Project Management for Sustainable Project Success

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ABSTRACT

The construction industry has been challenging the market with higher requirements for sustainable buildings. However, there is no clear method on how project management can support sustainability achievement of the building. This research focuses on this challenge and aims at developing a framework of sustainable project management. The study started with a conceptual model for Sustainable Project Management (SPM) with five key components, which were built on the classification of 35 project-management related success factors for achieving sustainability in building projects. Then, five hypotheses were proposed to test the inter-relationships among the five key components of SPM and their impacts on the achievement of Sustainable Project Success (SPS). Structural equation modelling (SEM) technique was employed to analyse data collected from a questionnaire survey with contributions of 144 professionals in the UK. The research results support the significant and positive impact of sustainability assessment and stakeholder management for achieving sustainable project success. The results also highlight the enhancement of project team, the definition of sustainable goals and the planning of sustainability in projects. On the ground of these findings, a comprehensive framework for sustainability management (GEPAS) was developed and validated.

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DECLARATION STATEMENT

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ABBREVIATIONS

AIPM	Australian Institute of Project Management
APM	Association of Project Management
BREEAM	Building Research Establishment Environmental Assessment Method
BS	British Standard(s)
BSI	British Standards Institution
DB (or D&B)	Design Build
DBB	Design-Bid-Build
EcS	Economic Sustainability
EnS	Environmental Sustainability
EPC	Engineering, Procurement, and Construction
IDP	Integrated Delivery Process
IPD	Integrated Project Delivery
IPMA	International Project Management Association
IPT	Integrated Project Team
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
LCSA	Life Cycle Sustainability Assessment
LEED	Leadership in Energy and Environmental Design
PDCA	Plan-Do-Check-Act
PM	Project manager(s)
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
PMKA	Project Management Knowledge areas
POE	Post Occupancy Evaluation
PPSP	Project Performance and Stakeholder satisfaction
SC	Sustainability champion(s)
SoS	Social Sustainability
SPM	Sustainable Project Management
SPS	Sustainable Project Success
TBL	Triple-Bottom-Line

LIST OF PUBLICATION

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Phung, Quan, Erdogan, Bilge, & Nielsen, Yasemin (2019). Exploring Critical Success Factors for Managing Sustainability in Construction Projects. In *14th Organisation, Technology & Management in Construction Conference (OTMC) & 7th IPMA Research Conference, Westin Zagreb, September 4-7, 2019* (pp. 374–388). Zagreb, Croatia: Croatian Association for Construction Management. Retrieved from http://www.otmc-conference.com/wp-content/uploads/2019/09/OTMC2019_Conference-Proceedings-01092019-v_9-resize.pdf

CHAPTER 1. INTRODUCTION

1.1. Background and justification for the research

Aligned with the targets of sustainable development, i.e. the "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987), the construction industry should take a strong position of responsibility due to its contribution to the economy, society and significant impacts on the environment. To adapt to the requirement, the industry has been challenging the market with higher requirements for sustainable buildings with more rigorous standards (Kibert, 2013). New types of sustainable buildings have been introduced, including zero-carbon buildings or net-zero buildings, to meet the target of cutting carbon emission. However, the current focus of sustainable construction operates mainly at a macro level (i.e. policies/incentives of the governments and corporates' development strategies). At the project level, insufficient efforts have been made to improve management practice to effectively deliver project sustainably. As a result, construction buildings are now delivered without a sustainable project management approach. The outcome cannot be sustainable if there is no sustainable process applied (Marcelino-Sádaba, González-Jaen, & Pérez-Ezcurdia, 2015).

The main reason for the lack of a sustainable management approach in practice should be the failure in addressing the sustainability issues in current project management standards (Eid, 2009). For instance, such project management standards as IPMA, AIPM, APM or ENAA have "no special attention to the issue of sustainability" (Martens & Carvalho, 2016). Analysing process-based project management standards (PMBOK guide, PRINCE2 and ISO21500), Silvius (2013) also found that these standards "refer mostly implicit to sustainability". These standards have formed the principles and characteristic of project management in an opposite way to the concept of sustainable development, as clarified by Silvius & Brink (2014) in Figure 1.1. As a result, current project management practice is oriented by a short-term vision to satisfy mainly financial goal by the interest of clients and investors, who often see sustainability as an extra of cost, time, resources and risks due to its uncertainty. Hence, sustainability targets are often put in a lower priority than targets of meeting expected time and budget. When the project is faced with a shortage of resources, especially budget for completion, sustainability is often in the first line to be eliminated. The new approach, therefore, should highlight the integration of sustainability into project management principles and activities.

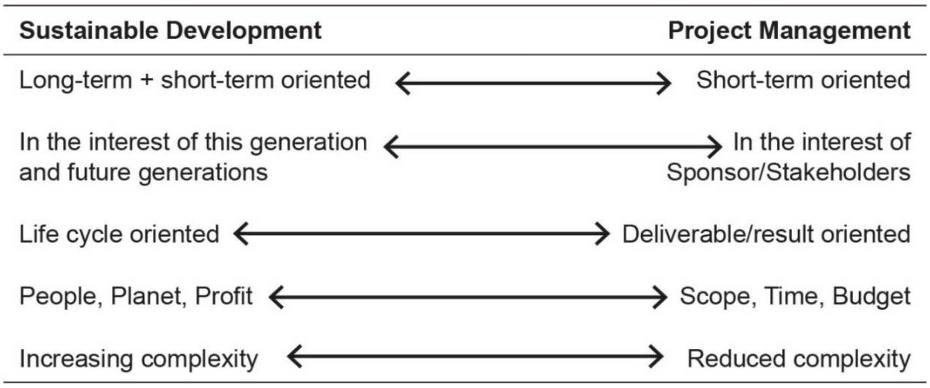


Figure 1.1. The difference between the current project management approach and sustainability (Silvius & Brink, 2014)

Several efforts have been made to support a sustainable project management approach. Through the literature review, there are five mainstreams in the trend of integrating sustainability into project management theory and practice (which is discussed in section 2.4); including: (1) the use of a checklist of suggested sustainability-related actions, (2) the use of a sustainability set of indicators (or project KPIs), (3) the integration of sustainability to project through another project management knowledge area, (4) proposed changes in the core principles of project management, and (5) the use of sustainability management process.

Among the five mainstream approaches listed above, the use of sustainability management process can be considered the most suitable approach to provide clear guidance for project managers in managing sustainable construction projects. However, very little research has focused on formulating of a process for sustainability management in construction, except the work of Khalfan (2006). Khalfan suggested a process of 11 steps called as "Sustainability Management Activity Zone - SMAZ" that focuses on scoping sustainability issues, prepare mission statement, plan and assess/review sustainability results. This framework was successful in forming the sustainability management approach with scope/mission definition, planning, and assessment - which are key important parts of management principles. However, several essential issues of sustainability management were not embedded in this framework. Other essential issues of sustainability management were listed by Tharp (2013) as stakeholder management, human resource management, procurement, risk management and communication management. In addition, the SMAZ framework failed to provide clear directions on documents/information needed for the implementation of each process, outcomes of management activities, and how participants involved and collaborate in the process. A practical and user-friendly guideline, therefore, should delivery these issues. In addition, project managers have a vital role to not only impacts the success of the project (Toney, 2002) but also able to influence the sustainability achievement of projects. Not only they hold a perfect position to affect the sustainability in corporate level (Russell, 2008), but also they have the power to influence to the implication of sustainability in project level (Goedknegt, 2012). Therefore, project managers should take a high responsibility in integrating sustainability in their project. However, no guideline is found in the literature that focuses on supporting project managers in initiating and managing sustainable projects to bypass barriers of sustainable construction.

In conclusion, it is necessary to develop a comprehensive guideline that supports project managers in initiating and delivering sustainable building projects. The guideline should not only focus on the use of sustainability assessment and planning, but it also needs to help the industry bypass human-related barriers (such as human resource, competencies, or stakeholder engagement and communication). The first step to build the framework should start at understanding key components that sustainability management in construction should have as well as how they can affect to the achievement of sustainable project success. Then, a framework with detail processes can be developed as step-by-step guidance for project managers.

1.2. Research question, aim and objectives

This study aims to develop a framework that integrates sustainability into project management theory and practice. It is envisaged that this framework will provide a practical guideline for project managers throughout the lifecycle of sustainable building projects. The framework is expected to close the gap in current project management standards by providing sustainability guidelines. To pursue the main aim, five objectives are set:

- *Objective 1:* To review previous work on sustainable construction, management and achievement of sustainability in construction projects;
- *Objective 2:* To develop a conceptual model for Sustainable Project Management;

- *Objective 3:* To empirically identify the relationship between sustainable project management (SPM) and sustainable project success (SPS);
- *Objective 4:* To develop a framework for managing sustainability in building projects that follows a holistic approach to support the achievement of sustainable project success;
- *Objective 5:* To evaluate the applicability and effectiveness of the framework.

1.3. Research methodology

Figure 1.2 shows a mapping of adopted research methods, research objectives and the structure of the thesis. Detail of research methodology is presented in Chapter 4, but it can be outlined in short as some context below.

The research started with the investigation of existing theories in the literature about the sustainable construction and sustainable project management (Objective 1, which is shown in Chapter 2) to identify the research problem. These reviews were based on secondary documents, such as journal papers, books, conference papers, government reports and PhD thesis.

Then, an extensive literature review was also carried out on the topics related project management led to the identification of 35 potential factors contributing to the achievement of sustainability in construction projects. These factors were then categorised under five groups of factors and further supported the forming of a conceptual framework for sustainable project management (SPM) with five key components. In order to understand the relationships between these groups of factors and each of these components to the success of sustainable projects in practice, five hypotheses were proposed. The identification, related supporting theories, and hypotheses for these components were demonstrated in Chapter 3 (Objective 2).

In order to collect the data for confirmatory factor analysis and hypothesis testing of the conceptual framework, this research employed a survey approach. An online questionnaire was sent to project managers or members of the project management team, who has more than two years of working experience in building project management in the UK. Participants were asked to provide their background information, evaluation on the actual performance of selected critical success factors for sustainable project management approach and the evaluation of project success criteria in their most recent project.

Data analysis in this research uses descriptive statistics and structural equation modelling (SEM) techniques. SPSS statistics supported the analysis of mean rating, median, standard deviation, normality, and correlation test. SmartPLS, an SEM-based data analysis software, helped to carry out the confirmatory factors analysis and to test the relationship between SPM and SPS (Objective 3, which is presented in Chapter 5).

Based on the result obtained from the data analysis, a comprehensive framework for sustainability management (GEPAS) was developed. The framework was modelled by IDEF0 modelling language (Objective 4, which is presented in Chapter 6).

To evaluate the framework (Objective 5 in Chapter 7), a series of structured interviews was conducted to determine the appropriateness and functionality of GEPAS frameworks and its processes in building projects. Descriptive statistic and thematic technique are used to analyse the quantitative and qualitative data from the interviews.

1.4. Thesis structure

The thesis structure is presented in the last column of Figure 1.2. The thesis consists of eight chapters with short descriptions as:

- *Chapter 1 - Introduction:* This chapter presents an overall introduction to the research with background, research justification, a brief of the methodology adopted, and structure of the thesis.

- *Chapter 2 - A review on Sustainability in Construction and Project Management:* This chapter reviews the literature on sustainability in the construction industry and project management. It presents the state-of-the-art on the research topic, including sustainable development, sustainability in construction, sustainable project success (SPS) in building projects, and the integration of sustainability into project management.

- *Chapter 3 - Sustainable Project Management (SPM): A conceptual model:* This chapter presents the development of a theoretical framework for Sustainable Project Management (SPM) approach in this research. It starts with an exploration of critical success factors for managing sustainability in construction projects. These CSFs were then categorised into five groups, which later accepted as the five key components of SPM. The chapter then presents a detail literature review on recent research and supporting theories for the form of the five components of SPM. In the last part, the chapter presents hypotheses for understanding inter-relationships among the five key components. The hypotheses were also expected to explore how SPM can support the achievement of SPS.

- *Chapter 4 - Research methodology:* This chapter demonstrates the methodology for this research. It starts at discussing the choice of research model and the general background of concepts in the research design approach, which then helped to choose the adopted research methods. The chapter then explains the adopted methods in data collection, data analysis, research result quality (validity and reliability), framework development and evaluation.

- *Chapter 5 – Exploring interrelationships among components of SMP and their impacts to SPS:* This chapter presents the findings of the data analysis procedure. It starts with a demographic of respondents and projects selected by respondents. Results of a preliminary analysis, descriptive analysis and SEM analysis are demonstrated. The chapter ends with discussion of results.

- *Chapter 6 - Developing the GEPAS framework for Sustainability Management in building projects:* This chapter presents the development of GEPAS framework for sustainability management in building projects. It begins with an explanation of the foundation, rationale, aims, and end-users of the framework, which is then followed by features and IDEF0 processes (and sub-processes) of the framework.

- *Chapter 7 - Evaluation of the GEPAS framework:* This chapter illustrates the evaluation of GEPAS framework, which was developed in the previous chapter. It starts with an explanation of aims for research evaluation and adopted evaluation method. Then, it presents the results found from the questionnaire survey and comments of respondents, followed by a discussion of evaluation results.

- *Chapter 8 - Summary, Conclusions and Recommendations:* This chapter summary the major findings and conclusions of the research. It also describes the limitations of the study and provides recommendations for further research.

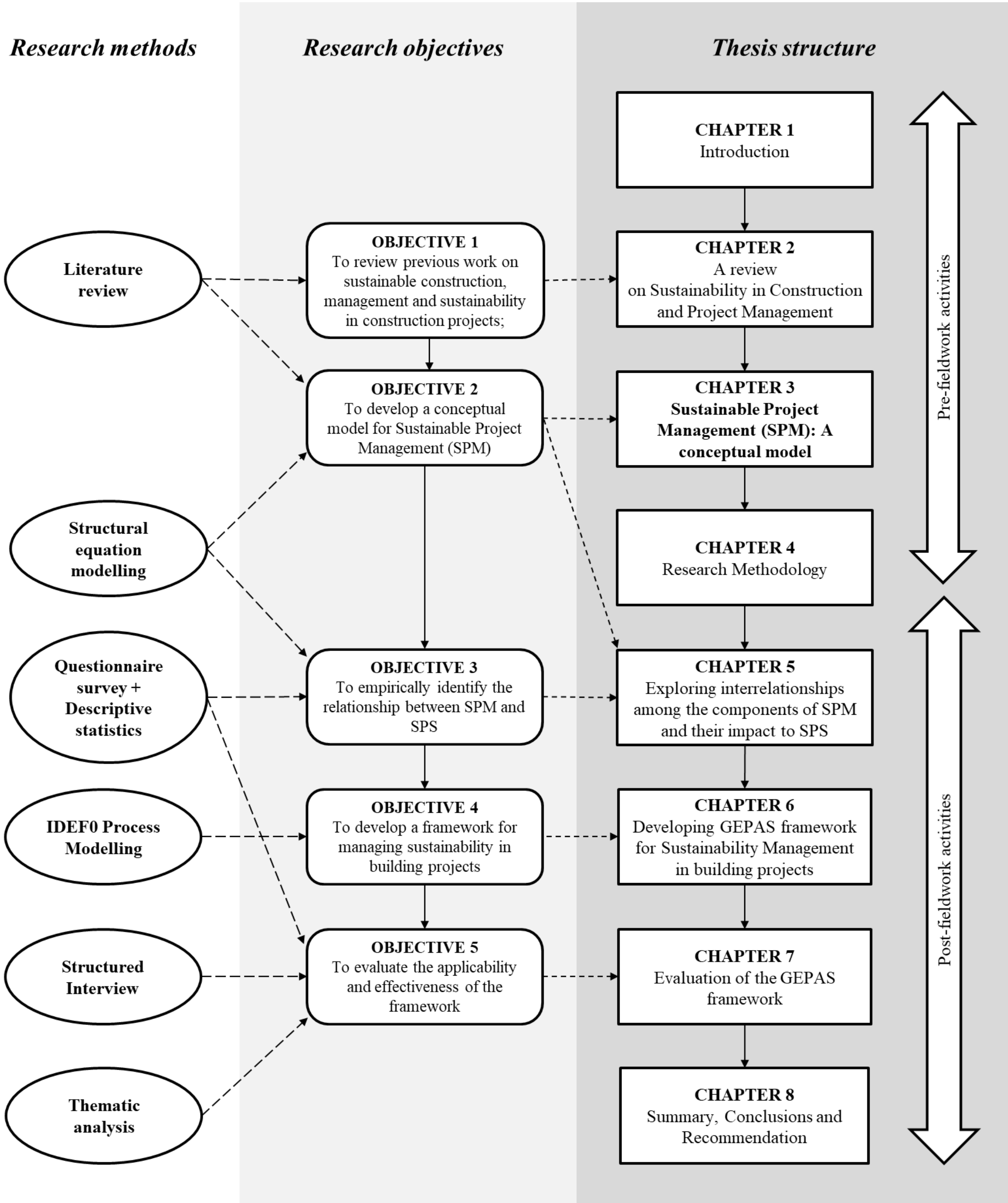


Figure 1.2. Mapping research methods, objectives and thesis structure

CHAPTER 2. A REVIEW ON SUSTAINABLE CONSTRUCTION AND PROJECT MANAGEMENT

This chapter aims at reviewing sustainability in construction industry, with a particular focus on project management related issues in achieving sustainability of building projects. The first part of this chapter zooms out the broad picture of sustainability concept, including sustainability concept, models, the need, barriers, and products of sustainable construction. The second part zooms in the adoption of sustainability in construction project management. The chapter also investigates the concept of sustainable project success and the current approaches to integrate sustainability into the management of construction projects.

2.1. Sustainable development and sustainability

The world has never faced with such serious changes in our economic, social and natural environment like the climate change and life quality retrograde experienced in the first decades of the twenty-first century in a global scale - which has put the human in a vulnerable position. The current situation of human's economy and society is contradictory to every single definition of "sustainability" that science community wrote down in the last 20 years - or in other words, the human is now in the worst sustainable position with the highest complexity and largest scale in our 200,000-year-history (Becker, 2014, p. 15). The pessimistic scenarios suggest that human could be faced with harsher living and health conditions due to the climate change and extreme events (McMichael, Woodruff, & Hales, 2006; Watson, Zinyowera, Moss, & Dokken, 1998). Therefore, several efforts related to sustainable development held during the last 25 years by United Nations, such key ones as: Agenda 21 (1992), Rio Declaration (1992), Millennium Declaration (2000), Johannesburg Plan (2002), as well as series of smaller committees in national levels of each country, including the United Kingdom. Many outcomes - such as Future We Want (UN in 2012), SAMOA Pathway (SIDS in 2014), Sendai Framework (UNDRR in 2015), Addis Ababa action agenda (by UN in 2015) or Paris Agreement (UNFCCC in 2016) - have been issued to boost up sustainable development.

2.1.1. Definition of sustainability and agendas for the sustainable development

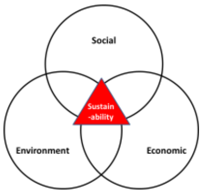
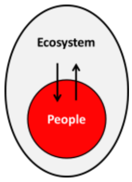
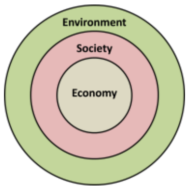
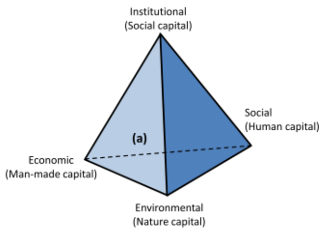
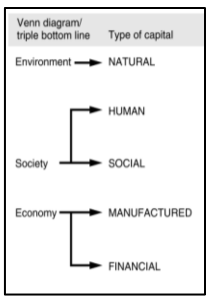
There are more than 200 slightly different definitions of "sustainable development" (Parkin, Sommer, & Uren, 2003). Many authors like Becker (2014) and Plessis (2002, p. 5) saw sustainability as not a new terminology, they considered that the nature of sustainability and its problems were raised from the ancient period when people tried to find the stage or condition for "continued existence of homo sapiens". One of the first recognized concepts for sustainability belongs to National Environmental Policy Act (NEPA-US) in 1969 as "to create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations" (NRC & National Research Council, 2011). Although this definition did not mention about environmental or ecological aspect, it also put a foundation for the development of sustainability. In the 1970s and 1980s, when the threat to human survival came to a global scale, the most widely cited definition of sustainability was stated as the "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987).

The definition of sustainability by the United Nations is clear, but its application to local countries might vary due to the difference in economic and development status. For rich countries with the high living quality of their citizens, sustainability relates to the change in human awareness and behaviour in producing goods with minimal impacts on the environment and society – i.e., avoid damaging the resources and life of future generations. However, for third-world countries, it is hard to adapt the need of future generations while the basic need of majority people at the moment are not satisfied (Kibert, Monroe, Peterson, Plate, & Thiele, 2012). The application of sustainability, therefore, went to the result of two opposite directions, Green Agenda and Brown Agenda (Du Plessis & Plessis, 2007; Plessis, 2002). Developed countries with Green Agenda gains more attention on the future generation by solving, preventing adverse effects on eco-system and preserving natural resources in long-term frame and global scale. The third world with Brown Agenda concentrates on current generation with immediate problems of low-quality life such as healthcare, poverty, high population density, or pollution. Developing countries are in the middle position between the two agendas.

2.1.2. Models of sustainable development

The following step to generate sustainability from the definition, the definition of sustainability has come up with numerous models to clarify key elements of sustainable development. Table 2.1 summarised the most outstanding models for sustainable development.

Table 2.1. Outstanding models of sustainable development

Name	Model vision	Dimensions	Focal points
Triple bottom line (TBL)		- Environmental - Social - Economic	Equitable balance among dimensions
Egg of sustainability		- Ecosystem - People	Balance and equal treatment of human and ecosystem well-being
Russian Doll (Bull's eye)		- Environment - Society - Economy	The role of the environment in the system is more important than economy and society because naturally both are fully embedded in Earth's system
Prism of sustainability		- Institutional - Economic - Social - Environmental	Interactions between different dimensions
Five-capital		- Nature - Human - Social - Manufactured - Financial	Resources are limited and need to use them smartly for our activities without generating waste and pollution. Natural capital is critical for protection because they cannot be reversed from any other types

- *The Triple-Bottom-Line (TBL):* TBL is the most well known model of sustainability, which also has different names as three-pillar, three-dimension, three-legged stool, or triangle of sustainability. This model is also embedded in the vast majority sustainability concepts of governments around the world. It focuses on the balance of three dimensions: environmental (conservation/planet), economic (growth/profit), and social (equity/people) sustainability.
- *The egg of sustainability*: The egg model was developed by International Union for the Conservation of Nature (Guijt & Moiseev, 2001) with emphasis on the balance of and equal treatment on human and ecosystem well-being under a metaphor that described the relationship of people and ecosystem is like the yolk and the white of an egg. If people over-consume existing resources from the nature, the yolk would get bigger and bigger until it breaks the egg.
- *Russian Doll or Bull's-eye model:* This model was introduced by Levett (1998); it has the same three dimensions as the TPL model, but it considers more of the relation among these dimensions in reality. It argued that the social and economic component are "fully embedded in Earth's ecological systems and could not exist without a thriving global environment" (Kibert et al., 2012). Moreover, economy is not an independent entity to our society as the whole economy is created by human activities. Therefore, the model uses three concentric circles to demonstrate the sustainability: "Economy" is put in the centre, "society" is the second layer, and biggest circle is "environment". In this model, environment dimension holds the most important role of the system (and it is the largest circle, which covers both society and economy). If the nature environment is destroyed, it will no longer protect human living; in other words, the society and economy will be in danger.
- *Prisms of sustainability:* The frame for prism of sustainability was built by United Nation Department of policy Co-ordination and Sustainable development in 1995 with four dimensions of institutional, economic, social and environmental imperatives. The sustainability can be achieved by regarding all the four dimensions simultaneously (Stenberg, 2001); and this model also focuses on the interactions between these dimensions. Beside core indicators for each of dimensions, inter-linkage indicators are proposed to define sustainable development (Valentin & Spangenberg, 2000). A similar model named as the MAIN prism of sustainability was adapted by Kain (2000) with a replacement of the four dimensions by the mind,

artefact, nature and institution, but it was considered as more confusing than explanatory (Keiner, 2005).

- *Five-capital framework*: This model was developed from four-capital model of World Bank (including natural, human, social and manufactured capital) in 1996 (Spangenberg & Bonniot, 1998) and then added financial capital as the fifth one by the UK sustainable development charity - Forum for the Future (Parkin et al., 2003). Natural capital or ecological assets are considered critical; once they are converted into manufactured capital, they cannot be reversed from any other types of capital (Plessis, 2002). Then, achieving sustainability requires human to face with the limited resource in the world, to use them smartly to spend for our activities without generating waste and pollution (Halliday, 2008) as well as to protect and reserve them for future generations.

2.1.3. The United Kingdom's stance for sustainable development

The definition of sustainable development by UK government is in line with the United Nations. The target for sustainable development in the UK was stated as to meet four interactive objectives simultaneously: "social progress that recognizes the needs of everyone"; "effective protection of the environment"; "prudent use of natural resources"; and "maintenance of high and stable levels of economic growth and employment" (DETR, 1999). All these targets are aligned with the TBL model, but environmental sustainability receives more attention than the other two. The concept of each dimension of sustainability was further explained as: Environmental or ecological dimension concerns with protecting and conserving the natural environment; social sustainability considers the problem of improving the health, safety, well-being for both current and future generations; and economic dimension focuses on stable economic growth within the capacity of the natural environment (OGC, 2007). As this study focuses on the UK construction industry, TBL is set as the principal model for sustainability.

2.2. Sustainability in construction

In this part, sustainability is reviewed in the context of construction, including the understanding and barriers of sustainable construction. New types of buildings – the critical products of the construction industry – are also discussed with life cycle thinking embedded in different stages of the project, and summary concept for sustainable project success (SPS).

2.2.1. A critical reason for sustainable construction

Under the common target of sustainability, the construction industry should take a strong position of responsibility due to its contribution to the economy, society and significant impacts on the environment. The construction industry in the UK from 1997-2014 contributed 5.5-6.9% of gross value added to the economy and brought employment for 6.2-7.1% of the population (Rhodes, 2015). Its products - buildings and infrastructure - have a significant role and influence on physical health and well-being of communities (Chileshe, 2011; Halliday, 2008). regarding environmental impact, the construction industry is the cause for approximately 40% of total annual waste (DEFRA, 2015), 38% of global greenhouse gasses emissions and 40% total energy use every year (UNEP, 2012). Therefore, sustainable construction is expected to create and operate a healthier built environment with ecological design, great potential reduction of resources and emissions at low cost as well as develop a higher living condition for users.

2.2.2. The final outcome of sustainable construction - Sustainable buildings

By the definition of sustainability and context of sustainable construction, the sustainable building has three sub-categories: high energy-performance buildings, green buildings, and low-carbon buildings. However, a building could bear all features of the three categories. This classification shows the three notable trends in adapting to sustainability in construction buildings.

- *High energy-performance buildings* focus on optimising energy efficiency. High energy-performance buildings usually relate to display energy certificate (DECs), energy performance certificate (EPC) or Passivhaus standard. This trend focuses on reducing the amount of energy consumption by using innovations such as high-efficient lighting, materials, biomass, heat-loss prevention, and mechanical ventilation (Xing, Hewitt, & Griffiths, 2011). UK government has led the market toward high energy-performance building type by a target of upgrading building energy performance EPC to band C by 2030 (BEIS, 2018). An excellent type of this category is Plus-Energy building, which refers to a building that its self-produced energy exceeds its inside energy consumption (Hossaini, Hewage, & Sadiq, 2015; Voss & Musall, 2013). It could be attractive to clients when their building has zero annual energy bills.
- *Green buildings* (or high-performance green buildings) are ones that reduce the use

of resources, create a healthier living environment for people and minimise adverse impacts on local, regional and global ecosystems. Green buildings are well-known by a wide range of sustainable ratting tools issues their credit system to assess the sustainability of buildings (Hossaini et al., 2015). The trend of green building has played an essential role in promoting the application of sustainable building and significantly affected to how a building designed, constructed and valued than any other initiatives since 1920 (Edwards & Naboni, 2013, p. 40). In the UK, green buildings are known with certifications of BREEAM, Code for Sustainable Homes, RICS SKA rating, and LEED.

