabilities to support sustainability. Finally, the results are used to confirm the SuProDem framework as a decision support tool for assessing sustainability performances.

7.2 Sustainable Procurement Decision Making (Suprodem) Framework for building projects

Although sustainability measures have implemented in the construction industry, they have not been systemically documented in the literature. In this chapter, SuProDem framework is proposed for assessing the suitable building procurement methods for promoting sustainability. To the best of knowledge, little sustainability framework regarding decision making for building projects has been presented in the literature. Case studies were conducted to assess the sustainability indicators for the SuProDem framework. The framework comprises a large number of indicators and sub-indicators. Table 7-1 shows the structure of the framework.

Table 7-1 The SuProDem framework 1

<table>
<tr><th>Indicators</th><td rowspan="11">Sub-indicators</td><td rowspan="11">Suitable building procurement method</td></tr>
<tr><td>1) Quality</td></tr>
<tr><td>2) Cost saving</td></tr>
<tr><td>3) Design</td></tr>
<tr><td>4) Time saving</td></tr>
<tr><td>5) Waste reduction</td></tr>
<tr><td>6) Procurement – materials</td></tr>
<tr><td>7) Health and safety – on-site</td></tr>
<tr><td>8) Employment</td></tr>
<tr><td>9) Profitability</td></tr>
<tr><td>10) Application of advanced management methods and technology</td></tr>
</table>

The SuProDem framework developed based on the complex calculation of the significance indices presented in Chapter 4. The sub-indicators were identified in the analysis of the previous chapter and were used in the case studies. The framework can be used to ascertain the appropriate procurement methods for sustainable construction. The identification of an effective procurement method for promoting sustainable building is an important objective of this thesis.

7.3 The Case Studies

Case studies were conducted to validate the results of the industry surveys. Although sustainability measures have previously been implemented in relation to building procurement methods, they have not been systemically investigated. The case study results are used to select the most effective building procurement methods based on the highest scores in the SuProDem framework.

7.3.1 Data collection

Data collection for the case studies was undertaken in Malaysia between August 2011 and September 2011. The aim of the case studies of this thesis was to gain a critical perspective on the analytical results presented in Chapter 6 by investigating the relationship between different building procurement practices and sustainable construction. The questionnaire for the case study survey investigated whether the traditional procurement method or the design and build method made the greatest contribution toward sustainable construction. The case studies were designed to fulfil the requirements of the questionnaire survey conducted for Objective 3 of this thesis. The questionnaires on the contribution of the different procurement methods to sustainable construction were sent to 100 schools in Malaysia at the beginning of August 2011. The schools were selected from the directory list, and the questionnaires were required to be returned by the end of August that year. The 100 schools were selected from the school list using simple random sampling to save cost and time. A list of school building projects was collected from a non-documented reliable source. Of the 100 questionnaires sent, fourteen completed questionnaires were returned; comprising ten responses on traditional and four on design and build building procurement methods. The case studies results are discussed in detail in this chapter. The case studies were assessed using the following Likert scale: (1) not significant; (2) less significant; (3) somewhat significant; (4) significant; and (5) very significant.

7.3.2 History of school building projects in Malaysia

School building projects were selected for the case study because two different types of building procurement methods were used in the implementation of the projects: (1) traditional and (2) design and build. In the 1990s, the Malaysian government adopted a management contracting approach for school building projects. However, a number of problems arose in relation to the management contracting process. Cost constraints for the projects pushed the government to adopt the traditional construction approach because the existing methods were not being successfully implemented. Moreover, although sustainable development was promoted in the school projects and sustainable construction was widely accepted as the way forward, its realization was hampered by numerous factors, many of which stemmed from government policies (A21 SCDC, 2002; Manoliadis *et al.*, 2006). Building procurement is a well-known method for assisting the decision-making of construction stakeholders and is considered to offer a strategic position from which to incorporate sustainability issues into construction projects. There is huge potential to improve the intrinsic capabilities of the existing building procurement methods to enhance sustainable construction (Bakhtiar *et al.*, 2009b; Bakhtiar *et al.*, 2010). A comprehensive school construction project was included in the Ninth Malaysian Plan for the 2006 to 2010 period announced by the then Malaysian Prime Minister, Dato' Seri Abdullah bin Haji Ahmad Badawi. The priorities of the school construction project are clearly described in Article 45 of the Ninth Malaysia Plan, 2006-2010:

> There will be more education opportunities at better equipped pre-schools and primary and secondary schools. During the plan period, the Government will build 180 primary schools and 229 secondary schools and full boarding schools. Dilapidated schools, especially those in Sabah and Sarawak will be replaced. The Government is also aware that 1,598 schools in Malaysia do not have piped water and 809 schools do not have 24-hour electricity supply. Therefore, RM1.15 billion is allocated to improve and enhance rural school facilities, primarily in Sabah and Sarawak. (Ninth Malaysia Plan, 2006-2010)

Moreover, Article 49 of the 2006-2010 plan states that:

> As part of the effort to make national schools the 'School of Choice,' all existing national schools will be made 'Smart Schools.' To this end, RM284 million will be allocated for the Smart School Program and RM1.51 billion will be allocated for the Computerization of Schools Program. Educational opportunities for special children and those with learning difficulties will also be improved.

7.3.3 School construction project and building procurement methods

The school building project involved a mix of building procurement methods, such as the traditional, design and build, and management contracting approaches. However, the majority of the school projects in Malaysia adopted traditional procurement methods. To date, very few school construction projects in Malaysia have used either the design and build or management contracting approaches.

7.3.3.1 Traditional procurement method

Traditional procurement methods are widely adopted for high to low cost school building projects in Malaysia. Construction industry stakeholders find this type of procurement approach easy to understand.

7.3.3.2 Design and build procurement method

The design and build approach is the second most widely used procurement method in school building projects in Malaysia. This type of procurement method has sufficient flexibility to allow the use of new technologies.

7.3.3.3 Management contracting procurement method

The management contracting approach has also been adopted as a procurement method in school building projects in Malaysia. This unique approach has sufficient flexibility to adjust to changing demand and technologies. However, this procurement method is less frequently used and has created many problems in school building projects in Malaysia.

7.3.3.4 Other procurement methods

Another procurement method that has been used in school building projects in Malaysia is the private-finance-incentives approach. However, few projects have adopted the private-finance-incentives procurement approach because of the high cost capabilities required of both the contractors and developers and the consequent difficulty in attaining a decent profit margin.

7.3.4 Comparison of the traditional and design and build methods

These two types of building procurement methods, which have been adopted by the Malaysian government for school building projects, are examined in the case studies. The traditional procurement method is generally easily understood by the various construction industry stakeholders. Most construction industry stakeholders are also very familiar with this approach. The traditional procurement method was introduced by the British when they occupied Malaya (now Malaysia). Although the traditional method is easy to understand, it does have problems with regard to quality and other factors. Moreover, because the traditional method is also lacking about design and is time-consuming, a number of school projects have used the design and build method in recent years. Accordingly, the design and build approach is now considered to be an alternative to the traditional procurement method.

7.3.5 School data on the traditional and design and build methods

7.3.5.1 Designation of the schools

Of the schools that returned questionnaires, ten school projects used the traditional procurement method and four used the design and build method for their school building projects. In the data, the schools are indicated by the letters A, B, C, others, rather than by their direct names, and the type of building procurement method used. Table 7-2 lists the designations of the schools and the type of building procurement method adopted.

Table 7-2 School projects and the building procurement method adopted

Traditional		Design and build	
Name of the school	Indication	Name of the school	Indication
1) A	T-1	1) a	D&B-1
2) B	T-1	2) b	D&B-1
3) C	T-1	3) c	D&B-1
4) D	T-1	4) d	D&B-1

5) E	T-1		
6) F	T-1		
7) G	T-1		
8) H	T-1		
9) J	T-1		
10) K	T-1		

7.3.5.2 Year of establishment of the schools

Most of the school building projects examined in the case studies were completed in 2010. All of the projects were completed as part of the Ninth Malaysian Plan; therefore the sample period was from 2006 to 2010. Table 7-3 shows the year in which each school project was finished.

Table 7-3 Year of completion of the school projects.

	2006	2007	2008	2009	2010	Others
(i) Traditional method	1	0	1	3	5	0
(ii) Design and build method	1	0	0	1	2	0
Total	2	0	1	4	7	0

7.3.5.3 Total cost of the school project

The typical cost of a school building project in the sample was between RM 20,000,001 and RM 25,000,000, which is normal for a school project. The total cost of the school projects, which is described as the cost given, ranged between RM 5,000,001 and RM 30,000,000. Table 7-4 shows the total cost of each school project.

Table 7-4 Total cost of the school projects

Building procurement / RM	RM 5,000,001 - RM 10,000,000	RM 10,000,001 - RM 15,000,000	RM 15,000,001 - RM 20,000,000	RM 20,000,001 - RM 25,000,000	RM 25,000,001 - RM 30,000,000	Others
(i) Traditional method	1	2	1	4	2	0
(ii) Design and build method	1	0	1	1	1	0
Total	2	2	2	5	3	0

7.3.5.4 School project categories

The typical cost of a school building project was between RM 20,000,001 and RM 25,000,000. The standard cost of a school project is an important consideration for cost estimation. The schools ranged between 18, 24, 30, and 36 rooms in size. Table 7-5 shows the school project categories.

Table 7-5 School project categories

	18 rooms	24 rooms	30 rooms	36 rooms	Others	Not given
(i) Traditional method	1	1	6	2	0	0
(ii) Design and build method	0	1	2	0	0	1
Total	1	2	8	2	0	1

7.3.5.5 Original school contract period

The typical original contract period was around 18 months, which is normal for a project of this type. The original period is defined as the overall projected construction period for the contractor to finish the project. Table 7-6 shows the original contract periods for the sample.

Table 7-6 Original contract period

	< 12 months	12 months	18 months	20 months	24 months	Other
(i) Traditional method	0	2	4	2	2	0
(ii) Design and build method	1	0	2	0	1	0
Total	1	2	6	2	3	0

7.3.5.6 Extension time approved

The normal time extension given by the client to the contractor to complete a construction project is 3 - 6 months. Table 7-7 shows the approved extension times for the sample of school building projects.

Table 7-7 Extension times approved

	No EOT	< 1 months	1 - 3 months	3 - 6 months	6 - 12 months	Other	Not given
(i) Traditional method	1	1	1	3	2	2	0
(ii) Design and build method	1	0	0	1	1	0	1
Total	2	1	1	4	3	2	1

7.3.5.7 Pre-construction stage (inception – design – tender)

The normal pre-construction period is 3 - 6 months, which is the typical amount of time needed to complete the pre-construction stage (inception – design – tender). Pre-construction involves construction planning, and some of the projects in the sample required school building blocks to develop. Table 7-8 shows the length of the pre-construction stage (inception – design – tender) for the sample of school building projects.

Table 7-8 Length of pre-construction stage (inception – design – tender – etc.)

	No Idea	< 3 months	3 - 6 months	6 - 12 months	12 - 18 months	> 18 months
(i) Traditional method	0	4	3	2	1	0
(ii) Design and build method	0	0	3	0	1	0
Total	0	4	6	2	2	0

7.3.6 School project characteristics

7.3.6.1 Main building and office

Figure 7-1 Main building and office

Figure 7-1 shows the main building of a typical school. The building houses the school administration and general office and provides offices for staff. The building occupied a number of offices where the administration work is done. The building has also become an intended for visitors including the students’ parents.

The combined figures for the school samples are listed in Table 7-9.

Table 7-9 Combined figures for the school samples

Name of the school	Indication	Procurement method	Year finished	Total cost	Category/ Room	Original contract period	EOT approved	Pre-construction stage
1) A	A	Traditional	2010	RM 10,000,001 - RM 15,000,000	24 rooms	18 months	1-3 months	3-6 months
2) Desa Perdana KL	B	Traditional	2010	RM 10,000,001 - RM 15,000,000	30 rooms	24 months	6-12 months	< 3 months
3) at Mukim Abu Bakar Baginda, Bangi, Selangor	C	Traditional	2009	RM 20,000,001 - RM 25,000,000	36 rooms	20 months	Others	< 3 months
4) Sekolah Kebangsaan Desa Perdana	D	Traditional	2010	RM 15,000,001 - RM 20,000,000	30 rooms	20 months	Others	3-6 months
5) B	E	Traditional	2010	RM 25,000,001 - RM 30,000,000	36 rooms	12 months	6-12 months	6-12 months
6) C	F	Traditional	2008	RM 20,000,001 - RM 25,000,000	30 rooms	24 months	< 1 months	3-6 months
7) D	G	Traditional	2009	RM 5,000,001 - RM 10,000,000	18 rooms	12 months	No EOT	12-18 months
8) Primary School in Precint 9, Putrajaya	H	Traditional	2006	RM 25,000,001 - RM 30,000,000	30 rooms	18 months	3-6 months	6-12 months
9) Sek Men Keb Pokok Sena 2	J	Traditional	2010	RM 20,000,001 - RM 25,000,000	30 rooms	18 months	3-6 months	< 3 months
1) D&B(1)	A	Design & Build	2010	RM 15,000,001 - RM 20,000,000	Not Given	18 months	Not given	3-6 months
2) D&B(2)	B	Design & Build	2006	RM 5,000,001 - RM 10,000,000	24 rooms	18 months	6-12 months	3-6 months
3) D&B(3)	C	Design & Build	2009	RM 25,000,001 - RM 30,000,000	30 rooms	12 months	No EOT	12-18 months
4) D&B(3)	D	Design & Build	2010	RM 20,000,001 - RM 25,000,000	30 rooms	24 months	3-6 months	3-6 months

7.3.6.2 Classrooms

Figure 7-2 Classroom block

Figure 7-2 shows a typical modern school classroom block. The architecturally designed classrooms are specifically designed to accommodate the student learning facilities. The building has multiplied floors to accommodate a large a number of students. The classroom, where the teacher teaches their student, as well as other activities associated with the school curriculum.

7.3.6.3 Canteen

Figure 7-3 Canteen

Figure 7-3 shows a typical school canteen. The canteen is an important part of a school project as it needs to cater for a large number of students and be located in an accessible area. The floor area of this canteen is depending on the size of the students. The canteen is where the students have their lunches with their classmates.

7.3.7 School specifications

A new school building will normally require a number of detailed specifications. Table 7-10 shows the specifications for a typical school.

Table 7-10 Typical school specifications

1) Date	The date is usually given by the contractor
2) Contract period	The contract period is stipulated in the contract
3) Completion date:	The completion date is an important factor in determining the project quality
4) Tentative E.O.T:	An E.O.T is given to a construction firm to extend the delivery date of a construction project
5) Contract Sum:	The original contract sum
6) Defects Liability Period:	The guarantee of the contractor's workmanship
7) Liquidated and Ascertained:	-
8) % Payment received:	-
9) Projected physical progress:	-
10) Actual physical progress:	-
11) Progress status:	-
12) Days ahead / delay:	-

7.3.7.1 Scope of work

The scope of work of a typical school building project includes:

i) Blok Bangunan Pentadbiran – An administration block

The school will also require three to five classroom blocks, for example:

ii) Academic block 1 – four floors

iii) Academic block 2 – four floors

iv) Academic block 3 – four floors

v) Academic block 4 – four floors

7.3.8 School project results

7.3.8.1 Priority rating and utility factor

In this section, priority rating is used to rank the ratings obtained from the respondents while the utility factor is used to weight the main objects of interest in the case studies. The results of the utility factor are based on the contributions from the respondents. The respondents were given the freedom to choose their preferred rating and were requested to assign a suitable rating to the sustainability indicators on a designated scale. The rationalized priority rating is determined by the respondent's selection on the weighting for each sub-indicator and its sub-element. The rating would be different for a different type and size of a construction project. Table 7-10 shows the results for the rationalized priority rating and utility factor.