- *Low-carbon buildings* also cover types of carbon-neutral and zero-carbon buildings. They are expected to mitigate the impacts of carbon/greenhouse gases emission to the environment, and they mainly focus on operating stage (Kibert, 2013). The introduction of the low-carbon building has a strong link with high energy-performance building (European Union, 2010), especially for building fabric design, high energy-efficient equipment, and micro-generation energy system inside the building (Xing et al., 2011). Low-carbon buildings are led by standards introduced by green building councils, climate bonds standard, or BRE group.

2.2.3. The context and targets of sustainable construction in building projects

One of the earliest explanations of sustainable construction belongs to Conseil International du Bâtiment (CIB), who defined sustainable construction as "a healthy built environment based on resources efficiency and ecological design" in in 1994. CIB then articulated seven principles of sustainable construction combining decision making during processes of designing and building, including reduce, reuse, recycle, protect nature, eliminate toxins, apply life-cycle costing and focus on quality (Kibert, 2013). CIB’s approach to sustainable construction focuses only on factors of environmental sustainability. This approach is more like green construction than the sustainable construction of the TBL model.

Bourdeau (1999) explained the context of sustainable construction by three key principles. Firstly, energy during the life cycle of construction products should be reduced, and resources should be used smartly to prevent depletion. Secondly, natural capital and bio-diversity surrounding construction buildings and cites need to be conserved. Finally, healthy indoor living quality of users should be highlighted in the design. The context of sustainable construction introduced by Bourdeau tried to balance with two criteria in environmental aspect and one in the social aspect of the TBL. However, the economic sustainability was not mentioned.

The TBL was fully embedded in the understanding of sustainable construction since 2000s. A most recent cited view of sustainable construction was introduced by Yami & Price (2006) – See Figure 2.1 of a function-analysis-system-technique diagram.

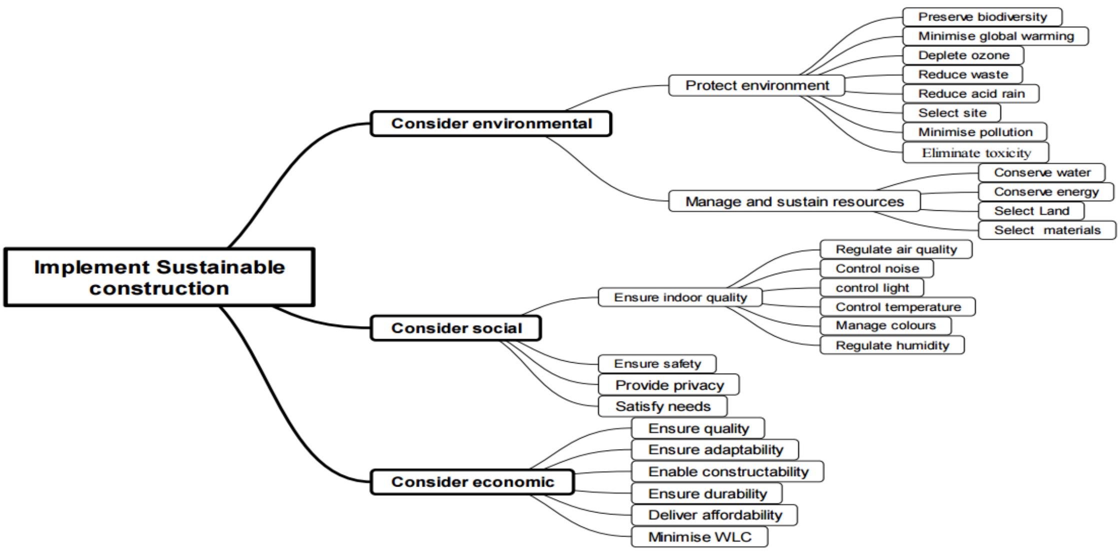


Figure 2.1. A function-analysis-system-technique diagram of "sustainable construction" (Al-Yami & Price, 2006)

The environmental aspect should focus on protecting the environment and on sustaining resources. Economic sustainability should ensure the quality, adaptability, constructability, durability, affordability and whole-life-costing. Also, the social sustainability in construction should put focal points on ensuring living quality, safety, privacy and satisfaction of stakeholders.

Sustainable construction in this study is understood as the achievement of a safety and healthy living/working quality for people, with the minimum life-cycle impacts to the nature environment, and ability to bring economical values to stakeholders in both short-term and long-term. Therefore, it should also meet excellence in achieving project performance and satisfy stakeholders of the project. Targets for the development of sustainable building is presented as in three dimensions of the TBL as below. Detail indicators that demonstrate the understanding of sustainable construction in building projects are illustrated in section on Sustainable Project Success (SPS).

- *Economic sustainability* in sustainable buildings is cited as cost-effectiveness or reduction of running cost in operational stage (Al-Yami & Price, 2006; Dobson, Sourani, Sertyesilisik, & Tunstall, 2013). Therefore, investors/clients are promoted toward sustainability because they could save a remarkable amount in bills of energy consumption, or bills of waste, or through recycle of waste. In addition, sustainable buildings are also known as potential opportunities to boost sales with higher rental income, or by increasing competitive advantages (Rodriguez-Melo & Mansouri, 2011; Windapo, 2014).

- *Environmental sustainability* is understood, but not limited to, the conservation of water, energy, and other nature resources (Heffernan, Pan, Liang, & de Wilde, 2015; Manoliadis, Tsolas, & Nakou, 2006), particularly the use of environmental-friendly or green materials/technologies, which help to reduce embodied energy, harmful emission, and better waste treatment methods (Al-Yami & Price, 2006).

- *Social sustainability* targets in building projects are expressed by giving a higher living and working quality for occupants. For instance, numerous post-occupant evaluation reports showed that high-performance green buildings are potential to increase users' working productivity or learning performance (Gregory, Capital, & Kats, 2003; Manoliadis et al., 2006; USGBC, 2003), to minimize absenteeism, and to enhance occupants' comfort, health and well-being (Kats, Alevantis, Berman, Mills, & Perlman, 2003; Manoliadis et al., 2006). These reports also reported higher satisfaction rates from occupants of sustainable buildings than conventional ones, such as in Bonde & Ramirez (2015), Newsham et al. (Newsham et al., 2013), Liang et al. (2014), to name but a few.

2.2.4. Barriers to sustainable construction

Barriers for sustainability approach are shown as (1) financial & risk disincentives, (2) lack and expensive alternative technologies/materials, (3) insufficiency of research, (4) legislative forces, (5) lack of stakeholder awareness and commitment to sustainability,, and (6) poor project performance due to competencies of the project team.

The most-discussed barrier is *financial and risk disincentive*. The biggest problem was blamed on the increase in initial costs (Dobson et al., 2013; Heffernan et al., 2015; Hwang & Tan, 2012). The cost premium to adopt sustainability was counted to be 1-3% in average (Kats, 2005, 2006; Kats et al., 2003; Nilson, 2005; Stegall, 2004), and it brought a higher financial risk and a longer payback time for the investment. For instance, Hwang & Ng (2013) showed that green solutions could lead to a lengthy approval process, and it could bear a higher risk of project delay. All those reasons could make the project's net-present value negative or less attractive than other alternative options in the investment portfolio. Besides, such decisions based on short-term economic grounds or lack of life cycle costing analysis also caused for limitation of sustainability application in construction projects (Menassa & Baer, 2014; Persson & Gronkvist, 2014).

Financial and risk disincentives can be bypassed easily if we can have cheaper sustainable materials or technologies. Unfortunately, the construction market has been facing with the *lack and expensive alternative technologies/materials* (Heffernan et al., 2015; Persson & Gronkvist, 2014). Moreover, Zhang et al. (2011) noticed that those new materials and technologies are often unfamiliar with builders or operators, then their performance would not be as efficient as expected.

Thirdly, *insufficiency of researches*, i.e. the lack of successful business cases, is considered as preventing the development of sustainable construction (Pitt, Tucker, Riley, & Longden, 2009). Too few case studies published to provide the construction industry confidence to embrace change (Halliday, 2008; Newsham, Mancini, & Birt, 2009). Besides, the credibility of published research is also another problem to be concerned (Hwang & Tan, 2012), where statistical numbers about visible benefits of sustainability are very limited.

In addition, the development of sustainable construction relied on a significant part on governments with their *legislative forces on sustainable development* (Heffernan et al., 2015; Manoliadis et al., 2006). UK government has put some positive targets to head the construction industry toward sustainability, such as zero-carbon building target (DCLG, 2007, 2015- which was scrapped recently), or target of upgrading building energy performance EPC to band C by 2030 (BEIS, 2018). However, Persson & Gronkvist (2014) criticised that many building regulations "are too easy to achieve" then it have no effective results.

Fifthly, *the lack of clients' (and stakeholder in general) awareness and demand* is also one of the main barriers to sustainable construction (Gan, Zuo, Ye, Skitmore, & Xiong, 2015; Heffernan et al., 2015; Wilson & Tagaza, 2006). Clients of projects with lack of knowledge on sustainability see it as a complex and uncertain problem, and then they tend to trade off sustainability/quality with a reduction of cost and time for completion of projects. Any decisions based barely on short-term economic grounds are also problematic to the appearance of sustainability (Menassa & Baer, 2014).

The final barrier of sustainability in construction is the *poor project performance* (Williams & Dair, 2007). An ineffectively management of project would leads to waste of allocated resources and/or project delay. When the funding/time is shorted, sustainability features would be the first thing to cut down by investors. Therefore, the achievement of sustainability should be along with an excellent in performance of the project team. The poor performance can be resulted from limited knowledge and competences of project team on sustainability issues, lack of collaborative working, resistance to change (Heffernan et al., 2015), or failure in solving interest conflicts (Bal, 2014).

2.2.5. Life-cycle thinking and the adopted life-cycle perspective for sustainable buildings

Life cycle thinking has become a crucial principle of sustainability in general (Finnveden et al., 2009; UNEP & SETAC, 2009) as well as in sustainable construction (BSI, 2008; Zamagni, Pesonen, & Swarr, 2013). Many sustainability assessment tools are also based on the principle of life cycle thinking, such as life-cycle assessment (LCA), life-cycle costing (LCC), or rating systems (BREEAM, LEED…). Life cycle thinking is critical because stages of project bear a strong relation to each other. Therefore, impacts created by an early stage could spread across all the following stages and a whole lifetime of final products (Crawford, 2011).

The scope of the life cycle can be classified into three categories, named as cradle-to-gate, cradle-to-grave, and cradle-to-cradle. Cradle-to-gate lifecycle examines the producing process from material extraction, manufacturing, transport to site, to onsite construction (Russell-Smith & Lepech, 2015), the final stage is understood as completion of a building (Dixit, Fernández-Solís, Lavy, & Culp, 2010). The cradle-to-grave viewpoint sees the product's life cycle counted from raw materials acquisition or/and production, to the final disposal (Mithraratne, Vale, & Vale, 2007), it also includes the use and end-of-life treatment (ISO, 2006a). Cradle-to-cradle is the widest point of view as it considers life cycle does not end at disposal, but still continues when it becomes the source for new product (Mithraratne et al., 2007).

In sustainable construction projects, the first viewpoint should be criticised as it ignores the impacts of building in operation stage, where the majority lifetime energy of the building is consumed. Cradle-to-cradle is a very positive approach to adopting sustainability, but it might be overly complicated and complex as there are so many types of building components and equipment resulting in intensive assessments to be very time consuming and costly. Besides, it is impossible to know how each component and equipment of the building can be used after the recycling process. Therefore, in a construction project, the cradle-to-grave viewpoint could be the most suitable one. In this study, the life-cycle viewpoint of sustainable buildings is in line with the Royal Institute of British Architects' plan of work (RIBA, 2013a), which are compatible with cradle-to-grave viewpoint, with 8 stages: (0) strategic definition; (1) preparation & brief; (2) concept design; (3) developed design; (4) technical design; (5) construction; (6) handover & close out; and (7) in-use.

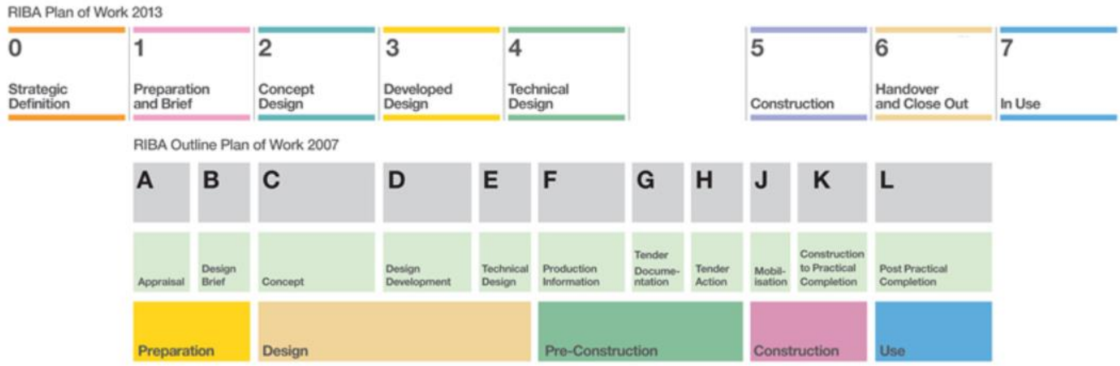


Figure 2.2. RIBA Plan of Work 2013 and 2007 (RIBA, 2013a)

2.3. Sustainable Project Success (SPS) in building projects

The concept of project success has changed in the last twenty years (see Figure 2.3), moving from the traditional thought of the "golden triangle" (process criteria) to the modern thinking with consideration of outcome criteria after the completion of construction stage such as stakeholder satisfaction. This concept is now turning to "sustainable project success" with more embedded criteria of sustainability.

In the 1990s, the traditional project success included only "process" criteria, which was the meeting project constraints (i.e., time, cost and quality requirements) or the "golden triangle" (Lam, Chan, & Chan, 2008; X. Wang & Huang, 2006). This understanding was still dominant in the early 2000s with the PMBOK Guide in 2004, which still highlighted the achievement of the triple constraints.

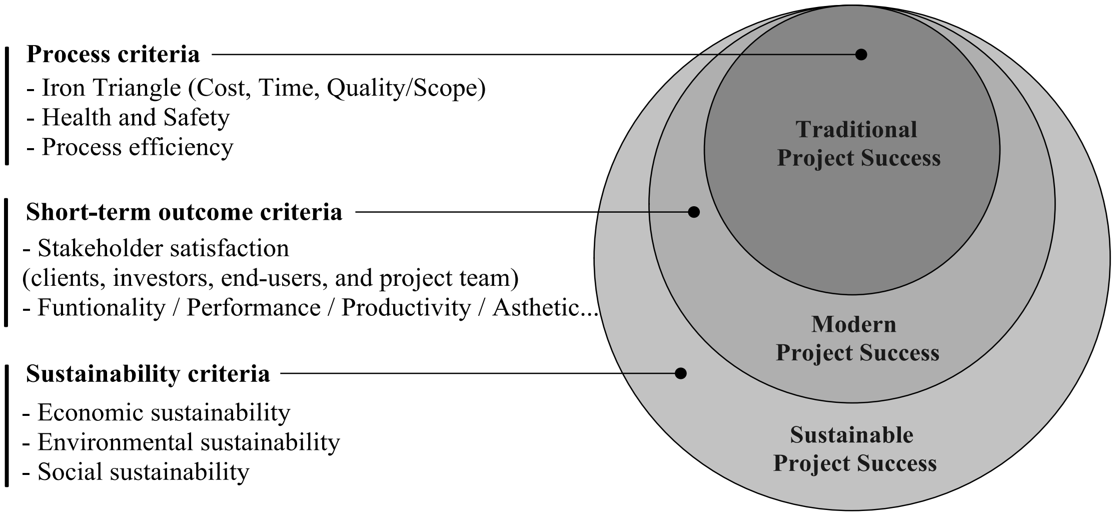


Figure 2.3. Different schools of thought in the concept of Project Success (Phung, Erdogan, & Nielsen, 2019a)

However, many flagship projects that had exceeded their time and cost targets in the past were generally considered successful, such as the Thames Barriers or Sydney Opera House (Lim & Mohamed, 1999). Project success was no longer assessed at the time of construction completion; outcome-criteria of projects were getting more attention. Therefore, the current or most widely accepted concept of project success does not only pay attention to the achievement of the golden triangle, but also to the meeting of project outcome criteria, for example, satisfaction of stakeholders, functionality or performance of building (Müller & Turner, 2007; Serrador & Turner, 2015; Songer, Molenaar, & Robinson, 2015).

Besides aspects of project performance (i.e., the meeting of time/budget/quality constraints) and stakeholder's satisfaction, the next evolution of thought in project success concept has integrated sustainability into the list of required criteria. For instance, Al-Tmeemy, Abdul-Rahman, & Harun (2010) introduced a model of success criteria for building projects, which considered the economic sustainability of buildings with criteria of "market success" (including revenue and profit, market share, reputation, and competitive advantage). Shenhar, Dvir, Levey & Maltz (2001) had a similar opinion when assessing the success of projects with dimensions of "business success" and "preparation for the future". Chan, Scott & Lam (2002) and Salminen (2005) had environmental sustainability as key criteria for assessing project success in their research. In addition, a model of "sustainable project management star" with five key criteria (economic, social, environmental, quality, and time) was introduced by Grevelman & Kluiwstra (2010) as one of the first models that merged the iron triangle and three pillars of sustainability.

This research views the success of building projects as Sustainable Project Success (SPS) viewpoint. Therefore, the criteria for evaluating the success of a project should embed not only the achievement of *project performance and stakeholder satisfaction* (PPSP), but also the achievements of *economic sustainability* (EcS), *environmental sustainability* (EnS) and *social sustainability* (SoS) targets under the triple-bottom-line model. Indicators for the four components of SPS mentioned above are shown in Table 2.2. These indicators are then used to model the constructs of SPS in the structural equation model in Chapter 5.

2.3.1. Project performance and stakeholder satisfaction

Achieving project performance and stakeholder satisfaction is a traditional approach when measuring project success. This approach includes the requirements for meeting project constraints, i.e., scope, budget, time and quality (Pulaski & Horman, 2005; Shenhar et al., 2001; Songer et al., 2015). The four project constraints are well known and are embedded in all current project management standards.

Besides, managing to achieve stakeholder satisfaction is also another issue to be concerned. It has just gained attention as a vital project performance criterion within a few recent decades. Stakeholder satisfaction aims to meet the expectation and requirements of all key stakeholders, including clients/investors, end-users, project team and external stakeholders (Chan et al., 2002; Salminen, 2005; Serrador & Turner, 2015)

2.3.2. Economic sustainability

Economic sustainability in construction focuses on stable economic growth within the capacity of the natural environment (OGC, 2007). To achieve economic sustainability, not only short-term profitability for investors should be ensured, but also long-term benefits of all related stakeholders are important (Albert & Ada, 2004; Bakar, Razak, Abdullah, & Awang, 2009; Tufinio et al., 2013). Some strategic criteria could be listed as cost-efficiency over time, affordability, job creations (Bennett & James, 1999), building functionality during its life cycle, and the ability that building can support clients and users to face with future challenges (Shenhar et al., 2001). Moreover, the further development of project team helps to minimise waste, prevent risks, improve performance, and have a better adaption with client's expectation for the following project; therefore, this factor brings a straight and positive impact on the economic aspect of buildings, and then the increase in competences (skills & experience) of the project team should be an indicator for the assessment of project success (Serrador & Turner, 2015; Songer et al., 2015).

Table 2.2. List of indicators and latent variables for Sustainable Project Success (SPS)

Variable	Indicators	Name of Indicators
[PPSS] Project Performance and Stakeholder Satisfaction	Ppss_1	Meeting scope requirements
	Ppss_2	Completion of project on budget
	Ppss_3	Completion of project on time
	Ppss_4	Completion to specified quality
	Ppss_5	Client satisfaction
	Ppss_6	Occupants/End-users satisfaction
	Ppss_7	Project team satisfaction
	Ppss_8	External stakeholder satisfaction
[EcS] Economic Sustainability	EcS_1	Profitability in the short term for investors
	EcS_2	Profitability in the long term for stakeholders
	EcS_3	Product functionality during life-cycle
	EcS_4	Preparation for future challenges
	EcS_5	Increase the skills and experience of the project team
[EnS] Environmental Sustainability	EnS_1	Minimise energy consumption over project LC
	EnS_2	Reduce, reuse and recycle waste over project LC
	EnS_3	Use of environmental-friendly materials
	EnS_4	Minimise carbon footprint over project LC
	EnS_5	Conserve biodiversity of surrounding areas
	EnS_6	Reduce soil, water and air pollution over project LC
[SoS] Social Sustainability	SoS_1	Health and safety on construction site
	SoS_2	High living quality for occupants
	SoS_3	Well-being of employees
	SoS_4	Public commitment to sustainability
	SoS_5	The use of local employment

2.3.3. Environmental sustainability

Environmental sustainability is concerned with protecting and conserving the natural environment. In this study, six aspects used to represent for environmental sustainability are selected: minimisation of energy consumption; reduce/reuse/recycle of waste, usage of environmental-friendly (green) materials, minimisation of carbon footprint; conservation of biodiversity of surrounding areas, and reduction of pollution (Bakar et al., 2009; Berardi, 2012; Kibert, 2013).

2.3.4. Social sustainability

Social sustainability considers the problem of improving the health, safety, and well-being for both current and future generations (OGC, 2007). In construction, this concept was translated as ensuring high living-quality for occupants, healthy and safe construction site, well-being for employees (fair salary, no use of child labour, no forced labour, or adequate working hour), and the priority use of local employment (Al-Yami & Price, 2006; Buys, Barnett, Miller, & Bailey, 2005; Dong & Ng, 2015). In addition, Dong & Ng (2015) found that "public commitment to sustainability" (which requires for obligation on public sustainability reporting) is an essential criterion in assessing social sustainability of building projects.

2.4. Integration of sustainability into project management

Zero-carbon buildings and net-zero buildings were introduced as new types of sustainable buildings in an attempt to meet the target of cutting carbon emission. However, the current focus of sustainable construction is mainly focused on the macro level (i.e. policies and strategies), and the transfer of these aims to the project level is weak (Ugwu, Kumaraswamy, Wang, & Ng, 2006b, 2006a). One of the reasons for this weakness is the insufficient amount of efforts to improve the management practice to direct and control the sustainable projects. In other words, sustainable buildings are now delivered without a sustainable project management approach. The outcome cannot be sustainable if there is no sustainable process applied (Marcelino-Sádaba et al., 2015). Therefore, it is a critical need to integrate sustainability into project management theory and practice; and the project manager should be the main person to manage the sustainable process because of their crucial position in the project.

Project managers has an important role to not only the success of project (Toney, 2002) but also to the achievement of sustainability in projects because they hold a perfect position to affect the organisation to achieve a higher level of sustainability (Russell, 2008) and have influence on the implication of sustainability in project management process (Goedknegt, 2012). A core value in transforming to sustainability is the mind shift of project manager (Silvius & Schipper, 2014b), who would face to several challenges in green construction projects (Hwang & Ng, 2013) and whose responsibility are mapped with almost all of the sustainability issues (Silvius, 2010). For project managers, Silvius & Schipper (2014a) highlighted system-thinking, anticipatory, normative, strategic and interpersonal skills as required project manager competences in facing with sustainability issues. Similarly, Hwang and Ng (2013) illustrated the most important skills for a project manager are decision-making, delegation, analytical, team-working and problem-solving skills to delivery sustainable projects.

Through the literature review, five mainstream approaches in the trend of integrating sustainability into project management theory and practice were identified: (1) sustainability checklists, (2) sustainability (standardized) indicators, (3) integration in a project management knowledge of area (PMKA), (4) change in core principles of project management, and (5) sustainable project management as a new PMKA.

2.4.1. Managing sustainability with a checklist

The most straightforward approach is to use a sustainability checklist. Outstanding examples of the sustainability checklists that follow a holistic approach can be named as publications of RIBA (2013b), Shen, Hao, Tam & Yao (2016) and CIBSE (2007). In general, these lists contain a wide range of sustainability-related actions/notes/tasks/questions in each stages of project lifecycle that users (project managers, engineers) are recommended to follow. The RIBA's checklist (30 notes as shown in Table 2.3) focuses more on general management-activities, while the list of CIBSE (61 notes) covers more technical activities as it is designed for engineers. The list of Shen, Hao et al. was developed to a more detail level (114 notes are distinguished in economic, environmental and social-related activities). For example, the life cycle cost of building is broken down to labour, energy, waste disposal, compensation, material, marketing; environmental impacts cover, to name but a few: land-use, water, noise, air pollution, waste generation, comfort disturbance, or ozone protection. Therefore, this list could be very useful for in-experienced users when they are not aware of all issues. Although this approach is simple to apply, it criticized that this is not considered as a systematic way to integrate sustainability (Silvius & Schipper, 2012). The users might be lost in the suggested tasks as they are lack of connections to each other; no list can clarify what outcomes documents would be served or where would they are stored, among tons of other project documents.

Table 2.3. Suggested checkpoint/tasks for managing sustainability by RIBA (2013b)

Stages of project	Sustainability checkpoint
Strategic definition	• Ensure that a strategic sustainability review of client needs and potential sites has been carried out, including reuse of existing facilities, building components or materials
Preparation and Brief	• Confirm that formal sustainability targets are stated in the Initial Project Brief. • Confirm that environmental requirements, building lifespan and future climate parameters are stated in the Initial Project Brief. • Have early stage consultations, surveys or monitoring been undertaken as necessary to meet sustainability criteria or assessment procedures? • Check that the principles of the Handover Strategy and post-completion services are included in each party's Schedule of Services. • Confirm that the Site Waste Management Plan has been implemented
Concept design	• Confirm that formal sustainability pre-assessment and identification of key areas of design focus have been undertaken and that any deviation from the Sustainability Aspirations has been reported and agreed. • Has the initial Building Regulations Part L assessment been carried out? • Have 'plain English' descriptions of internal environmental conditions and seasonal control strategies and systems been prepared? • Has the environmental impact of key materials and the Construction Strategy been checked? • Has resilience to future changes in climate been considered?
Developed design	• Has a full formal sustainability assessment been carried out? • Have an interim Building Regulations Part L assessment and a design stage carbon/energy declaration been undertaken? • Has the design been reviewed to identify opportunities to reduce resource use and waste and the results recorded in the Site Waste Management Plan?
Technical design	• Is the formal sustainability assessment substantially complete? • Have details been audited for airtightness and continuity of insulation? • Has the Building Regulations Part L submission been made and the design stage carbon/energy declaration been updated and the future climate impact assessment prepared? • Has a non-technical user guide been drafted and have the format and content of the Part L logbook been agreed? • Has all outstanding design stage sustainability assessment information been submitted? • Are building Handover Strategy and monitoring technologies specified? • Have the implications of changes to the specification or design been reviewed against agreed sustainability criteria? • Has compliance of agreed sustainability criteria for contributions by

Stages of project	Sustainability checkpoint
	specialist subcontractors been demonstrated?
Construction	• Has the design stage sustainability assessment been certified? • Have sustainability procedures been developed with the contractor and included in the Construction Strategy? • Has the detailed commissioning and Handover Strategy programme been reviewed? • Confirm that the contractor's interim testing and monitoring of construction has been reviewed and observed, particularly in relation to airtightness and continuity of insulation. • Is the non-technical user guide complete and the aftercare service set up? • Has the 'As-constructed' Information been issued for post-construction sustainability
Handover and Close Out	• Has assistance with the collation of post-completion information for final sustainability certification been provided?
In-use	• Has observation of the building operation in use and assistance with fine-tuning and guidance for occupants been undertaken? • Has the energy/carbon performance been declared?