Table 7-11 Rationalized priority rating and utility factor

		ALL			Traditional			Design & Build		
1. Quality	**RPR**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**
Better quality control and assurance of the project	0.024	3.43	0.85	0.08	3.60	0.84	0.09	3.00	0.82	0.07
Better quality of service and advice from the project team	0.024	3.21	0.80	0.08	3.40	0.70	0.08	2.75	0.96	0.07
Meeting user's satisfaction	0.024	3.57	0.85	0.08	3.70	0.82	0.09	3.25	0.96	0.08
Better quality of client's brief	0.024	3.64	0.84	0.09	3.90	0.74	0.09	3.00	0.82	0.07
Meeting the client's needs	0.024	4.07	0.73	0.10	4.20	0.79	0.10	3.75	0.50	0.09
Reduction of engineering rework	0.024	3.79	0.97	0.09	3.90	0.99	0.09	3.50	1.00	0.08
Reduction of error in the contract documents	0.024	3.64	1.01	0.09	3.70	0.95	0.09	3.50	1.29	0.08
Reduction of inadequate supervision of the project	0.024	3.50	1.02	0.08	3.60	0.70	0.09	3.25	1.71	0.08
2. Cost saving	**RPR**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**
Better value for money	0.022	3.93	1.00	0.09	4.20	0.92	0.09	3.25	0.96	0.07
Reduction of maintenance costs (life-cycle)	0.022	3.36	0.93	0.07	3.60	0.97	0.08	2.75	0.50	0.06
Improving utilization efficiency of the contractor's resources	0.022	3.14	1.03	0.07	3.30	0.95	0.07	2.75	1.26	0.06
Better budget control	0.022	3.36	1.01	0.07	3.60	1.07	0.08	2.75	0.50	0.06
Reduction of cost overrun (project)	0.022	3.36	1.15	0.07	3.60	1.07	0.08	2.75	1.26	0.06
3. Design	**RPR**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**
Better integrated design and construction	0.021	3.71	0.73	0.08	3.80	0.79	0.08	3.50	0.58	0.07
Promoting green design (energy conservation, etc.)	0.021	3.07	0.73	0.07	3.10	0.74	0.07	3.00	0.82	0.06
Better cost-effective design	0.021	3.43	0.76	0.07	3.70	0.67	0.08	2.75	0.50	0.06
Promoting design innovation (prefabrication, etc.)	0.021	3.14	0.77	0.07	3.10	0.74	0.07	3.25	0.96	0.07

Note: (1) **RPR** = Rationalized priority rating; (2) **UF** = Utility factor; (3) **SD** = Standard deviation

Better flow of information on design (reduction of insufficient or incorrect information, etc.)	0.021	3.43	0.65	0.07	3.60	0.52	0.08	3.00	0.82	0.06
Better control of the design and supervision of the work	0.021	3.21	0.80	0.07	3.40	0.84	0.07	2.75	0.50	0.06
4. Time saving	**RPR**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**
Better planning and designing time	0.023	3.57	1.02	0.08	3.60	1.07	0.08	3.50	1.00	0.08
Better cooperation among the project team	0.023	3.50	0.85	0.08	3.80	0.79	0.09	2.75	0.50	0.06
Better detailing and coherent work program	0.023	3.43	0.85	0.08	3.70	0.82	0.08	2.75	0.50	0.06
5. Waste reduction	**RPR**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**
Better waste management	0.018	2.64	0.84	0.05	2.70	0.82	0.05	2.50	1.00	0.05
Promoting green technologies	0.018	2.71	0.73	0.05	2.80	0.63	0.05	2.50	1.00	0.05
Better site communication to avoid abortive works	0.018	3.14	1.03	0.06	3.50	0.85	0.06	2.25	0.96	0.04
Reduction of unused materials and products	0.018	2.93	0.92	0.05	3.20	0.63	0.06	2.25	1.26	0.04
6. Procurement – materials	**RPR**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**
Promoting green procurement – material (environmentally friendly products)	0.017	2.64	0.93	0.05	2.70	1.06	0.05	2.50	0.58	0.04
Better quality materials specification	0.017	3.07	1.14	0.05	3.30	1.06	0.06	2.50	1.29	0.04
Better value for money (material)	0.017	3.21	1.25	0.06	3.40	1.07	0.06	2.75	1.71	0.05
Better choice of materials (project)	0.017	3.29	1.20	0.06	3.50	0.97	0.06	2.75	1.71	0.05
7. Health and safety – on-site	**RPR**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**
Better attitude and culture towardshealth and safety issues	0.021	3.43	1.22	0.07	3.50	1.18	0.07	3.25	1.50	0.07
Increasing awareness of health and safety issues	0.021	3.36	1.15	0.07	3.50	1.08	0.07	3.00	1.41	0.06
Improved safety performance on-site	0.021	3.43	1.02	0.07	3.70	0.95	0.08	2.75	0.96	0.06
Better decisions on health and safety issues	0.021	3.29	1.07	0.07	3.60	1.07	0.07	2.50	0.58	0.05
Reduction of negligence (professional)	0.021	3.79	0.97	0.08	4.10	0.88	0.09	3.00	0.82	0.06

Note: (1) **RPR** = Rationalized priority rating; (2) **UF** = Utility factor; (3) **SD** = Standard deviation

Reduction of accident rate	0.021	3.36	1.15	0.07	3.70	1.16	0.08	2.50	0.58	0.05
8. Employment	**RPR**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**
Better knowledge sharing	0.018	3.29	1.07	0.06	3.50	0.71	0.06	2.75	1.71	0.05
Increasing productivity	0.018	3.50	1.09	0.06	3.70	0.67	0.07	3.00	1.83	0.05
Better allocation of responsibilities among staff	0.018	3.36	1.01	0.06	3.60	0.52	0.06	2.75	1.71	0.05
Improving performance and motivation among project members	0.018	3.43	0.94	0.06	3.60	0.70	0.06	3.00	1.41	0.05
Better working relationship in the project team (reduction of conflicts, etc.)	0.018	3.64	0.93	0.06	3.90	0.88	0.07	3.00	0.82	0.05
9. Profitability	**RPR**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**
Better financial control	0.017	3.00	1.18	0.05	2.90	1.20	0.05	3.25	1.26	0.06
Better risk management	0.017	3.07	0.83	0.05	2.90	0.88	0.05	3.50	0.58	0.06
Better cash flow	0.017	3.07	1.00	0.05	3.00	1.15	0.05	3.25	0.50	0.06
10. Application of advanced management methods and technology	**RPR**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**	**UF**	**SD**	**Result**
Better concern for environmental issues (general)	0.019	2.93	0.92	0.06	3.10	0.74	0.06	2.50	1.29	0.05
Better use of information technology (IT)	0.019	3.21	0.97	0.06	3.30	0.48	0.06	3.00	1.83	0.06
Promoting value management	0.019	3.07	0.92	0.06	3.10	0.88	0.06	3.00	1.15	0.06
Improving the accountability of the contractors	0.019	3.14	0.66	0.06	3.30	0.67	0.06	2.75	0.50	0.05
Promoting lean construction	0.019	3.07	0.62	0.06	3.30	0.48	0.06	2.50	0.58	0.05

Note: (1) **RPR** = Rationalized priority rating; (2) **UF** = Utility factor; (3) **SD** = Standard deviation

7.3.8.2 Ranking summary

The results were also ranked in relation to the traditional and design and build approaches. Table 7-12 shows the summary of the ranking results.

Table 7-12 Summary of the ranking results

Indicators	**ALL**		**Traditional**		**Design and Build**	
	Point	Ranking	Point	Ranking	Point	Ranking
1) Quality	0.686	1	0.71	1	0.62	2
2) Cost saving	0.379	4	0.40	1	0.31	2
3) Design	0.425	3	0.44	1	0.39	2
4) Time saving	0.236	7	0.25	1	0.20	2
5) Waste reduction	0.209	9	0.22	1	0.17	2
6) Procurement – materials	0.213	8	0.22	1	0.18	2
7) Health and safety	0.430	2	0.46	1	0.35	2
8) Employment	0.307	5	0.33	1	0.26	2
9) Profitability	0.159	10	0.15	2	0.17	1
10) Application of advanced management methods and technology	0.295	6	0.31	1	0.26	2
Sub-total				11		19
Ranking (the lowest sub-total)				1		2

The summary of the ranking reflects the respondents' perspectives on sustainability. Quality and cost saving are considered to be important economic factors. Design is guided by the selection of a suitable building procurement method. Time saving refers to efficiency in finishing a project on time. Waste reduction is an important indicator of sustainable construction. Procurement – materials ensures that sustainable materials are used on-site. Health and safety is an important element in sustainable construction. Employment is also an important criteria for sustaining the supply and demand of employment in the construction market. Profitability is the ‘norm’ in the construction industry for sustaining growth and contributing to the economy. The application of advanced management methods and technology supports sustainable construction by introducing new ways for developing an advanced environment. Finally, the respondents selected traditional procurement as a more important method for sustainable construction than design and build.

7.3.9 Discussion

Although sustainability measures have previously been implemented with regard to procurement methods such as the traditional and design and build approaches, they have not been systemically documented. One of the main aims of the case studies was to systematically examine the selected school projects identifying the best practices for sustainable building. The analysis of the case study results also provides a means of summarizing the main research results of this thesis, including those of the literature review, the practical investigations, and the analysis of the sustainability indicators. The SuProDem framework for evaluating sustainability performance is also discussed in relation to the case study results.

7.3.9.1 Environmental benefits

The respondents believed that the mitigation of health and safety issues provide major benefits for the environment. The respondents also believed that high levels of wastage have no positive environmental benefits. Given the significance of environmental protection, waste reduction is an important factor in achieving sustainable construction.

7.3.9.2 Economic benefits

Economic benefits such as cost saving are important for sustainable construction. The respondents also believed that quality contributes to sustainable construction and is an important economic factor in building projects. Cost saving and profitability were also considered to be in line with sustainable construction. The application of advanced management methods and technology is also important.

7.3.9.3 Social benefits

The social benefits of sustainable building include improved employment and on-site health and safety. Procurement can also have important short- and long-term social benefits, especially when durable materials are selected. The selection of proper materials can directly affect human health and wellbeing.

7.4 Qualitative Results of the School Building Projects

A qualitative approach was adopted to examine school building projects in Malaysia. The results were generated from interviews with the clients and contractors regarding the school projects. This approach produces particular relevant information from the interviews that have been conducted among respondents.

<u>(A) Sustainable construction and school projects</u>

(1) The concept of sustainable construction

The respondents stated that the construction industry needs to adopt the concept of sustainable construction to achieve a high quality of construction within the specified contract time, as the following quotes form the interviews show. It is appreciated that the government should taken into account the developed a legislative framework in order to promote sustainable construction, in-order to promote a higher quality for the built environment.

"Sustainable construction benefits society, but at the same time, the construction firm wants to meet targeted cost with the minimum or acceptable requirement of quality, and also complete the project on time."

"In general, the Ministry of Education of Malaysia (MOE) is less awareness of sustainable construction, and so far has only used industrialized building systems in their projects. However, it is only limited to design and build projects."

(2) General views about sustainable construction in Malaysia

The government of Malaysia is seriously promoting sustainable construction in relation to current and future projects. Moreover, the government will take into account regarding sustainable construction in building project, and to urban development as a whole. The government, as the largest construction client, would take a principal role in promoting sustainable construction.

"The government of Malaysia is aggressively promoting the sustainable construction concept. However, people involved in the concept often have little expertise and training. Some of them feel that it is a new thing and need some time to get exposure to it. Besides, there should be more in-depth research in this area."

(3) Acceptance of sustainable construction among contractors

Sustainable construction is well addressed among contractor. However, it needs special attention concerning sustainable construction implementation among them.

"The contractor is relatively slow to respond regarding the sustainable construction concept. Contractors in Malaysia may be 10-20 years behind contractors in the developed countries. Authorities such as the Construction Industry Development Board (CIBD) need to enforce local contractors to achieve sustainability."

(4) Acceptance of sustainable construction among consultants

Sustainable construction has a high acceptance among consultants. They understand the characteristic of sustainable construction. Thus, it is not a problem among consultant.

"Consultants are quite educated. They accept the sustainable construction concept, and have the highest willingness to implement it; and also work closely with the government and comply with the policies that are implemented."

(5) Contribution of sustainable construction to the Malaysian construction industry

Sustainable construction perceived as new paradigm shift in the Malaysian construction industry. The normal problem facing the construction industry in Malaysia is cost, time, and quality issues.

"The construction industry in Malaysia is normally focused on time, cost and quality, and safety. These elements are considered basic requirements. If a project completed on time, then (eventually) the public can benefit from it. If cost saving also occurs, the project will avoid wasting public money."

(6) Environmental issues in Malaysia

Environmental issue is a huge issue in developing countries. It has a significance impact towards sustainable construction and compromising the human need for progression.

“Typically, a contractor has little concern for environmental issues. Therefore, the government of Malaysia needs to promote awareness and allocate some funds to promote sustainability.”

(7) Regarding sustainability; what percentage of the budget should the government allocate to the contractor and the architect (designer)?

The budget remain constrain for the government to allocate some fund for sustainable construction project. Most government in developing countries has limited budget to promote sustainable construction.

“The government should allocate between 3 and 10 percent of an extra budget to promote sustainability. However, it depends on location; for example in a remote area, it should be between 3 and 5 percent; and it should be enough to protect the surrounding area of a project. In a town area, however, because of the pollution, dust and noise, the cost should be higher; (perhaps) the cost should be between 5 and 10 percent.”

(8) Sustainability awareness of the end user (client)

The sustainability awareness for the client is very important for the client, and the end user. The client would be reluctant to implement sustainable construction if the cost to implement it passed to them.

“The majority of end users are less awareness of sustainable construction. This is because the education system in Malaysia does not promote sustainability. Thus, there is a need to promote sustainable construction concept in the education syllabus, seminars, and newspapers.”

(9) Contribution of sustainable construction to school building projects in Malaysia in regard to:

A school building project is critical in Malaysia as a developing country. The construction industry in Malaysia has been facing issues related to poor quality for its school project. Below are the comments from respondents:

(a) The environment

“The concept of sustainable construction in an environmental aspect in a school project is normally the client (the government) seeking advice from consultants regarding the project.”

(b) The economy

“The economics of a school project take a macro scale perspective that requires seeking advice from the public.”

(c) Society

“Economic development is more important than the social agenda for a developing country. It is not like a European country that may focus on social issues.”

(B) Technical characteristics of the different building procurement methods

Technical terms may not be used frequently in sustainability, but it may be used in building procurement method. Below is an interview that has been conducted with the clients and contractors regarding school building projects:

(1) Quality

"The traditional method achieves much better quality compared with design and build. This is because the contractor tends to maximize profit, and produce low quality product (output) for a construction project ... Moreover, the method contributes to quality, because client and consultant have started the project at the beginning, and produced the specification. However, if supervision is weak, the quality of the product construct will be much lower."

(2) Order variation

"A traditional procurement method normally creates much variation order, and lengthens the time of the construction project."

(3) Waste management

"Design and build has better waste management measures."

(4) Procurement of materials

“I believe that the design and build method is easier to monitor than traditional methods.”

(5) Health and safety

“Both procurement methods have less significantce for health and safety, and it depends on site management.”

(6) Employment

“Regarding employment, there is no significant difference between the procurement methods. Both approaches can create jobs. The traditional procurement method provides construction professionals with a good learning experience in a construction project. Moreover, both procurement methods can contribute towards productivity.”

(7) Profitability

“Design and build is much more profitable than traditional methods.”

(8) Administration costs

“Administrative costs do not apply in any procurement methods; they depend on the number of employees the firm employs.”

(9) Other (information technology, environmental issues)

Information technology

Information technology is adopted in the construction sector to stimulate efficiency working environment.

"The traditional method to some extent is a far better at promoting information technology and is better concerned with environmental issues, partly because design and build needs to follow the client's needs."

Accountability of the contractor

"The accountability of contractor is much better with design and build."

(10) Advantages of design and build over traditional methods for the contractor

"Design and build contractors normally understand traditional methods as well. Design and build contractors normally have more educated staff, have better capabilities and are financially stronger."

"The (construction) design regarding a design and build contractor was normally conducted by contractor, however it is far much better if the design prepare by the consultant (refer to traditional methods)."

"The traditional method is handled by the consultant, and there is a lot of variance in the traditional method."

(11) Health and safety

"Health and safety is identical in both traditional and design and build because it is normally handled by the consultant."

(12) The design and build method

"The design and build method, the contractor needs the engineer to design for themselves in design and build procurement. This does not make a contribution to local employment. If you are the employee, the working environment will be stressful, with problems with clients, contractors and others. However, the benefits include better financial control, cash flow, and administrative costs."

(C) Case study of a school project

School project was selected to understand sustainable construction concept. One comment is that there is a need to narrow down a broad concept of sustainability. Below is the comments from respondents regarding this matter:

1) Typical procurement method used for a Ministry of Education funded school project

"The typical procurement method used is traditional; however, design and build and direct-negotiation are also used. The traditional method is the most popular."

2) Clients choose the traditional method rather than design and build or management contracting

"This is because government staff have used traditional method for so many years, followed the British system. Generally, the Malaysian construction industry follows British standards for construction project. Design and build is a new concept, and contractors need to be educated because design and build needs knowledge and experience. Management contracting is not suitable for a school project, because this type of procurement is only used in large and high-profile projects."

3) Other procurement methods

Other procurement methods have been used in Malaysia. Below are the comments from respondents regarding this matter:

"Public Finance Incentives are not so common in Malaysia, because a lot of the design is bureaucratic, and needs to be carried out by big and cash-rich firms. The process is long, including a complicated process of submitting documents to various agencies. Regarding Build-Operate-Transfer (BOT), there is no BOT procurement method. However, it is used in some government projects, such highways and plaza tolls. This method generates money."

4) Difference between school projects handled by the Ministry of Education and the Public Works Department in Malaysia

"Typically the Ministry of Education, Malaysia will manage new school projects, whereas the Public Works Department will extend existing school buildings."

"Typically for a school project the Ministry of Education will give some variation order to the contractor."

"Typically the Ministry of Education will manage a school project that has 6, 12, 18, 24, 36 or 40 rooms."

"Design and build is typically used in more than 40 million projects."

"Typically design and build is selected from a pre-contract."

7.5 Comparison of the Results of the Industry Survey and the Case Studies

Table 7-13 Summary for (1) Quality

Indicators	Traditional						Design and build					
	Industry survey			Case study (Analysis 4)			Industry survey			Case study (Analysis 4)		
(1) Quality	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank
Better quality control and assurance of the project	8.33	7.24	5	4.00 x 2 = 8.00 (Adjust ment)	3.60 x 2 = 7.20	6	8.33	7.15	7	4.00 x 2 = 8.00 (Adjust ment)	3.00 x 2 = 6.00	6
Better quality of service and advice from the project team		7.29	4		3.40 x 2 = 6.80	8		7.28	4		2.75 x 2 = 5.50	8
Meeting user's satisfaction		7.36	3		3.70 x 2 = 7.40	4		7.28	4		3.25 x 2 = 6.50	4
Better quality of client's brief		7.49	2		3.90 x 2 = 7.80	2		7.10	8		3.00 x 2 = 6.00	6
Meeting the client's needs		7.71	1		4.20 x 2 = 8.40	1		7.44	2		3.75 x 2 = 7.50	1
Reduction of engineering rework		6.57	8		3.90 x 2 = 7.80	2		7.44	2		3.50 x 2 = 7.00	2
Reduction of error in the contract documents		6.97	6		3.70 x 2 = 7.40	4		7.49	1		3.50 x 2 = 7.00	2
Reduction of inadequate supervision of the project		6.75	7		3.60 x 2 = 7.20	6		7.26	6		3.25 x 2 = 6.50	4
Overall ranking (Priority rating)	2			1			2			1		
Utility factor (Total)		57.38			30.00 x 2 = 60.00			58.44			26.00 x 2 = 52.00	
Differences of utility factor	2.62						6.44					
Pearson correlation (Ranking)	0.30						0.69					

Table 7-14 Summary for (2) Cost saving

	Traditional						**Design and build**					
	Industry survey			Case study (Analysis 4)			Industry survey			Case study (Analysis 4)		
(2) Cost saving	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank
Better value for money	8.361	7.35	1	3.714 x 2 = 7.428 (Adjustment)	4.20 x 2 = 8.40	1	8.361	7.38	4	3.714 x 2 = 7.428 (Adjustment)	3.25 x 2 = 6.50	1
Reduction of maintenance costs (life-cycle)		6.93	4		3.60 x 2 = 7.20	2		7.06	5		2.75 x 2 = 5.50	2
Improving the utilization efficiency of the contractor's resources		6.58	5		3.30 x 2 = 6.60	5		7.79	1		2.75 x 2 = 5.50	2
Better budget control		7.22	2		3.60 x 2 = 7.20	2		7.47	3		2.75 x 2 = 5.50	2
Reduction of cost overrun (project)		6.96	3		3.60 x 2 = 7.20	2		7.50	2		2.75 x 2 = 5.50	2
Overall ranking (Priority rating)	1			3			1			3		
Utility factor (Total)		35.04			18.30 x 2 = 36.60			37.19			14.25 x 2 = 28.50	
Difference in the utility factor	1.56						8.69					
Pearson correlation (Ranking)	0.83						-0.35					

Table 7-15 Summary for (3) Design

	Traditional						Design and build					
	Industry survey			Case study (Analysis 4)			Industry survey			Case study (Analysis 4)		
(3) Design	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank
Better integrated design and construction	7.903	6.76	3	3.571 x 2 = 7.142 (Adjustment)	3.80 x 2 = 7.60	1	7.903	8.01	1	3.571 x 2 = 7.142 (Adjustment)	3.50 x 2 = 7.00	1
Promoting green design (energy conservation, etc.)		6.94	2		3.10 x 2 = 6.20	5		7.42	6		3.00 x 2 = 6.00	2
Better cost-effective design		6.71	4		3.70 x 2 = 7.40	2		7.89	3		2.75 x 2 = 5.50	5
Promoting design innovation (prefabrication, etc.)		6.32	6		3.10 x 2 = 6.20	5		8.00	2		3.25 x 2 = 6.50	4
Better flow of information on design		6.61	5		3.60 x 2 = 7.20	3		7.68	4		3.00 x 2 = 6.00	2
Better control of the design and supervision of the work		7.08	1		3.40 x 2 = 6.80	4		7.44	5		2.75 x 2 = 5.50	5
Overall ranking (Priority rating)	4			4			4			4		
Utility factor (Total)		40.43			20.70 x 2 = 41.40			46.44			18.25 x 2 = 36.50	
Difference in the utility factor	0.97						9.94					
Pearson correlation (Ranking)	0.00						0.16					

Table 7-16 Summary for (4) Time saving

	Traditional						Design and build					
	Industry survey			Case study (Analysis 4)			Industry survey			Case study (Analysis 4)		
(4) Time saving	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank
Better planning and designing time	7.931	7.81	3	3.786 x 2 = 7.572 (Adjustment)	3.60 x 2 = 7.20	3	7.931	7.81	1	3.786 x 2 = 7.572 (Adjustment)	3.50 x 2 = 7.00	1
Better cooperation among the project team		7.69	2		3.80 x 2 = 7.60	1		7.69	3		2.75 x 2 = 5.50	2
Better detailing and coherent work program		7.74	1		3.70 x 2 = 7.40	2		7.74	2		2.75 x 2 = 5.50	2
Overall ranking (Priority rating)	3			2			3			2		
Utility factor (Total)		21.18			11.10 x 2 = 22.20			23.24			9.00 x 2 = 18.00	
Difference in the utility factor	1.02						5.24					
Pearson correlation (Ranking)	0.50						0.87					

Table 7-17 Summary for (5) Waste reduction

	Traditional						**Design and build**					
	Industry survey			Case study (Analysis 4)			Industry survey			Case study (Analysis 4)		
(5) Waste reduction	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank
Better waste management	7.472	6.40	3	3.071 x 2 = 6.142 (Adjustment)	2.70 x 2 = 5.40	4	7.472	7.46	3	3.071 x 2 = 6.142 (Adjustment)	2.50 x 2 = 5.00	1
Promoting green technologies		6.61	2		2.80 x 2 = 5.60	3		7.19	4		2.50 x 2 = 5.00	1
Better site communication to avoid abortive works		6.65	1		3.50 x 2 = 7.00	1		7.72	1		2.25 x 2 = 4.50	3
Reduction of unused materials and products		6.35	4		3.20 x 2 = 6.40	2		7.51	2		2.25 x 2 = 4.50	3
Overall ranking (Priority rating)	7			7			7			7		
Utility factor (Total)		26.01			12.20 x 2 = 24.40			29.89			9.50 x 2 = 19.00	
Difference in the utility factor	1.61						10.89					
Pearson correlation (Ranking)	0.40						-0.89					

Table 7-18 Summary for (6) Procurement – materials

	Traditional						**Design and build**					
	Industry survey			Case study (Analysis 4)			Industry survey			Case study (Analysis 4)		
(6) Procurement – materials	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank
Promoting green procurement – material	7.528	6.83	4	2.929 x 2 = 5.858 (Adjustment)	2.70 x 2 = 5.40	4	7.528	7.31	2	2.929 x 2 = 5.858 (Adjustment)	2.50 x 2 = 5.00	3
Better quality materials specification		7.21	1		3.30 x 2 = 6.60	3		7.11	4		2.50 x 2 = 5.00	3
Better value for money (material)		7.06	3		3.40 x 2 = 6.80	2		7.36	1		2.75 x 2 = 5.50	1
Better choice of materials (project)		7.13	2		3.50 x 2 = 7.00	1		7.28	3		2.75 x 2 = 5.50	1
Overall ranking (Priority rating)	6			9			6			9		
Utility factor (Total)		28.22			12.90 x 2 = 25.80			29.06			10.50 x 2 = 21.00	
Difference in the utility factor	2.42						8.06					
Pearson correlation (Ranking)	0.40						0.45					

Table 7-19 Summary for (7) Health and safety – on-site

	Traditional						Design and build					
	Industry survey			Case study (Analysis 4)			Industry survey			Case study (Analysis 4)		
(7) Health and safety – on-site	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank
Better attitude and culture toward health and safety	7.347	6.90	3	3.500 x 2 = 7.000 (Adjustment)	3.50 x 2 = 7.00	5	7.347	7.21	3	3.500 x 2 = 7.000 (Adjustment)	3.25 x 2 = 6.50	1
Increasing awareness of health and safety issues		6.93	2		3.50 x 2 = 7.00	5		7.28	1		3.00 x 2 = 6.00	2
Improving safety performance on-site		6.85	4		3.70 x 2 = 7.40	2		7.21	3		2.75 x 2 = 5.50	4
Better decisions on health and safety issues		6.81	5		3.60 x 2 = 7.20	4		7.21	3		2.50 x 2 = 5.00	5
Reduction of negligence (professional)		7.00	1		4.10 x 2 = 8.20	1		7.29	2		3.00 x 2 = 6.00	2
Reduction of accident rate		6.75	6		3.70 x 2 = 7.40	2		7.10	6		2.50 x 2 = 5.00	5
Overall ranking (Priority rating)	8			5			8			5		
Utility factor (Total)		41.24			22.10 x 2 = 44.20			43.29			17.10 x 2 = 34.20	
Difference in the utility factor	2.96						9.09					
Pearson correlation (Ranking)	-0.03						0.62					

Table 7-20 Summary for (8) Employment

	Traditional						Design and build					
	Industry survey			Case study (Analysis 4)			Industry survey			Case study (Analysis 4)		
(8) Employment	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank
Better knowledge sharing	6.611	7.03	1	3.000 x 2 = 6.000 (Adjustment)	3.50 x 2 = 7.00	5	6.611	7.47	4	3.000 x 2 = 6.000 (Adjustment)	2.75 x 2 = 5.50	4
Increased productivity		6.76	4		3.70 x 2 = 7.40	2		7.65	1		3.00 x 2 = 6.00	1
Better allocation of responsibilities among staff		6.92	2		3.60 x 2 = 7.20	3		7.42	5		2.75 x 2 = 5.50	4
Improving performance and motivation among the team		6.71	5		3.60 x 2 = 7.20	3		7.50	3		3.00 x 2 = 6.00	1
Better working relationship in the project team		6.86	3		3.90 x 2 = 7.80	1		7.60	2		3.00 x 2 = 6.00	1
Overall ranking (Priority rating)	10			8			10			8		
Utility factor (Total)		34.28			18.30 x 2 = 36.60			37.64			14.50 x 2 = 29.00	
Difference in the utility factor	2.32						8.64					
Pearson correlation (Ranking)	-0.53						0.87					

Table 7-21 Summary for (9) Profitability

	Traditional						**Design and build**					
	Industry survey			Case study (Analysis 4)			Industry survey			Case study (Analysis 4)		
(9) Profitability	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank
Better financial control	7.625	6.79	1	2.929 x 2 = 5.858 (Adjustment)	2.90 x 2 = 5.80	2	7.625	7.75	1	2.929 x 2 = 5.858 (Adjustment)	3.25 x 2 = 6.50	2
Better risk management		6.61	2		2.90 x 2 = 5.80	2		7.67	2		3.50 x 2 = 7.00	1
Better cash flow		6.54	3		3.00 x 2 = 6.00	1		7.46	3		3.25 x 2 = 6.50	2
Overall ranking (Priority rating)	5			9			5			9		
Utility factor (Total)		19.94			8.80 x 2 = 17.60			22.88			10.00 x 2 = 20.00	
Difference in the utility factor	2.34						2.88					
Pearson correlation (Ranking)	-0.87						0.00					

Table 7-22 Summary for (10) Application of advanced management methods and technology

	Traditional						**Design and build**					
	Industry survey			Case study (Analysis 4)			Industry survey			Case study (Analysis 4)		
(10) Application of advanced management methods and technology	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank	Priority rating	Utility factor	Rank
Better concern for environmental issues (general)		6.92	1		3.10 x 2 = 6.20	4		7.25	5		2.50 x 2 = 5.00	4
Better use of information technology (IT)		6.79	3		3.30 x 2 = 6.60	1		7.57	3		3.00 x 2 = 6.00	1
Promoting value management	7.292	6.75	4	3.214 x 2 = 6.428 (Adjustment)	3.10 x 2 = 6.20	4	7.292	7.58	2	3.214 x 2 = 6.428 (Adjustment)	3.00 x 2 = 6.00	1
Improving accountability of contractors		6.86	2		3.30 x 2 = 6.60	1		7.68	1		2.75 x 2 = 5.50	3
Promoting lean construction		6.51	5		3.30 x 2 = 6.60	1		7.43	4		2.50 x 2 = 5.00	4
Overall ranking (Priority rating)	9			6			9			6		
Utility factor (Total)		33.83			16.10 x 2 = 32.20			37.51			13.75 x 2 = 27.50	
Difference in the utility factor	1.63						10.01					
Pearson correlation (Ranking)	-0.29						0.52					

Discussions

(i) The priority rating scale

Priority rating was used to rank the respondents' opinions or perception on the issue. The priority rating scales for the industry survey and case study were measured and compared. The Spearman rank-order correlation coefficient of the rankings was then calculated. Table 7-23 shows the priority rating scale for all of the respondents.

Table 7-23 Priority rating scale of all respondents

Indicators	Industry survey	Ranking	Case study	Ranking
1) Quality	8.33	2	8.00	1
2) Cost saving	8.36	1	7.43	3
3) Design	7.90	4	7.14	4
4) Time saving	7.93	3	7.57	2
5) Waste reduction	7.47	7	6.14	7
6) Procurement – materials	7.53	6	5.86	9
7) Health and safety – on-site	7.35	8	7.00	5
8) Employment	6.61	10	6.00	8
9) Profitability	7.63	5	5.86	9
10) Application of advanced management methods and technology	7.29	9	6.43	6
Spearman rank-order correlation coefficient	0.66			

Note: Includes public and private clients

The priority rating was also used to determine the significance indicators. The indicators were ranked to analyze the weighting for each importance indicator. The Spearmen rank-order correlation coefficient was calculated to be around 0.66 and the result was almost the same for both parties. In the first survey, the respondents selected the suitable indicators of sustainable construction. The top ranking indicators were quality, cost saving, time saving, and design. It is not surprising that the respondents considered quality, cost saving, and time saving to be essential elements for sustainable construction. Employment and profitability were the lowest ranked indicators. This result was unexpected, and suggests that construction industry stakeholders have a lack of understanding of sustainability.

(ii) Utility factor

The utility factor of the indicator ranking was calculated to see whether there were any differences or similarities between the results. To generate the results, the difference between the utility factors for the industry survey and the case study was divided by the sum of all the utility factors. Figure 7-4 shows the calculation of the utility factor.

$$\frac{\text{The difference in the utility factors of the industry survey and case study}}{\text{Total utility factor}} = \%$$

Figure 7-4 Calculation of the utility factor

The generated results were used to determine the efficiency indicators for sustainable construction in relation to the traditional and design and build building procurement methods. Table 7-24 shows the differences in percentages for the two procurement methods.

Table 7-24 Percentage differences

Indicators/building procurement methods	Traditional			Design and build		
	Industry survey	Case study	Differences (%)	Industry survey	Case study	Differences (%)
1) Quality	4.57%	4.37%	0.20%	11.02%	12.38%	1.36%
2) Cost saving	4.45%	4.26%	0.19%	23.37%	30.49%	7.12%
3) Design	2.40%	2.34%	0.06%	21.40%	27.23%	5.83%
4) Time saving	4.82%	4.59%	0.22%	22.55%	29.11%	6.56%
5) Waste reduction	6.19%	6.60%	0.41%	36.43%	57.32%	20.88%
6) Procurement – materials	8.58%	9.38%	0.80%	27.74%	38.38%	10.65%
7) Health and safety – on-site	7.18%	6.70%	0.48%	21.00%	26.58%	5.58%
8) Employment	6.77%	6.34%	0.43%	22.95%	29.79%	6.84%

9) Profitability	11.74%	13.30%	1.56%	12.59%	14.40%	1.81%
10) Application of advanced management methods and technology	4.82%	5.06%	0.24%	26.69%	36.40%	9.71%

The percentages were calculated to identify any similarities or difference in the results. These results provide important in-depth information to enable decision-makers to achieve sustainable construction.

(iii) Relationship between the results of the industry survey and the case study

The Spearmen rank-order correlation coefficients of the industry survey and case study rankings were calculated to reflect the differences between the two types of ranking. Table 7-25 shows the Spearman rank-order correlation coefficient results.

Table 7-25 Spearman rank-order correlation coefficients

Indicators	Spearman rank-order correlation coefficient			
	Traditional		Design and build	
	Industry survey	Case study	Industry survey	Case study
1) Quality	0.30		0.69	
2) Cost saving	0.83		-0.35	
3) Design	0.00		0.16	
4) Time saving	0.50		0.87	
5) Waste reduction	0.40		-0.89	
6) Procurement – materials	0.40		0.45	
7) Health and safety – on-site	-0.03		0.62	
8) Employment	-0.53		0.87	
9) Profitability	-0.87		0.00	
10) Application of advanced management methods and technology	-0.29		0.52	

The results shows that time saving and employment have the highest coefficients of 0.87 under the design and build building procurement method, followed by cost saving, with a coefficient of 0.83, under traditional procurement methods. Waste reduction and profitability have the lowest coefficients of -0.89 and -0.87, respectively. These results indicate the relationship between the industry survey and the case study, and thus reflect the perspectives of both groups of respondents.