2.4.2. Managing sustainability by a set of indicators

The second approach employs a list of selected sustainability indicators. This approach has outstanding guidelines demonstrated by International Organization for Standardization (BSI, 2015; ISO, 2011) and European Committee for Standardization (BSI, 2010b, 2012). The idea of adopting a set of indicators can be easily accepted by top managers as it could be compatible with key performance indicators of organisations (Keeble, Topiol, & Berkeley, 2003). A set of sustainability indicators can help to demonstrate the expected outcomes of the final products; and then, project team can evaluate different alternatives in relation with potential impacts of the project (Agol, Latawiec, & Strassburg, 2014; Ding, 2005; Russell-Smith & Lepech, 2015) or to use these indicators in monitoring the process of goals achievement (Sánchez, 2014). Giving requirements for the expected outcomes can indirectly affect to activities of project managers and project team in a way that they are forced to seek a solution, plan, and deliver sustainable value.

In general construction projects, Kylili, Fokaides, & Lopez Jimenez (2016) classified 8 categories of indicators for sustainability, including: economic, environmental, social, technological, time, quality, disputes, and project administration aspects; but most of other authors agree on the first three categories as in the TBL (i.e., economic, environmental, social aspects). However, there is no common consensus among the sub-categories and the indicators used (Kylili et al., 2016). For instance, Table 2.4 shows the two different list of indicators designed for infrastructure project. The difference might be from the viewpoint and selection approach of the designers. But it implies that no standardized method is proposed for the selection of sustainability indicators in construction projects.

Following this approach, the project manager and project team might find difficulty on how to select an appropriate set of measurable indicators. The effort of achieving sustainability might be destroyed if traditional project success criteria (like time and budget) is put in high priority than sustainability-related indicators as in finding of Silvius, Kampinga, Paniagua & Mooi (2017).

In building projects, the project team could follow a standardised set of criteria developed by green-building-rating services, such as BREEAM or LEED. This does not require the project team to select an appropriate list of sustainability indicators/criteria for the project. These standardised sets are also supported by specific means of assessment. With the commercial power of the tools, they also allow users to get support from specialized parties to join in the project, and to handle with sustainability features and issues. The detail of these green building standards and other means of sustainability assessment are represented in Chapter 3.

The final outcomes are important, but the process to deliver these outcomes, i.e. project management process, should not be ignored. Following the indicator-based approach, the actual result of the project might all depend on the performance of project management team, who might not know what to do, or who follow the traditional project management standards that do not mention about sustainability, and in some worst case, who do not even know what sustainability is. Therefore, the list of indicators does not find helpful in guiding project managers and the project team on their actual work; but the its value for the assessment of results is undeniable - it is a must-have-but-not-only activity in the management of sustainability.

Table 2.4. Examples of sustainability indicators for infrastructure projects

Indicators selected by Fuzzy logic (L. Shen, Wu, & Zhang, 2011)	Indicators selected by Risk management standards (Fernández-Sánchez & Rodríguez-López, 2010)

1. Energy consumption 2. Waste management 3. Ecological footprint 4. CO2 emissions 5. Safety and health 6. Necessity of work - urgency of work 7. Life cycle cost 8. Material consumption 9. Renewable energy use 10. Economical cost/economical benefit 11. Project declaration of general interest 12. Water resource protection 13. Disaster risks (quakes, floods) 14. Adaptation and vulnerability to climate change—environment 15. Design for disassembly 16. Public participation and control on the project 17. Barrier effect of the project 18. Project governance and strategic management 19. Accessibility for human biodiversity 20. Biodiversity protection 21. Respect for local customs 22. Innovative elements 23. Environmental management 24. Ecological value of soil 25. Cost incurred to users 26. Noise pollution 27. Visual impact 28. Use of regional materials 29. Functional and flexible 30. Increase in economic value of environment	1. Analysis on the market supply and demand 2. Financial risk 3. Life-cycle benefit/profit 4. Project budget 5. Internal return ratio (IRR) 6. Life-cycle cost 7. Technical advantage 8. Payback period 9. Public safety 10. Effects on local development 11. Scale of serviceability 12. Provision of ancillary amenities to local economic activities 13. Public sanitation 14. Effect on water quality 15. Effect on land pollution 16. Ecological effect 17. Effect on air quality 18. Environment protection measures in project design 19. Influence on public health 20. Energy saving

2.4.3. Integrating sustainability into a knowledge area of project management

There are plenty of suggestions to integrate sustainability into a particular knowledge area such as quality, stakeholder or risk. For instance, Maltzman & Shirley (2010) used the terminology of 'greenality' to manage the green quality in the project. Sim & Putuhena (2015) also believed that quality management should be flexible to solve issues of environmental problems. A framework of stakeholder engagement to achieve the sustainability-related project performance was proposed by Bal (2014). Also, considering sustainability is an additional value for buildings. For example, Abidin et al. (2008; 2007) saw value management could be a potential approach for the integration of sustainability (Abidin, 2008; Abidin & Pasquire, 2007). Among a bunch of suggestions, Marcelino-Sádaba et al. (2015) suggested to identify the most affected project management knowledge area to sustainability; and Hwang et Ng (2013) found that the most essential knowledge areas in green projects can be listed down as schedule management and planning, stakeholder management, communication management, cost management, and human resources management. The scholars following the third approach have had a certain level of success in integrating sustainability in depth in a particular aspect of project management. However, sustainability should be an essential target of the project as same as the target for meeting project constraints like scope, time, cost or quality. This approach, therefore, is similar to an effort of merging schedule management to cost management, which has less meaning in practice. It is also worthy to note that sustainability is a complex target and it affects all knowledge areas (Eid, 2013). Therefore, sustainability should be embedded in project management in a way that it can relate to all knowledge area of project management, but not a single area. In brief, this approach could be helpful in some special cases that the impacts of sustainability focus on a single aspect, but it is not the complete solution for bypassing barriers of sustainable construction in most of the cases.

2.4.4. Proposed changes in the core principles of project management

The fourth approach represents efforts to change the core principles of the current project management approach. Silvius & Schipper (2014b) proposed a model with three shifts of scope, paradigm. They argued that managing to meet constraints of time, budget and quality should be replaced by managing the triple-bottom-line impacts. Their shift of project paradigm suggested to have a holistic view on change management, i.e. that project managers should not continue to follow predictability and controllability, but follow 'flexibility, complexity and opportunity' instead. Sabini (2005) also recommended managing project complexity and dynamic, with a continuous review of the boundary of the project. Thirdly, project managers are expected to take responsibility for not only the project but also the sustainability of organisations and society/community. With a similar effort, Sertyesilisik (2016) discussed more changes should be taken to approach a regenerative construction project management.

In brief, these proposed changes are positive efforts to navigate and formalise concept for the new generation of project management that facilitates sustainability to be fully integrated into. However, they seem to be quite far with the current condition of project management. Therefore, more attainable and affordable approaches are highly required.

2.4.5. Sustainability management process

In this approach, sustainability is embedded in project management as a process. The process has a special meaning in management practice as it can not only help to provide clear step-by-step guidance but also support for leaning and strategising for users (Easterby-Smith, Thorpe, & Jackson, 2012, pp. 4–5). There are a few numbers of research in line with this approach.

Sustainability management processes developed by Reusch, Silva, and Carboni et al. are all developed in the theme of the five project management phases (including: initiating, planning, executing, monitoring control, and closing). Table 2.5 illustrates all activities of the three management processes above.

First, Reusch (2015) suggested having sustainability management as a new project management area of knowledge under the theme of PMBOK standard. Five sub-processes for the project management including sustainability are stated as (1) analyse and determine strategies and standards to use, (2) plan sustainable management, (3) perform sustainable project execution, (4) control sustainable project execution, and (5) collect and submit lessons learnt. The five sub-processes are adapted with the five stages of project management, i.e. initiating, planning, executing, monitoring control, and closing, respectively. In this process, a sustainability management plan is based on the selected sustainability standards and strategies, so it is strong linked with quality management, and later activities of management would base upon standards. Then the project team is required to perform and control the project execution that fit with requirements of a sustainability plan. Finally, the sustainability management process ends with a reflective session that learning lessons should be collected and shared. This idea potentially has a practical value, however, Reusch (2015) had no chance to develop this idea to a detailed process, and till now, no further research has developed this idea and developed a complete process.

Similarly to the proposal of Reusch, Silva (2015) suggested having carbon-footprint (CFP) management as a core project management area in PMBoK, as which would go along with the new constraint of carbon footprint (besides cost, time and scope of projects). This process begins at the identification of the stakeholders of the project, which leads to an output of a stakeholder CFP register. In planning phase, it is required to estimate the CFP of resources in each activity, and the total CFP of project. In the executing and control phase, CFP values of resources used would be managed, monitored the change, and ensured that appropriate CFP standards are used. Finally, all the over-run or under-run of CFP would be reported to stakeholders in closing report. Besides, CFP in this approach is also managed similarly to cost in earned-value management method. However, this approach focuses only on greenhouse gases emission – a particular issue of environmental sustainability; it might not be able to reflect the true meaning of sustainability under the concept of the triple-bottom-line model.

Introducing a more comprehensive approach, Carboni, González, & Hodgkinson (2013) has developed a project integrating sustainable methods (PRiSM) to incorporate tools and methods to balance the limited of project resource, fulfilment of social responsibility, and achievement of "green" outcomes for the project. The PRiSM was developed on ISO:25000 and P5 standards to help reducing risks related to sustainability but still able to support the expansion of benefit to corporate and society (Obradovi, Todorovi, & Bushuyev, 2018). It does so by embedding an impact analysis in initiating phase, which would help to define sustainability objectives and sustainability management plan for the project. This management plan is executed and managed during the project life-cycle, and reviewed/reported in the closure meeting with the engagement of corporate-social-responsibility officer of the organisation. PRiSM is recognised as the only generic project management standard that integrated sustainability into the management process (Silvius, Neuvonen, & Eerola, 2017). However, due to activities in the initiating and closing phase, this process might fit in organisation level. The project-based construction industry is inspired by the method demonstrated by PRiSM, but it might need take a further consideration in adopting this process, especially in how to dealing with a large number of stakeholders, and how specific technical parts (like commissioning, procurement route, communication, and collaboration) should be embedded. Moreover, a holistic approach that follows project stage should be highly encouraged than the project-management phase to deal with the complexity of sustainability.

More specifically aimed in the build environment, FIDIC (2004) developed a process of project sustainability management involving the classic plan-do-check-act (PDCA) cycle of management (See Figure 2.4). This process starts with the development of a set of project targets and specific indicators for sustainability (plan). Then, it is followed by an action of setting up a programme to monitor and measure the performance of sustainability (do). In the next step (check), the selected indicators will be measured and monitored against project targets. During the continuous "checking" of sustainability performance, appropriate adjustments might be made along with the recording, reporting results and learning lessons. FIDIC's approach also demonstrated as a management process, but relies heavily on the selection and monitor of sustainability indicators, which is similar to the second approach shown in this session. It also meets all problems that a set of indicators has to face with, and then, it is not helpful in guiding project managers and the project team on their actual work.

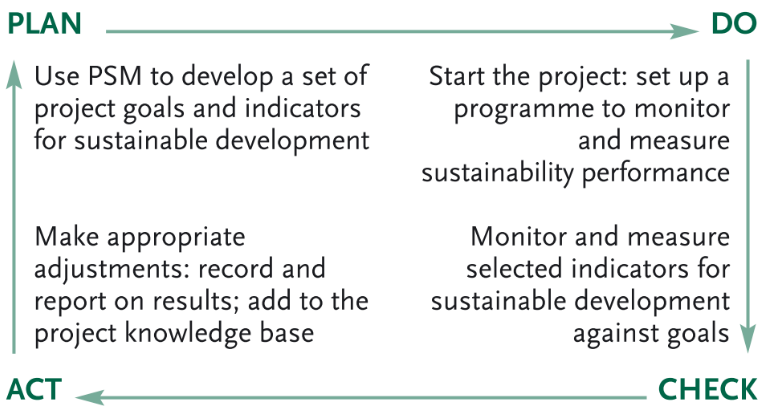


Figure 2.4. PDCA model for managing sustainability in construction (FIDIC, 2004)

Table 2.5. Sustainability Management Processes and Project Management phrases

Phases	Initiating	Planning	Executing	Monitoring Control	Closing
Sustainability Management (Reusch, 2015)	Analyse and determine strategies and standards to use	Plan Sustainable Management	Perform Sustainable Project Execution	Control Sustainable Project Execution	Collect and submit lessons learned
Carbon Footprint Management (Silva, 2015)	Identifying the stakeholders	- Estimate activity carbon footprint - Determine total carbon footprint	Manage carbon footprint	Control carbon footprint	Report carbon footprint over-run or under-run
Project integrating sustainable methods - PRiSM (Carboni et al., 2013)	- Review Organisational Sustainability Goals - Level Business Case against environmental management system - Perform P5 impact analysis - Define Sustainability Objectives - Develop Sustainability Management Plan	- Define Sustainability Quality components - Refine Sustainability Management Plan	- Requirement Management - Update documentation - Update Project Plan - Enforce change control process - Submit reports		- Sustainability meeting with CSR officer - Produce End of Project report - Submit report to stakeholders - Distribute Lessons learned to project management office

A final process that should not be forgotten is Sustainability Management Activity Zone (SMAZ - See Figure 2.5) developed by Khalfan (2006), which integrated sustainability into the generic design and construction process protocol. SMAZ model has 12 activities during the life cycle of construction projects. It supports the achievement of sustainability in projects by targeting sustainability goals, planning, assessing and reviewing results against the original plan. SMAZ starts at identifying scope of sustainability issues, and according to that, a mission statement (goals) is then prepared. The process is then followed with strategies and plans of sustainability management. During the design and construction stage, a series of sustainability assessment would be undertaken and reviewed against the plan and original goals. Post-construction review is the final activity of this process in in-use stage.

In reviewing of the SMAZ process, key activities can be seen as: (1) the definition of scope and goals for sustainability, (2) planning, and (3) assessment/review. These key actions are also existing (fully or partly) in all current sustainability management processes demonstrated above. However, all of them bear no attention to human-related factors, which has recently been recognised as a significant barrier of sustainable projects. The barrier is referred as the lack of stakeholders' awareness and engagement, limited knowledge and skills of employees, lack of collaborative working, resistance to change, and poor competencies of the project team (as discussed in section 2.2.5). Likewise, Tharp (2013) suggested that the incorporation of sustainability into project management practices should consider stakeholder management, human resource management, and communication management. The weakness on these models can be filled by suggestions of Robichaud & Anantatmula (Robichaud & Anantatmula, 2010) on how to make construction project management practice “greener”. This approach paid special attention on human-related factors of managing sustainability, for instance, the enhancement of the project team by on-going training and communication, and the collaborative working process with the whole-team design approach.

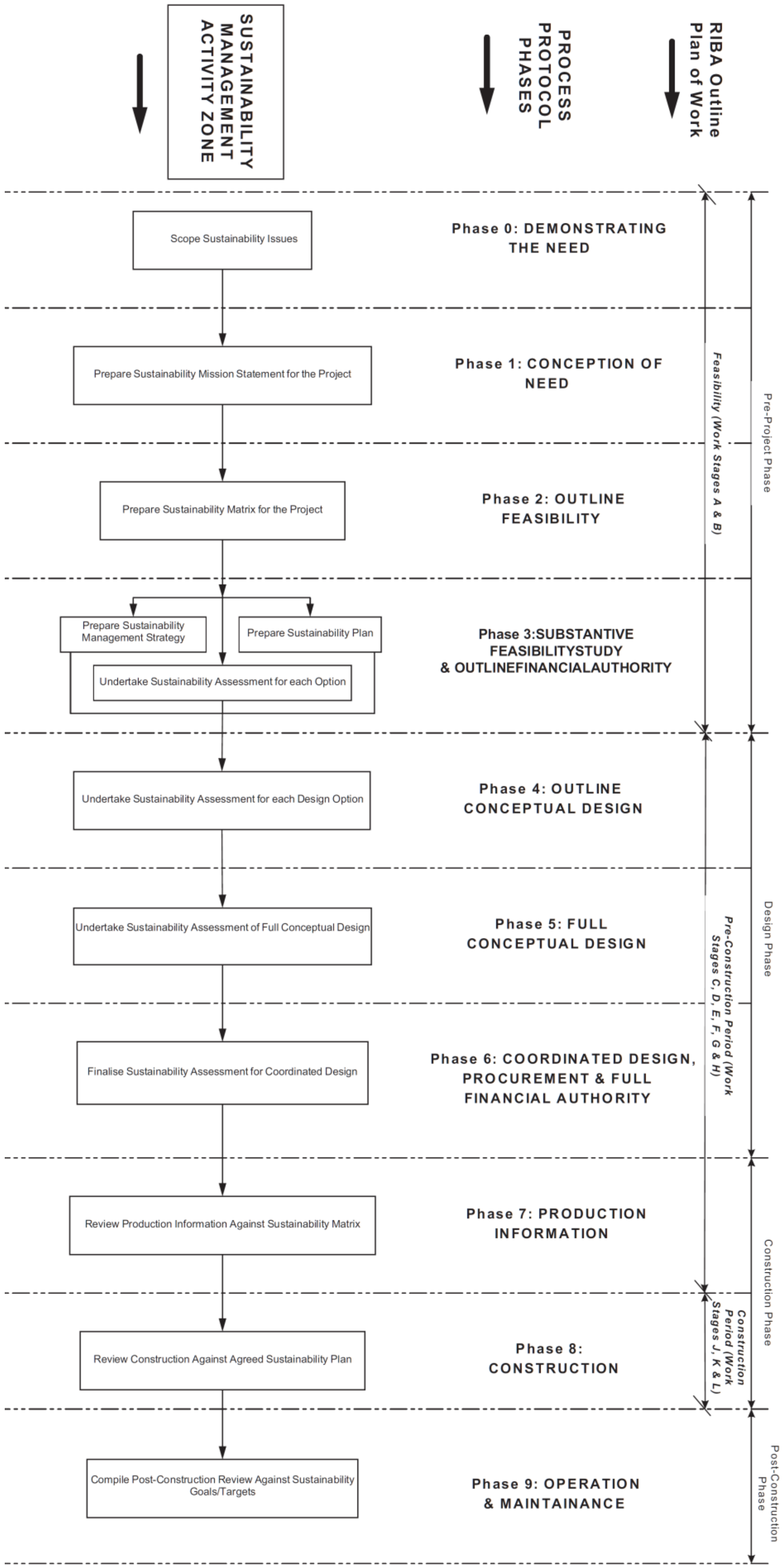


Figure 2.5. Model of Sustainability Management Activity Zone - SMAZ (Khalfan, 2006)

2.4.6. A suitable approach for project managers to initiate and deliver sustainable projects

In reviewing all the five current approaches to integrating sustainability in project management, the first four approaches explored several disadvantages in their implementation. The first approach of using a sustainability checklist was criticised as not a systematic way to integrate sustainability into project management (Silvius & Schipper, 2012). In the use of sustainability indicators, project manager and project team might find it difficult to select an appropriate set of measurable indicators; and the effort of achieving sustainability might be destroyed if traditional project success criteria are put in high priority than sustainability-related indicators. These indicators provide final-outcomes assessment criteria, but they do not help to direct management actions for the achievement of sustainability. Besides, the integration of sustainability through a particular project management area (the third approach) might be not sufficient to solve the problem as sustainability is a complex target and it affects all knowledge areas. Lastly, all proposed changes in the core principles of project management (the fourth approach) are still ambitious principles. This approach might be not welcomed by most of project managers, as it requires more responsibilities but it does not show them how to perform or benefits they would gain. There is also a big gap between these proposals and current project management standards (leading by ISO21500, PMBOK, CIOB, BS 6079 or others); a big jump sounds not practical within the next 10 years. In brief, none of all four approaches can provide project managers a clear and step-by-step guidance on management and directing of project towards sustainability targets, especially in how to keep a balance between traditional project requirements and sustainability requirements.

The fifth approach with a sustainability management process might be the most appropriate approach to integrate sustainability into the practice of project management. The use of a sustainability management process can not only inherit efforts in using a sustainability checklist, or sets of indicators, but it could also a bridge for bringing the modern project management practice to regenerative project management. Figure 2.6 compares the level of sustainability integration and complexity of the five approaches. The first and the second approach are in line with the modern project management standards, as they do not require any changes, but embed in the foundation of current best practice. The fourth approach is regenerative project management, which proposed several significant changes to the principles of current project management standards. Although these changes are in a right direction with ability to achieve full integration of sustainability into project management, its proposal might not be accepted by users at the moment or in shortly. The third and fifth approach is on the edge of modern and regenerative project management as they require some changes in principles of project management, but still be practical and can be accepted by users. Therefore, they can potentially be the middle step to the future that sustainability is fully integrated into project management.

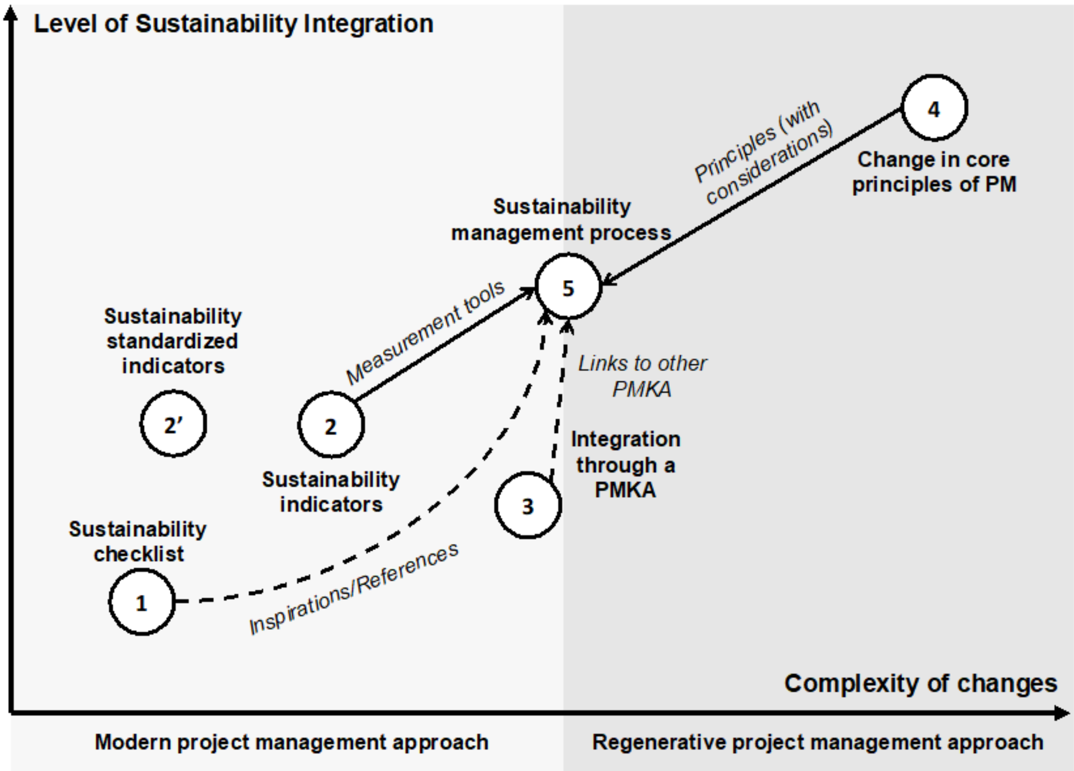


Figure 2.6. Recent efforts in integrating sustainability into project management and how these approaches can be combined

Moreover, the implementation of a sustainability management process would be able to benefit from all other approach; in other words, it could be the core part to mix-and-match the other approaches (as illustrated in Figure 2.6). For instance, sustainability checklists could be used as references or inspiration for critical / important issues during activities of management; a set of indicators (or standardised set of indicators like BREEAM or LEED) would work as targeted outcomes and mean of sustainability measurement/assessment. Current research on the integration of sustainability through PMKA would support the link between the current PMKAs and the new "sustainability management" knowledge area of project management. And the ideas of regenerative project management approach (as proposed by the fourth approach) plays as potential principals for the running of the sustainability management process.

In comparing the difference between the modern and regenerative project management, the use of sustainability management process (the fifth approach) might be the best option among five approaches. Sustainability is considered as a complex issue that impacts all aspects of project management. Therefore, the integration of sustainability into a particular knowledge area (particular quality management) might make users underestimate the vital value of sustainability. Also, sustainability is soon considered as a key target of project besides cost, time, scope and quality; it is more reasonable to have a separated process to manage it. The relationship between the sustainability management process and other project processes should also reflect the connection of sustainability to current constraints (time, budget, cost) and brings such context like management of the resource, risk, or procurement, stakeholder, communication to support the achievement of sustainability.

2.5. Summary

The construction industry has made remarkable progress to reduce detrimental impacts to the economy, society and environment towards the sustainability targets as demonstrated in the early part of this chapter, but sustainable construction is likely what people want to hear than what it should be, then there is still a distance to a genuinely sustainable position. The core target is achieving a balance of social, environmental and economic pillars, which define sustainability; but less progress has been made for social matters (Marcelino-Sádaba et al., 2015; Martens & Carvalho, 2015).

Through the literature review, this chapter has summarised the concept of sustainability, sustainability context in the construction industry, drivers and barriers to sustainability in the construction industry. Economic, social and environmental benefits and legislative forces on sustainable development are positive drivers. Also, financial & risk disincentives, insufficiency of research and the lack of client's awareness and demand could prevent sustainability achievement in construction.

The chapter also reviews and summarises the concept of sustainable project success (SPS), which covers not only the traditional project success criteria (meeting constraints and stakeholder satisfaction) but also three pillars of sustainability, name as economic, environmental, and social sustainability. Several indicators/criteria for assessing the success of sustainable projects are also reviewed, and they would be used as measurement indicators for modelling the construction of SPS in Chapter 5.

At the end of this chapter, a review on sustainability integration in construction project was carried out. The results show a critical need for further research to integrate sustainability into project management theory and practice. Project managers are the ones who should take primary responsibility in trying to bring their professional work of directing and managing projects toward sustainability. Among the five mainstream approaches in sustainability integration in project management, the use of a sustainability management process is highlighted as the approach, which has the highest potential to support project managers in initiate and delivery sustainable projects. Moreover, this approach could also be a bridge for bringing current/modern project management practice to the state of regenerative project management.

CHAPTER 3. SUSTAINABLE PROJECT MANAGEMENT (SPM): A CONCEPTUAL MODEL

This chapter presents the development of a theoretical framework for Sustainable Project Management (SPM) approach, which would inform the development of GEPAS framework (Chapter 6) which enables project managers to manage their projects whilst achieving sustainability. It starts with an exploration of critical success factors for managing sustainability in construction projects. These CSFs were then categorised into five groups, which became the five key components of SPM. Then, the conceptual framework model for SPM is built from the five key components of SPM and their reflective indicators. The model is also put SPM in relation to the achievement of Sustainable Project Success (SPS - which is conceptualised in Chapter 2). This chapter also introduce theoretical background for the five key components of SPM. Next, it is continued with the development of hypotheses for understanding inter-relationships among the five key components as well as relationship between SPM and SPS. This conceptual model would be tested using methods introduced in Chapter 4, and the findings are demonstrated in Chapter 5.

3.1. Exploring critical success factors for managing sustainable projects

As demonstrated in Chapter 2, the construction industry is facing several barriers to achieving sustainability such as lack of financial incentives, high risk of investment and lack of client's awareness and demand. To overcome these barriers and achieve sustainability, the project management team needs to know the essentials for managing sustainability in building projects.

This study approaches the key factors of sustainability management by using critical success area of factors (CSFs). CSF is defined as a "small number of truly important matters" in which "satisfactory results will ensure successful competitive performance" (Bullen & Rockart, 1981). Leidecker & Bruno (1984) saw the value of CSFs as a mean to develop a strategic process. In the construction project management area, many researchers have used CSFs to conceptualise constructs and to hypothesise the relationships between them (Banihashemi, Hosseini, Golizadeh, & Sankaran, 2017; Molwus, 2014; Zhao, Hwang, & Low, 2013).

To identify the CSFs for managing the sustainable project, this research started with an intensive literature review on factors that bring success to sustainable construction projects. Four main search engines were employed to support the identification, including Google Scholar, web of knowledge, construction information service (CIS) system and Scopus. The searched publications were varied in type: journal papers, conference papers, theses, books, reports and guidelines. This approach aims to have a completed set of CSFs for managing sustainability in the construction industry. A total of 48 publications was reviewed in depth. To avoid missing important CSFs, the search was conducted in different keywords, and it was not only in project management theme or building projects, but also in general projects. The CFSs for sustainable success in organisational level were also examined. Invested materials were also in different countries to provide the broader view of success factors for sustainability achievement. The search was stopped when no new factors identified and the final result was a of 35 CSFs for the study (the code, name and sources of these CSFs are shown in Table 3.1)

Almost all of these publications are descriptive literature review papers or case-study-based papers, which lack a detailed quantitative approach to understand the actual performance and prioritisation of these factors in real projects. Furthermore, in order to highlight the key issues, it is necessary to group the 35 factors into fewer strategic components. In this research, CSFs were categorised into five main groups, namely: sustainable **goal** definition (GOAL), project team **enha**ncement toward sustainability (ENHA), **plan**ning for sustainability (PLAN), sustainability **asse**ssment (ASSE) and **stak**eholder management (STAK). The allocation of 35 CSFs under five categories is shown in Table 3.1. The detailed theoretical background that supports the classification of CSFs is illustrated in Section 3.2. The confirmatory factor analysis for assessing the validity and reliability for the five groups is presented in Section 5.4.4 (Evaluation of the measurement model).

Table 3.1. Critical success factors for managing sustainability in building projects

Code	Critical success factors	Sources / Contributors
GOAL	**Sustainability goal definition**	
Goal_1	Promotion of stakeholders' awareness, knowledge and commitment to invest in sustainability	Banihashemi et al. (2017), Saleh, Mohammed & Abdullah (2015), Swarup, Korkmaz & Riley. (Swarup, Korkmaz, & Riley, 2011), Vink et al. (2010)
Goal_2	A sustainability ambition is created among project team members at the beginning of the project	Silvius, Neuvonen & Eerola (2017), Volker (2011)
Goal_3	A declaration of the owner on sustainability goals is announced to all relevant stakeholders	RIBA (RIBA, 2013b)
Goal_4	A sustainability mission statement with tangible objectives in project brief or project plan	Banihashemi et al. (2017), Wang N. et al. (2015), Vink et al. (2010), Khalfan (Khalfan, 2006), FIDIC (2004)
ENHA	**Project team enhancement toward sustainability**	
Enha_1	Responsibility and power for project team members to do their jobs	Low, Gao & Tay (2014)
Enha_2	Innovative solutions from project team members proposed (and discussed)	Shen, Tang et al. (2017), Sim & Putuhena (2015), Vink et al. (2010),
Enha_3	Workers' health, safety and working conditions in a construction site	Gudiene et al. (2014), Zou & Moon (2014), Glavinich (2008),
Enha_4	Project team's skills and knowledge in executing project activities	Banihashemi et al. (2017), Shen, Tang et al. (2017), Saleh, Mohammed & Abdullah (2015), Gudiene et al. (2014)
Enha_5	Project managers' competences and experience about sustainability in construction projects	Shen, Tang et al. (2017), Banihashemi et al. (2017), Saleh, Mohammed & Abdullah (2015), Gudiene et al. (2014)
Enha_6	Collaboration and communication among project team members	Wang N. et al. (2015)
Enha_7	Information transparency among project team members	Wai (2012), Klotz (2008), Kaatz (2006), Zutshi & Sohal (2004), Jackson et al. (2015)
Enha_8	Special advisors' involvement in a project to support for achieving sustainability targets/goals	Thomson et al. (2011)
Enha_9	Project team members are motivated towards sustainability at the beginning of the project	Shen, Tang et al. (2017), Gudiene et al. (2014)
Enha_10	The continuous learning process is implemented among the project team	Low, Gao & Tay (2014), FIDIC (2004)
PLAN	**Planning for sustainability**	
Plan_1	Identification, assessment and planning of sustainability-related risks	Gudiene (2014), Wai (2012), Wang N. (2015), Saleh (2015), Pojasek (2012)
Plan_2	Identification and prioritization of sustainability issues	Khalfan (Khalfan, 2006), FIDIC (2004), Perrott (2015), Pojasek (2012)
Plan_3	Considering sustainability achievement when selecting the project delivery method	Wai (2012), Volker (2011), Kibert (Kibert, 2013), Swarup et al. (Swarup et al., 2011), Mallaoglu-Korkmaz et al. (2013)
Plan_4	Waste reduction, reuse and recycle in the project is considered in the project plan	Yunus (2012), Shami (2008), RIBA (2013a), Zaini & Endut (2014), Kalutara et al. (2017)

Code	Critical success factors	Sources / Contributors
Plan_5	Natural environment conservation is considered in the project plan	Yunus (2012), Wang N. (2015), Banihashemi (2017), Al-Yami & Price (2006), Berardi (2012), Kalutara et al. (2017)
Plan_6	Planning a realistic schedule	Wai (2012), Disterheft (2015), Wang N. (2015), Zaini & Endut (2014), Low, Gao & Tay (2014)
Plan_7	Effectiveness in allocating project resources	Wai (2012), Zutshi & Sohal (2004), Jackson et al. (2015), Kalutara et al. (2017), Low, Gao & Tay (2014)
Plan_8	Efficient and environmental-friendly technologies and materials are used	Gudiene (2014), Glavinich (2008), Kibert (Kibert, 2013), Spiegel & Meadows (2012), Kalutara et al. (2017)
Plan_9	Proposing and prioritising sustainability-related activities	Verboven & Vanherck (2015, 2016)
ASSE	**Sustainability assessment**	
Asse_1	Green building or energy performance certificates targeted	Gudiene et al. (2014), Vink et al. (2010)
Asse_2	Project management team considered sustainability-related standards to apply in project	Zaini & Endut (2014)
Asse_3	The project management team had sufficient understanding about SD regulations	Kalutara et al. (2017), Gudiene et al. (2014), FIDIC (2004)
Asse_4	Environmental, economic and social impacts assessment in design and early stages	Curran (2012), Lapinski, Horman & Riley. (Lapinski, Horman, & Riley, 2006)
Asse_5	Sustainability performance/progress is monitored and measured the project	Banihashemi et al. (2017), Perrott (2015), FIDIC (2004)
Asse_6	Building commissioning is carried out	Robichaud & Anantatmula (Robichaud & Anantatmula, 2010), Stum (2000), Tseng (2005), Djuric & Novakovic (2009), Xiao & Wang (2009), Enck (2010), RSMeans (2011)
Asse_7	Post-occupancy evaluation (POE) is carried out	Saleh, Mohammed & Abdullah (2015), Halliday (2008)
STAK	**Stakeholder management**	
Stak_1	Long-term value creation by all stakeholders is fully considered	Vink et al. (2010)
Stak_2	Key stakeholders' vision, strategies & objectives are determined to align them with project goals	Verboven & Vanherck (2015), FIDIC (2004)
Stak_3	Engagement of internal and external stakeholder to project activities	Marcelino-Sádaba, González-Jaen & Pérez-Ezcurdia (2015)
Stak_4	Effective communication with clients and other stakeholders	Shen, Tang et al. (2017), Wang N. et al. (2015), Saleh, Mohammed & Abdullah (2015), Gudiene et al. (2014), Low, Gao & Tay (2014), Volker (2011)
Stak_5	Stakeholders are involved in the early stages of projects	Kalutara et al. (2017), Shen, Tang et al. (2017), Robichaud & Anantatmula (Robichaud & Anantatmula, 2010)

3.2. Conceptual model Managing Sustainability in Building Projects (MaSBuP model)

To be able to develop project management guidance, it is essential to understand the relationships between these groups of factors (Phung, Erdogan, & Nielsen, 2019b), in details on how they could impact to the achievement of sustainability and project success, and how strong the relationships are. In the literature review, there is no research investigating inter-relationships among the five key components of sustainable project management as well as their ability to support the achievement of Sustainable Project Success (SPS).

On the light above, the third objective of this research aims to understand the relationship between sustainable project management (SPM) and sustainable project success (SPS). From the literature review, models for SPM and SPS were defined, the combination of these two models and hypotheses formed the conceptual model in this study (i.e., MaSBuP model for managing sustainability in building projects).

First, SPM model based on the grouping of the CSFs for managing sustainable project demonstrated above. The five groups of CSFs for managing sustainability in building projects were accepted as the five key components for the conceptual model of Sustainable Project Management (SPM) approach in this study; and 35 CSFs were used as measurement units to reflect the five components (variables). The detail background for the five key components of SPM is illustrated in the following part - Section 3.3. The conceptual model is presented in Figure 3.1. The list of indicators for the five components of SPM is presented in Table 3.1 while the list of indicators for SPS is illustrated in Table 2.2.

Second, SPS model was developed with a new viewpoint on the success of a project, criteria for evaluating the success of a project should embed not only the achievement of *project performance and stakeholder satisfaction* (PPSP), but also the achievements of *economic sustainability* (EcS), *environmental sustainability* (EnS) and *social sustainability* (SoS) targets under the triple-bottom-line model. These four components (PPSP, EcS, EnS and SoS) were accepted as new conceptual model for SPS in this study, the development of SPS model is presented in details in Chapter 2.

Third, after SPM and SPS were modelled, four hypotheses were proposed to test the inter-relationships among the five key components of SPM and one hypothesis was created to understand the impact of these components on sustainable project success. The development of five hypotheses (which is further expanded to 15 sub-hypotheses) is discussed in Section 3.4. The conceptual model was named as MaSBuP (Model for Managing Sustainability in Building Projects). The hypothesised relationships among components of SPM would answer for the question on how they would support each other in the implementation of project, which component should be focused, or whether any components in the theoretical viewpoint are not particularly necessary in the real performance of projects. Besides, the confirmed relationships between SPM and SPS would tell if the management toward the SPM approach conceptualised by this research could support for the achievement of project success and sustainability.

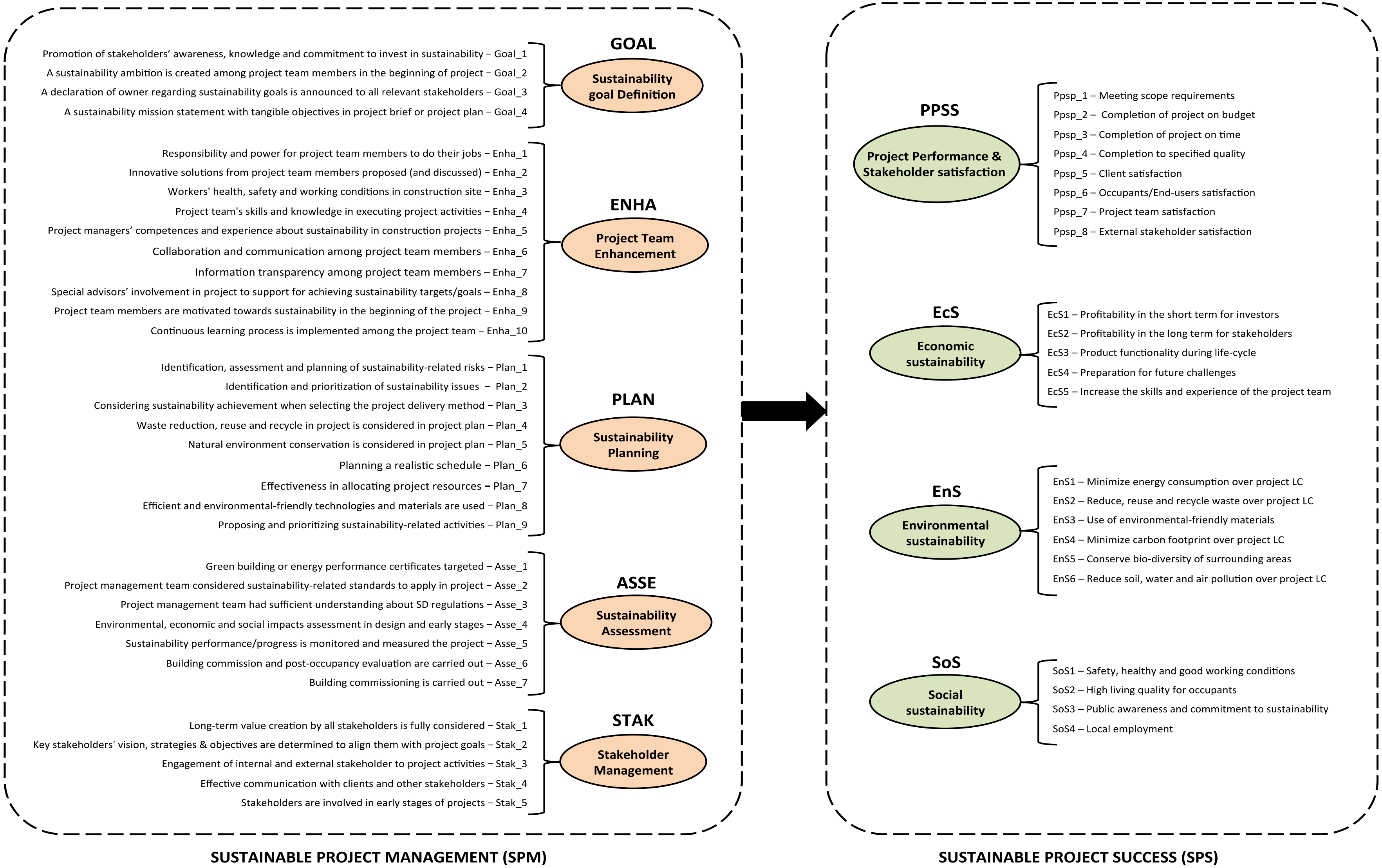


Figure 3.1. A conceptual model for SPM and hypothesised relationships to SPS (MaSBuP model)

3.3. The theoretical background for the five key components of SPM

3.3.1. Define sustainability goals

Considering sustainability as an essential goal (objective, target or ambition) besides other performance goals (like scope, time, budget, quality, or stakeholder satisfaction) has a special meaning to the achievement of sustainability in the project. Project goals are crucial to direct all project activities; they decide not only the outcomes and but also success criteria of the project. Without a sustainability goal defined in the beginning, the project is hard to be sustainable.

The definition of sustainability goals relies heavily on the clients supporting the sustainability of the project. Clients are driven by governmental incentives, regulations on sustainable developments; they are also in the position of fulfilling corporate social sustainability and corporate sustainable development strategy. However, clients used to be in an awkward position as they had a lack of knowledge on sustainability (Hwang & Tan, 2012) and they saw sustainability as a complex, risky, timely and costly issue. It was found more reasonable to trade-off sustainability with reduction of cost and time for completion of projects when the project resources were limited. Therefore, the clients should be receiving early advice from experienced professionals to raise their awareness, expand their knowledge and promote their commitment to invest in sustainability. If the client's advisor and project manager are already appointed, they should take responsibility for this promotion.

In terms of timing for the goal of sustainability, Robichaud & Anantatmula (Robichaud & Anantatmula, 2010) and Alias, Isa & Samad (2014) recommended the definition of sustainability goal should be made before the design stage starts. Sustainability features are not a supplemental part of the project; it affects to the whole design solution by choice of material, site and landscape, the design of lighting, heating, ventilation, air conditioning, and water system. Therefore, if sustainability was proposed after the designer made the first draft, the change could be timely and costly. Furthermore, literature showed that the sustainability goal should be tangible, clear and in a formal form (Banihashemi et al., 2017; N. Wang et al., 2015); and it should be announced officially by clients (RIBA, 2013b).

3.3.2. Enhance project team toward sustainability

The project team is defined as all internal employees, including not only project managers and management team, but also designers, main and sub-contractors, and other key ones who work in the project and contribute to the success of the project. The selection and working of the project team have a critical value to the success of project and achievement of sustainability. Among the project team, the project manager has leading role and sustainability champion can support significantly to the success of the project. The parts below discussed their role in the sustainable project.

Many competencies of the project team are highlighted as key factors for the success of the project. The most cited factor is the skills and knowledge of the project team in executing project activities (Disterheft et al., 2015; Saleh et al., 2015; W. Shen et al., 2017). Besides, a project would have a higher chance to be successful if it has a proper allocation of empowerment (Perrott, 2015; Verboven & Vanherck, 2015, 2016), collaboration, communication (Z. Alias, Zawawi, Khalid, & Aris, 2014; Martinez & Olander, 2015), information transparency (Kaatz et al., 2006; Wai et al., 2012), and innovative staffs (W. Shen et al., 2017).

In terms of sustainability achievement, Kibert (2013) clarified several requirements for project team of a sustainable project, including a greater communication among team members, an engagement to the broadest possible range of stakeholders; special qualification in green building concept; experience with charrette process; and strong familiarity with sustainability assessment systems and their requirements. Alias et al. (2014) identified that core knowledge, education and collaboration on sustainability issues of project management teams are very important strategies to integrate sustainability through project planning. All these findings suggest a stronger and larger collaboration of the project team and, sometimes, external stakeholders. A very important benefit of collaborating participants is to get their knowledge contribution, which can be converted to a new innovative idea, including sustainability orientation and solutions (Ayuso, Rodriguez, Garcia-Castro, & Arino, 2011; Vanegas, 2003; Vazquez-Brust, Sarkis, & Cordeiro, 2014).

In order to achieve a higher collaboration for the project team in the sustainable project, there are three key questions to be concerned, including who is the leader of the team, who are members of the team (and how to get them), and which method should be used to form the team. The following parts discuss these questions in detail.

3.3.2.1. The leader of the project team: Project manager with support of sustainability champion

In the project team, project managers (PM) has an important role to not only impacts the success of the project (Toney, 2002) but also able to influence the sustainability achievement of projects. Not only project managers hold a perfect position to affect the sustainability in corporate level (Russell, 2008), but also they have the power to influence to the implication of sustainability in project level (Goedknegt, 2012). Project managers may get support from the sustainability champion in directing and managing the project in sustainability approach.

Sustainability champion is also referred to sustainability advisor, accredited professional, sustainability consultant, or sustainability manager. Sustainability champions are advisory professionals with intensive knowledge on sustainability and practical experience in similar building type. The value that sustainability champion can bring to clients can begin from the inception stage of projects (C. S. Thomson et al., 2011). They take responsibility in giving expert advice during the project, supporting project team on issues of sustainability, and interpreting results of assessment – which then support for decision-making process (C. Thomson, El-Haram, Emmanuel, A, & Rohinton, 2009). Furthermore, sustainability champion is highlighted as a supportive role in helping clients to achieve targets of business purpose, environmental performance and social responsibility (Schaefer, 2004).

3.3.2.2. Members of the project team: The early engagement of stakeholders to the project team

The collaboration of stakeholders is recommended to carry out in the early stages of the project and to involve more stakeholders in decision-making process (Herazo & Lizarralde, 2015; Kaatz et al., 2006). The result of early stakeholder involvement is pointed out as more effective collaboration and innovation process as well as risk reduction (Herazo & Lizarralde, 2015). These stakeholders are not only include more specialties of design, such as general architecture, HVAC, lighting, electrical, interior and landscape design (Kibert, 2013), but also construction managers, contractors, facilities managers & operators, owners, specialty consultants (Keeler & Burke, 2009; U.S. Department of Energy, 2011), operation and maintenance staff from owner's other buildings and occupants (RSMeans, 2011, p. 227). This combination covers several key stakeholders in different stages of the project life cycle and asks them to work together at certain key points in the schematic design. Then, it can help to look for highly attractive sustainable solutions by an interdisciplinary work and a discussion among different specialists. On the ground of that meeting, project value can be increased, not only the environmental performance but also functional improvement, structure system selection and architectural expression (Larsson, 2004). For example, a collaboration between designers and engineers can help to reduce waste (Sieffert, Huygen, & Daudon, 2014) or the organisations can enhance their reputation and legitimacy through a collaboration with environment groups (Fiedler & Deegan, 2007).

3.3.2.3. Procurement routes for sustainable projects

Procurement route (project delivery method or type of contracting) in sustainable building projects is required to meet high requirement of collaboration, transparency of information, and minimisation of adversarial relationships; in other words, the team integration is expected to be key success factor to deliver a sustainable project (Mollaoglu-Korkmaz et al., 2013). Because adversarial climate of design-bid-build (DBB) delivery system makes it not suitable for delivering a green building, then such procurement routes as design-build (DB), construction management (CM), or integrated project delivery (IPD) are more suitable with the sustainable project than the traditional approach DBB. As there is no complicated process of bidding, and a platform of high collaboration, DB, CM and IPD can avoid numerous conflicts inside the project team, the time for completion, to increase the quality of projects (Kibert, 2013; Molenaar, Sobin, & Antillón, 2010; Riley, Sanvido, Horman, McLaughlin, & Kerr, 2005). Molenaar et al. (2009) also found that CM and IPD can help to maximise sustainability within a given budget, especially for projects using GMP payment provisions. Moreover, Franz, Leicht, Molenaar, & Messner (2010) compared four different types of procurement routes (DBB, DB, CM and IPD) and found that IPD had a higher chance to enhance group cohesion and team integration, which would lead to reduction of costs, schedule growth, improvement of turnover experience and system quality.

Integrated Project Delivery (IPD) aims at integrating "people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants" through all phases from design to construction (AIA California council, 2007). Therefore, it is different from other types of procurement routes regarding stakeholder relationship and timing of engagement. This approach allows key stakeholders like contractors to be involved in the early stage of the project, unlikely in other project delivery approaches where they usually join in project process after the design is partly or entirely completed (El Asmar, Hanna, & Loh, 2013).

A multi-party contract among three triangular keys participants (owner, designer and builder) is the most common way to carry out the IPD approach (Thomsen, 2009). This type of contract defines the relationships and promotes a gain-share/pain-share system among all members involved (Kent & Becerik-Gerber, 2010; Kibert, 2013; Thomsen, 2009). The mechanism of this multi-party agreement motivates stakeholders by aligning their self-interests into project's targets (Bomba & Parrott, 2010; Thomsen, 2009, p. 25). Therefore, trust-based collaboration in an open communication is the key element of IPD (AIA California council, 2007). However, if the self-interests of each participant were not considered carefully, it would be the cause for conflicts among them.

Also, the use of IPD has met some other barriers, for example, challenges in selecting compensation and incentive structures, in assigning liability to each participant (Jonathan Cohen, 2010), and in changing the mindset built on the traditional procurement approach of the construction industry (AIA California council, 2007). These barriers are reasons why the use of IPD still be in the infancy period (Kent & Becerik-Gerber, 2010). As a result, IPD was questioned about the feasibility in practical application (Bomba & Parrott, 2010; Kent & Becerik-Gerber, 2010), however, recent research has supported the success of projects used IPD when stakeholders can be rewarded from a risk-sharing mechanism (Post, 2015), and from a quality, schedule, and budget-control improvement (El Asmar et al., 2013). Moreover, IPD is judged to be compatible with the use of building information modelling BIM (Ilozor & Kelly, 2012; Kent & Becerik-Gerber, 2010).

By definition, IPD is in line with the whole-team design approach or integrated design process (IDP), which tries to cover a large number of internal participants to involve in early stages of the project. The stakeholders to be involved in the whole-team design approach are not only owners, designers in design process (Kibert, 2013) but also others in further stages of project life cycle, such as contractors (Korkmaz, Riley, & Horman, 2010), specialty consultants (Keeler & Burke, 2009; U.S. Department of Energy, 2011), building operators, maintainers, and occupants (RSMeans, 2011, p. 227). Early involvement of these internal participants enables the design team to get a broader view about the project and more feasible solutions through a multidisciplinary collaboration; then it is necessary for delivering cost-effective project (Robichaud & Anantatmula, 2010). As a result, the project can reach to the real optimal solution instead of the sub-optimisation resulted from a combination of optimal subsystems (Kibert, 2013) thanks to systematic and life cycle thinking (Zimmerman, 2006). Moreover, the integrated design process is mentioned as a working method to motivate active role of clients and designers (Larsson, 2004; Zimmerman, 2006); and to save the cost of change (CURT, 2004; Kibert, 2013). Therefore, the implementation of a whole-team design approach (or integrated project design) is necessary for the management of sustainability.

3.3.3. Manage stakeholders in sustainable projects

Stakeholder management is gaining an important role in sustainability practices (Marcelino-Sádaba et al., 2015), and it is considered as a crucial mission in delivering sustainability (Bal, Bryde, & Fearon, 2011). A good project management approach can keep balances between the interests of stakeholders (Goodijk, 2003; Karlsen, 2002). It can also improve the collaboration among them; a stronger collaboration of stakeholders, then, can support for a higher project performance (Khalfan, Mcdermott, & Cooper, 2004; Menassa & Baer, 2014) and sustainability advancement (Martinez & Olander, 2015; Sarkis, Cordeiro, & Brust, 2013).

The literature has pointed out several principles for the stakeholder management in sustainable projects. First, the project is required to pay attention to not only short term but also long-term values for stakeholders (Vink et al., 2010). It also needs to consider stakeholders' vision, strategies and objective to aligns them with project goals (FIDIC, 2004; Pojasek, 2012). Also, communication is one of the most important keys to engage stakeholders in the project (Disterheft et al., 2015; Wai et al., 2012; Zutshi & Sohal, 2004). During the communication, clients and project team should provide sufficient information transparency to strengthen the position and keep a high level of engagement from external stakeholders (Garvare R., Johansson P., Garvare, & Johansson, 2010). On top of that, following a proactive approach when dealing with stakeholders is highly recommended by Ali (2014), Chinyio & Akintoye (2008) and Orkar (2011).

In construction projects, different stakeholders have different priority requirements for sustainability. Clients and investors are mainly directed by generating economic value and avoiding risk (Bügl, Leimgruber, Hüni, & Scholz, 2009). Occupiers focus on the level of living comfort (Reed & Jailani, 2014). Whereas, the government and authority parties pay more attention to push the project to minimise impact on the environment. To balance these different requirements, proper stakeholder management is critical for the success of sustainable projects. The following parts represent recent research on approaches and tools/techniques to manage stakeholders in sustainable projects.

3.3.3.1. Approaches for managing stakeholders in sustainable projects

The mainstream of stakeholder management in best practices has four steps, named as identification, analysis, planning, and control stakeholder engagement. First, stakeholder management is started with an identification of a full list of stakeholders and a detailed information sheet of each of them (PMI, 2013; R. Yang & Shen, 2015). Then, data and information of stakeholder were analysed to determine stakeholders' attributes and their potential contribution to project success. Useful information for this stage could be stakeholders' expectations (Jepsen & Eskerod, 2009; Olander & Landin, 2005, 2008), constraints and interest (Freeman, Harrison, & Wicks, 2007; Karlsen, 2002), power, urgency & legitimacy (Mitchell, Wood, & Agle, 1997; R. Yang & Shen, 2015), and the interrelationships among stakeholders (J. Yang, Shen, Ho, Drew, & Xue, 2011; R. Yang & Shen, 2015). Third, plans and strategies should be created and decided for each individual or each group of stakeholders (Sutterfield, Friday-Stroud, & Shivers-Blackwell, 2006). The primary context of the stakeholder engagement plan is choosing a reasonable target of engagement (R. Yang & Shen, 2015) and suitable communication channels to engage stakeholder to the project (Preble, 2005). The final step aims at implementing a two-way communication and controlling stakeholder engagement (Bal, Bryde, Fearon, & Ochieng, 2013; Chinyio & Akintoye, 2008; Preble, 2005; Sutterfield et al., 2006).