Conclusions

Previous research suggested that traditional building procurement methods hinder sustainability. However, the results of the case studies suggest that traditional building procurement methods are still suitable for school construction projects. This indicates that different building procurement methods are suitable for different building projects. Moreover, identifying the strengths and weaknesses of the different types of building procurement can facilitate and improve their sustainability. Sustainable construction has to be based on win-win principles for both clients and contractors, and consultants should act as the ‘middlemen’ in facilitating effective sustainable construction. The findings of the case studies indicate that the government should lead the way in promoting sustainable construction by introducing public tendering processes and practical procurement processes. Moreover, the government should carefully examine the procurement methods used in existing building projects in Malaysia and make the results available to the public. This would make the research on ‘sustainable procurement method’ open for discussion among researchers.

7.6 Summary

The results of the case studies show a wider application of the existing building procurement methods is needed to increase understanding of sustainable construction. The findings would help construction industry stakeholders to choose suitable building procurement methods. The huge sums invested by the Malaysian government should be taken seriously by the public sector. Instead of investigating all of the existing building procurement methods, these case studies focused on the traditional and design and build approaches, which are the typical building procurement methods in Malaysia. School building projects were selected for the case studies. The school construction projects are major social policy of the Malaysian government for supporting a harmonious society and promoting sustainability. The projects were also selected because of their inherent cost and time constraints. However, in the 1990s, the Malaysian government adopted management contracting as the procurement approach for delivering school projects, which was eventually found to be problematic. Although the concept of sustainability is widely accepted, its realization is hampered by numerous factors, such as the political situation in Malaysia and prevailing government policies (see also A21 SCDC, 2002; Manoliadis *et al.*, 2006).

CHAPTER 8 CONCLUSIONS

8.1 Introduction

8.2 Review of research objectives and overview of the thesis

8.3 Discussion on research findings

8.4 Research contributions

8.5 Conclusions

8.6 Limitations of the research

8.7 Recommendations for future research

8.8 Personal attainments from completing this thesis

CHAPTER 8

CONCLUSIONS

8.1 Introduction

This concluding chapter provides an overall summary of the research. Problem identification and research objectives are highlighted in Chapter 1. These objectives lead to literature reviews in Chapter 2 and development of research methodology in Chapter 3; Chapter 4 reports on the findings of comprehensive reviews over sustainable construction, building procurement method in developing countries and the development of scoring framework; Chapter 5 explains in details regarding data collection procedures; Chapter 6 interprets findings from industrial surveys and development of SuProDem framework; and Chapter 7 interprets the findings from case studies.

Lastly, Chapter 8 summarizes all research findings and concludes the overall contributions. Achievement of the stated objectives is explained in this chapter through review of research objectives and development processes, drawing of conclusion of research questions, contributions, the limitations, and recommendations for future study.

8.2 Review of Research Objectives and Overview of the Thesis

This thesis focuses on three conceptual foundations, i.e. (1) sustainable construction methods; (2) sustainable construction in developing countries; and (3) the relationship between sustainable construction and building procurement methods. Research gaps were identified between the three areas through literature reviews in Chapter 2. Specifically, this research has sought to achieve the following objectives:

1. To identify methods already developed for promoting sustainable construction, through a comprehensive literature reviews;

2. To establish integrated sustainability indicators for measuring performance of different building procurement methods;

3. To develop a scoring framework as a decision making support tool for evaluating sustainability performance of different building procurement methods;

4. To demonstrate the applicability of the scoring framework through case studies.

The objectives have provided a clear direction for the study. Subsequently, they were made achievable by the adoption of an appropriate research methodology. There were two steps for data collection. Firstly, it was done through industry surveys to identify an ‘integrated set of indicators’ for analyzing different building procurement methods. An extensive literature review was conducted on the integration of building procurement methods with sustainability, in particular in the context of developing and newly industrialized countries. A research gap on the relationship between sustainability and procurement practices in those countries was successfully identified. The SuProDem framework has been developed based on the identified scoring framework and integrated indicators.

Secondly, the framework has been used to evaluate sustainability performance of different building procurement methods through critical comparisons of school construction projects in Malaysia. The projects being examined in this study developed under two specific types of building procurement methods, i.e. the traditional and design and build procurement methods. The outcome from case studies was used to compare and validate with the results obtained from industry surveys.

8.3 Discussion on Research Findings

The primary aim is to develop a scoring framework as a decision support tool to assess sustainability performance using different building procurement methods, particularly by responding to conceptual foundation of sustainable construction and building procurement methods in developing countries**.** Problem statements and research gaps were identified so as to achieve the objectives. Sub sections from 8.3.1 to 8.3.4 provide discussions of the results in Chapter 2, 4, 5, 6 and 7, respectively.

8.3.1 Research Objectives 1 (RO1)

RO1: *Identify methods already developed for promoting sustainable construction, through comprehensive literature reviews;*

The reviews in Chapter 2, Section 2.4 and 2.5 (from page 51) provide in-depth insights into the knowledge and practice of sustainability about current building procurement methods. Love *et al.* (1998) stated that the term ‘contractual arrangement’ and ‘procurement systems’ are usually used synonymously. In their studies, the definition used for procurement system is ‘an organizational system that assigns specific responsibilities and authorities to people and organizations and defines the relationships of various elements in construction project’.

The procurement systems can be categorized as (1) traditional (design-tender-construct) method; (2) design and construct method; and (3) management method. Some researchers have used the term ‘procurement method’ to describe the procurement system. There are other procurement methods in the industry such as (1) partnering; (2) build-operate-transfer; (3) public-private partnership. These methods are not considered in this study since they are rarely used in Malaysia and are unsuitable for the case studies of this research. However, they are described here to complement the overall understanding of procurement methods that can be considered.

Hashim (1999) described that in a traditional method, a client appoints design and cost consultants who produce a set of detailed drawings and a bill of quantities, detailed and quantified list of all categories of materials and labor in a job. The client will enter into a separate contract with the main contractor who carries out the construction work. The design and build method is where the main contractor accepts responsibility for designing and building to meet the client's requirements. Management contracting method is a method whereby a specialist who plans and controls construction work is appointed early in the project to help to ensure building ability or ease of construction, and then manages the actual construction by several other contracting firms. Two major factors highlighted in the literature review presented in Chapter 2 were the identification of the most effective sustainable construction methods and the corresponding factors that can be used as indicators of sustainability.

The indicators were identified by matching the characteristics of sustainable construction with different building procurement methods. The literature reviews also identified a gap about the contribution that different building procurement methods towards sustainable construction. There has also been a gap between sustainable construction and building procurement methods in the integration between building procurement methods and sustainable construction. The identified gap was then expanded and developed to add to the pool of knowledge in 'sustainable' building procurement.

The traditional procurement, design and build, and management contracting will be analyzed for different types of buildings such as residential, commercial, and others. It has been extensively reviewed, particularly for developing countries in the suggested conceptual framework above.

8.3.2 Research Objectives 2 (RO2)

RO2: *Establish integrated sustainability indicators to promote sustainable construction*

The study presented in Chapter 2 (Literature Review), Chapter 3 (Research Methodology), and Chapter 4 (Scoring Framework for Sustainable Procurement Decision Making Framework) was used to identify and establish the indicators for sustainability measurement. Section 4.2 (from page 105) provides in-depth insights and discussions to establish integrated sustainability indicators for measuring the performance of different building procurement methods. In addition, Morledge *et al.* (2006) suggested a relative importance between cost, time and performance in relation to any project would affect the choice of the most suitable procurement strategy for the project. Furthermore, there is also a client's need in each project characteristics. Skitmore and Marsden (1998) were among the earliest research on sustainable construction who discussed the importance of building procurement methods.

8.3.3 Research Objectives 3 (RO3)

RO3: *Develop a scoring framework as a decision making support tool for evaluating sustainability performance of different building procurement methods in building projects*

The scoring framework was successfully developed in Chapter 4 Section 4.3 (page 118) by incorporating the previously identified indicators into a realistic tool for construction industry stakeholders. The framework was then used for the subsequent case studies. The proposed scoring framework for developing Sustainable Procurement Decision Making was named as SuProDem framework at Stage 1. It has been developed to expand the knowledge and integrating empirical and theoretical knowledge between sustainable development, sustainable construction and building procurement method in promoting sustainable procurement.

Base on above discussion and data analysis from respondent feedback, the proposition – final stage of scoring framework for SuProDem framework which becomes a fundamental platform in this research. The framework was designed to complement framework at stage 1, and subsequent scoring method was developed from qualitative results generated by a series of interviews among clients, contractors, and consultants. The scoring framework for SuProDem framework was finally proposed as a decision making tool that can be utilized for the selection of sustainability-compliant building procurement methods in next chapter.

8.3.4 Research Objectives 4 (RO4)

RO4: *Demonstrate the applicability of the scoring framework through case studies*

In Chapter 7 (from page 233), the scoring framework, SuProDem, was used to evaluate case studies of building procurement methods used for school construction projects in Malaysia. The findings of case studies did fill the research gaps between sustainable construction and building procurement methods. The Spearmen rank-order correlation coefficients of the industry survey and case study rankings were calculated to reflect the differences between the two rankings.

The results show that time saving and employment score the highest coefficients of 0.87 under the design and building procurement method, followed by cost saving, with a coefficient of 0.83, under traditional procurement methods. Waste reduction and profitability score the lowest coefficients of -0.89 and -0.87, respectively. These results indicate the relationship between industry survey and case study, and thus reflect the perspectives of both groups of respondents.

Previous research suggested that traditional building procurement methods hinder sustainability (Ngowi, 1998). However, the results of the case studies suggest that traditional building procurement methods are still suitable for school construction projects. It indicates that different building procurement methods are suitable for different building projects. Moreover, identifying the strengths and weaknesses of different types of building procurements facilitate and improve their sustainability. Sustainable construction has to be based on win-win principles for both clients and contractors, and consultants should act as the 'middlemen' in facilitating effective sustainable construction. The findings of case studies indicate that the government should lead the way in promoting sustainable construction by introducing public tendering process and practical procurement process. Moreover, it should carefully examine procurement methods used in existing building projects in Malaysia and make the results available to the public. This would make the research on 'sustainable procurement method' open for discussion among researchers.

8.4 Research Contributions

Although sustainable agenda is a global issue, past research mostly focused on developed nations and overlooking challenges faced by developing countries. This study is valuable to developing countries since they are undergoing rapid urbanization. This research significantly adds to the existing body of knowledge with respect to:

5) Establish a conceptual foundation based on sustainable development, sustainable construction and building procurement method in developing countries to assess sustainability performance using different building procurement methods.

6) Establish integrated indicators and sub-indicators suitable for accessing sustainability performance of different building procurement methods through

industry surveys. The integrated indicators were first derived from a comprehensive literature review of sustainable development, sustainable construction, and building procurement methods in developed and developing countries.

7) Recommend SuProDem framework developed based on identified scoring techniques and integrated indicators. The framework is used as a decision support tool to assess sustainability performance of different building procurement methods.

8) Fill the significant research gaps and demonstrate relationship between sustainable construction and building procurement methods in developing countries, specifically in Malaysia.

Three main conclusions drawn from the results of industry survey:

1) The design and build method makes the greatest contribution to sustainability performance, followed by traditional procurement method. On the other hand, management contracting contributes very little to sustainability performances.

2) Sustainability performance can be improved if construction stakeholders have mutual understanding and working together as a team.

3) Some building procurement methods achieved greater sustainability performance through different indicators. The design and build method contributes more to sustainability performances through cost saving, design, time saving, waste reduction, application of advanced management methods and technology, profitability and employment indicators. While the management contracting method contributes to quality, health and safety on site and procurement material indicators. However, traditional procurement method has very little contributions to the above indicators and therefore does not cover any indicators when being compared to the design and build method and management contracting method (Refer Figure 6-12).

Two main conclusions drawn from the results of case studies:

1) Results from case studies suggested that traditional building procurement methods are suitable for building projects. The findings show that results from industry surveys and case studies are not consistent. Therefore, wider application of the existing building procurement methods is needed to increase understanding of sustainable construction especially when dealing with complex construction projects.

2) Clients, contractors, and consultants have different perspectives regarding the relationship between sustainable constructions and building procurement methods.

8.4.1 Contribution to construction industry stakeholders

The SuProDem framework as a decision support tool provides decision making with an objective reference to choose effective and sustainable building procurement methods for their particular projects. The choices of suitable procurement methods should not only based on the lowest tender, but should also ensure that the selected methods comply with the principles of sustainable construction. The response from industry stakeholders can be used for future reference.

8.4.2 Contribution to academic knowledge

Four research papers based on the results of this research have been published in conference proceedings. One of the conference papers won the Best Paper Award of Sustainable Urbanization and Construction Management at the First International Postgraduate Conference on Infrastructure and Environment, 5-6 June 2009, at The Hong Kong Polytechnic University, Hong Kong.

This research has published one journal paper in Jurnal Alam Bina with the title: A Framework for Comparison Study on Major Methods in Promoting Sustainable Construction Practice. This paper has been cited eight (8) times by several papers in high index journals according to Google Scholars citations index. In addition, two drafts of journal papers are ready to be submitted for publication in other international journals.

Furthermore, this research could be extended by examining additional indicators of sustainable construction that are relevant to other countries conventions and laws. Moreover, the most significant contribution of this study is the development of SuProDem framework, which can be used by any other scholars to assist them for selecting indicators, generating scoring method and assessing sustainability performance of different procurement methods.

8.5 Conclusions

The contribution of this research to the existing knowledge of sustainable construction is a scoring framework as a decision support tool to assess the sustainability performance using different building procurement methods in the construction industry in Malaysia. The novel of this study is the development of building procurement sustainability assessment framework using theoretical framework, data collection and case study.

There were two steps of data collection in this study:

1) First, it was done through industry surveys to identify an 'integrated set of indicators' for analyzing different building procurement methods. The SuProDem framework has been developed based on identified scoring framework and integrated indicators.

2) Second, the framework was used to evaluate sustainability performance of different building procurement methods through critical comparisons of school construction projects in Malaysia. The projects were investigated under two specific types of building procurement methods; i.e. the traditional and design and build procurement method. The outcome from case studies was used to compare and validate the results of industry surveys.

Significant findings of this study have highlighted the need for proper selection of building procurement methods to meet the requirements of sustainable construction:

1) This study has identified ten integrated indicators with relevant sub-indicators suitable for accessing sustainability performance using different building procurement methods in developing countries. The findings has also broadened an interpretation of sustainable construction knowledge and building procurement methods. It adds to the existing knowledge on enhancing sustainability of existing building procurement methods.

2) This study also recommends the SuProDem framework that provides decision making with an objective reference to choose effective sustainable building procurement methods for their particular projects. The framework takes into account of the environmental, economic, and social dimensions of sustainable construction. It allows construction practitioners to select the most useful set of required indicators for sustainable construction. Lastly, it also enables one to deliver optimum results for each indicator.

3) The findings supports design and build method that makes greatest contribution to sustainable construction if compared to traditional methods.

4) However, the findings of the industry surveys and case studies are not consistent. Therefore, a wider application of the existing building procurement methods is needed to increase understanding of sustainable construction especially when dealing with a complex construction projects.

Finally, the overall findings have filled research gaps significantly and demonstrated the relationship between sustainable construction and building procurement methods for building projects in Malaysia. This research can be strategically used to promote and enhance sustainability performance of future construction projects in other developing countries. There is no similar study in Malaysia, and this research contributes to existing knowledge of sustainable construction.

8.6 Limitations of the Research

In spite of its contributions, limitations of this study should be pointed out. The main limitation is the technical nature of construction industry samples, different perspectives of different countries, and the research scope. This study has only focused on one particular type of the construction project which is the school projects in Malaysia. Therefore, the findings may not be directly applicable to other types of construction projects in other countries. However, the methodological approach used here is applicable to similar studies on sustainable construction and building procurement methods. For the case study, the size of sample is different between traditional and design and build, and therefore it is a limitation for this study.

8.6.1 Technical issues

The scoring framework developed here was based on the traditional and design and build methods. It can be improved by adding of weighting from expert opinions. The inclusion of "expert opinion" parameters in the framework would improve technical accuracy of the selection analysis.

8.6.2 Perspectives of other countries

Different countries have different perceptions and priorities with regard to sustainable construction. Numerous factors, such as cost, government policies, and purchasing power of consumers, can shape the sustainable agenda of a particular country. Thus, they are likely to require specific sets of sustainable construction indicators that are uniquely weighted. For this reason, this study is only applicable to the Malaysian construction industry. The value of this research is the contribution of sustainable construction research in Malaysia.

8.6.3 Research scope

As mentioned above, this study has only focused on school construction projects in Malaysia over two specific types of building procurement methods, i.e. the traditional and design and build methods. Other types of procurement methods were not considered due to the present state of the Malaysian construction industry, the nature of the projects selected, and constraints of time. Future studies could widen the scope to include other procurement methods as well, which should benefit a wider audience of construction industry stakeholders.