Regarding stakeholder engagement in sustainable construction projects, Bal (2014) proposed a process with six steps as shown in Figure 3.2. This process is different with the common approach of stakeholder management by process of relating stakeholders to sustainability targets. The step aims at ensuring important stakeholders have sufficient understanding and commitment to the sustainability objectives of the project. On the contrary, the project objectives should be in line with their stakeholders' responsibility, skills and interests (Bal et al., 2013). The step of controlling stakeholder engagement is broken down in detail with three steps named as managing stakeholders, measuring their performance and putting targets into action. However, this process is lack of a planning step, which helps to prepare for an active stakeholder management.

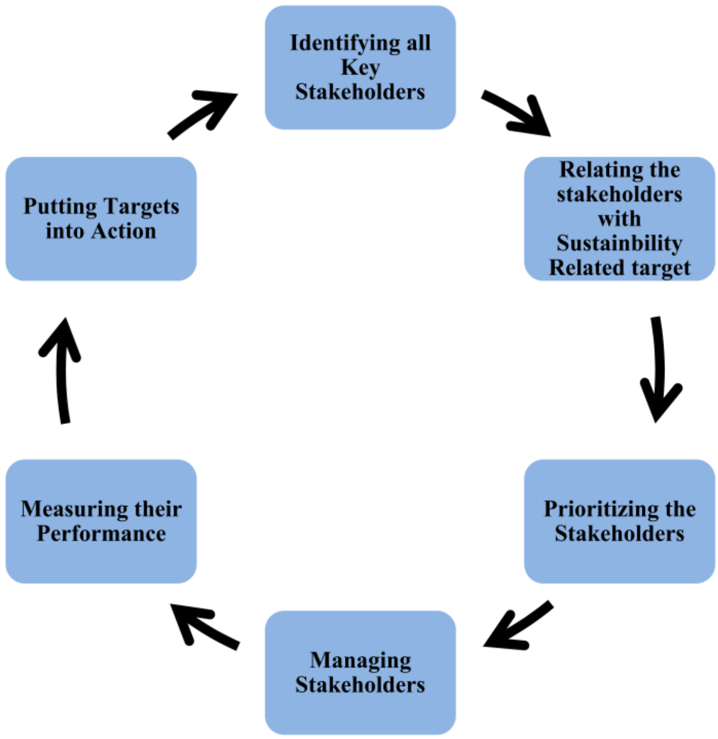


Figure 3.2. Stakeholder engagement process for sustainability ((Bal et al., 2013)

3.3.3.2. <u>Support tools/techniques to manage stakeholders in construction projects</u>

To manage the stakeholder engagement and communication as well as to meet their satisfaction, several tools and techniques were found as effective to do so. In the following part, 14 tools and techniques for managing stakeholders are demonstrated as summarised in Table 3.2.

(1) *Brainstorming:* Project manager and the team can conduct a *brainstorm* as the most simple way based on their past experiences and knowledge (Bryson, 2004; Calvert, 1995; J. Yang et al., 2011). However, this approach is criticised as too general and important stakeholders might not be revealed in some cases (Jepsen & Eskerod, 2009) because identifying informal stakeholders is much more difficult than formal ones (Newcombe, 2003).

(2) *Expert judgment and expertise:* Experts should be specialised individuals such as other staffs in the organization (Pouloudi & Whitley, 1997), managers of similar projects, professional service as consultants, NGOs or associations (PMI, 2013; J. Yang et al., 2011). When the expert is a pre-identified stakeholder, who helps to reveal known stakeholders, it is called as a snowballing technique to identify stakeholders. The expert judgement technique is cited as effective and cost-saving

(Ananda & Herath, 2003) but Mathur et al. (2007) noticed that it lead to bias, due to significant differences between stakeholders in different social circles; therefore, he suggested combining different techniques to overcome silo weakness, especially for mapping of the stakeholder identified.

Table 3.2. Tools and techniques for managing stakeholders in building projects

Purpose of management	*Tools and techniques*	
Identify stakeholders	• Brainstorming • Expert judgment (Snowballing)	
Analyse and categorise stakeholders	• Impact indexes • Stakeholder Circle • Stakeholder Salience • Socio-dynamic • Influence map	• 2x2 matrixes/grids • Stakeholder-Issue Interrelationship diagrams • Social network analysis
Plan for stakeholder engagement	• Stakeholder-commitment matrix • Engagement profile matrix • Engagement assessment matrix	
Control stakeholder engagement	• Balanced performance measurement	

(3) *Impact indexes:* Using index is a measurable technique to support for classification of stakeholders. Two examples for the use of impact indexes are vested interest-impact index by Bourne & Walker (2006) and stakeholder impact index by Olander (2007).

(4) *Stakeholder Circle:* This tool uses a concentric circle to indicate the distance of stakeholders, patterns of entities, scale, the scope of influence and degree of impact (Bourne & Walker, 2005). Then, a stakeholder is presented as an annular sector, his/her influence is demonstrated by the size of the sector, and the position of the sector will illustrate the distance and potential impact as presented in Figure 3.3.

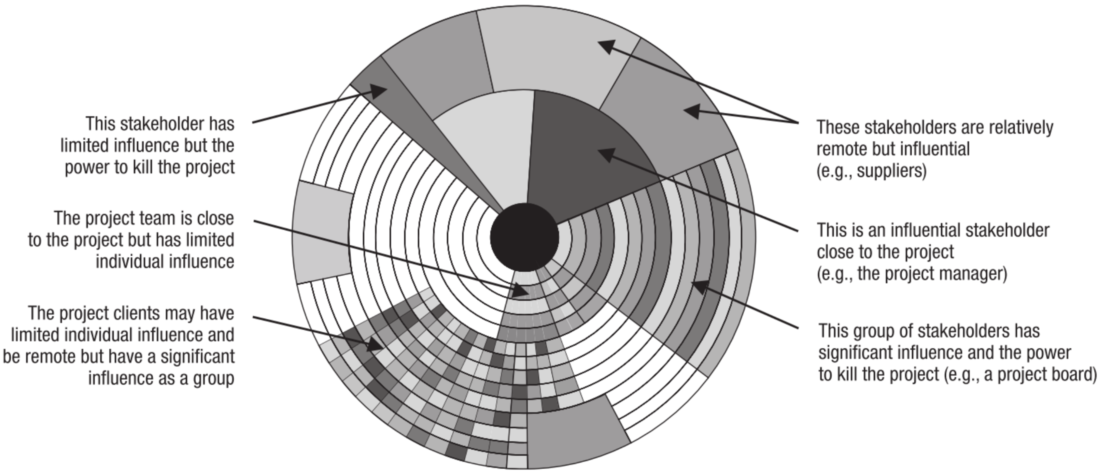


Figure 3.3. Stakeholder cycle (Bourne & Walker, 2006)

(5) *Stakeholder Salience (triple circle typology):* The stakeholders will be analysed by three attributes of power, urgency, and legitimacy (Mitchell, Agle, Wood, & Mitchell, 1997). The combination of the three attributes in brings to 8-group classification as in Figure 3.4.

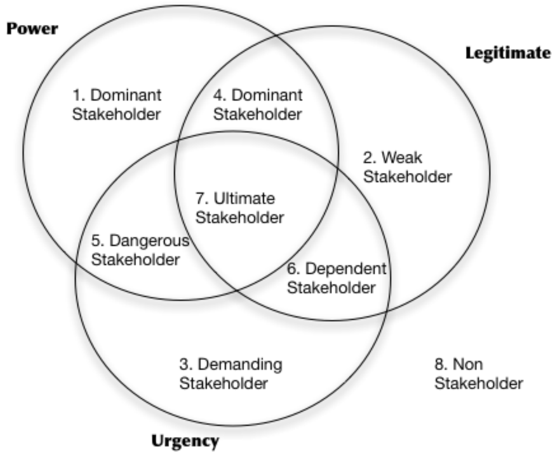


Figure 3.4. Stakeholder salience (Mitchell, Wood, et al., 1997)

(6) *Socio-dynamic matrix:* Based on positive or negative energy of stakeholders (synergy and antagonism), they are classified into eight different groups with distinctive characteristic (D'Herbemont & César, 1998) in Figure 3.5. The tool is helpful in identifying the role of some key stakeholders, realising misinterpretation of trouble-makers, and utilising the positive benefits of resistance to change (Walley, 2013).

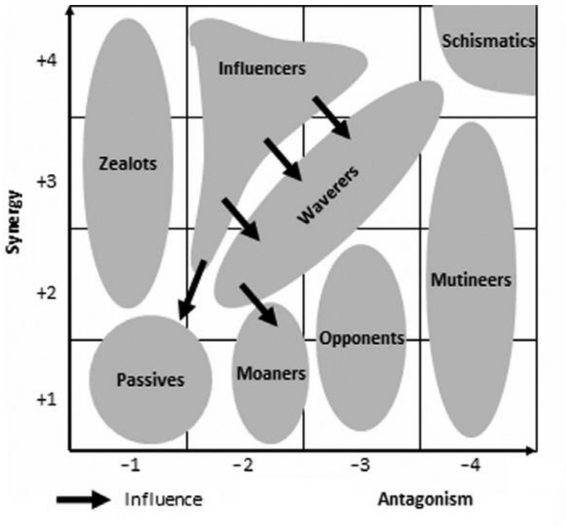


Figure 3.5. Stakeholders in Synergy/Antagonism grid (D'Herbemont & César, 1998)

(7) *Influence map:* The map is designed to evaluate and express the influence of stakeholders. It is shaped like a triangle, and the top apex is the activity/project. Then stakeholders are drawn as circles, and the nearer they are to the top apex, the higher influence they hold and the bigger the circle is, the more significant it is (Bourne & Walker, 2005). To make this model simpler, it was suggested to divide stakeholder into three levels for each rule as presented in Figure 3.6

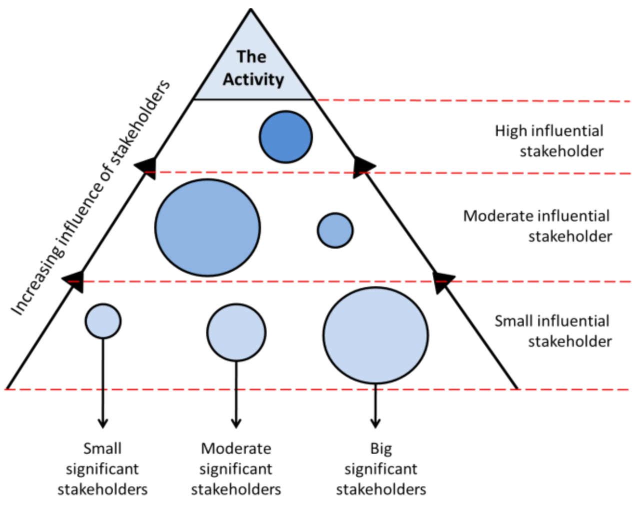


Figure 3.6. Influence map (adapted from Bourne, 2009)

(8) *Stakeholder-Issue Interrelationship diagrams:* This tool helps to relate stakeholders through their relationship with particular issues they are interested in, and then potential corporation and risk of conflict can be apparent (Bryson, 2004). An example of this tool is shown in Figure 3.7.

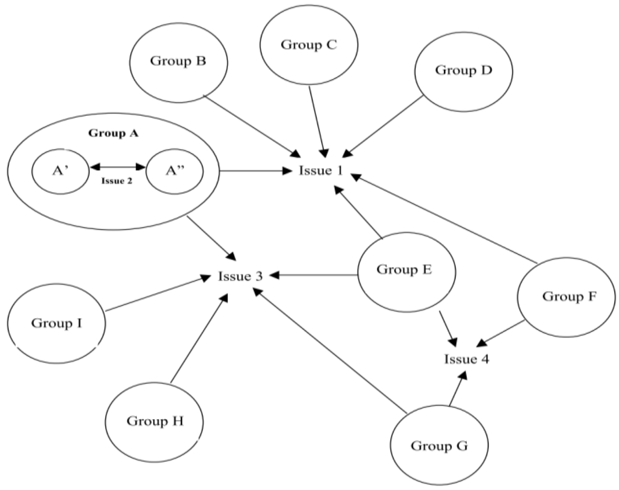


Figure 3.7. Stakeholder-Issue Interrelationship diagrams (Bryant, 2003; Bryson, 2004)

(9) *Interest-power matrix:* The technique allocated the stakeholders based on their level of two chosen attributes (See Figure 3.8). Power/interest matrix evaluates stakeholder's authority and their level of concern regarding the project (Johnson, Whittington, & Scholes, 2005). The evaluation of attributes can be in both qualitative and quantitative approach. Other matrixes/girds are named by attributes chosen to evaluate, such as power/influence, influence/impact (PMI, 2013), knowledge/attitude (Turner, 2009), power/predictability grid (Newcombe, 2003).

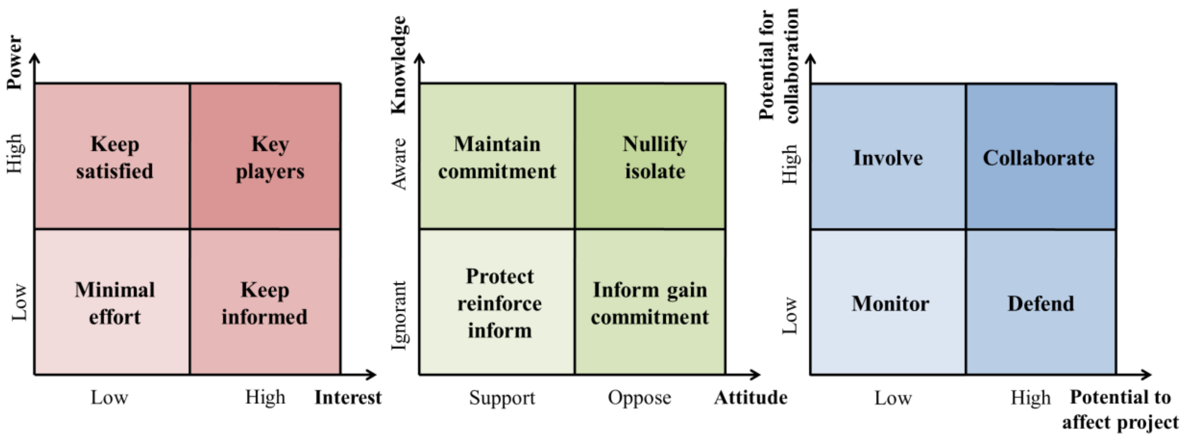


Figure 3.8. Common models of 2x2 matrixes/grids (Adapted from Ackermann & Eden, 2011; Savage, Nix, Whitehead, & Blair, 1991; Turner, 2009)

(10) *Social network analysis (SNA)*: SNA is sourcing from the application of social network theory to manage stakeholder in a dynamic and emergent nature of relationships of stakeholders. It is a network of relationships to illustrate a broader connection of not only the project and its key stakeholders, but also linkages among these stakeholders (Newcombe, 2003). SNA is different from other tools as it

focuses on interactions among stakeholders than their characteristics to have a better understanding of the decision making process (J. Yang, Shen, & Ho, 2009). Some outstanding benefits of SNA can be listed as the ability to visualise power and examine how the relationship influences organisation's behaviour (Bourne & Walker, 2005) and the possibility to manage relationships in complex construction projects (J. Yang et al., 2009). In order to apply SNA, J. Yang et al. (2009) suggested to use the snowballing technique or interviewing network's members to gather linkages among stakeholders. Ackermann & Eden (2011) also developed a network analysis in the theme of interest-power matrix (See Figure 3.9). This matrix is visualised in working place, where every staff can watch for and keep updating the change in stakeholders. All the required materials are sticky notes, a board, and pens. The relationship between stakeholders can be shown as one-way arrows (one-way direction affections) or two-way arrows (two-way direction affections).

(11) *Stakeholder-commitment matrix:* The matrix expresses stakeholder's commitment and type of commitment (which can be ranged from active opposition to active support) at current and target position (Jepsen & Eskerod, 2009; McElroy & Mills, 2003) – See Figure 3.10a

(12) *Engagement assessment matrix:* Evaluate current and desired engagement level for each stakeholder in 5 classes, including unaware, resistant, neutral, supportive of leading (PMI, 2013) - – See Figure 3.10b

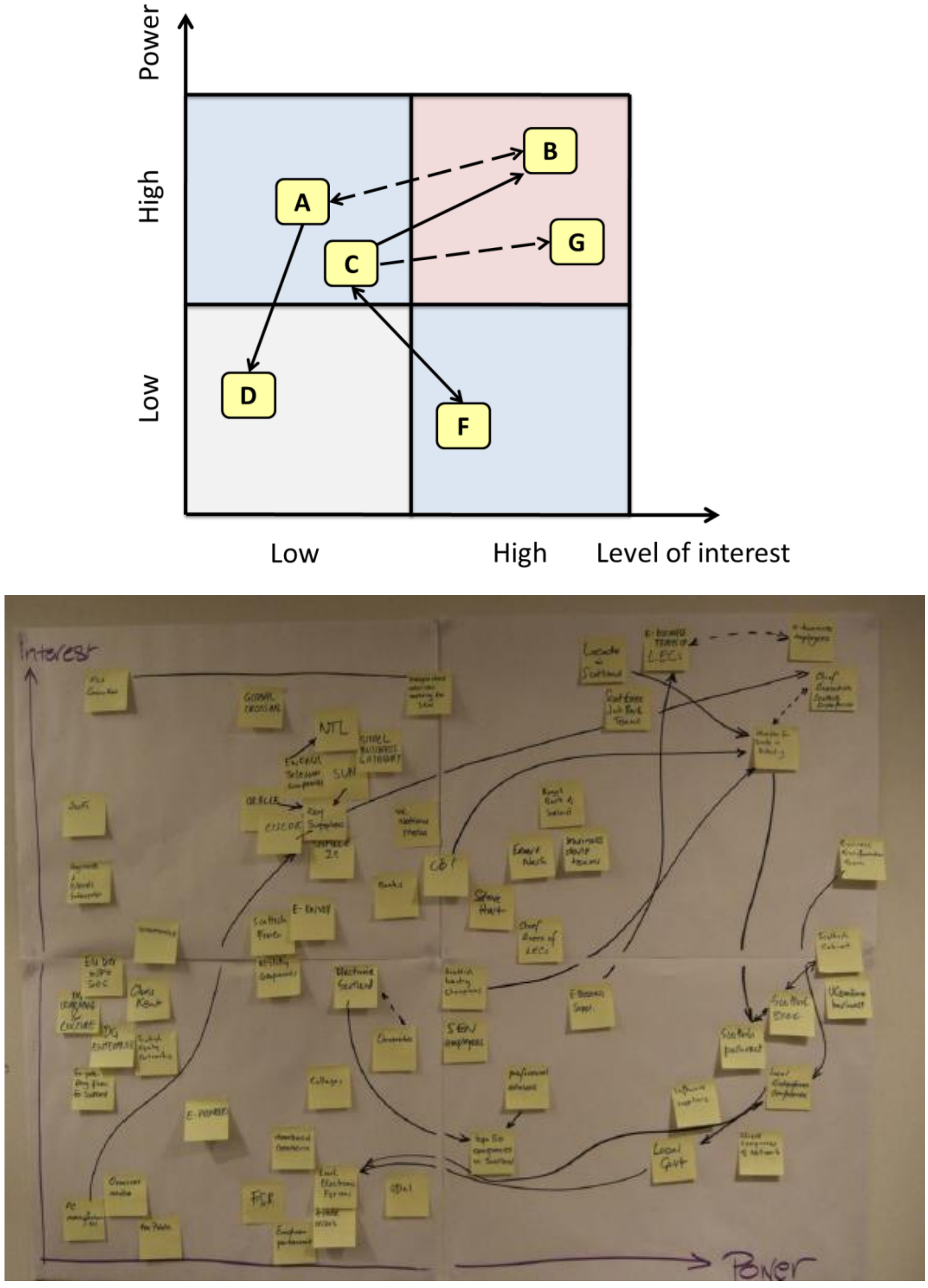


Figure 3.9. Stakeholders' influence network in the theme of interest-power grid – Model and a real example of application (Ackermann & Eden, 2011)

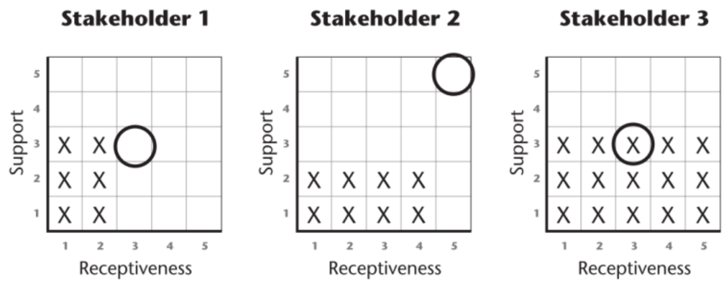
(13) *Engagement profile matrix:* The engagement profile matrix is one of two important diagrams in Stakeholder cycle methodology. It can evaluate the attitude of stakeholder in two points of time, current and desirable moment. Therefore, this matrix can be used to compare two positions of each stakeholder and to be proactive in communication plan with stakeholders. Matrix displays willingness to support for the activity in the vertical axis and receptiveness (willingness to receive information) in the horizontal axis. Inside the matrix, symbols of X is used to express current status, where O is marked for the desirable situation. The gap between two engagement positions will tell the managers about the attitude of stakeholders, and help them in forecasting possible reaction, planning and applying communication (Bourne, 2009) – See Figure 3.10c.

Stakeholder	Active Opposition	Passive Opposition	Neutral	Passive Support	Active Support
Suppliers			XO		
Top Management				X→→	→→ O
Colleagues in the permanent organisation		X →	→ → → →	→ → O	

a.

Stakeholder	Unaware	Resistant	Neutral	Supportive	Leading
Stakeholder 1	C			D	
Stakeholder 2			C	D	
Stakeholder 3				D C	

b.



c.

Figure 3.10. Stakeholder engagement tools and techniques: a. Commitment matrix (exampled by Jepsen & Eskerod, 2009; original from McElroy & Mills, 2003); b. Engagement assessment matrix (PMI, 2013); c. Engagement profile matrix (Bourne, 2009)

(14) *Balanced performance measurement*: This is a stakeholder-based management method developed and applied in Acme Electric enterprise. It aims to balance and

create a general picture of performance that managers provide critical insight and suggestion for reaction. This analysis model can be recognised as "an opportunity for real organisational learning", results in insights about the fundamental mission and vision of the company" (Curtice, 2006). Firstly, managers need to find out all the potential stakeholders and their expectations; each of these expectations is graded by its level of importance. The following step named "performance metrics and measurements" where satisfaction of stakeholders in each expectation can be transferred into metrics evaluated and marks/grades are collected by empirical observation, sampling, questionnaire, or focus group assessment. In the third step, targets will be set up, and a performance report will be made in a table form as shown in Figure 3.11.

Stakeholder	Satisfaction Attribute	Relative Importance	X	Current Satisfaction Gap	=	Need for Improvement	Business Processes					
							Supply Electric Energy	Serve the Customer	Manage Human Resources	Manage Financial Resources	Provide Materials & Supplies	Provide Infrastructure
Customers	Quality of Electric Service	3		60		180	3.4	0.4	2.3	1.7	3.2	2.8
	Quality of Customer Service	2		80		160	0.4	4.5	4.3	0.8	0.4	1
	Fair Price	2		40		80	2.2	0.3	0	2	0.7	1
Employees	Fair Compensation	3		60		180	0	0	2.9	3.4	0	0
	Safe Work Conditions	2		20		40	0.5	0.6	1.6	0.6	1.6	1.3
	Pleasant Work Environment	1		50		50	0	0.8	0.6	0	0.5	0.8
	Career Development	2		70		140	0	0	4.2	0.3	1	0
Owners	Return on Investment	3		20		60	2.1	0.5	0.5	2.4	0.6	1.3
	Liquidity of Investment	2		30		60	0	0	0	0.8	0	0
	Stability	2		40		80	2	0.9	2.1	1.8	0.9	0
	Attention	1		60		60	0	0	2.8	0	1	0.2
Suppliers	Good Business Relations	2		40		80	1	0	0.5	1.5	0.8	2
	Fair Price for Goods	3		50		150	0	0	0	0.7	3.8	1.8
	On Time Payment	2		80		160	0.3	0	0.2	0.8	1.3	0.6
						Priority for Improvement	11.9	8	22	16.8	15.8	12.8

Figure 3.11. Business Processes with Need for Improvement (Curtice, 2006)

3.3.4. Plan for sustainability of building projects

This part distinguishes the effort of planning for sustainability in two periods of the project. The first period is from the conceptual stage to the construction stage, which focuses on the development and control of a sustainability management plan. The second period is from the construction stage to operation stage of projects, which emphasise the preparation for a smooth transition of the project from designers/builders to the occupants by end-users guideline and logbook and a proper maintenance plan for operation of buildings.

3.3.4.1. *Plan for sustainability of the project from the conceptual to the construction stage*

A sustainability management plan is critical to navigate further actions of managing sustainability-related activities in the project. To make the plan, project managers are recommended to start with the identification and assessment of sustainability-related risks and issues (Gudienė et al., 2014; Khalfan, 2006; Perrott, 2015; Pojasek, 2012), then necessary actions might be proposed and prioritized (Verboven & Vanherck, 2015, 2016) to face with risks and issues identified. Yu, Zhu, et al. (Yu, Zhu, Yang, Wang, & Sun, 2018) identified three key dimensions of sustainable project planning, name as managerial control, risk response and work consensus.

To support for the development of a sustainability management plan, some templates have been proposed, include: "Sustainability Management Plan" of PRiSM from Carboni (2013), "Project Sustainability Logbook" in engineering and infrastructure industry from FIDIC (2013) and "Sustainability Management Plan" by Silvius (2015). Table 3.3 summarised the core contents of these formats; which could be classified in 4 main parts:

- *Introduction of the project, organisational context and objectives:* All the three templates start with an introduction of the project, organisational context, and project (sustainability) objectives. This part helps to clarify the context of the project, its conditions and objectives that the plan should target. The template of Silvius (2015) has a stronger focal point on explaining detail information related to sustainability objectives, such as interests of stakeholders and organisation's sustainability strategies. It suggests that a sustainability plan should be developed in line with not only the project objectives, but also need to take into consideration of stakeholder's needs and be in line with sustainable development strategies of the client.
- *Preliminary analysis of project impacts, risks and opportunities:* The second part demonstrates the summary of impact assessment analysis, sustainability-related risks analysis, and potential opportunities of the project. This part helps to enlarge understanding of project management teams on issues of sustainability as well as to record important information to the decision-making process of projects.
- *Metrics for controlling sustainability*: In this part, the plan aims to propose metrics for measuring the performance of project in different stages of projects.
- *Sustainability governance:* The final part of a sustainability plan provides direction for how sustainability management process could be implemented and how

information could be reviewed/reported.