8.7 Recommendations for Future Research

The limitations of this study, as discussed above present some opportunities for future research. The scoring framework developed here only focus on the traditional, design and build, and management contracting methods. Therefore, a wider application of the existing building procurement methods, such as build-operate-transfer and private finance initiatives is needed for better understanding of sustainable construction especially when dealing with a complex construction projects.

The framework also could be improved by taking into account the various responses from industry stakeholders and experts, which should enhance the accuracy of the framework. This research can be expanded by adding more construction projects or apply in different countries as they are likely to require specific sets of sustainable construction indicators that are uniquely weighted. Furthermore, this framework can be adopted in other country.

8.8 Personal attainments upon completing this study

This study has taken almost seven years to finish and has been a very long exhausting and challenging journey. However, upon the completion, I regard that it has been a fruitful journey and fully rewarding learning process. Through the completing of the work, I have gained significant research experience, having learnt how to use qualitative and quantitative research methods, and successfully conducted an extensive case study. Overall, I believe that I have finally contributed successfully to the main goal of delivering sustainability through the selection of effective building procurement methods. The experience and knowledge I have gained here are immeasurable. When I first found the research topic was particularly challenging, I felt that improving the sustainability of construction industry was extremely and globally important. However, only a few researchers, mostly in developing countries, have been willing to undertake this challenging study. I hope that the SuProDem framework recommended in this thesis will make a significant contribution to sustainability agenda. In a nutshell, this study has been a remarkable journey of learning and academic development which I will remember for the rest of my life.

Appendices

4.1 Appendix A – covering letters

4.2 Appendix B – questionnaires

4.3 Appendix C – calculation table

4.4 Appendix D – calculation ranking

Appendix A – Covering letters

<u>(a) Objective one</u>

Date: 12th Feb 2009

Address

………………………….……

…...as mail/email address…..

…………………………..………

Dear Sir or Madam,

Pilot study-Major methods in promoting sustainable construction practice

I am carrying out research on comparative study of the major methods in promoting sustainable construction practice for pursuing my PhD degree. I would appreciate if you could help me by completing the questionnaire. Your inputs will allow the survey to be shaped to reflect the needs of sustainable construction.

If you have any queries about the research in general or the questionnaire in particular, please do not hesitate to contact me. Please be assured that all information received will be treated confidentially. Kindly return the questionnaire **on/before: 28th Feb 2009**). I thank you very much in advance for your assistance in undertaking this research.

If you are unable to complete the survey, please feel free to pass it to a colleague

Kind regards

………………………………….

Khairul Anuar Bin BAKHTIAR

Room TU521, Building & Real Estate Department,
The Hong Kong Polytechnic University, Hung Hom, Kowloon.

Contacts: 1) Hong Kong: Khairul1982@ , Tel: +852-6804 (HP)
2) Malaysia: Khanuar@ , Tel: +6016-259 (HP)

(b) Objective two

25th March 2010

Address: **As mail address**

Dear Sir / Madam,

Application of Building Procurement Methods in Attaining Sustainable Construction in Malaysian Building Projects

I am carrying out a study on Application of Building Procurement Methods in Attaining Sustainable Construction in Malaysian Building Projects for pursuing my PhD degree. I would like to invite you to participate in the above project by completing this questionnaire.

The aim of this study is to investigate the significance of sustainability indicators that to be adopted in the procurement methods. The questionnaire will take you around **20 minutes** to complete. All data and information will be treated strictly confidentially.

Please kindly return the questionnaire **on/before 28 April 2010**. Please provide your correspondence address at the end of this questionnaire if you are like to receive the summary of this survey. If you have any queries about the research in general or the questionnaire in particular, please do not hesitate to contact me.

Thank you very much in advance for your assistance in responding this questionnaire. Your early reply is highly appreciated.

Kind regards

…………………………………….

Khairul Anuar Bin BAKHTIAR
PhD candidate
TU521, Building and Real Estate Department
The Hong Kong Polytechnic University Hung Hom, Kowloon, HONG KONG
Mobile: +852-6804 (Hong Kong)
+6016-259 (Malaysia)
Email: Khairul1982@

Endorsed by Chief Supervisor:

……………………….

Prof Li-Yin SHEN
Professor of Building and Real Estate Department,
The Hong Kong Polytechnic University

(c) Objective three

28th October 2010

Address: **As mail address**

Dear Sir / Madam,

Application of Building Procurement Methods in Attaining Sustainable Construction in Malaysian Building Projects

I am carrying out a study on Application of Building Procurement Methods in Attaining Sustainable Construction in Malaysian Building Projects for pursuing my PhD degree. I would like to invite you to participate in the above project by completing this questionnaire.

The aim of this study is to investigate the validation of sustainability indicators to adopt in the building procurement methods. The questionnaire will take you around **15 minutes** to complete. All data and information will be treated strictly confidentially.

Please kindly return the questionnaire **on/before 26 November 2010**. Please provide your correspondence address at the end of this questionnaire if you are like to receive the summary of this survey. **If you have any queries about the research in general or the questionnaire in particular, please do not hesitate to contact me.**

Thank you very much in advance for your assistance in responding this questionnaire. Your early reply is highly appreciated.

Kind regards

…………………………………
Khairul Anuar Bin BAKHTIAR
PhD candidate
Student No: 0890
TU521, Building & Real Estate department,
The Hong Kong Polytechnic University,
Hung Hom, Kowloon, HONG KONG
Mobile: **+852-6804 (Hong Kong)**;
Email: **Khairul1982@**
&
Tutor, Quantity Surveying department,
Fakulti Alam Bina, UTM Skudai, MALAYSIA

Endorsed by Chief Supervisor:

………………………
Prof Li-Yin SHEN, PhD
Professor of Building & Real Estate department,
The Hong Kong Polytechnic University,
Hung Hom, Kowloon, HONG KONG

(d) Objective four (a)

01st August 2011

Address: **As mail address**

Dear Sir / Madam,

Case study: School project using traditional procurement method to achieve sustainable construction

I am carrying out this study for pursuing my PhD degree. I would like to invite you to participate in the above project by completing this questionnaire.

The questionnaire will take you around **15 minutes** to complete. **All data and information will be treated strictly confidentially**.

Please kindly return the questionnaire **on/before 31 August 2011**. If you have any queries about the research in general or the questionnaire in particular, please do not hesitate to contact me.

Thank you very much in advance for your assistance in responding this questionnaire. Your early reply is highly appreciated.

Kind regards

…………………………………

Khairul Anuar Bin BAKHTIAR
PhD candidate
Student No: 0890
TU521, Building & Real Estate department,
The Hong Kong Polytechnic University,
Hung Hom, Kowloon, HONG KONG
Mobile: **+852-6804** **(Hong Kong)**;
Email: **Khairul1982@**
&
Tutor, Quantity Surveying department,
Fakulti Alam Bina, UTM Skudai, MALAYSIA

Endorsed by Chief Supervisor:

………………………

Prof Li-Yin SHEN, PhD
Professor of Building & Real Estate department,
The Hong Kong Polytechnic University,
Hung Hom, Kowloon, HONG KONG

(e) Objective four (b)

01st August 2011

Address: **As mail address**

Dear Sir / Madam,

Case study: School project using design and build method to achieve sustainable construction school projects

I am carrying out this study for pursuing my PhD degree. I would like to invite you to participate in the above project by completing this questionnaire.

The questionnaire will take you around **15 minutes** to complete. **All data and information will be treated strictly confidentially**.

Please kindly return the questionnaire **on/before 31 August 2011**. If you have any queries about the research in general or the questionnaire in particular, please do not hesitate to contact me.

Thank you very much in advance for your assistance in responding this questionnaire. Your early reply is highly appreciated.

Kind regards

Endorsed by Chief Supervisor:

…………………………………
Khairul Anuar Bin BAKHTIAR
PhD candidate
Student No: 0890
TU521, Building & Real Estate department,
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&
Tutor, Quantity Surveying department,
Fakulti Alam Bina, UTM Skudai, MALAYSIA

……………………….
Prof Li-Yin SHEN, PhD
Professor of Building & Real Estate department,
The Hong Kong Polytechnic University,
Hung Hom, Kowloon, HONG KONG

Appendix B – Questionnaires

(a) Objective one

Survey on Major Methods in promoting sustainable construction practice

This survey questionnaire forms part of an academic research which investigates the major methods and indicators that has been used to promote sustainable construction

QUESTIONNAIRE

Part A. Company and Personal Particular

Please tick [X] (key-in/write capital X)

A1: Your company/organization is categorized as:

[ ] Clients (owners, developers) [ ] Contractors [ ] Consultants [ ] Academia [ ] Others __________

A2: Your position is:

[ ] Managing director / Director / Principal [ ] CEO / General-Manager / Head [ ] Manager [ ] Professional [ ] Executive [ ] Academician

[ ] Others ______________

Part B. Sustainable construction & construction industry

B1: To what extent do you think that public or private project is complying with the principles of sustainable construction (please tick one only)

Project	No Idea	Totally disagree	Disagree	Neutral	Agree	Totally agree
	0	**1**	**2**	**3**	**4**	**5**
1) Public						
2) Private						

B2: Please indicate the relative significance of the following indicators to indicate the level of achievement in practicing sustainable construction (please tick one only)

Indicators	Not Applicable	Not Significance	Less Significance	Medium Significance	Significance	Totally Significance
	0	**1**	**2**	**3**	**4**	**5**
1) Waste reduction						
2) Cost saving						
3) Time saving						
4) Quality						
5) Material recycling						
6) Flora & fauna protection						
7) Air pollution control						
8) Noise pollution control						
9) Water pollution control						

10) Energy saving						
11) Others________						

Part B. Sustainable construction & construction industry (cont')

B3: To what level do you think that the following sustainable construction methods contribute to the performance of the indicators (please key-in/write 1,2,3,4,5 or 0)

Not Adopted	No contribution	Less contributable	Medium contributable	Contributable	Major contribution
0	**1**	**2**	**3**	**4**	**5**

Sustainable Construction Methods	Indicators										
	Waste Reduc tion	Cost saving	Time saving	Quality	Material recycling	Flora & Fauna protection	Air pollution control	Noise pollution control	Water pollution control	Energy saving	Others _____
1) Education & training											
2) Environmental management system											
3) Green building											
4) Green design											
5) Green procurement											
6) Green roof technologies											
7) Lean construction											
8) Prefabrication											
9) Waste management											
10) Others _____________											
11) Others _____________											

B4: To what extent do you think that various stakeholders in the construction industry are willing to implement the following sustainable construction methods (please key-in/write 1,2,3,4,5 or 0)

No Idea	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
0	**1**	**2**	**3**	**4**	**5**

Sustainable Construction Methods	Government	Client	Contractor	Designer	Material Supplier	Others _________
1) Education & training						
2) Environmental management system						

3) Green building						
4) Green design						
5) Green procurement						
6) Green roof technologies						
7) Lean construction						
8) Prefabrication						
9) Waste management						
10) Others ____________						
11) Others ____________						

Part C. Sustainable construction & procurement methods

C1: What level of effectiveness of these sustainable construction methods if different procurement systems are adopted (please key-in/write 1,2,3,4,5 or 0)

No Idea	Not effective	Less effective	Medium effective	Effective	Totally Effective
0	**1**	**2**	**3**	**4**	**5**

Sustainable Construction Methods	Procurement			
	Traditional	Design & Build	Management Contracting	Others ___________
1) Education & training				
2) Environmental management system				
3) Green building				
4) Green design				
5) Green procurement				
6) Green roof technologies				
7) Lean construction				
8) Prefabrication				
9) Waste management				
10) Others ____________				
11) Others ____________				

Part D. Comment or suggestion

If you have any additional comments or suggestion, please feel free to add them below.

Would you be interested in receiving a copy of the analyzed results of this questionnaire survey and have a follow-up discussion with the researchers? If yes, please provide the following contact information:

Name:	
Email or Address:	

(b) Objective two

THE SIGNIFICANT OF SUSTAINABILITY INDICATORS THAT TO BE ADOPTED IN THE PROCUREMENT METHODS

Thank you for your participation in this questionnaire survey. Normally the benefits of procurement method in the literature tend to focus on cost, time and quality. Only a limited number of studies assess the combination of environmental, economic, and social benefits of using procurement method. Thus, the aim of this study is to investigate the significant of sustainability indicators that to be adopted in the procurement methods.

This questionnaire was divided into 4 sections; general information, general questions, significance of indicators and further comments which take around 20 minutes. Please begin here.

Section 1: General information

(1) Name of organization / firm (Optional)

☐

(2) Name (Optional)

☐

(3) Designation (Managing director / Principal / Project manager / etc.)

☐

(4) Total years of experience in the construction industry (personal)

☐ < 5 years ☐ 5 - 10 years ☐ 10 - 15 years ☐ 15 - 20 years ☐ 20 - 25 years ☐ > 25 years

(5) Please state the nature of your organization / firm

☐ Clients (Public) ☐ Clients (Private) ☐ Clients (Other) _______ ☐ Contractors, Grade (CIDB/PKK) _____

☐ Consultants (Architect) ☐ Consultants (Quantity surveying) ☐ Consultants (Engineering) ☐ Others _______

Section 2: General questions

(1) Familiarity with building project (**please tick √ ONE only**)

Not familiar	Less familiar	Neutral	Familiar	Very familiar
1	**2**	**3**	**4**	**5**

(2) Familiarity with sustainable construction concept (**please tick √ ONE only**)

Not familiar	Less familiar	Neutral	Familiar	Very familiar
1	**2**	**3**	**4**	**5**

(3) To what extent does the sustainable construction concept can contribute to environmental, economic, and social pillars within the Malaysian construction industry perspective (**please tick √ ONE only**)

Sustainability pillars	No contribution	Less contributable	Medium contributable	Contributable	Major contribution
	1	**2**	**3**	**4**	**5**
1) Environmental					
2) Economic					
3) Social					

(4) For each kind of the following building projects in Malaysia, in your opinion, which type of procurement method is frequently used (**can tick √ MORE than one**)

Building types	**Traditional**	**Design and Build**	**Management Contracting**
1) Residential			
2) Commercial (office, shop, hotel, etc.)			
3) Industrial (factory, mill, etc.)			
4) Government (parliament, police station, etc.)			
5) Health (Hospital, Clinic, etc.)			
6) Educational (school, university, etc.)			
7) Military (barracks, tower, etc.)			
8) Transit stations (airport, bus, etc.)			
9) Religious (mosque, church, etc.)			
10) Other ___________________________			

Section 3: Significance of indicators

To what extent do you think that the indicators below are significant to improving building sustainability performance (**please tick √ ONE only**). The answer should reflect your opinion and knowledge.

Not Applicable	**Not Significant**	**Less Significant**	**Medium Significance**	**Significant**	**Very Significant**
0	**1**	**2**	**3**	**4**	**5**

.

Significance of indicators						
(1) Quality	**0**	**1**	**2**	**3**	**4**	**5**
Better quality control and quality assurance of the project						
Better quality of service and advice from project team						
Better quality of client's brief						
Meeting the clients' needs						
Meeting user's satisfaction						
Meeting project team satisfaction						
Reduction of inadequate supervision of the project						
Reduction of error in the contract documents						
Reduction of engineering rework						

(2) Cost saving	**0**	**1**	**2**	**3**	**4**	**5**
Better value for money						
Better price competition from the bidding process						
Better budget control						
Controllable variation in cost						
Improving contractor's resources utilization efficiency						
Reduction of cost overrun (project)						
Reduction of incorrect cost estimation						
Reduction of maintenance cost (life-cycle)						
Reduction of monetary claims						
(3) Design	**0**	**1**	**2**	**3**	**4**	**5**
Better integrate design and construction						
Better cost-effective design						
Better flow of information on design (reduction of insufficient or incorrect information, etc.)						
Better control of the design and supervision of the work						
Enhanced aesthetic appearance of the building						
Promoting green design (energy conservation, etc.)						
Promoting design innovation (prefabrication, etc.)						
Reduction of conflict of interests among parties involved in design process						
Reduction of design changes (general)						
Reduction of delays due to drawing revision and distribution						
(4) Time saving	**0**	**1**	**2**	**3**	**4**	**5**
Better early start to implement a construction project						
Better planning and designing time						
Better detailing and coherent work program (project)						
Better cooperation amongst project team						
Completing works by dates agreed						
Minimization of activities interference (general)						
Reduction of overall project duration						
Reduction of changes (construction)						
Rapid response to client needs (project)						
(5) Waste reduction	**0**	**1**	**2**	**3**	**4**	**5**
Better waste management						
Better site communication to avoid abortive works						
Better site planning to avoid travel distance						
Promoting education and training						
Promoting green technologies						
Reduction of insufficient or incorrect information						
Reduction of changes due to client's requirements						
Reduction of unused materials and products						
Reduction of paperwork (using less paper)						
(6) Procurement – materials	**0**	**1**	**2**	**3**	**4**	**5**
Better client involvement in choice of materials						

Better choice of materials (project)						
Better quality materials specification						
Better value for money (material)						
Promoting green procurement – material (environmentally friendly products)						
Reduction of ordering error (not in compliance with specification)						
Reduction of quantities error – material (over ordering and under ordering)						
Reduction of unused materials and products						
Reduction of unclear specification						
(7) Health and safety – on site	**0**	**1**	**2**	**3**	**4**	**5**
Better decision on health and safety issues						
Better attitude and culture towards health and safety issues						
Improving safety performance on site						
Increasing awareness on health and safety issues						
Reduction of negligence (professional)						
Reduction of accident rate						
(8) Employment	**0**	**1**	**2**	**3**	**4**	**5**
Better allocation of responsibilities amongst staff						
Better working relationship in the project team (reduction of conflicts, etc.)						
Better knowledge sharing						
Improving level of empathy within the project team						
Improving performance and motivation amongst project members						
Increasing productivity						
Job creation and empowerment						
Promoting local employees (professional)						
Promoting gender equity and community empowerment						
Reduction of stressful working environment						
(9) Profitability	**0**	**1**	**2**	**3**	**4**	**5**
Better financial control						
Better risk management						
Better cash flow						
Better project risks sharing amongst project participants						
Improving profit margin						
Reduction of cost (loan interest, etc.)						
Reduction of construction and design risk to client						
Reduction of administrative cost (general)						
(10) Application of advanced management methods and technology	**0**	**1**	**2**	**3**	**4**	**5**
Better use of information technology (IT)						
Better concern for environmental issues (general)						
Improving accountability of contractors						
Promoting value management						

Promoting lean construction						
Promoting partnering						

Section 4: Further Comments

Please state any other relevant point which I have not mentioned in this questionnaire:

Would you be interested in receiving a copy of the analyzed results of this questionnaire survey and have a follow-up discussion with the researchers? If yes, please provide the following contact information.