Table 3.3. The content of existing templates for the Sustainability Management Plan

Contents	Sustainability Management Plan (Carboni et al., 2013)	Project Sustainability Logbook (FIDIC, 2013)	Sustainability Management Plan (Silvius, 2015)
Introduction of the project, organisational context and objectives	- Executive summary - Scope exclusions	Project description and characterisation	- Project definition - (Key) stakeholder and interests - Organisation's sustainability strategy
	Project Sustainability Objectives	Sustainability Issues, Objectives	Project objectives
Preliminary analysis of project impacts, risks and opportunities	- Environmental impact assessment results - Sustainability Risk Management		- Confrontation matrix (Organization sustainability ambitions vs Project objectives) - Sustainability opportunities & Enhanced Project Objectives - Sustainability risks
Metrics for controlling sustainability	Key Measures and Performance Indicators	Sustainability performance targets (monitoring tables for each stage of the project)	
Sustainability governance	Reviews and Reporting		Sustainability Management Structure

From the contents shown in the table, each template has a different approach in supporting managers to make a sustainability plan for their project. FIDIC's and PRiSM's approach focus mainly on selecting metrics for measuring and controlling sustainability; then they might be suitable to control a project with measurement and indicators from the planning/design stage to the end of the project. Sivilus's template pays more attention to understanding the ambition of organisation, opportunity and ability in enhancing sustainability objectives; then this approach from Silvius might be helpful in the conceptual stage. From a viewpoint on project management in the construction industry, FIDIC's and PRiSM's approach might be more practical as it helps to narrow down the complexity of sustainability.

Regarding construction and building project, a sustainability management plan should pay special attention to strategic issues of the industry, including waste management, energy, carbon reduction, materials and technology selection, minimisation of adverse impacts in a construction site, and workforce conservation. These issues are key mechanisms to enable sustainability in the construction industry, and then they need to be embedded in the plan of sustainable building projects.

- ***Waste management:*** The creation of waste strongly damages all three pillars of sustainability goal due to environmental pollution, economic burden, and loss of resources. An effective waste management requires a realistic measurable goal, and a thoughtful on-site waste management plan (Glavinich, 2008; Scheuer & Keoleian, 2002). The waste of a building project might be generated mainly in a construction site and operation stage, but it sources from before stages, especially in design (Osmani, Glass, & Price, 2008). A poor design could create more waste by creating premature facilities from users or unnecessary consumption of materials (Chandrakanthi, Hettiaratchi, Prado, & Ruwanpura, 2002; Innes, 2004). Therefore, a target and plan for waste management should be created as soon as initial project objectives and plans are made. There are several models for waste management; almost all of them suggested for the treatment of waste with a similar approach: recycle/reuse of the actual waste and reduce/minimise the amount of waste could potentially be generated (DECLG, 2012; Hoornweg & Bhada-tata, 2012; Lu & Yuan, 2011). Moreover, the core principle for managing waste is cited as to maintain a life cycle perspective in evaluating waste management (Klang, Vikman, & Brattebø, 2003).
- ***Energy reduction:*** The goal of energy reduction is cited as one of the main sustainability targets for building design (Al-Yami & Price, 2006). Many green building rating systems pay strong attention to how energy performance is optimised (Berardi, 2012). The global energy crisis and requirement for reserving resources for future generations also encourage the construction project to minimise the energy consumption in buildings. Such tools as Life Cycle Energy Analysis or Cumulative Energy Demand system were developed to quantify the amount of embodied energy and operating energy during all lifecycle of projects (Berardi, 2012; Hastings & Wall, 2007; Mithraratne et al., 2007), which then help decision makers to go for the most suitable option of design. Besides, the construction industry is also promoted with new incentives and technologies that help reducing energy consumption, such as radiant/ground cooling in the summer, heat-lost prevention in the winter, photovoltaic, wind, or biomass energy (Kibert, 2013).

- ***Carbon reduction:*** In order to measure the climate change impact, carbon footprint was introduced to quantify the amount of CO_2 and other carbon gases emission (Kibert, 2013). It has become the international target after the Paris climate conference - COP21 (European Commission, 2015) with a commitment of significant cut-down carbon emissions from 195 countries. UK seems to be one of the most active countries with the target of reducing 80% of carbon emissions by 2050, which has been put in the law since 2008 (Parliament of UK, 2008; Scottish Parliament, 2009). In construction, the adoption of carbon footprint reduction scheme is represented by the low, neutral and zero carbon buildings. Regarding the control of carbon in the building, a sustainable target value (STV) with a combination of LCA analysis can be a useful tool for decision-making process (Russell-Smith, Lepech, Fruchter, & Meyer, 2014). By its methodology, STV can not only support for the selection of design iterations but also helps to control environmental impacts during project life cycle (Russell-Smith & Lepech, 2015).
- ***Materials and technology selection:*** Designers can help to reduce energy consumption and carbon impacts of the building by selecting environmental-friendly materials, which have higher energy efficiency and lower embodied carbon than traditional materials. Embodied carbon presents for the amount of carbon embedded in building components from raw material extraction, manufacturing, transport and installation into buildings as well as the amount of carbon emission occurred from the replacement of material/equipment, maintenance and refurbishment of the building (Lockie & Berebecki, 2012). In addition, several successful high-performance green buildings are also well-known by special technological initiative such as photovoltaic, green-roof, solar water heating, or micro-hydro system - which can help to reduce environmental impacts (Calkins., 2009; Halliday, 2008; Kibert, 2013) and risks to occupants' health (Calkins., 2009, p. 7). However, the application of the green or environmental-friendly materials and technologies in practice is till limited due to their less competitive cost than traditional products that they could replace (Dobson et al., 2013; Kibert, 2013).

- ***Minimisation of negative impacts in construction site:*** Controlling negative impacts in a construction site is another strategic issue in planning for sustainability. The negative impacts can be listed down as erosion and sedimentation, air, noise pollution (Kibert, 2013; Webster & Dunn, 2011; Zou & Moon, 2014), and other impacts to the surrounding areas. The primary source for a pollutant is executing equipment on site (Ahn, Lewis, Golparvar-Fard, & Lee, 2013). Some strategies to reduce pollution and its impacts are proposed as planning equipment spreads, avoiding idling, replacing diesel with electricity/battery or alternative fuels (Glavinich, 2008, p. 180).
- ***Workforce conservation:*** The worker health, safety and training are considered important indicators to enhance green construction operation (Zou & Moon, 2014). Worker's health and working condition need to be address in occupational ergonomics as well as the use of local workforce whenever possible (Glavinich, 2008, pp. 166-167;176-179).

3.3.5. Preventing the drop of sustainability from the construction to in-use stage

Numerous of research cases showed that the actual performance of green buildings is not as in design, for example, in Azizi, Sakina, & Fassman (2013), Newsham, Mancini, & Birt (2009) and Sakina, Fassman, & Wilkinson (2011), to name but a few. This problem is tricky because it is hard to make a change when buildings are already in operation stage when contracts with designers and builders are terminated, and the cost of change might be very expensive.

Therefore, the proper approach should be to prevent any drop in sustainability in the beginning, in other words, a proactive approach is highly recommended. In order to prepare for the in-use stage, RIBA (RIBA, 2013b) suggested having a ‘nontechnical user guild and aftercare services’ for occupations as assistance with fine-tuning & guidance from equipment suppliers and contractors to help the technologies transmitted smoothly from construction to in-use stage, from designers and engineers to users. Good guidance from designers and builders, a sufficient, complete and transparent project document, therefore, can help maintainers, operators and occupants to operate the building as in design.

In addition, the operation of buildings needs good maintenance. It is not only essential to the normal performance of buildings, but also has a strong connection to the achievement of sustainability target (Lai, Joseph & Yik, Francis, 2006) and direct impact to the satisfaction of occupants (Kwon, Chun, & Kwak, 2011). Paradoxically, Saghatforoush, Trigunarsyah, & Too (2012) found that maintenance and operation of the building were ignored by current constructability principles; and this might be the reason to explain for an underperformance building in practice.

3.3.6. Assess sustainability during the life-cycle of building projects

Sustainability assessment plays a significant role in measuring and assuring sustainability in the built environment. The development of almost all of the sustainable building assessment is strongly correlated with life-cycle thinking. It is important to note that all project stages bear a close-knit relation to each other. Therefore, an error/mistake occurred in a earlier stage could spread across the later stages, and it might result a damage to final products,

To prevent and remedy the error/mistake on time, multi-evaluation approach is necessary; in other words, sustainability assessment should be carried out from the start to the end of the project: In the early stage of design, environmental, social and economic impacts of the project should be carefully considered (Bakar et al., 2009; Curran, 2012), then, the project team need to monitor and measure the performance and progress of sustainability achievement in the construction stage (Djuric & Novakovic, 2009; Enck, 2010; FIDIC, 2004; Xiao & Wang, 2009). When construction finishes, building commissioning is highlighted as a systematic process for quality control to ensure the owner's goal for a green building (Stum, 2000) and real building performance (Tseng, 2005); the sooner building commissioning is carried out, the more significant benefits it could bring to project (Enck, 2010; Kibert, 2013; RSMeans, 2011). In operation stage, post-occupancy evaluation (POE) can help to diagnose operational problems such as cost, aesthetics, occupant satisfaction, management or environmental performance (Halliday, 2008, p. 349), and then may allow improvement of user’s satisfaction (Bonde & Ramirez, 2015; Paul & Taylor, 2008; Pei, Lin, Liu, & Zhu, 2015) and performance of the building (Newsham et al., 2009).

3.3.6.1. Tools for assessing sustainability in building projects

After 30 years of strong development in sustainability trend, there are plenty of assessment tools to evaluate the sustainability of buildings. They can be divided into two main categories as shown in Figure 3.12: mono-dimensional and multi-dimensional tools. The mono-dimensional tools are mainly focused on a particular pillar of sustainability such as environmental, economic or social problem. This group includes Life Cycle Assessment (LCA) and Life Cycle Costing (LCC). Multi-dimensional tools are developed as a new approach to adapt to the requirement of a synthesised and unique tool to cover all the dimensions of TBL under the integration trend in construction.

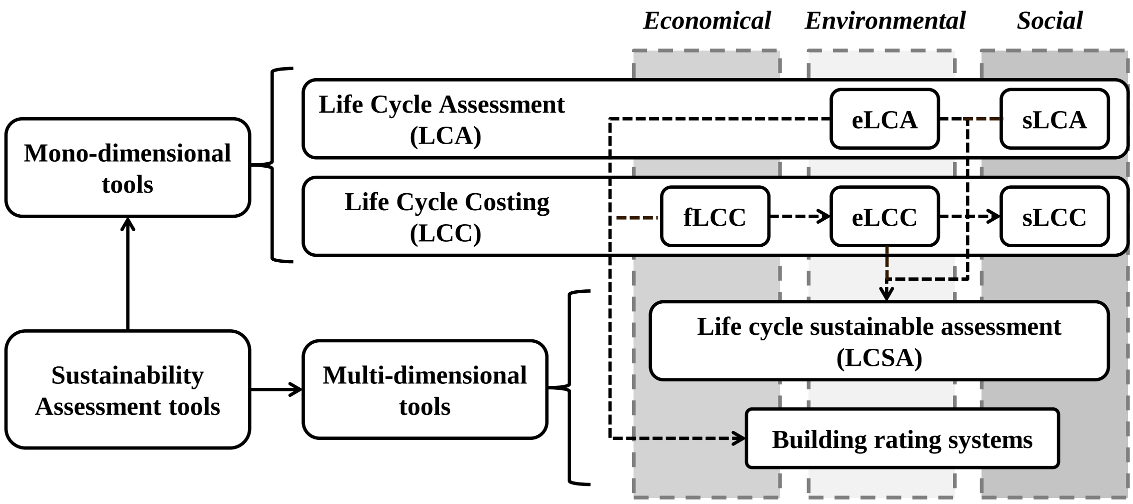


Figure 3.12. Sustainability assessment tools (Adapted from Hoogmartens, Van Passel, Van Acker, & Dubois, 2014) - Dashed arrows show that one tool may include heritage information from another tool

a) Life Cycle Assessment (LCA)

The first guideline for LCA methodology was introduced in 1992, advanced in the past decade by several efforts of the Dutch government, SETAC, ISO and UNEP (Guinée, 2004), and got well-known with ISO:14040 and ISO:14044. LCA has become a major tool for supporting sustainability decision (Curran, 2012) and expected to be a mandatory measurement for building design (Kibert, 2013). LCA is a cradle-to-grave evaluation (ISO, 2006a, 2006b), it means that the assessed product's life cycle is counted from raw materials acquisition to the final disposal (Mithraratne et al., 2007), also including the production, use, end-of-life treatment, recycling (ISO, 2006a). Therefore, LCA can avoid problem-shifting between different phases in the life cycle, regions of production flow and environmental aspects (Finnveden et al., 2009) as well as bridging design, construction, and maintenance issues together (Edwards & Naboni, 2013, p. 25).

LCA includes four steps of assessment under guidelines from ISO (2006a) and UNEP-SETAC (2009). In the first step, the goal, scope, function, functional unit, reference flows and the boundary of a particular production system are defined. The second step is life-cycle inventory (LCI) analysis, in which relevant data of inputs and output for the product system are collected and calculated. The use of available databases, such as German PROBAS, European council ELCD, Eco-Invent, Eco-Quantum or IVAN data 4 could help to reduce the time for collecting a large amount of required data. In the third step, inventory data are classified, characterised, normalised and weighted to evaluate the impact to the natural or social environment. Softwares such as TRACI, Envest, BEES or SimaPro7 can be used to support the second and third phase (Keeler & Burke, 2009). Finally, in the interpretation step, the results and conclusions are presented in the report.

Based on the type of evaluated impact, LCA has two branches: environmental LCA (or eLCA) and social LCA (or sLCA). eLCA is designed to assess ecosystem damage and natural resource depletion, for example, global warming, ozone exhausting, water or fossil energy source depletion (Li, Zhu, & Zhang, 2010) under a comprehensive environmental scope (Hoogmartens et al., 2014). Whereas, sLCA is carried out to evaluate social and socio-economic impacts of the product life cycle, such as human rights, working condition, health and safety, culture heritage, governance and socio-economic repercussions (UNEP & SETAC, 2009). If eLCA is embedded clearly in the built environment, the application of sLCA is quite limited in the construction industry, but a few types of research about buildings (Bozhilova-kisheva, Olsen Irving, & Olsen, 2012; Dong & Ng, 2015) and power plant (Corona, Bozhilova-Kisheva, Olsen, & San Miguel, 2017).

b) Life cycle costing (LCC)

Life cycle costing (LCC) is development after LCA (Edwards & Naboni, 2013) to assess all cost related to the product over its life cycle, then consultancy can get the benefit of LCA as it supports useful information for conducting LCC analysis (UNEP & SETAC, 2009). In principle, it has a similar procedure of four phases as LCA (Swarr et al., 2011).

Depend on the number of actors involved, LCC tools are developed as three main categories, including financial LCC (fLCC), environmental LCC (eLCC) and social LCC (sLCC).

- fLCC, or conventional LCC works with internal costs borne with a particular actor (Hunkeler, Lichtenvort, & Rebitzer, 2008). Therefore, the term ‘life cycle’ in fLCC is understood as the lifetime that has involvement of that actor. The most typical actor used in fLCC is manufacture, it means that all end-of-life costs are neglected in fLCC (Swarr et al., 2011).

- eLCC tool relates to costs borne by a certain amount of actors in the supply chain of a product, and then evaluated the scope of a lifetime is larger than fLCC. Some examples about the cost in eLCC are waste disposal costs, taxes, or global warming adaption costs (Hoogmartens et al., 2014).

- sLCC, or societal LCC covers all costs borne by everyone in the society (Neugebauer, Forin, & Finkbeiner, 2016), even who are in the future (Hunkeler et al., 2008). However, sLCC is just a concept until now. Although fLCC is a part of eLCC, and they all are parts of sLCC; but in general LCC meets several difficulties in translating social-related cost into monetary unit, and its result does not reflect the actual environmental emission and damage (Hoogmartens et al., 2014), then it is hard to become a completely and independent tool for sustainable assessment, but surely it should play as a key tool to combine with others in sustainability assessment.

c) Life cycle sustainability assessment (LCSA)

Because neither LCA nor LCC can address all the three pillars of the TBL alone, it is necessary to have a synthesised tool that can assess all the economic, social and environmental impacts of projects, therefore, life cycle sustainability assessment (LCSA) was introduced. One of the first model for LCSA was developed by Klöpffer (2003) with a proposal of combining eLCA, sLCA, and LCC into one instrument under the consistency of product system boundary. Schau et al. (2011) considered that to combine with eLCA and sLCA, LCC should be an LCA-type; and eLCC seems to be the most suitable one for that requirement.

The biggest problem for LCSA is life cycle inventory, which requires a large amount of data to assess impact. Klöpffer (2008) came to two options: (1) LCSA is implemented by conducting three separated eLCA, sLCA and eLCC or (2) it is made as a unique tool that sLCA and eLCC are categories of eLCA to benefit from only one life cycle inventory. The second option was agreed by Hoogmartens et al. (2014), but the conflict of results is unavoidable. One of the most recent models proposed with a common life-cycle inventory (LCI) and specific LCIs for different TBL dimensions was illustrated by Keller et al. (2015). However, the application of LCSA is minimal because sLCA is less addressed as difficulties in data collection (i.e. life cycle inventory) and lack of conceptual understanding about life-cycle-based mechanistic perspective (Zamagni et al., 2013).

d) Building rating systems

Rating assessment tools have rapidly developed from fashionable certifications to current practices. Now they are recognised as playing an essential role in promoting green building application in recent years (Shah, 2012) as well as significantly affected to how a building designed, constructed and valued than any other initiatives since 1920 (Edwards & Naboni, 2013, p. 40). Building rating systems have satisfied market demand in standardising what a high-performance green building should be. Assessment tools in this group also adapted to score and certify the effects of a building's design, construction, and operation among their environmental impacts, resources consumption, and occupant living quality (Kibert, 2013). These tools evaluate construction buildings by several chosen parameters, with a comparison of real performances and reference data to collect points or credits. Then, the overall result is calculated, and the rank of certification will be given.

Two of the oldest systems - BREEAM (UK) and LEED (US) - were established in 1990 and 1998, respectively. Until now, they have become the basis for many other tools; for example, LEED has its widely recognised versions in Brazil, Canada, New Zealand, Mexico, China and India, when BREEAM is also essential foundation for HK-BEAM (Hong Kong) or MSBG (Fowler & Rauch, 2006). Figure 3.13 illustrates the relationship of development basis between different rating tools.

Yearly, new rating systems or are also introduced, such as Green Star (Australia) in 2003, Living Building Challenge in 2006, DGNB (Germany) in 2007 or CASBEE (Japan) in 2008, as well as updated version of existing systems like BREEAM or LEED. New rating tools have been made to challenge the low-impact of buildings and performance of construction projects with higher and higher requirements. Living Building Challenge (LBC) is an interesting example of this trend. Within a few years after established, it has got great fame as the leading assessment tool in the world designed for net-zero buildings (Hossaini et al., 2015), the most demanding assessment tool in North America (Kibert, 2013) or called the future of sustainability design (Krygiel & Nies, 2008). Imperative achievement of LBC is also very demanding when compare with other rating tools. For example, to achieve water imperative requires 100% of water collected, used and reused, purified onsite without using chemical, and released in harmony with surrounding natural water flows (ILFI, 2014) whereas full number of credits for water reduction in LEED (BD+C) will be awarded to design that could reduce 45-50% indoor water use (USGBC, 2015); this number in BREEAM (NC) is 55% (UKGBC, 2014).

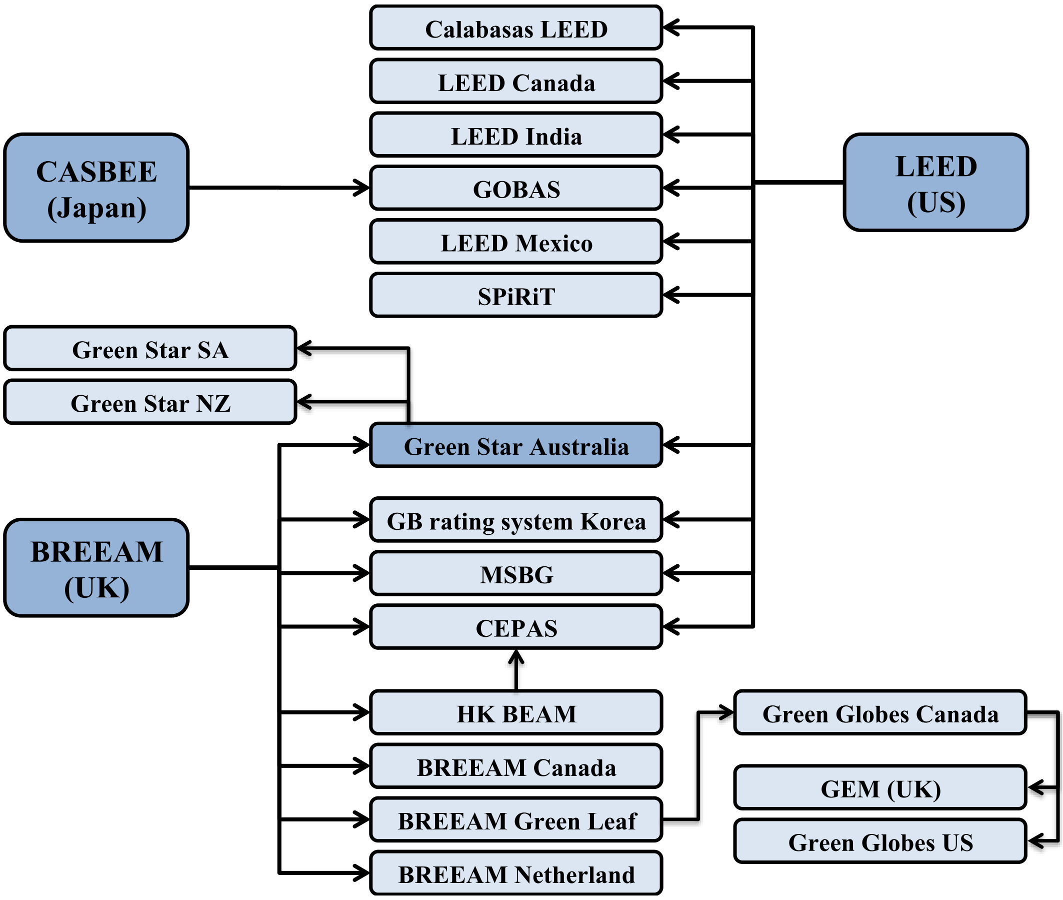


Figure 3.13. Building rating systems and their development basis (Adapted from Fowler & Rauch, 2006)

Building rating systems tried to cover all sustainability dimensions, but illustrate them not as balance as described in the TBL model. The most emphasis point dropped on environmental aspect, less attention is paid on social sustainability, and economical aspect seems to be ignored. The balance of TBL is, once again, questioned:

- Environmental sustainability is expressed through efforts but not limited to reduce energy, water, carbon footprint, waste, and to use low-impact materials. DGNB also requires carrying out a LCA to achieve some of criteria points.
- Social sustainability is understood as an effort to increasing users' healthy and comfortable living condition (GBCD, 2012), neighbourhood development (USGBC, 2015), improve public physical and psychological health and well being, promotes culture, interaction and equity among people, and even donation (ILFI, 2014). However, such tools as BREEAM are criticised to provide low priority to social issue (Edwards & Naboni, 2013; Halliday, 2008, p. 98).
- The economic aspect is mainly cited as to have a LCC analysis (GBCD, 2012; UKGBC, 2014). For example, LCC analysis is required to achieve 9.6% of the total

score; it includes construction and operation cost, but dismantling and disposal costs are not counted in the latest version (DGNB, 2014). Regarding BREEAM, LCC is carried out to evaluate value from the investment. Therefore, they are close to fLCC than eLCC. In addition, LBC has one imperative to encourage 'contribution to the expansion of a regional economy rooted in sustainable practices, products and services' (ILFI, 2014). However, many other rating systems do not have criteria for this, such as LEED v4 or CASBEE.

3.3.6.2. Commissioning

Recently, the role of building commissioning is increasing. It is highly recommended by Green Globes as well as in federal and state government levels (Kibert, 2013). Commissioning is considered a systematic process for quality control to ensure the owner's goal and performance for a sustainable building (Stum, 2000; Tseng, 2005). Therefore, the commissioning process should start from the design stage (Legris, Choiniere, & Ferretti, 2010; Stum, 2000). The sooner building commissioning is carried out, the greater the benefits it could bring to project (Enck, 2010; Kibert, 2013; RSMeans, 2011).

3.3.6.3. Post-Occupancy Evaluation (POE)

POE is developed for analysing the performance of buildings in operation (Dimitrijević, 2013, p. 55). It can help to diagnose operational problems such as cost, aesthetics, occupant satisfaction, management or environmental performance (Halliday, 2008, p. 349), and then may allow improvement of performance (Newsham et al., 2009); it also support architectures and contractors in further projects (Edwards & Naboni, 2013).

The results of recent POE reports for sustainable buildings showed that users' overall satisfaction is rated higher than conventional buildings (Bonde & Ramirez, 2015; Liang et al., 2014; Newsham et al., 2013; Paul & Taylor, 2008; Pei et al., 2015). Also, they also demonstrated the reduction of energy consumption in green certified. Newsham, Mancini & Birt (2009) analysed 100 certified buildings to identify that they used 18-39% less energy than non-certified counterparts. Unfortunately, POE of buildings is rarely carried out and published (Halliday, 2008; Newsham et al., 2009). A few numbers of the case study cannot make the construction industry confidence to embrace change.

3.4. Development of research hypotheses

The hypotheses are built up based on the identification of relationship among the five key components of Sustainable Project Management (SPM) and four aspects of sustainable project success (SPS) (project performance & stakeholder satisfaction, economic, environmental and social sustainability) as in Figure 3.14.

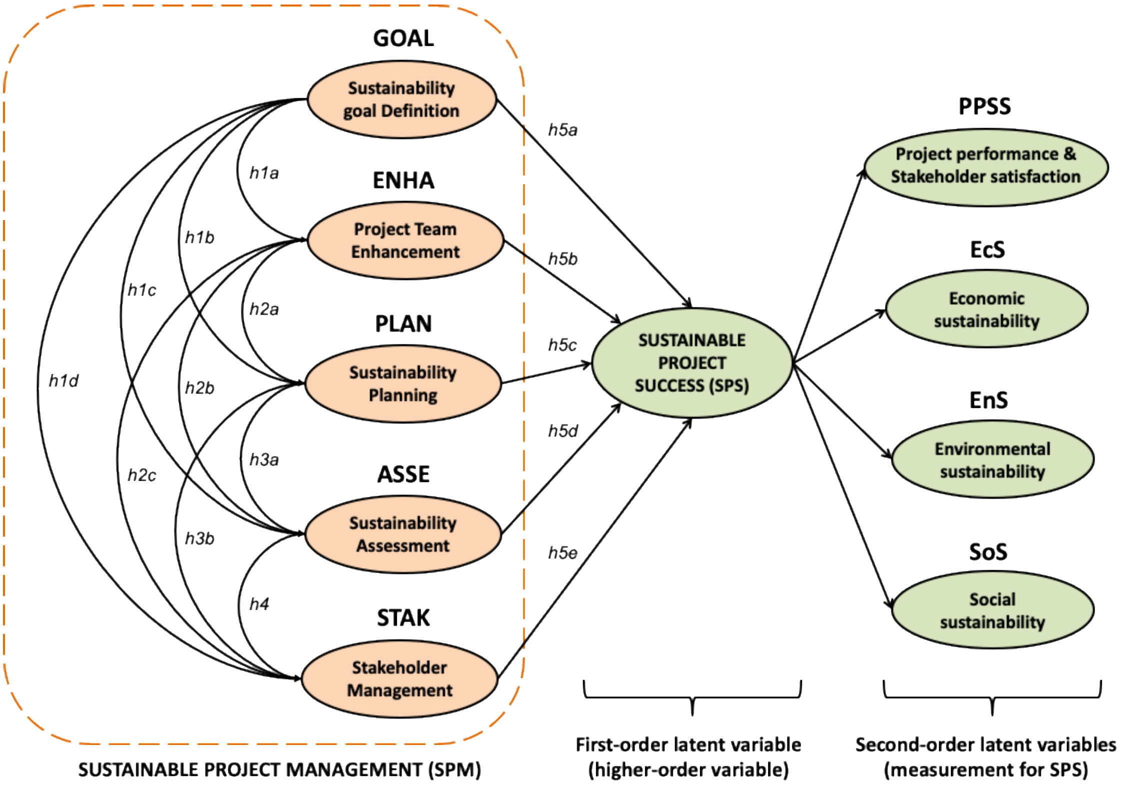


Figure 3.14. Research hypotheses about SPM and SPS and structure of testing model

3.4.1. Hypotheses of sustainability goal definition (GOAL)

As Kibert (Kibert, 2013) considered the definition of sustainability goal is 'ultimately necessary to provide the various players a direction for their activities'. Such activities as the enhancement of project team (ENHA), sustainability planning (PLAN), sustainability assessment (ASSE), and stakeholder management (STAK), therefore, might also be impacted directly and positively by a proper sustainability goal. In order to identify the impact of sustainability goal definition to the listed activities, this model tested the relationship between variable GOAL and variables ENHA, PLAN, ASSE and STAK in pairs (h1a, h1b, h1c, and h1d, respectively). Besides, the model also examined the support of sustainability goal definition to the achievement of SPS (h5a).

The above hypotheses are stated as:

- *Hypothesis h1a (GOAL -> ENHA): The definition of sustainability goals supports the* *enhancement of the project team toward sustainability in building projects;*

- *Hypothesis h1b (GOAL -> PLAN): The definition of sustainability goals supports the planning of sustainability in building projects;*
- *Hypothesis h1c (GOAL -> ASSE): The definition of sustainability goals supports the assessment of sustainability in building projects;*
- *Hypothesis h1d (GOAL -> STAK): The definition of sustainability goals supports the management of stakeholder communication and engagement in building projects;*
- *Hypothesis h5a (GOAL -> SPS): The definition of sustainability goals supports the achievement of sustainable project success in building projects;*

3.4.2. Hypotheses of project team enhancement toward sustainability (ENHA)

The project team is defined as all internal stakeholders, including not only project managers and management team, but also client advisory, designers, main and sub-contractors, and other key ones who work directly in the project and contribute to the success of that project.

Initially, if a team has a strong competence in managing the project activities, the project-management-related activities are also in higher performance. It is also the core principle of the standard IPMA Competence Baseline (IPMA, 2006). Therefore, in this model, the enhancement of project team was tested its support to the effectiveness of the three SPM's components, including the sustainability planning (PLAN), sustainability assessment (ASSE) and stakeholder management (STAK) – i.e. h2a, h2b, and h2c, respectively). The above hypotheses are stated as:

- *Hypothesis h2a (ENHA -> PLAN): The enhancement of the project team toward sustainability supports the planning of sustainability in building projects;*
- *Hypothesis h2b (ENHA -> ASSE): The enhancement of the project team toward sustainability supports the assessment of sustainability in building projects;*
- *Hypothesis h2c (ENHA -> STAK): The enhancement of the project team toward sustainability supports the management of stakeholder communication and engagement in building projects.*

Moreover, skills and knowledge of project team in executing project activities are highlighted as key factors for the success of the project and the achievement of sustainability (Disterheft et al., 2015; Saleh et al., 2015; W. Shen et al., 2017). Then, the enhancement of the project team's ability toward sustainability was put in the hypothesis of a supportive relationship with the achievement of sustainable project success - SPS (h5b) as:

- *Hypothesis h5b (ENHA -> SPS): The enhancement of the project team toward sustainability supports the achievement of sustainable project success in building projects;*

3.4.3. Hypotheses of sustainability planning (PLAN)

A management plan is critical to navigating further activities in projects. Therefore, sustainability planning can be a necessary preparation for the further assessment of sustainability by identifying the methodology, by allocating the necessary resources for the assessment (h3a). A sustainability plan should cover not only the environment management plan or waste management plan, but it also needs to consider the sustainability strategy to face with issues of energy, water, carbon footprint, green materials & technology, site negative impact control, or workforce conservation. Therefore, the planning for sustainability should contribute to the achievement of SPS (h5c).

Besides, a clear sustainability plan could visualise the roadmap to sustainability achievement, and therefore, it can help to raise awareness from stakeholders of the projects, and promote their engagement to achieve sustainability objectives. Furthermore, the planning for stakeholder engagement and communication should be compatible with guidance from the sustainability plan. In brief, sustainability planning might be able to support the stakeholder management process (h3b)

For all these arguments, they are hypothesised as:

- *Hypothesis h3a (PLAN -> ASSE): The planning for sustainability supports the assessment of sustainability in building projects;*
- *Hypothesis h3b (PLAN -> STAK): The planning for sustainability supports the management of stakeholder communication and engagement in building projects;*
- *Hypothesis h5c (PLAN -> SPS): The planning for sustainability supports the achievement of sustainable project success in building projects;*

3.4.4. Hypotheses of sustainability assessment (ASSE)

Sustainability assessment plays a significant role in measuring and assuring sustainability in the built environment. No one can deny the significant contribution of such assessment tools as green-building ratings, LCA, LCC or energy ratings to the development of sustainable buildings in the early years of the 21st century. In this study, sustainability assessment, therefore, is put in the hypothesis of positive relationship with the achievement of SPS (h5d). Besides, its valuable assessment information can potentially promote the engagement of stakeholders (h4) to the project.

Under this variable, the following hypotheses are stated:

- *Hypothesis h4 (ASSE -> STAK): The assessment of sustainability supports the management of stakeholder communication and engagement in building projects;*
- *Hypothesis h5d (ASSE -> SPS): The assessment of sustainability supports the achievement of sustainable project success in building projects;*

3.4.5. Hypotheses of stakeholder management (STAK)

Stakeholder in construction projects is recognised as playing a vital role for sustainability achievement in construction (Ali, 2014; Feige, Wallbaum, & Krank, 2011) through their collaboration and contribution of knowledge, ideas and innovative solutions to overcome barriers of sustainability. Although the supportive impact of stakeholder management to sustainability achievement and project success has been mentioned in many research, this study also checked it one more the time to see the whole network of relationships and to compare the strength of relations between different components of SPM to the achievement of SPS. The hypothesis is stated:

- *Hypothesis h5e (STAK -> SPS): The management of stakeholder engagement and communication supports the achievement of sustainable project success in building projects;*

3.5. Summary

This chapter has reviewed and summarised 35 the critical success factors (CSFs) for managing sustainability in building projects. These CSFs were then classified into five groups, name as (1) sustainable goal definition, (2) project team enhancement toward sustainability, (3) planning for sustainability, (4) sustainability assessment and (5) stakeholder management. The five groups of CSFs were then accepted as the five key components in the conceptual model for SPM. The chapter was continued with theoretical backgrounds for the five key components.

To develop project management guidance, it is essential to understand the relationships between these components of SPM as well as how they can support the achievement of SPS. Therefore, 4 hypotheses were proposed to identify the inter-relationships among the five key components of SPM and one hypothesis was created to understand the impact of these components on sustainable project success. The development of five hypotheses (which is further expanded to 15 sub-hypotheses) is discussed in the later part of this chapter. Methods for the testing were presented in Chapter 4 and results were illustrated and discussed in Chapter 5.

CHAPTER 4. METHODOLOGY

This chapter represents the research methodology and methods for this study. In this study, the research design perspective for methodology is mainly in social science, business and management aligned with the characteristics of the aim and research questions. This chapter begins with the choice of research design, then research progress is represented in link with methods conducted. The later part of the chapter focuses on explaining particular methods adopted. It ends with considerations of quality assurance and ethics.

4.1. The research design of the study

Several models in designing research are considered for the study, including the ring onion by Saunders, Lewis, & Thornhill (2012), four elements of research by Crotty (1998), research framework by Creswell (2014), research choices by Blaikie (2010), and the research tree by Easterby-Smith, Thorpe, & Jackson (2012). Finally, the ring onion model (represented in Figure 4.1) is employed as a research design approach for this study because it not only provides the most detailed guidance but also has an excellent structure to navigate the choice of research methods. Based on the onion ring model, the research design for this study is explained below.

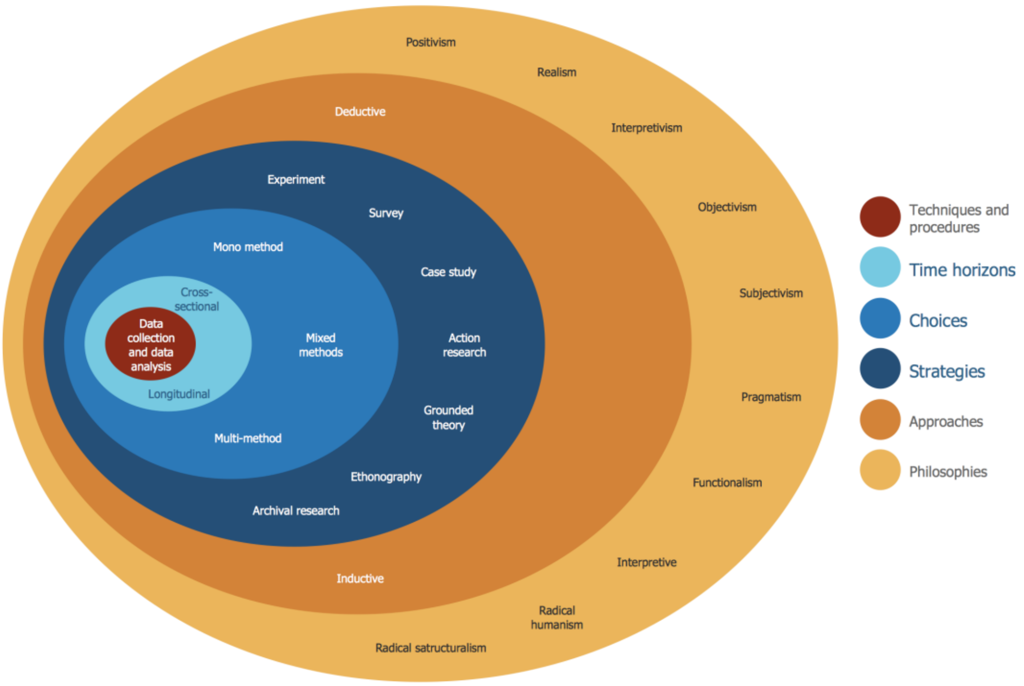


Figure 4.1.Ring onion of research design by Saunders, Lewis & Thornhill (2012)

Research philosophy

The adopted research philosophical viewpoint in this research is *critical realism*. This philosophical stance considers a similar scientific approach to the *positivism* of nature science in developing knowledge. Regarding to this philosophy, data is only credible when phenomena are quantifiably observed, in other words, a large sample size of quantitative data is needed to be tested and scientifically verified to build up a theory (Collis & Hussey, 2014; Saunders et al., 2012). However, critical realism stance is different from positivism as it considers social conditions interpret the reality; the philosophy sees the experience of the social actor is built through their senses. This research bases on an evaluation of participants (expert opinions) on one of their most recent previous projects, which actually, is their experience on the things they observed through their senses in the past.

However, mental processing sometimes interrupts the human senses. The distortion or bias of individual viewpoint might not be a significant problem as it would be flattened by a large number of sample sizes; but strong factors - which are shared in the majority of people, such as religious, education or culture - might be embedded in the knowledge identified. Therefore, the research focused more on the localisation. Research participants were selected in the UK construction industry only, and the research evaluators were the potential users of the framework to assure that they were all shared similar local specifications. However, it does not limit the value of findings in regions with a similar culture, politics, education, and level of economic development to the UK's, such as EU, USA, Canada, or Australia. The Asia, Africa, and Middle East might take into account critical considerations of generalisation of findings.

Research approach

According to the critical realism philosophical viewpoint, deduction stance was adopted. This stance is used to verify or falsify a theory under the form of a law of the relationships between concepts and variables. Therefore, the research started with existing theories in the literature on sustainable project management (Chapter 3), which resulted in the identification and classification of 35 critical success factors for achieving sustainability. Then the MaSBuP model for SPM and its positive impact to SPS was modelled with six variables (See Figure 3.1). Following this, five hypotheses (and 15 sub-hypotheses) were proposed to test the relationships among the these variables (as demonstrated in Chapter 3).

The research strategy

In this study, *surveying* strategy was employed. ***Survey*** strategy is often select to identify such detail questions like ‘how much’ or ‘how many’, ‘what’, ‘who’, ‘where’ in exploratory and descriptive research. It usually refers to the questionnaire with several advantages such as achievement of standardised, easy-comparative data, low-cost data collection, better control of research process, and potential approach to producing models and relationships.

This research was dealing with one of the most complicated problems in the construction - sustainability - with an insufficient and uncommon understanding from people. Any efforts to reduce the complexity and diversification of sustainability would result in a bias to the research. Therefore, a comprehensive view should be highly considered in this research topic. This viewpoint led to a large number of indicators and variables in the modelling of SPM as demonstrated (MaSBuP model in Chapter 3). To achieve the research aim and objectives, a research strategy that able to collect a large amount of information and also a large number of participants is necessary. For this reason, survey strategy showed itself as the most suitable candidate, and the online mode was conducted for surveying in this study for several of its benefits. However, it also contains several disadvantages that needed to be carefully considered. Section 4.2.1 would critically discuss these issues. Details structure and questions of the survey would also be introduced later in this chapter with the justification of its suitability and limitation.

Methodological choice

This study used multiple-method, particularly, mixed-method and multiphase design. In details, there are two phases of data collection in this study. In the first phase, quantitative data was collected and analysed to identify the inter-relationship between SPM and SPS. This is the major data collection in this research that survey strategy was accepted. Second, the combination of quantitative and qualitative data was used to evaluate the framework for sustainability management in a building project (GEPAS) as demonstrated in Chapter 7. It is worthy to notice that the GEPAS framework was not only built from the result of the first data collection phase, but it also considered other factors, including the best practice in the current construction management. It was also resulting from a subjective developing process by the writer. As a result, the knowledge developed in GEPAS might falsify the reality. Therefore, the second phase of data collection was conducted to review this main finding. Result of the collected mixed-type data would not only help to confirm the no-sign of bias, but also provide ideas for fine-turning the framework as well as enhancing its value in practice.

Time horizons

Time horizon option is cross-sectional as no change over time is required in this research.

4.2. Conducted research process and summary of adopted methods

This section explains the overall research process conducted in this study. Figure 4.2 shows the links between activities and sources of inputs and outputs of each activity. The research started with the literature review to identify the research gaps. It further focused on filling a gap in integrating sustainability into project management theory and practice. Main solution for the gap in this research is to build a framework of sustainability management that support project managers and their teams in initiating and managing sustainability in building project.

The first step to build the framework was beginned at understanding key components that sustainability management in construction should have as well as how they can affect to the achievement of sustainable project success. From this viewpoint, project-management related critical success factors (CSFs) for achieving sustainability in construction were reviewed from the literature. After synthesizing and selecting process, 35 CSFs were kept as final list and they were later categorised into five groups as demonstrated in Chapter 3. From this, the conceptual model for Sustainable Project Management (SPM) was developed with five components corresponding to the five groups of CSFs identified. The five components are (1) GOAL - sustainable goal definition, (2) ENHA - project team enhancement, (3) PLAN - sustainability planning, (4) ASSE - sustainability assessment, and (5) STAK - stakeholder management. These five components were not only from the CSFs, but also enlightened with a comprehensive and synthesised view of previous project management processes/models in the literature review. In details, GOAL, PLAN, and ASSE came from FIDIC (2004), Reusch (2015), Silva (2015), Carboni et al (2013), Khalfan (2006), and Robichaud & Anantatmula (2010) – see details in Section 2.4. The other two groups (ENHA and STAK) were added to deal with barriers of construction industry in integrating sustainability, including working with stakeholders to overcome financial & risk disincentives, to promote their awareness and commitment, and to deal with insufficient competencies of project teams.

After the new conceptual model for SPM was developed, it was linked with a new conceptual model for Sustainable Project Success (SPS) to find the relationship between the new approach in SPM to the achievement of project success. The integrated model of both SPM and SPS and hypotheses of their relationships called MasBuP.

To test the hypotheses in MaSBuP, data was collected from experienced professionals in the UK with an online questionnaire survey. Details of this survey and its rationale is demonstrated in Section 4.3. The result of hypotheses testing (see Chapter 5) was further used to develop a framework name GEPAS, and this is also the main output of this research. The methodology for the development of GEPAS framework was introduced in detail in Section 4.5. The framework was then evaluated using structured interviews with 14 experienced professionals in the UK construction industry. The method and results of the framework evaluation is presented separately in Chapter 7.

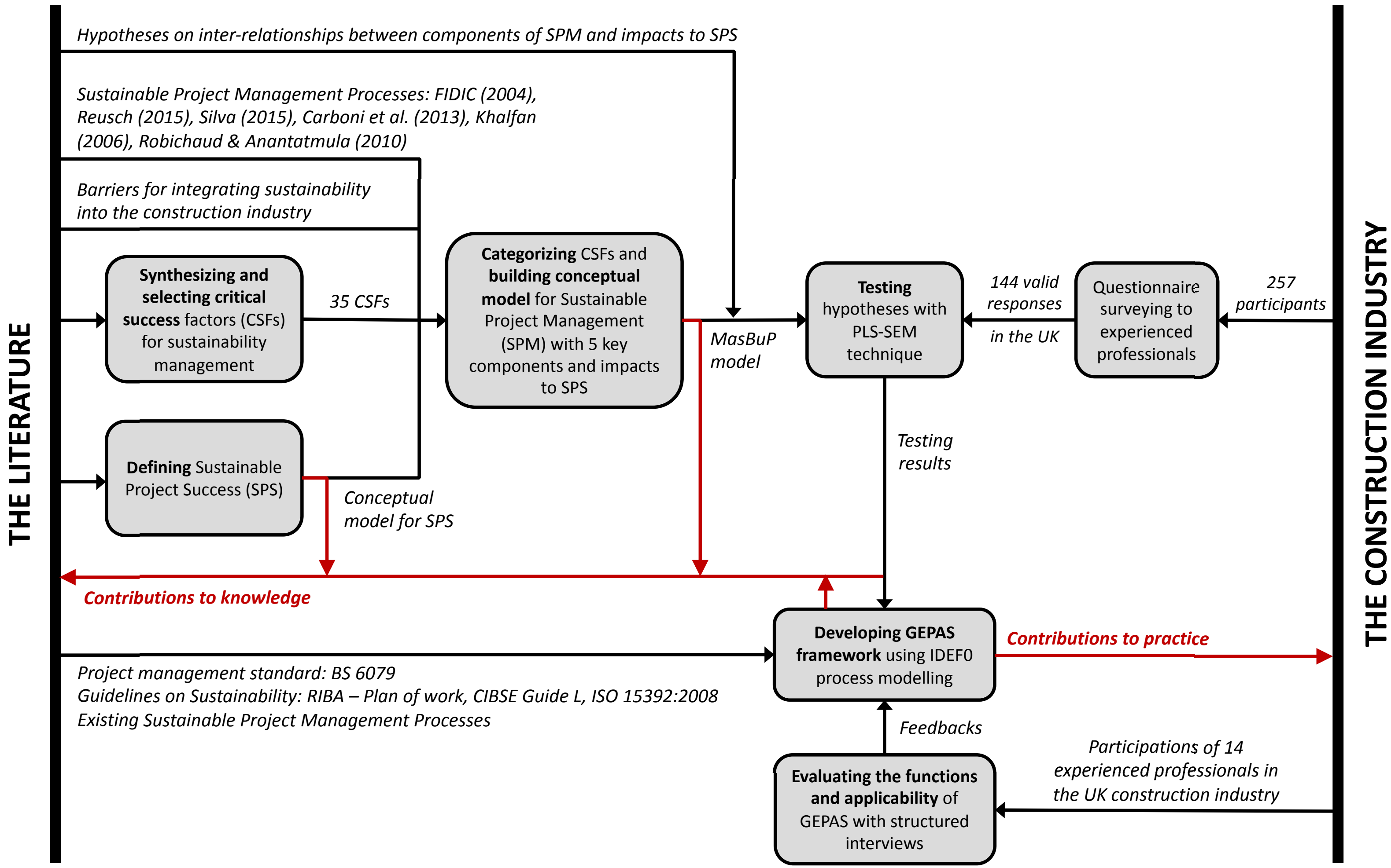


Figure 4.2. Summary of conducted research process in this study

4.3. Data collection method

This section explains the use of an online survey for collecting data, and targeted participants in designing the survey. It also clarifies the delivery of the survey, the consideration of ethical issues in data collection and the analysis for the response rate.

4.3.1. Consideration of online survey technique

The study selected online survey as data collection technique with the four major considerations:

- *It matched with adopted philosophical stance and research design*: The research adopted realism philosophy and deduction stance, which are open for the choice of survey strategy. This technique is also able to collect both quantitative and qualitative data for the choice of mixed methods design.
- *It is an excellent choice to delivery research objectives*: The collected data in surveying approach would be standardised and easy-comparative data. When the data is uniformed, it allows testing relationships among variables directly, without any biased transformations (as objective 3, which aims to understand the relationship between SPM and SPS). Moreover, the hypotheses testing also require a large amount of answer to be validated; online questionnaire with scalability can gather information form a large audience. Besides, the use of online survey allows the collection of a large amount of data, which would help to overcome bias and subjectiveness of individuals. Then the identified knowledge would be able to represent and to apply for the whole population.
- *It is suitable to the practice of the research*: The online survey is able to deliver and to get survey records back effectively from the large geographic area with low cost (Ronald D. Fricker & Schonlau, 2002; Wright, 2005). An online questionnaire also allows a quick information transfer to the database (Jones, Murphy, Edwards, & James, 2008; Sue & Ritter, 2007) without generating transcription inaccuracies or alterations in deciphering handwriting (Stewart, 2003). Therefore, it can reduce time and cost to collect data than other techniques.
- *It is convenient to respondents*: Questionnaire is now familiar to most of the people in modern society. It provides respondents with a better display and access to questions. Respondents can join the survey in their mobile phones, tablets, laptops or desktop computers. More importantly, they are free to answer in their spare time, to have time to think about the questions or to look back information/documents they

have. This is considered a decisive factor in the quality of responses (Lefever, Dal, & Matthíasdóttir, 2007). On top of that, it secures the respondent anonymity, an important ethical issue for all social research (Brindle, Douglas, Van, & Vanora, 2005; Hunter, 2012).

4.3.2. Development of questionnaire survey

The questionnaire was formed mainly with close-ended questions, with total 71 questions divided over four sections: The first section (with four questions) is about background information of participant (their area of expertise, years of experience, familiarity with different project management standards, and working experience in sustainable projects). All these questions are in multiple-choice format with the provision of participants adding their own answer under "other". The second section with four questions aimed to identify the characteristic of the most current (sustainable) building project that the respondent had engaged in; such as building purpose, type of construction, location and targeted sustainability-related certifications. In the third and fourth sections (with 35 and 24 question, respectively), participants were asked to evaluate 35 critical success factors related to managing sustainability in a building project (factors that formed components of the SPM – See Chapter 3) and 24 project success criteria (that formed SPS concept – See Chapter 2), respectively. In the end of the survey, participants were asked to provide their concern (if applicable) on any issues related to the questions. Detailed questions in the survey are presented in the appendix.

With the choice and structure of questionnaire survey as demonstrated above, there are potential risks/threats and to ensure the quality of the collected data. Firstly, a large number of questions in the survey might make participants lose their interest when answering a half of them. The target time for finishing the survey was about 15 minutes, therefore it needs to make answer speed faster. To do so, this study used a standardized structure or similar question style for the majority of questions (in Likert scale), the standardize data was also required to test hypotheses. However, many CSFs are not easy to be asked in form of Likert scale, the ordinal measure might make participants feel hard to answer. Therefore, easy quantified questions were put in the earlier part, and hard quantified questions followed later. The answering process of participants was seen as a learning period, and they need to answer questions with increase of hardness level. Easy-quantified questions in the earlier parts helped to create a sense of ordinal level in their mind and they could handle with hard-quantified questions later. Besides, in the answer sheet, participants were encouraged to select "N/A" option if they are not sure about the answer. In fact, the number of NA choice for all questions were all lower than 10%, this revealed that the participants can managed to answer them all. Furthermore, participants in this study all had high education level (bachelor's degree or higher), and it was believed that they were able to understand, compare, adjust and select appropriate choices. Thanks to the higher education, participants were familiar with Likert scale questions. All these considerations were expected to mitigate the risk of unqualified answers from participants but might not totally. The detail discussion and limitation of the ordinal structure for question is further discussed in the following part.

Secondly, questions in surveys could *easily lead to respondents' confusion or misunderstanding*, especially in new areas of knowledge like sustainability. Therefore, a pilot investigation was carried out with the assistance of eight academic advisors and colleagues, who also had working experience in the industry. Their feedbacks and further suggestions helped to improve the clarity of questions. Besides, telephone number and email address are included in the survey so that participants' queries can be addressed.

Thirdly, *ambitious questions are also rephrased*, and respondents are reminded that there is no right or wrong answer and that only their honest evaluation can contribute to the success of the research. This action aims to remove bias when putting too much attention on the terms of sustainability, which could make people adopt fictional identities (Whitehead, 2007).

Another potential threat is that online survey can bring to the *possibility of repeat participation*, i.e., the same person has more than one recorded answer (Whitehead, 2007). The first two parts of the survey are designed with demographic questions about the backgrounds of respondents and projects. Then, repeat answers can be removed by comparing these questions; answers with high a level of similarity would be reviewed.

Finally, delivering questionnaire online meets a *notoriously low rate of response* (Aitken, Power, & Robyn Dwyer, 2008; Lefever et al., 2007). However, it enables reaching to a wider group. Therefore, a cover letter is prepared to encourage them joining the questionnaire as a chance to review their past projects and to get research findings. The letter also motivates respondents by respecting their ethical responsibility in supporting research and development; it has explained clearly what the research objectives are, and what their contribution can bring. This approach was successfully to attract a remarkable percentage of participants. More than 40% (103/257) of respondents left their contact address to get an update for the research. Another solution to increase the response rate is by a reminder. After ten days of sending the first invitation, potential participants were kindly reminded with another email; many of them responded after the second invitation, some also replied that they would like to join in the survey, but busy working schedule made them forgot the first email. After the second effort to engage them, no more reminders were sent to avoid causing aggravation. It is worthy to notice that money-equivalent incentive like shopping vouchers or random-selected awards are not using in this research; although this approach can boost up the response rate, they might bring negative impacts on data quality (Ilieva, Baron, & Healey, 2001).

4.3.3. The consideration of ordinal measurement for collecting expert opinion

For the majority of questions in the survey, a five-point Likert-scale was used to elicit the level of agreement (level 1 means "strongly disagree"; and level 5 presents "strongly agree" with the statements provided in each question). This ordinal psychometric measurement of attitude or opinion asked the participants to indicate a degree or a level in their justification. Since it does not require the respondents to provide a clear answer of yes or no, which might be not very clear in some situations. Besides, the target participants are professionals working in the UK, found as very familiar with marking questions; therefore, the structure of ordinal measurement in the majority of questions would fasten the answer speed, and then a more massive amount of data for each record could be collected. This advantage is critical in this research as the conceptual framework (MaSBuP) illustrated 59 factors in total. Without using the standardised structure for questions to speed up the answer speed, the study might not be able to collect a sufficient sample size. Furthermore, the standardised structure of questions (and then answers) allows statistical analysis to hypothesis the relationships between variables; this makes the ordinal measurement (for the factors of the conceptual framework) the only option to achieve the research objectives.