Name (Optional):	
Email or Address:	

.

Thank you very much for your time and cooperation in responding to the request for information. All answers will be treated as confidential.

(c) Objective three

THE VALIDATION OF SUSTAINABILITY INDICATORS TO ADOPT IN THE BUILDING PROCUREMENT METHODS

Thank you for your participation in this questionnaire survey. The aim of this survey is to assess the correlation between sustainability indicators and procurement methods (traditional, design and build, and management contracting). This questionnaire was divided into 4 sections; (1) general information; (2) general questions; (3) priority rating scale and utility factor; and (4) further comments. Your answer should reflect your knowledge and opinion. Below is the explanation about sustainable construction and procurement method.

What is sustainable construction?
Table 1 shows the typical sustainability indicators for measuring sustainability performance in the construction process.

Table 1 Typical sustainability indicators

Waste reduction	Cost saving	Water pollution control
Procurement	Time saving	Site selection
Flora and fauna protection	Employment	Solid waste
Quality	Non-toxic	Health and safety
Transportation	Design	Durability and maintenance
Profitable	Protecting health and comfort	etc.
Recycling	Noise pollution control	
Energy efficiency	Air pollution control	

The typical building procurement characteristics include (1) quality; (2) cost; (3) time; (4) risk; (5) flexibility; and etc.

Section 1: General information

(1) Name of organization / firm (Optional)

(2) Name (Optional)

(3) Designation (Managing director / Principal / Project manager / etc.)

(4) Total years of experience in the construction industry (personal). (**please tick √ ONE only**)

< 5 years	5 - 10 years	10 - 15 years	15 - 20 years	20 - 25 years	> 25 years

(5) Please state the nature of your organization / firm

☐ Clients (Public) ☐ Clients (Private) ☐ Clients (Other) _______ ☐ Contractors, Grade (CIDB/PKK) ___

☐ Consultants (Architect) ☐ Consultants (Quantity surveying) ☐ Consultants (Engineering) ☐ Others _____

Section 2: General questions

(1) In your opinion, procurement method can contribute to sustainable construction?

No contribution	Less contributable	Medium contributable	Contributable	Major contribution

(2) In your opinion, which procurement method can contribute to sustainable construction in developing a building project?

	No contribution	Less contributable	Medium contributable	Contributable	Major contribution
Traditional					
Design and build					
Management Contracting					

Section 3: Priority rating scale and utility factor

This section is divided into two stages; **A) Priority rating scale** and **B) Utility factor**

EXAMPLE to answer the questionnaire survey, as below:

A) Priority rating scale

In the following list of attributes of sustainable construction performance, which are significant when considering to selecting building procurement method? (**PLEASE √ ONE ONLY**)

Not Significant	Less Significant	Medium Significance	Significant	Very Significant
1 – 10				

Indicators / scores	1	2	3	4	5	6	7	8	9	10
(1) Quality									√	
...								√		

B) Utility factor

To what extent do you think that the indicators below are associated to the building procurement method (traditional, design and build, & management contracting) to a building project (**PLEASE WRITE 1-10**) the minimum is **1**, and the maximum is **10**.

Not Significant	Less Significant	Medium Significance	Significant	Very Significant
1 – 10				

Indicators	**Utility factor**		
(1) Quality	**Traditional**	**Design and Build**	**Management Contracting**
Better quality control and assurance of the project	**10**	**7**	**8**
…	**9**	**8**	**10**

~Please begin here …

A) Priority rating scale

In the following list of attributes of sustainable construction performance, which are significant when considering to selecting building procurement method? (**PLEASE √ ONE ONLY**)

Not Significant	Less Significant	Medium Significance	Significant	Very Significant
1 – 10				

.

Indicators / Scores	1	2	3	4	5	6	7	8	9	10
(1) Quality										
(2) Cost saving										
(3) Design										
(4) Time saving										
(5) Waste reduction										
(6) Procurement – materials										
(7) Health and safety – one site										
(8) Employment										
(9) Profitability										
(10) Application of advanced management methods and technology										

.

B) Utility factor

To what extent do you think that the indicators below are associated to the building procurement method (traditional, design and build, & management contracting) to a building project (**PLEASE WRITE 1-10**) the minimum is **1**, and the maximum is **10**.

Not Significant	Less Significant	Medium Significance	Significant	Very Significant
1 – 10				

.

Indicators and sub-indicators	**Utility factor**		
(1) Quality	**Traditional**	**Design and Build**	**Management Contracting**
Better quality control and assurance of the project			
Better quality of service and advice from project team			
Meeting user's satisfaction			
Better quality of client's brief			
Meeting the client's needs			
Reduction of engineering rework			
Reduction of error in the contract documents			
Reduction of inadequate supervision of the project			
(2) Cost saving	**Traditional**	**Design and Build**	**Management Contracting**
Better value for money			

Reduction of maintenance cost (life-cycle)			
Improving contractor's resources utilization efficiency			
Better budget control			
Reduction of cost overrun (project)			
(3) Design	**Traditional**	**Design and Build**	**Management Contracting**
Better integrate design and construction			
Promoting green design (energy conservation, etc.)			
Better cost-effective design			
Promoting design innovation (prefabrication, etc.)			
Better flow of information on design (reduction of insufficient or incorrect information, etc.)			
Better control of the design & supervision of the work			
(4) Time saving	**Traditional**	**Design and Build**	**Management Contracting**
Better planning and designing time			
Better cooperation amongst project team			
Better detailing and coherent work program			
(5) Waste reduction	**Traditional**	**Design and Build**	**Management Contracting**
Better waste management			
Promoting green technologies			
Better site communication to avoid abortive works			
Reduction of unused materials and products			
(6) Procurement – materials	**Traditional**	**Design and Build**	**Management Contracting**
Promoting green procurement – material (environmentally friendly products)			
Better quality materials specification			
Better value for money (material)			

Better choice of materials (project)			
(7) Health and safety – one site	**Traditional**	**Design and Build**	**Management Contracting**
Better attitude and culture towards health and safety issues			
Increasing awareness on health and safety issues			
Improving safety performance on site			
Better decision on health and safety issues			
Reduction of negligence (professional)			
Reduction of accident rate			
(8) Employment	**Traditional**	**Design and Build**	**Management Contracting**
Better knowledge sharing			
Increasing productivity			
Better allocation of responsibilities amongst staff			
Improving performance and motivation amongst project members			
Better working relationship in the project team (reduction of conflicts, etc.)			
(9) Profitability	**Traditional**	**Design and Build**	**Management Contracting**
Better financial control			
Better risk management			
Better cash flow			
(10) Application of advanced management methods and technology	**Traditional**	**Design and Build**	**Management Contracting**
Better concern for environmental issues (general)			
Better use of information technology (IT)			
Promoting value management			
Improving accountability of contractors			
Promoting lean construction			

.

Section 4: Further comments (ideas, critics, etc.)

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Would you be interested in receiving a copy of the analyzed results of this questionnaire survey and have a follow-up discussion with the researchers? If yes, please provide the following contact information.

Name (Optional):	
Email or Address:	

~ Thank you for your time and cooperation for responding this questionnaire.
All answers will be treated as confidential ~

(d) Objective four

CASE STUDY: SCHOOL PROJECT & SUSTAINABLE CONSTRUCTION

This questionnaire was divided into 3 sections; (1) general information; (2) scoring; and (3) comments; which take around 15 minutes. I wish to assure you that all data and information will be treated strictly confidential. Your answer should reflect your knowledge and opinion. For your good reference, the following table below provides typical terms of sustainable construction.

Waste reduction	Cost saving	Water pollution control
Procurement	Time saving	Site selection
Flora and fauna protection	Employment	Solid waste
Quality	Non-toxic	Health and safety
Transportation	Green design	Durability and maintenance
Profitable	Protecting health and comfort	etc.
Recycling	Noise pollution control	
Energy efficiency	Air pollution control	

SECTION 1: GENERAL INFORMATION

(1) The name of the school project (**OPTIONAL**) - The name will indicate as School 'A - Z' to ensure confidentiality (Note: please refer to a **finished school** project that you/your firm have been undertaking for the last **5 years**)

(2) The procurement method used for the school project mention above (**PLEASE √ ONE ONLY**)

Traditional	Design and Build	Management Contracting	Other ________________

(3) The year of the school project finished (**PLEASE √ ONE ONLY**)

2006	2007	2008	2009	2010	Other _______

(4) The total cost of the school project (**PLEASE √ ONE ONLY**)

RM 5,000,001 – RM 10,000,000	RM 10,000,001 – RM 15,000,000	RM 15,000,001 – RM 20,000,000	RM 20,000,001 – RM 25,000,000	RM 25,000,001 – RM 30,000,000	Other _________

(5) The school project category/size (Malay: *Bilik darjah*) (**PLEASE √ ONE ONLY**)

18 rooms	24 rooms	30 rooms	36 rooms	Other _________

(6) The contract original period (**PLEASE √ ONE ONLY**)

< 12 months	12 months	18 months	20 months	24 months	Other _______

(7) The extension of time (EOT) approved, IF any (**PLEASE √ ONE ONLY**)

No EOT	< 1 month	1 – 3 months	3 – 6 months	6 – 12 months	Other _______

(8) The time consumed (months) in pre-construction stage (inception → design → tender, etc.) (**PLEASE √ ONE ONLY**)

No idea	< 3 months	3 - 6 months	6 - 12 months	12 - 18 months	> 18 months

SECTION 2: SCORING

A) Priority rating scale

In the following list of attributes of sustainable construction performance, which are significant to the school project (**PLEASE √ ONE ONLY**)

Not Significant	Less Significant	Medium Significance	Significant	Very Significant
1	**2**	**3**	**4**	**5**

.

Indicators / Scores	1	2	3	4	5
(1) Quality					
(2) Cost saving					
(3) Design					
(4) Time saving					
(5) Waste reduction					
(6) Procurement – materials					
(7) Health and safety – one site					
(8) Employment					
(9) Profitability					
(10) Application of advanced management methods & technology					

B) Utility factor

To what extent do you think that the indicators below are associated to the **building procurement method** for the finished school project that you indicated in the Section 1: General Information previously (**PLEASE √ ONE ONLY**)

Not Significant	Less Significant	Medium Significance	Significant	Very Significant
1	**2**	**3**	**4**	**5**

.

(1) Quality	**1**	**2**	**3**	**4**	**5**
Better quality control and assurance of the project					
Better quality of service and advice from project team					
Meeting user's satisfaction					
Better quality of client's brief					
Meeting the client's needs					
Reduction of engineering rework					
Reduction of error in the contract documents					

Reduction of inadequate supervision of the project					
(2) Cost saving	**1**	**2**	**3**	**4**	**5**
Better value for money					
Reduction of maintenance cost (life-cycle)					
Improving contractor’s resources utilization efficiency					
Better budget control					
Reduction of cost overrun (project)					
(3) Design	**1**	**2**	**3**	**4**	**5**
Better integrate design and construction					
Promoting green design (energy conservation, etc.)					
Better cost-effective design					
Promoting design innovation (prefabrication, etc.)					
Better flow of information on design (reduction of insufficient or incorrect information, etc.)					
Better control of the design & supervision of the work					
(4) Time saving	**1**	**2**	**3**	**4**	**5**
Better planning and designing time					
Better cooperation amongst project team					
Better detailing and coherent work program					
(5) Waste reduction	**1**	**2**	**3**	**4**	**5**
Better waste management					
Promoting green technologies					
Better site communication to avoid abortive works					
Reduction of unused materials and products					
(6) Procurement – materials	**1**	**2**	**3**	**4**	**5**
Promoting green procurement – material (environmentally friendly products)					
Better quality materials specification					
Better value for money (material)					
Better choice of materials (project)					
(7) Health and safety – one site	**1**	**2**	**3**	**4**	**5**
Better attitude and culture towards health and safety issues					

Increasing awareness on health and safety issues					
Improving safety performance on site					
Better decision on health and safety issues					
Reduction of negligence (professional)					
Reduction of accident rate					
(8) Employment	**1**	**2**	**3**	**4**	**5**
Better knowledge sharing					
Increasing productivity					
Better allocation of responsibilities amongst staff					
Improving performance and motivation amongst project members					
Better working relationship in the project team (reduction of conflicts, etc.)					
(9) Profitability	**1**	**2**	**3**	**4**	**5**
Better financial control					
Better risk management					
Better cash flow					
(10) Application of advanced management methods & technology	**1**	**2**	**3**	**4**	**5**
Better concern for environmental issues (general)					
Better use of information technology (IT)					
Promoting value management					
Improving accountability of contractors					
Promoting lean construction					

SECTION 3: COMMENTS

Would you be interested in receiving a copy of the analyzed results of this questionnaire survey and have follow-up discussion with the researchers? If yes, please provide the following contact information.

Name (Optional):	
Email or Address:	

~ Thank you for your time and cooperation ~

Appendix C – Calculation table

(a) Objective one

-NIL-

(b) Objective two

The t-test

Table 6-55 (1) Client and contractor

Indicators	T	Significance	Conclusion	t-Critical (2-tail test)
(1) Quality				
Better quality control and assurance of the project	1.135	0.262	Accept Ho	2.008
Better quality of service and advice from project team	1.217	0.229	Accept Ho	
Better quality of client's brief	1.079	0.286	Accept Ho	
Meeting the client's needs	0.528	0.600	Accept Ho	
Meeting user's satisfaction	-0.788	0.434	Accept Ho	
Meeting project team satisfaction	0.692	0.492	Accept Ho	
Reduction of inadequate supervision of the project	0.274	0.785	Accept Ho	
Reduction of error in the contract documents	1.975	0.054	Accept Ho	
Reduction of engineering rework	1.549	0.127	Accept Ho	
(2) Cost saving				
Better value for money	0.268	0.790	Accept Ho	2.008
Better price competition from the bidding process	0.920	0.362	Accept Ho	
Better budget control	-0.550	0.585	Accept Ho	
Controllable variation in cost	0.464	0.644	Accept Ho	
Improving contractor's resources utilization efficiency	-0.687	0.495	Accept Ho	
Reduction of cost overrun (project)	0.043	0.966	Accept Ho	
Reduction of incorrect cost estimation	0.954	0.345	Accept Ho	
Reduction of maintenance cost (life-cycle)	1.125	0.266	Accept Ho	
Reduction of monetary claims	1.765	0.084	Accept Ho	
(3) Design				
Better integrate design and construction	1.083	0.284	Accept Ho	2.008
Better cost-effective design	1.854	0.070	Accept Ho	
Better flow of information on design (reduction of insufficient or incorrect information, etc.)	0.909	0.368	Accept Ho	
Better control of the design and supervision of the work	1.630	0.109	Accept Ho	
Enhanced aesthetic appearance of the building	0.602	0.550	Accept Ho	
Promoting green design (energy conservation, etc.)	-0.573	0.569	Accept Ho	
Promoting design innovation	0.099	0.922	Accept Ho	

(prefabrication, etc.)				
Reduction of conflict of interests among parties involved in design process	1.055	0.296	Accept Ho	
Reduction of design changes (general)	1.464	0.149	Accept Ho	
Reduction of delays due to drawing revision & distribution	0.176	0.861	Accept Ho	
(4) Time saving				
Better early start to implement a construction project	0.469	0.641	Accept Ho	2.008
Better planning and designing time	0.859	0.394	Accept Ho	
Better detailing and coherent work program (project)	1.972	0.054	Accept Ho	
Better cooperation amongst project team	1.622	0.111	Accept Ho	
Completing works by dates agreed	1.789	0.079	Accept Ho	
Minimization of activities interference (general)	1.344	0.185	Accept Ho	
Reduction of overall project duration	1.589	0.118	Accept Ho	
Reduction of changes (construction)	0.609	0.545	Accept Ho	
Rapid response to client needs (project)	1.873	0.067	Accept Ho	
(5) Waste reduction				
Better waste management	-1.798	0.078	Accept Ho	2.008
Better site communication to avoid abortive works	1.474	0.147	Accept Ho	
Better site planning to avoid travel distance	1.176	0.245	Accept Ho	
Promoting education and training	0.332	0.741	Accept Ho	
Promoting green technologies	-0.126	0.900	Accept Ho	
Reduction of insufficient or incorrect information	1.164	0.250	Accept Ho	
Reduction of changes due to client’s requirements	0.845	0.402	Accept Ho	
Reduction of unused materials and products	-0.671	0.505	Accept Ho	
Reduction of paperwork (using less paper)	-0.636	0.527	Accept Ho	
(6) Procurement – materials				
Better client involvement in choice of materials	2.530	0.015	Reject Ho	2.008
Better choice of materials (project)	1.863	0.068	Accept Ho	
Better quality materials specification	2.654	0.011	Reject Ho	
Better value for money (material)	0.938	0.352	Accept Ho	
Promoting green procurement – material (environmentally friendly products)	0.085	0.932	Accept Ho	
Reduction of ordering error (not in compliance with specification)	0.565	0.574	Accept Ho	
Reduction of quantities error – material (over ordering and under ordering)	-0.146	0.885	Accept Ho	
Reduction of unused materials and products	-0.658	0.513	Accept Ho	
Reduction of unclear specification	0.797	0.429	Accept Ho	
(7) Health & safety - on site				
Better decision on health and safety issues	1.815	0.075	Accept Ho	2.008
Better attitude and culture towards health and safety issues	1.329	0.190	Accept Ho	

Improving safety performance on site	2.463	0.017	Reject Ho	
Increasing awareness on health and safety issues	2.401	0.020	Reject Ho	
Reduction of negligence (professional)	2.147	0.037	Reject Ho	
Reduction of accident rate	2.750	0.008	Reject Ho	
(8) Employment				
Better allocation of responsibilities amongst staff	1.178	0.244	Accept Ho	2.008
Better working relationship in the project team (reduction of conflicts, etc.)	2.081	0.042	Reject Ho	
Better knowledge sharing	2.130	0.038	Accept Ho	
Improving level of empathy within the project team	3.985	0.000	Reject Ho	
Improving performance and motivation amongst project members	1.379	0.174	Accept Ho	
Increasing productivity	0.854	0.397	Accept Ho	
Job creation and empowerment	1.552	0.127	Accept Ho	
Promoting local employees (professional)	2.081	0.042	Reject Ho	
Promoting gender equity & community empowerment	1.650	0.105	Accept Ho	
Reduction of stressful working environment	1.965	0.055	Accept Ho	
(9) Profitability				
Better financial control	1.478	0.146	Accept Ho	2.008
Better risk management	2.125	0.038	Reject Ho	
Better cash flow	1.449	0.154	Accept Ho	
Better project risks sharing amongst project participants	2.438	0.018	Reject Ho	
Improving profit margin	0.550	0.584	Accept Ho	
Reduction of cost (loan interest, etc.)	1.036	0.305	Accept Ho	
Reduction of construction and design risk to client	1.072	0.289	Accept Ho	
Reduction of administrative cost (general)	1.257	0.215	Accept Ho	
(10) Application of advanced management methods and technology				
Better use of information technology (IT)	1.142	0.259	Accept Ho	2.008
Better concern for environmental issues (general)	0.541	0.591	Accept Ho	
Improving accountability of contractors	0.761	0.450	Accept Ho	
Promoting value management	0.986	0.329	Accept Ho	
Promoting lean construction	1.065	0.292	Accept Ho	
Promoting partnering	1.349	0.183	Accept Ho	

Table 6-56 (2) Client and consultant

	T	Significance	Conclusion	t-Critical (2-tail test)
(1) Quality				
Better quality control and assurance of the project	1.969	0.053	Accept Ho	1.993
Better quality of service and advice from project team	1.410	0.163	Accept Ho	
Better quality of client's brief	1.062	0.292	Accept Ho	
Meeting the client's needs	0.943	0.349	Accept Ho	
Meeting user's satisfaction	0.216	0.830	Accept Ho	
Meeting project team satisfaction	1.474	0.145	Accept Ho	
Reduction of inadequate supervision of the project	0.330	0.742	Accept Ho	
Reduction of error in the contract documents	1.600	0.114	Accept Ho	
Reduction of engineering rework	2.573	0.012	Reject Ho	
(2) Cost saving				
Better value for money	1.762	0.082	Accept Ho	1.993
Better price competition from the bidding process	2.147	0.035	Reject Ho	
Better budget control	1.656	0.102	Accept Ho	
Controllable variation in cost	1.415	0.161	Accept Ho	
Improving contractor’s resources utilization efficiency	-0.012	0.991	Accept Ho	
Reduction of cost overrun (project)	1.081	0.283	Accept Ho	
Reduction of incorrect cost estimation	2.201	0.031	Reject Ho	
Reduction of maintenance cost (life-cycle)	0.899	0.371	Accept Ho	
Reduction of monetary claims	2.065	0.043	Reject Ho	
(3) Design				
Better integrate design and construction	1.952	0.055	Accept Ho	1.993
Better cost-effective design	1.757	0.083	Accept Ho	
Better flow of information on design (reduction of insufficient or incorrect information, etc.)	1.422	0.159	Accept Ho	
Better control of the design and supervision of the work	1.159	0.250	Accept Ho	
Enhanced aesthetic appearance of the building	1.908	0.060	Accept Ho	
Promoting green design (energy conservation, etc.)	-0.567	0.573	Accept Ho	
Promoting design innovation (prefabrication, etc.)	-0.624	0.535	Accept Ho	
Reduction of conflict of interests among parties involved in design process	2.043	0.045	Reject Ho	
Reduction of design changes (general)	1.821	0.073	Accept Ho	
Reduction of delays due to drawing revision & distribution	2.130	0.037	Reject Ho	
(4) Time saving				
Better early start to implement a construction project	1.295	0.199	Accept Ho	1.993

Better planning and designing time	0.943	0.349	Accept Ho	
Better detailing and coherent work program (project)	3.032	0.003	Reject Ho	
Better cooperation amongst project team	1.744	0.085	Accept Ho	
Completing works by dates agreed	2.251	0.027	Reject Ho	
Minimization of activities interference (general)	1.424	0.159	Accept Ho	
Reduction of overall project duration	1.574	0.120	Accept Ho	
Reduction of changes (construction)	1.449	0.152	Accept Ho	
Rapid response to client needs (project)	1.720	0.090	Accept Ho	
(5) Waste reduction				
Better waste management	0.272	0.786	Accept Ho	1.993
Better site communication to avoid abortive works	2.204	0.031	Accept Ho	
Better site planning to avoid travel distance	2.137	0.036	Reject Ho	
Promoting education and training	0.666	0.508	Accept Ho	
Promoting green technologies	-0.370	0.712	Accept Ho	
Reduction of insufficient or incorrect information	1.765	0.082	Accept Ho	
Reduction of changes due to client's requirements	2.380	0.020	Reject Ho	
Reduction of unused materials and products	0.742	0.461	Accept Ho	
Reduction of paperwork (using less paper)	1.403	0.165	Accept Ho	
(6) Procurement – materials				
Better client involvement in choice of materials	2.288	0.025	Reject Ho	1.993
Better choice of materials (project)	1.684	0.097	Accept Ho	
Better quality materials specification	2.190	0.032	Reject Ho	
Better value for money (material)	1.051	0.297	Accept Ho	
Promoting green procurement – material (environmentally friendly products)	0.910	0.366	Accept Ho	
Reduction of ordering error (not in compliance with specification)	1.758	0.083	Accept Ho	
Reduction of quantities error – material (over ordering and under ordering)	1.796	0.077	Accept Ho	
Reduction of unused materials and products	1.678	0.098	Accept Ho	
Reduction of unclear specification	1.981	0.051	Accept Ho	
(7) Health & safety - on site				
Better decision on health and safety issues	2.596	0.011	Reject Ho	1.993
Better attitude and culture towards health and safety issues	1.588	0.117	Accept Ho	
Improving safety performance on site	2.620	0.011	Reject Ho	
Increasing awareness on health and safety issues	2.587	0.012	Reject Ho	
Reduction of negligence (professional)	1.746	0.085	Accept Ho	
Reduction of accident rate	2.797	0.007	Reject Ho	
(8) Employment				
Better allocation of responsibilities amongst staff	3.114	0.003	Reject Ho	1.993
Better working relationship in the project	2.928	0.005	Reject Ho	

team (reduction of conflicts, etc.)				
Better knowledge sharing	1.983	0.051	Accept Ho	
Improving level of empathy within the project team	3.765	0.000	Reject Ho	
Improving performance and motivation amongst project members	2.954	0.004	Reject Ho	
Increasing productivity	1.568	0.121	Accept Ho	
Job creation and empowerment	2.174	0.033	Reject Ho	
Promoting local employees (professional)	2.761	0.007	Reject Ho	
Promoting gender equity and community empowerment	2.546	0.013	Reject Ho	
Reduction of stressful working environment	3.218	0.002	Reject Ho	
(9) Profitability				
Better financial control	2.356	0.021	Reject Ho	1.993
Better risk management	3.125	0.003	Reject Ho	
Better cash flow	2.110	0.038	Reject Ho	
Better project risks sharing amongst project participants	2.596	0.011	Reject Ho	
Improving profit margin	1.991	0.050	Accept Ho	
Reduction of cost (loan interest, etc.)	1.697	0.094	Accept Ho	
Reduction of construction and design risk to client	1.960	0.054	Accept Ho	
Reduction of administrative cost (general)	1.749	0.085	Accept Ho	
(10) Application of advanced management methods and technology				
Better use of information technology (IT)	0.753	0.454	Accept Ho	1.993
Better concern for environmental issues (general)	-0.252	0.802	Accept Ho	
Improving accountability of contractors	1.298	0.198	Accept Ho	
Promoting value management	0.877	0.384	Accept Ho	
Promoting lean construction	1.038	0.303	Accept Ho	
Promoting partnering	1.338	0.185	Accept Ho	

Table 6-57 (3) Contractor and consultant

	T	Significance	Conclusion	t-Critical (2-tail test)
(1) Quality				
Better quality control and assurance of the project	0.459	0.648	Accept Ho	1.997
Better quality of service and advice from project team	-0.089	0.930	Accept Ho	
Better quality of client's brief	-0.107	0.915	Accept Ho	
Meeting the client's needs	0.365	0.716	Accept Ho	
Meeting user's satisfaction	1.064	0.291	Accept Ho	
Meeting project team satisfaction	0.734	0.466	Accept Ho	
Reduction of inadequate supervision of the project	0.003	0.997	Accept Ho	
Reduction of error in the contract documents	-0.325	0.747	Accept Ho	

Reduction of engineering rework	0.804	0.425	Accept Ho	
(2) Cost saving				
Better value for money	1.317	0.192	Accept Ho	1.997
Better price competition from the bidding process	1.022	0.310	Accept Ho	
Better budget control	2.070	0.042	Reject Ho	
Controllable variation in cost	0.954	0.344	Accept Ho	
Improving contractor's resources utilization efficiency	0.735	0.465	Accept Ho	
Reduction of cost overrun (project)	0.907	0.368	Accept Ho	
Reduction of incorrect cost estimation	1.105	0.273	Accept Ho	
Reduction of maintenance cost (life-cycle)	-0.317	0.752	Accept Ho	
Reduction of monetary claims	0.424	0.673	Accept Ho	
(3) Design				
Better integrate design and construction	0.865	0.390	Accept Ho	1.997
Better cost-effective design	-0.289	0.773	Accept Ho	
Better flow of information on design (reduction of insufficient or incorrect information, etc.)	0.529	0.599	Accept Ho	
Better control of the design and supervision of the work	-0.421	0.675	Accept Ho	
Enhanced aesthetic appearance of the building	1.187	0.240	Accept Ho	
Promoting green design (energy conservation, etc.)	-0.567	0.573	Accept Ho	
Promoting design innovation (prefabrication, etc.)	-0.627	0.533	Accept Ho	
Reduction of conflict of interests among parties involved in design process	0.940	0.351	Accept Ho	
Reduction of design changes (general)	0.489	0.626	Accept Ho	
Reduction of delays due to drawing revision & distribution	1.651	0.103	Accept Ho	
(4) Time saving				
Better early start to implement a construction project	0.746	0.458	Accept Ho	1.997
Better planning and designing time	-0.100	0.921	Accept Ho	
Better detailing and coherent work program (project)	0.386	0.700	Accept Ho	
Better cooperation amongst project team	-0.248	0.805	Accept Ho	
Completing works by dates agreed	0.233	0.816	Accept Ho	
Minimization of activities interference (general)	0.050	0.960	Accept Ho	
Reduction of overall project duration	0.000	1.000	Accept Ho	
Reduction of changes (construction)	0.652	0.517	Accept Ho	
Rapid response to client needs (project)	-0.355	0.724	Accept Ho	
(5) Waste reduction				
Better waste management	1.999	0.050	Reject Ho	1.997
Better site communication to avoid abortive works	0.675	0.502	Accept Ho	
Better site planning to avoid travel distance	0.986	0.328	Accept Ho	

Promoting education and training	0.279	0.781	Accept Ho	
Promoting green technologies	-0.171	0.864	Accept Ho	
Reduction of insufficient or incorrect information	0.352	0.726	Accept Ho	
Reduction of changes due to client's requirements	1.255	0.214	Accept Ho	
Reduction of unused materials and products	1.411	0.163	Accept Ho	
Reduction of paperwork (using less paper)	2.022	0.047	Reject Ho	
(6) Procurement – materials				
Better client involvement in choice of materials	-0.169	0.867	Accept Ho	1.997
Better choice of materials (project)	-0.624	0.535	Accept Ho	
Better quality materials specification	-1.014	0.314	Accept Ho	
Better value for money (material)	0.065	0.948	Accept Ho	
Promoting green procurement – material (environmentally friendly products)	0.828	0.411	Accept Ho	
Reduction of ordering error (not in compliance with specification)	1.084	0.282	Accept Ho	
Reduction of quantities error – material (over ordering and under ordering)	1.794	0.077	Accept Ho	
Reduction of unused materials and products	2.505	0.015	Reject Ho	
Reduction of unclear specification	0.970	0.336	Accept Ho	
(7) Health & safety - on site				
Better decision on health and safety issues	0.520	0.605	Accept Ho	1.997
Better attitude and culture towards health and safety issues	0.212	0.833	Accept Ho	
Improving safety performance on site	0.065	0.949	Accept Ho	
Increasing awareness on health and safety issues	-0.109	0.914	Accept Ho	
Reduction of negligence (professional)	-0.399	0.691	Accept Ho	
Reduction of accident rate	-0.110	0.913	Accept Ho	
(8) Employment				
Better allocation of responsibilities amongst staff	1.599	0.115	Accept Ho	1.997
Better working relationship in the project team (reduction of conflicts, etc.)	0.771	0.443	Accept Ho	
Better knowledge sharing	-0.109	0.913	Accept Ho	
Improving level of empathy within the project team	0.484	0.630	Accept Ho	
Improving performance and motivation amongst project members	0.854	0.397	Accept Ho	
Increasing productivity	0.652	0.517	Accept Ho	
Job creation and empowerment	0.718	0.475	Accept Ho	
Promoting local employees (professional)	0.924	0.359	Accept Ho	
Promoting gender equity & community empowerment	1.010	0.316	Accept Ho	
Reduction of stressful working environment	1.160	0.250	Accept Ho	
(9) Profitability				
Better financial control	0.696	0.489	Accept Ho	1.997
Better risk management	1.110	0.271	Accept Ho	

Better cash flow	0.408	0.685	Accept Ho	
Better project risks sharing amongst project participants	0.198	0.844	Accept Ho	
Improving profit margin	1.068	0.289	Accept Ho	
Reduction of cost (loan interest, etc.)	0.387	0.700	Accept Ho	
Reduction of construction and design risk to client	0.704	0.484	Accept Ho	
Reduction of administrative cost (general)	0.389	0.698	Accept Ho	
(10) Application of advanced management methods and technology				
Better use of information technology (IT)	-0.451	0.653	Accept Ho	1.997
Better concern for environmental issues (general)	-0.912	0.365	Accept Ho	
Improving accountability of contractors	0.546	0.587	Accept Ho	
Promoting value management	-0.211	0.833	Accept Ho	
Promoting lean construction	-0.109	0.914	Accept Ho	
Promoting partnering	0.054	0.957	Accept Ho	

T-test (sample calculation)

(1) Quality

(a)

(A) Client and contractor

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	4.433333333	4.173913043
Variance	0.46091954	0.968379447
Observations	30	23
Pooled Variance	0.679823814	
Hypothesized Mean Difference	0	
Df	51	
t Stat	1.135252231	
P(T<=t) one-tail	0.130788451	
t Critical one-tail	1.675284951	
P(T<=t) two-tail	0.261576901	
t Critical two-tail	2.007583728	

(B) Client and consultant

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	4.433333333	4.06818182
Variance	0.46091954	0.71617336
Observations	30	44
Pooled Variance	0.613362795	
Hypothesized Mean Difference	0	
df	72	
t Stat	1.969180372	
P(T<=t) one-tail	0.026390576	
t Critical one-tail	1.666293697	
P(T<=t) two-tail	0.052781153	
t Critical two-tail	1.993463539	

(C) Contractor and consultant

t-Test: Two-Sample Assuming Equal Variances

	Variable 1	*Variable 2*
Mean	4.173913043	4.068181818
Variance	0.968379447	0.716173362
Observations	23	44
Pooled Variance	0.801535421	
Hypothesized Mean Difference	0	
df	65	
t Stat	0.458981056	
P(T<=t) one-tail	0.323889479	
t Critical one-tail	1.668635976	
P(T<=t) two-tail	0.647778958	
t Critical two-tail	1.997137887	

(c) Objective three

Pearson significance test (sample calculation)

(1) Quality

(A) Client and contractor

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.654608234
R Square	0.42851194
Adjusted R Square	0.346870788
Standard Error	2.155104265
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	24.37756813	24.37756813	5.248724843	0.055724547
Residual	7	32.51132075	4.644474394		
Total	8	56.88888889			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.743396226	1.549550138	1.1250983	0.297640319	-1.920707608	5.407500061	-1.920707608	5.407500061
X Variable 1	0.643396226	0.280835242	2.291009569	0.055724547	-0.020673597	1.30746605	-0.020673597	1.30746605

(B) Client and consultant

SUMMARY
OUTPUT

Regression Statistics	
Multiple R	0.581955217
R Square	0.338671875
Adjusted R Square	0.244196429
Standard Error	2.318319041
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	19.26666667	19.26666667	3.58476078	0.100181314
Residual	7	37.62222222	5.374603175		
Total	8	56.88888889			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.055555556	1.684219736	1.220479437	0.261797068	-1.926991277	6.038102388	-1.926991277	6.038102388
X Variable 1	0.566666667	0.299293701	1.89334645	0.100181314	-0.141050477	1.274383811	-0.141050477	1.274383811

(C) Contractor and consultant

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.807511902
R Square	0.652075472
Adjusted R Square	0.602371968
Standard Error	1.710843104
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	38.4	38.4	13.11930586	0.008486939
Residual	7	20.48888889	2.926984127		
Total	8	58.88888889			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.888888889	1.2428987	0.715174044	0.497654758	-2.050099518	3.827877296	-2.050099518	3.827877296
X Variable 1	0.8	0.220868895	3.622058235	0.008486939	0.277728055	1.322271945	0.277728055	1.322271945

...

(d) Objective four

Pearson significance test (sample calculation)

(1) Quality

Traditional		Design and Build	
Industry	Case study	Industry	Case study
5	6	7	6
4	8	4	8
3	4	4	4
2	2	8	6
1	1	2	1
8	2	2	2
6	4	1	2
7	6	6	4

Pearson 0.30 0.69

(2) Cost saving

Traditional		Design and Build	
Industry	Case study	Industry	Case study
1	1	4	1
4	2	5	2
5	5	1	2
2	2	3	2
3	2	2	2

Pearson 0.83 -0.35

(3) Design

Traditional		Design and Build	
Industry	Case study	Industry	Case study
3	1	1	1
2	5	6	2
4	2	3	5
6	5	2	4
5	3	4	2
1	4	5	5

Pearson 0.00 0.16

(4) Time saving

Traditional		Design and Build	
Industry	Case study	Industry	Case study
3	3	1	1
2	1	3	2
1	2	2	2

Pearson 0.50 0.87

(5) Waste reduction

Traditional		Design and Build	
Industry	Case study	Industry	Case study
3	4	3	1
2	3	4	1
1	1	1	3
4	2	2	3

Pearson 0.40 -0.89

(6) Procurement – materials

Traditional		Design and Build	
Industry	Case study	Industry	Case study
4	4	2	3
1	3	4	3
3	2	1	1
2	1	3	1

Pearson 0.40 0.45

(7) Health and safety – on site

Traditional		Design and Build	
Industry	Case study	Industry	Case study
3	5	3	1
2	5	1	2
4	2	3	4
5	4	3	5
1	1	2	2
6	2	6	5

Pearson -0.03 0.62

(8) Employment

Traditional		Design and Build	
Industry	Case study	Industry	Case study
1	5	4	4
4	2	1	1
2	3	5	4
5	3	3	1
3	1	2	1

Pearson -0.53 0.87

(9) Profitability

Traditional		Design and Build	
Industry	Case study	Industry	Case study
1	2	1	2
2	2	2	1
3	1	3	2

Pearson -0.87 0.00

(10) Application of advance management method and technology

Traditional		Design and Build	
Industry	Case study	Industry	Case study
1	4	5	4
3	1	3	1
4	4	2	1
2	1	1	3
5	1	4	4

Pearson -0.29 0.52

Appendix D – Calculation ranking

(a) Objective one

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(b) Objective two

(1) Quality

	Client			Contractor			Consultant	
Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking
4.43	88.67	1	4.17	83.48	1	4.07	81.36	1
4.23	84.67	2	3.96	79.13	3	3.98	79.55	2
4.00	80.00	4	3.70	73.91	4	3.73	74.55	4
3.80	76.00	6	3.65	73.04	5	3.57	71.36	5
3.80	76.00	6	4.00	80.00	2	3.75	75.00	3
3.70	74.00	8	3.52	70.43	7	3.34	66.82	9
3.57	71.33	9	3.48	69.57	8	3.48	69.55	6
3.90	78.00	5	3.35	66.96	9	3.45	69.09	7
4.03	80.67	3	3.65	73.04	5	3.41	68.18	8

(2) Cost saving

	Client			Contractor			Consultant	
Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking
4.23	84.67	1	4.17	83.48	1	3.86	77.27	1
3.77	75.33	5	3.52	70.43	7	3.23	64.55	7
3.80	76.00	3	3.96	79.13	2	3.34	66.82	5
3.70	74.00	6	3.57	71.30	6	3.27	65.45	6
3.63	72.67	8	3.83	76.52	3	3.64	72.73	3
3.67	73.33	7	3.65	73.04	5	3.36	67.27	4

3.80	76.00	3	3.52	70.43	7	3.20	64.09	8
4.03	80.67	2	3.74	74.78	4	3.82	76.36	2
3.63	72.67	8	3.22	64.35	9	3.09	61.82	9

(3) Design

	Client			Contractor			Consultant	
Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking
4.37	87.33	1	4.13	82.61	1	3.91	78.18	3
4.27	85.33	2	3.87	77.39	3	3.93	78.64	2
3.93	78.67	3	3.74	74.78	4	3.59	71.82	5
3.90	78.00	4	3.48	69.57	7	3.59	71.82	5
3.37	67.33	10	3.22	64.35	10	2.89	57.73	10
3.90	78.00	4	4.04	80.87	2	4.16	83.18	1
3.77	75.33	6	3.74	74.78	4	3.91	78.18	3
3.57	71.33	8	3.26	65.22	8	2.95	59.09	9
3.60	72.00	7	3.26	65.22	8	3.11	62.27	7
3.57	71.33	8	3.52	70.43	6	2.98	59.55	8

(4) Time saving

	Client			Contractor			Consultant	
Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking
3.53	70.67	8	3.39	67.83	5	3.14	62.73	8
3.93	78.67	3	3.65	73.04	1	3.68	73.64	1
4.13	82.67	1	3.57	71.30	2	3.45	69.09	3
4.00	80.00	2	3.52	70.43	3	3.59	71.82	2
3.93	78.67	3	3.35	66.96	6	3.27	65.45	4
3.57	71.33	7	3.17	63.48	7	3.16	63.18	7
3.43	68.67	9	3.00	60.00	9	3.00	60.00	9

3.60	72.00	6	3.43	68.70	4	3.23	64.55	6
3.67	73.33	5	3.17	63.48	7	3.27	65.45	4

(5) Waste reduction

	Client			Contractor			Consultant	
Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking
3.90	78.00	2	4.30	86.09	1	3.84	76.82	2
4.17	83.33	1	3.83	76.52	3	3.64	72.73	3
3.70	74.00	5	3.39	67.83	7	3.11	62.27	7
3.57	71.33	8	3.48	69.57	6	3.41	68.18	5
3.83	76.67	3	3.87	77.39	2	3.91	78.18	1
3.73	74.67	4	3.39	67.83	7	3.30	65.91	6
3.63	72.67	6	3.39	67.83	7	3.00	60.00	8
3.60	72.00	7	3.78	75.65	4	3.43	68.64	4
3.37	67.33	9	3.57	71.30	5	2.95	59.09	9

(6) Procurement – materials

	Client			Contractor			Consultant	
Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking
3.77	75.33	5	3.13	62.61	9	3.18	63.64	5
3.93	78.67	2	3.48	69.57	4	3.61	72.27	4
4.10	82.00	1	3.48	69.57	4	3.70	74.09	2
3.87	77.33	4	3.65	73.04	3	3.64	72.73	3
3.93	78.67	2	3.91	78.26	1	3.75	75.00	1
3.43	68.67	8	3.26	65.22	8	2.95	59.09	8
3.43	68.67	8	3.48	69.57	4	2.95	59.09	8
3.60	72.00	6	3.78	75.65	2	3.18	63.64	6
3.60	72.00	6	3.35	66.96	7	3.09	61.82	7

(7) Health and safety – on site

	Client			Contractor			Consultant	
Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking
4.13	82.67	3	3.65	73.04	2	3.50	70.00	4
4.07	81.33	5	3.74	74.78	1	3.68	73.64	1
4.20	84.00	1	3.61	72.17	3	3.59	71.82	3
4.20	84.00	1	3.61	72.17	3	3.64	72.73	2
3.90	78.00	6	3.35	66.96	5	3.45	69.09	5
4.10	82.00	4	3.30	66.09	6	3.34	66.82	6

(8) Employment

	Client			Contractor			Consultant	
Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking
4.03	80.67	1	3.74	74.78	1	3.30	65.91	3
4.00	80.00	3	3.48	69.57	5	3.25	65.00	5
4.00	80.00	3	3.57	71.30	4	3.59	71.82	1
3.97	79.33	5	3.17	63.48	7	3.05	60.91	7
4.03	80.67	1	3.70	73.91	2	3.30	65.91	3
3.90	78.00	6	3.65	73.04	3	3.45	69.09	2
3.63	72.67	8	3.30	66.09	6	3.11	62.27	6
3.60	72.00	9	3.13	62.61	9	2.84	56.82	8
3.27	65.33	10	2.87	57.39	10	2.57	51.36	10
3.70	74.00	7	3.17	63.48	7	2.80	55.91	9

(9) Profitability

	Client			Contractor			Consultant	
Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking
4.13	82.67	2	3.78	75.65	1	3.59	71.82	1

4.20	84.00	1	3.74	74.78	2	3.43	68.64	2
3.93	78.67	3	3.52	70.43	3	3.39	67.73	3
3.83	76.67	4	3.26	65.22	6	3.20	64.09	5
3.63	72.67	6	3.48	69.57	4	3.16	63.18	6
3.57	71.33	7	3.26	65.22	6	3.14	62.73	7
3.73	74.67	5	3.43	68.70	5	3.23	64.55	4
3.57	71.33	7	3.22	64.35	8	3.09	61.82	8

(10) Application of advance management methods and technology

	Client			Contractor			Consultant	
Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking	Mean	Sig Indexes	Ranking
3.93	78.67	2	3.70	73.91	2	3.80	75.91	2
4.00	80.00	1	3.87	77.39	1	4.05	80.91	1
3.87	77.33	4	3.65	73.04	3	3.50	70.00	5
3.90	78.00	3	3.65	73.04	3	3.70	74.09	3
3.77	75.33	5	3.52	70.43	5	3.55	70.91	4
3.50	70.00	6	3.17	63.48	6	3.16	63.18	6

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(c) Objective three

The comparison between traditional, design and build & management contracting

(1) Clients (ALL)

Table 4-51 Ranking summary of clients

	Traditional	Design & Build	Management Contracting
1) Quality	7	6	5
2) Cost saving	5	4	6
3) Design	9	5	4
4) Time saving	8	4	5
5) Waste reduction	8	4	6
6) Procurement – material	7	6	5
7) Health & Safety	8	5	4
8) Employment	8	4	6
9) Profitability	6	7	5
10) Application of advance management methods and technology	8	5	5
Total	74	50	51
Ranking (lowest ranking)	3	1	2

(A) Clients (Public)

Table 4-51 Ranking summary of clients (public)

	Traditional	Design & Build	Management Contracting
1) Quality	2	3	1
2) Cost saving	1	2	1
3) Design	3	2	1
4) Time saving	3	2	1
5) Waste reduction	3	1	2
6) Procurement – material	3	2	1
7) Health & Safety	3	2	1
8) Employment	3	2	1
9) Profitability	2	3	1
10) Application of advance management methods and technology	3	2	1
Total	26	21	11
Ranking (lowest ranking)	3	2	1

(B) Clients (Private)

Table 4-51 Ranking summary of clients (public)

	Traditional	Design & Build	Management Contracting
1) Quality	2	1	3
2) Cost saving	1	1	3
3) Design	3	1	2
4) Time saving	2	1	3
5) Waste reduction	2	1	3
6) Procurement – material	1	2	3
7) Health & Safety	3	1	2
8) Employment	2	1	3
9) Profitability	1	2	3
10) Application of advance management methods and technology	2	1	3
Total	19	12	28
Ranking (lowest ranking)	2	1	3

(C) Clients (Others)

Table 4-51 Ranking summary of clients (public)

	Traditional	Design & Build	Management Contracting
1) Quality	3	2	1
2) Cost saving	3	1	2
3) Design	3	2	1
4) Time saving	3	1	1
5) Waste reduction	3	2	1
6) Procurement – material	3	2	1
7) Health & Safety	2	2	1
8) Employment	3	1	2
9) Profitability	3	2	1
10) Application of advance management methods and technology	3	2	1
Total	29	17	12
Ranking (lowest ranking)	3	2	1

(2) Contractors

Table 4-52 Ranking summary of contractors

	Traditional	Design & Build	Management Contracting
1) Quality	3	1	2
2) Cost saving	3	1	1
3) Design	3	1	2
4) Time saving	3	1	2

5) Waste reduction	3	1	2
6) Procurement – material	3	1	2
7) Health & Safety	3	2	1
8) Employment	3	1	2
9) Profitability	3	1	2
10) Application of advance management methods and technology	3	1	2
Total	30	11	18
Ranking (lowest ranking)	3	1	2

<u>(3) Consultants (ALL)</u>

Table 4-53 Ranking summary of consultants

	Traditional	Design & Build	Management Contracting
1) Quality	6	8	3
2) Cost saving	7	6	5
3) Design	9	3	6
4) Time saving	7	3	8
5) Waste reduction	9	3	6
6) Procurement – material	7	7	4
7) Health & Safety	9	4	5
8) Employment	9	5	4
9) Profitability	9	5	4
10) Application of advance management methods and technology	9	5	4
Total	81	49	49
Ranking (lowest ranking)	3	1	1

<u>(A) Consultants (Architect)</u>

Table 4-53 Ranking summary of consultants

	Traditional	Design & Build	Management Contracting
1) Quality	2	3	1
2) Cost saving	3	2	1
3) Design	3	1	2
4) Time saving	2	1	3
5) Waste reduction	3	1	2
6) Procurement – material	2	3	1
7) Health & Safety	3	1	2
8) Employment	3	2	1
9) Profitability	3	2	1
10) Application of advance management methods and technology	3	2	1
Total	27	18	15
Ranking (lowest ranking)	3	2	1

(B) Consultants (QS)

Table 4-53 Ranking summary of consultants

	Traditional	Design & Build	Management Contracting
1) Quality	2	3	1
2) Cost saving	3	2	1
3) Design	3	1	2
4) Time saving	2	1	3
5) Waste reduction	3	1	2
6) Procurement – material	2	3	1
7) Health & Safety	3	1	2
8) Employment	3	2	1
9) Profitability	3	2	1
10) Application of advance management methods and technology	3	2	1
Total	27	18	15
Ranking (lowest ranking)	3	2	1

(C) Consultants (Eng)

Table 4-53 Ranking summary of consultants

	Traditional	Design & Build	Management Contracting
1) Quality	2	2	1
2) Cost saving	1	2	3
3) Design	3	1	2
4) Time saving	3	1	2
5) Waste reduction	3	1	2
6) Procurement – material	3	1	2
7) Health & Safety	3	2	1
8) Employment	3	1	2
9) Profitability	3	1	2
10) Application of advance management methods and technology	3	1	2
Total	27	13	19
Ranking (lowest ranking)	3	1	2

(4) Others

Table 4-54 Ranking summary of others

	Traditional	Design & Build	Management Contracting
1) Quality	2	1	3
2) Cost saving	2	1	2
3) Design	2	1	2
4) Time saving	1	1	1
5) Waste reduction	1	1	1

6) Procurement – material	1	1	1
7) Health & Safety	2	1	3
8) Employment	2	1	2
9) Profitability	1	1	1
10) Application of advance management methods and technology	1	1	1
Total	15	10	17
Ranking (lowest ranking)	2	1	3

(d) Objective four

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