Although the Likert-scale questions are used popularly in an uncountable number of quantitative social research and because of its essential benefits, this ordinal measurement has a detrimental impact to the reliability of research results (Alwin & Krosnick, 1991). First, it fails to measure the real attitudes of respondents. Many respondents tended to avoid choosing extremes options (level 1 and/or level 5) on the scale due to negative implications involved with extremists, even in cases that ultimate choice would be the most correct. However, many others were also happy to give a very high or low score for factors. The different marking system between respondents made the absolute value of collected answers had less meaning. Still, the relative value of data would not be impacted significantly because relative value sees the relations in each respondents' answers. Therefore, the significance of relationships found would be risk-free from this limitation.

A more noticeable limitation of the method, respondents might found difficult in, firstly theoretical justifying the measurement, and then, in conveying a specific opinion to the survey as it exists in their minds (Alan Ladd & Alan, 2009). During the processing in their thinking, respondents sometimes create or magnify bias that is not factored into the survey. It could be explained that people see things in relations to others and asking a specific question might lead them thinking about one or more strong related issues. As a result, the answer is about another thing. This problem could be worse if the respondent does not understand the question or the question is not clear, and they would likely try to guess what they are asking. To solve this limitation, the design of the survey should assure questions in a clear voice, unique meaning, and have an appropriate language. Moreover, each variable had more than one reflective indicator to present it, so a failure in one or a few indicators would not lead to the erosion of latent variables. Unfortunately, these might not be able to eliminate the potential problems due to the complexity and insufficient understanding of sustainability terminology in the construction industry; the risk remains as an inherent limitation of the adopted method. As a potential result, it might reduce the reliability of measurement units, predictive power, and predictive relevance of the overall model. This limitation might also impact the strength and significance of relationships. With an assumption that the potential error made by the misunderstanding of questions and/or failing in conveying appropriate answer of respondents is in a normal distribution (means that they might make mistakes randomly), this impact is more likely toward the reduction of strength than an increase. Besides, it is very unlikely that random errors in answering questions of more than 140 different participants could make an insignificant relationship significant, but it might make significant relationships insignificant.

4.3.4. The delivery of the questionnaire survey

The questionnaire wasofficially launched in 30/08/2017 and was closed in 01/11/2017. The questionnaire used Bristol Online Survey platform with the license provided by Heriot-Watt University. Potential participants got two emails, the first invitation and then a reminder after ten days. Figure 4.2 demonstrates the evolution of successful responses gathered during September and October 2017.

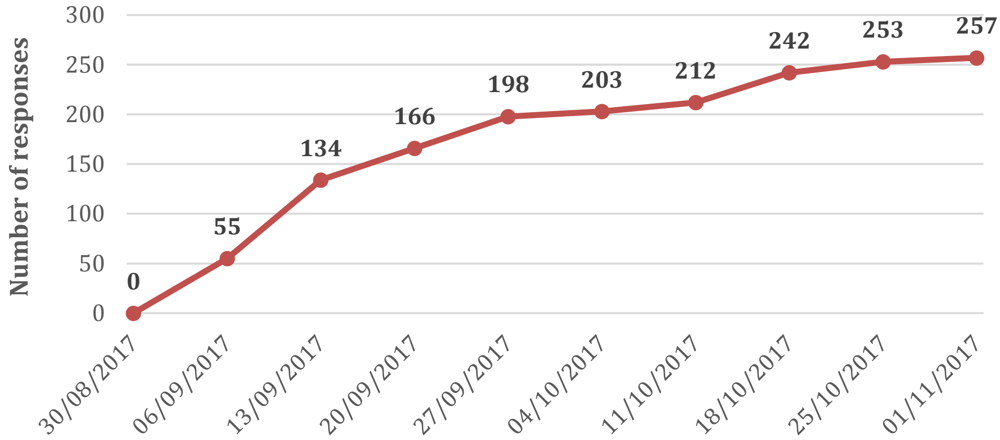


Figure 4.3. Evolution of successful responses

Targeted participants for the research are project managers or members of the project management team, who could able to answer questions about the management process (the third part of the questionnaire), and to evaluate outcomes of the project (the forth part of the questionnaire). Because these questions covered a wide range of management areas (from the initiation of project objectives to the management of resources, stakeholders, planning, materials, and risks), so the participants must have sufficient experience in the industry to answer them. Therefore, the study focused on professionals with at least two years of working experience in building project management in the UK. This "two-year" requirement was set as they must pass the graduate schemes, be independent in their working activities, and potetially have a position that could access all necessary information of the project.

The sampling approach for this research is non-probability, which is the only choice when no sampling frame exists and the total number of population is unknown. In this approach, samples are selected by systematically or purposefully selection (Maylor & Blackmom, 2005). The questionnaire is delivered to participants mainly through LinkedIn because a very high percentage of professionals in the UK (83%) use it as social media for careers (Trendence research, 2017). Because the Linkedin platform allows making a new connection via an existing connection, therefore sending an invitation email to participants, in this case, is a mix between convenience and snowball sampling approach.

4.3.5. Sample size

Regarding SEM analysis, there are several suggestions for the number of minimum sample size. First, Hair, Ringle, & Sarstedt (Hair, Ringle, & Sarstedt, 2011) suggested the minimum sample size is 10 times the largest number of indicators to measure one latent variable (i.e. 9*10=*90 samples* because ENHA has nine indicators) or 10 times the largest number of structural paths directed at a latent variable (i.e. 10*5=*50 samples* because PSP has five arrows pointing to). Second, G*Power software version 3.1 has a function to calculate the number of sample size in this case (Faul, Erdfelder, Lang, & Buchner, 2007; Ringle, Da Silva, & Bido, 2014). With a medium effect size of 0.15, alpha error probability at 5%, recommended power of 0.80 (Jacob Cohen, 1998; Hair, Hult, Ringle, & Sarstedt, 2017) and maximum five predictors in the model, then the minimum sample size calculated is *92 samples*. Third, Wong (2013) suggested having at least *70 samples* for five arrows pointing at construction in the model. To sum up, 92 samples is the larger than the three suggestions for the minimum of sample size in the quantitative research.

4.3.6. Response rate

Response rate shows the percentage of collected responses in the total number of people invited to participate in the survey. After two months of running the online questionnaire, about 1700 invitations were sent, and 257 responses were successfully achieved. Then, the response rate achieved is 14.91%, which is higher than an acceptable response rate for online survey defined (11%) by Saunders et al. (2012).

However, in 257 results collected, only 144 records are used for quantitative analysis. It means that 113 samples are eliminated from the research, due to several reasons. Firstly, all nine answers from participants with less than two years of experience working in the construction industry are removed. In the first two years of a new career, people are often in the graduate scheme of companies. Moreover, because the duration of a building project is longer than another type of industrial production, then two years of working experience would be very limited in answering the survey. Secondly, 46 answers about the projects outside the UK are eliminated from the database. Although participants are members of UK companies or they have experience in the UK construction industry, an international project would be very different from a domestic project regarding culture, local employment and many other factors. Thirdly, 32 non-building projects are removed as this research focus on buildings only. Finally, 23 answers are invalid because they are suspicious responses or their missing data exceed the threshold of 15%.

4.4. Data analysis techniques

The Partial Least Square Structural Equation Modelling (PLS-SEM) was employed as the primary data analysis technique in this study. PLS-SEM is a second-generation multivariate data analysis technique in analysing the cause-effect relationships between latent variables. This statistic method aims at maximising the explained variance of the dependent latent constructs/variables, and then the results can help to answer the relationship between them (Hair et al., 2011).

PLS-SEM is the most suitable method in this study. First, it can solve complex models like MaSBuP - which has ten constructs and up to 59 indicators. Other correlation tests such as Pearson or Spearman can only examine the relationship between two variables. By using these tests, the chain impacts between them and other variables in the model can not be examined; in other words, the whole picture of the problem would not be explored by these tests. PLS-SEM, however, can detect the strength and significance of relationships in the network of variables; in other words, all the five hypotheses (which aimed at empirical understanding the relationships among SPM's components and their impact to SPS – Objective 3) could be solved in a single model. The detected network of variables could further help to explain the mediation effect between them – a unique feature that none of the other correlation-testing techniques (such as Chi-Square, ANOVA, Pearson, Kendall, or Spearman) can do. With the complex network structure of the conceptual model presented in MaSBuP model, SEM was found as the most useful tool to test the hypotheses. Second, PLS-SEM is sturdy with a small sample size, and it can run with non-normal data (Afthanorhan, 2013; Hair et al., 2011). The collected data experienced a small amount of data missing (as some of the respondents might not be able to access all project documents in all stages; therefore, they were unable to answer all of the questions). Final, PLS-SEM fits with the research area. It was well-known in the field of operation and strategic management research (Hair, Ringle, & Sarstedt, 2013; Hair, Sarstedt, Pieper, & Ringle, 2012; Rigdon, 2012). Some examples of qualified research using PLS-SEM in construction management could be named as Banihashemi, Hosseini, Golizadeh, & Sankaran, (2017), Carvalho, Patah, & Souza Bido, (2015), Carvalho & Rabechini, (2017), Nagapan & Rahman (2016) or Alzahrani (2015).

SmartPLS software version 3.2.7 with license no 2017-03599 and 2018-09664 was selected to carry out SEM analysis. SmartPLS is a well-developed platform with more features and settings for analysing models than other competitors (like Adanco or SEMinR). Raw data was extracted from the Bristol Online Survey platform in the form of an MS Excel file. Then, it was coded and transferred to the SAV file for further analysis in SmartPLS.

Besides, the study used descriptive and preliminary analysis of data. The analysis was conducted in SPSS software. SPSS statistics version 20 software provided by Heriot-Watt University with support from IBM, which helped to analyse the mean, standard deviation (SD), frequency distribution histogram, missing data, suspicious response pattern, outliers, and normality test of collected data. The result of the descriptive and preliminary analysis is demonstrated in session 5.1 and 5.2. Besides, a mean rating was used to analyse the respondent's ratings for their actual performance of CSFs in the past projects. Result and discussion of mean rating analysis are presented in session 5.3. Finally, the study employed Spearman's rank of correlation test to assess the strength and sign of the relationship between each pair of indicators in the same latent variable of the hypothesised model. Spearman's test is selected as the data collected is non-normal distribution and in the form of the continuous variable of the Likert scale.

4.5. Framework development and evaluation

The most important objective of the research was to develop a framework for life-cycle project management practice in order to achieve project success and sustainability outcomes. The framework aims at giving guidance for the PM and their team in directing and managing building projects toward sustainable project success under the form of a holistic process map (from strategic definition stage to in-use stage) that is compatible with project management processes of BS: 6079-1:2010 standard.

The framework (named as GEPAS) was developed with IDEF0 modelling language. The development of this framework was shown in Figure 4.4. It was developed from the MaSBuP model. MaSBuP model was the combination and testing model in this research, with two main parts from the literature review: (1) SPM model with the five key components as shown in Chapter 3, and (2) SPS model with 4 components as defined in Chapter 2. This framework was also based on the testing results of inter-relationships between components of MaSBuP model (as results demonstrated in Chapter 5, using questionnaire survey to collect data and structural equation modelling technique for data analysis as demonstrated in the early parts of this Chapter). GEPAS developed the five components of SPM to five corresponding processes of sustainability management. These five processes were further broken down into 16 sub-process (or activities). The development of these 16 activities and its inputs/outputs were enlightened from 35 CSFs, significant relationships between variables in the model, guidelines on sustainable construction (including RIBA – Plan of work, CIBSE Guide L, and ISO 15392:2008) as well as existing Sustainable Project Management Processes (which were reviewed in Chapter 2).

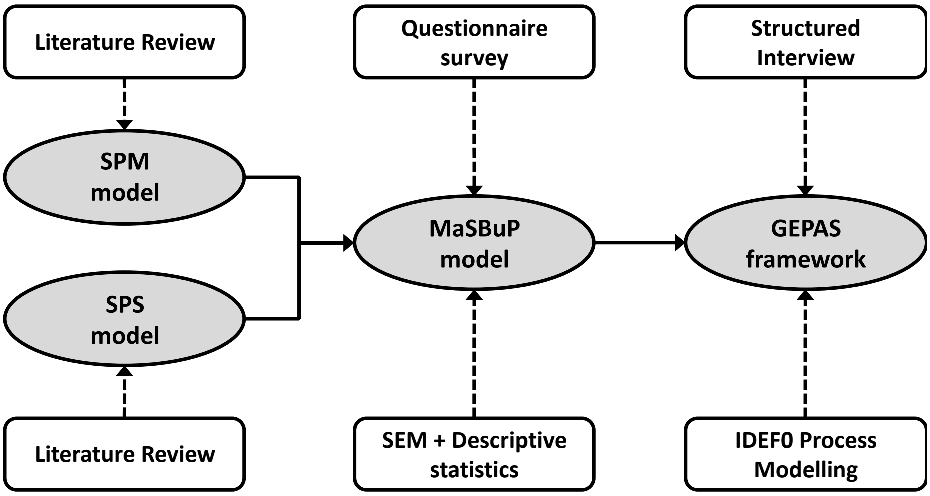


Figure 4.4. The development of GEPAS framework

The detail of GEPAS development is demonstrated in Chapter 6. After that, an evaluation was carried out to determine the verification and validation of the framework. The evaluation (presented in Chapter 7) used structured interviews with a mix of closed-end and open-ended questions.

4.6. Judging the adopted research design and methods

The quality assessment for research findings is demonstrated in Chapter 5, and the evaluation for the developed framework is shown in Chapter 7. This part aims at clarifying efforts made to minimise the threats to research quality in research design and methods selection.

The criteria for judging the quality of research depends on the epistemological stance (Easterby-Smith et al., 2012, p. 70). Because this research was put in critical realism philosophy worldview and in the use of a quantitative approach, therefore, the assurance of validity and reliability are critical for assessing the quality of this research design.

4.6.1. Reliability

Reliability focuses on whether measurement findings of the research can yield the consistent results with another repeated research (Easterby-Smith et al., 2012). Threats to the reliability of the research demonstrated by Robson (2011, pp. 86–87) were carefully considered in designing the research methods.

- *Participant error* was minimized by collecting data about the most recent project, which the participants could have the best memory in their mind. Questions in the survey were carefully piloted to reduce misunderstanding from respondents. Besides, the rule for answering questions in the Likert scale was designed with a similar structure to reduce the complexity. Moreover, the invitation was only sent to potential participants with more than two years of working experience to ensure that they could provide a proper evaluation.

- *Participant bias* was solved by giving anonymity to the research; no questions asked participants to provide their name, working for position or organisation. They were free to choose to join the survey in their spare time, so they were not under any pressure. However, the ethical aspect of sustainability could lead participants to the illusion of "good things" and make the result biased. Therefore, no stress was put on the terminology of sustainability, and questions related to the terminology were put in the very end of the survey. The questionnaire also reminded, two times, that the answer should be based on their personal experiences, and there was no right or wrong answer.
- Threads of *observer error and observer bias* were not affected to this research as the researcher position was in independence and all results were treated with statistical methods for data analysis. The errors from coding were eliminated by a double check and review.

4.6.2. Validity

Validity examines the accuracy of how research is conducted; in the context of a quantitative approach, it presents for the quality of measurement (Maylor & Blackmom, 2005, p. 158). Most of the threads to validity clarified by Creswell (2014, pp. 174–177) were not considered as a risk to this research, but the regression (i.e., participants with extreme score) was experienced. In preliminary data analysis, records of the suspicious pattern were removed.

4.6.3. Ethical issues

There are no major ethically pertinent concerns. Heriot-Watt University Code of Practice governing recruitment of research participants is followed in this research. Anonymous data collection and analysis is carried out; all responses are treated with the strictest confidence, and the data is only used for research purpose. Results are not published in any form that allows the identification of individuals or organisations. Participants could have stopped the survey at any time if they had been not comfortable. Moreover, the questionnaire came with a cover letter that indicates the aim of the survey, data collection and analysis procedures, their rights, potential contributions to the research, and contact information of the investigator.

4.7. Summary

This chapter has demonstrated the research design approach and discussed how it was adopted in the study. Basing on the philosophical viewpoint and adopted design, the study selected online questionnaire survey for the data collection and structural equation modelling (SEM) as primary data analysis technique, which was found as the most appropriate methods to achieve the research objectives. These methods are able to ensure the reliability and validity of the collected data and outcomes. The following Chapter shows the results of the adopted methods.

CHAPTER 5. EXPLORING INTER-RELATIONSHIPS BETWEEN THE COMPONENTS OF SPM AND THEIR IMPACTS TO SPS

This chapter presents SEM analysis and results of hypotheses testing, which aims to understand the inter-relationships between the five key components of SPM and their impacts to the achievement of SPS, which were conceptualised in Chapter 3. The input data obtained from the online survey demonstrated in Chapter 4.

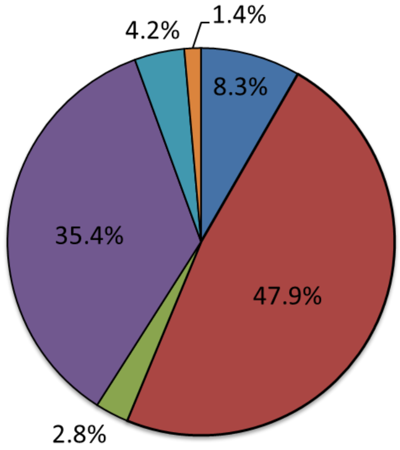
The chapter contains seven sections. The first section demonstrates the demographics of respondents and projects, which show the general characteristics of the group of participants and selected project for their evaluations. Then, the preliminary analysis examined and eliminated the potential risks/errors of collected data. Next, section of descriptive analysis of model variables scans through evaluated results of all indicators used in the model. The data interpretation was continued with the SEM analysis to test the stated hypotheses. A further detail analysis on the impact of SPM to SPS was carried out before discussing on the findings. The chapter ends with the conclusion.

5.1. The demographic profile of respondents and their selected projects

Demographic is the first part of the questionnaire survey as well as in this data interpretation. This section provides information on respondent profiles and their projects, which are used to identify patterns and interpret the findings in the study. Initially, a summarised profile of the participants was introduced with their main expertise areas and the number of years they had been working in project management and execution. Then, the following part introduced the characteristic of evaluated projects, such as types of property usage, locations, and sustainability-related certifications targeted/achieved of projects given by participants.

5.1.1. Respondents of the research

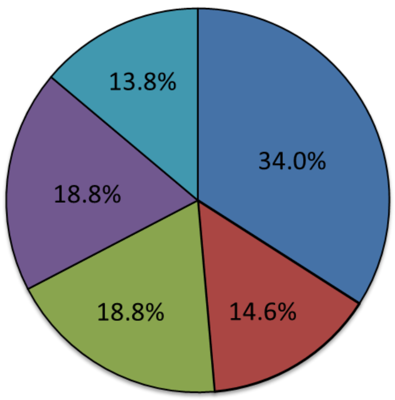
The research obtained 144 valid participants in different areas of expertise as illustrated in Figure 5.1. Participants in the questionnaire included managers at both program level (project directors) and project level (project managers, design manager, construction manager, building manager, and quantity surveyors), providing a multi-perspective view of the collected data. Answers from such participants like technical engineers and consultants were eliminated from the list of valid answers because they mainly focused on a narrow aspect of the project. Moreover, such respondents as pre-construction managers were not counted because they mainly worked in the early stage of the projects. All the selected participants for data analysis were in positions that could answer the complete assessment of the project.



Areas of expertise	Frequency	Percentage
Project director	12	8.3%
Project manager	69	47.9%
Design manager	4	2.8%
Construction manager	51	35.4%
Quantity surveyor	6	4.2%
Building manager	2	1.4%
Total	*144*	*100%*

Figure 5.1. Main expertise and experience of respondents

As the target was experienced professional, the research only considered contribution from participants with at least 2-year working in building projects. As demonstrated in Figure 5.2, the percentages of participants regarding their length of experience are 13.8% with 2-5 years, 18.8% with 6-10 years, 18.8% with 11-15 years, 14.6% with 16-20 years, and 34.0% with above 20 years of experience. Therefore, 86.2% of respondents have more than five years of experience in project management and execution, and 67.4% of them have more than ten years of such an experience.

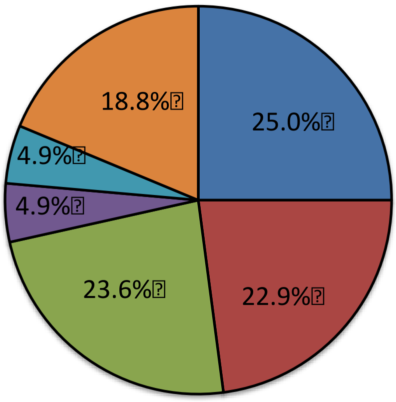


Years of experience	N	%	Cumulative %
Above 20 years	49	34.0%	34.0%
16-20 years	21	14.6%	48.6%
11-15 years	27	18.8%	67.4%
6-10 years	27	18.8%	86.2%
2-5 years	20	13.8%	100%
Total	*144*	*100%*	

Figure 5.2. Years of experience in managing and directing building projects of respondents

5.1.2. Selected projects for the evaluation

In the questionnaire, the participants were asked to provide general information on the most recent project they had worked in, which they can remember clearly. According to their answers, Figure 5.4 shows the types of ***property usage of the project***, including commercial buildings (36), residential buildings (33), educational buildings (34), medical buildings (7), governmental buildings (7) and mix-type buildings (27).

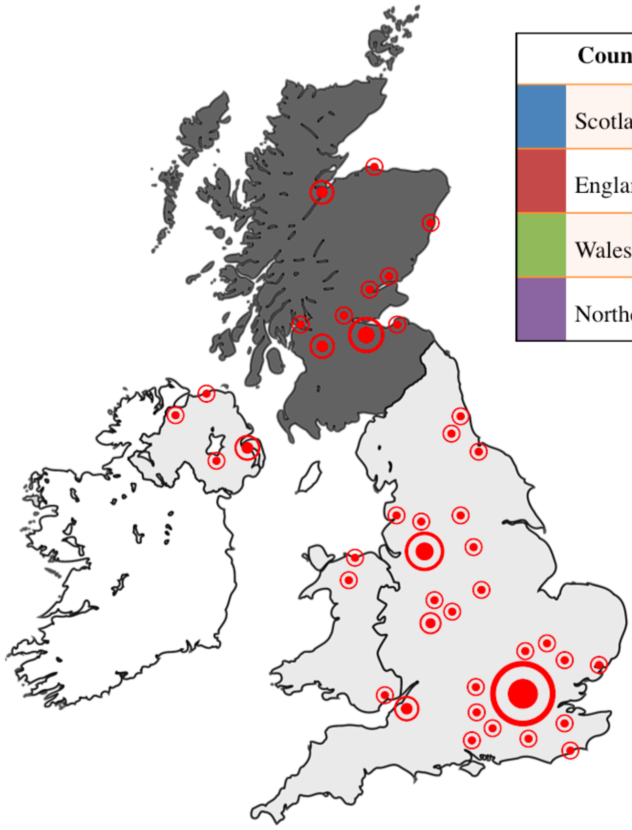


Property usage	N	%
Commercial buildings	36	25.0%
Residential buildings	33	22.9%
Educational buildings	34	23.6%
Medical buildings	7	4.9%
Governmental buildings	7	4.9%
Mixed-type buildings	27	18.8%
Total	*144*	*100%*

Figure 5.3. Types of property usage of building projects assessed

The projects assessed are located in all the four countries of the UK (as in Figure 5.5); England had the highest number of projects - at 106 buildings - whereas this number in Scotland, Wales, and Northern Ireland is 24, 3 and 5 buildings, respectively. These buildings are placed in cities and towns along the area of the UK, but there are some regions with a higher number of project in this sampling, for example, London (46), Manchester (8), Edinburgh (6) and Glasgow (4).

Most of the projects (125/144 or 87% of valid answers) were targeted for at least one type of **sustainability certifications.** Building Research Establishment Environmental Assessment Method (BREEAM) is the most popular one (92/125 projects) with all ranges of ranking from good (20/92), very good (19/92), excellent (30/92), to outstanding (1/92). Energy Performance Certificate (EPC) is the second highest number of projects in the research samples, at 23/124 or 18.5% of projects targeted. Other types of sustainability certifications are LEED, Code for sustainable homes, Passivhaus, SAP's impact report, Creative Carbon Scotland and RICS SKA rating. Many of the buildings also have features related to sustainability such as the use of photovoltaic panels, green/brown/blue roof, using green materials or the use of rainwater.



	Country	N	%
	Scotland	24	17.4%
	England	106	76.8%
	Wales	3	2.2%
	Northern Ireland	5	3.6%

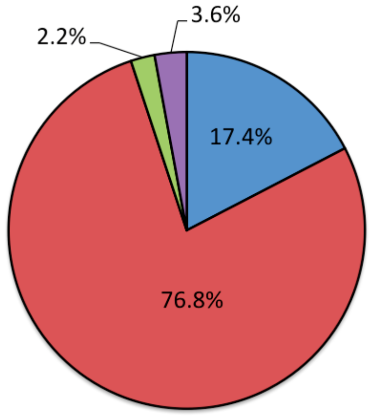


Figure 5.4. Locations of project assessed

5.2. Preliminary analysis

The main aim of the preliminary analysis is to identify errors in the data collected and to remove them from the database. In this step, data collected was examined to fit with the use of PLS-SEM, including issues related to missing data, suspicious response patterns, outliers, and data distribution.

- ***Missing data:*** The survey allowed participants to skip questions that they were not sure or were inappropriate to their working experience. However, if a record has more than 15% of missing data, it is not qualified for the running of SEM; therefore, 19 response with missing data in the section C and D of the questionnaire were removed from the analysis.
- ***Suspicious response patterns:*** It happens when participants provide the same answer to almost all of questions. Four records were found as extreme pole responses to the highest value of the measurement scale (i.e., the value of 5 – strongly agree/very high); they were removed from the database.
- ***Outliers:*** Outlier is an extreme response to one or more questions asked. By using the Explore tool in IBM SPSS, outlier-cases for indicators (illustrated in section C and D

of the questionnaire) of the testing model were identified. These outliers were all cases with lower rates of indicators assessment, which demonstrated a small number of projects with less-effective results. There was no reason to remove these outliers from the analysis, so they retained in the final database.

- o ***Non-normal data distribution:*** Skewness and kurtosis parameters were used to test normality in IBM SPSS. A distribution is considered to be normal when both their absolute values of skewness and kurtosis parameters are smaller than the double value of the correlative standard error of the parameter. The data were all non-normal for evaluated section C & D of the survey, which is typical in real data of social researches (Blanca, Arnau, López-Montiel, Bono, & Bendayan, 2013). Therefore, such non-parametric tests as PLS-SEM and Spearman's rank-order correlation were used in further analysis.

5.3. Descriptive analysis of the model variables

This part illustrates the mean, standard error, standard deviation and ranking for the evaluated performance of 35 critical success factors of the SPM model. All the evaluation of success factors were compared by their mean score value as illustrated in Table 5.1. In general, all 35 factors are rated at high level; the lowest mean value is 3.47/5.

When the top 12 high-performance factors (with a mean score equal or exceeding 3.9/5) were investigated; it was seen that there were 5 (out of 5) stakeholder-management factors and 6 (out of 8) project-team-enhancement factors. This implies that, on average, participants were relatively satisfied with efforts to improve the engagement of stakeholders and the ability of the project team in their projects. However, the 2 other factors of project team enhancement were quite low ranked in the list, reflecting the lower performance of the project management team in innovative thinking (Enha2 in rank #28) and continuous learning (Enha10 in rank #22). This shows that participants paid attention to developing innovation and on-going learning in the team, but were not yet entirely successful in these endeavours.

Table 5.1. Mean rating and ranking for the performance of critical success factors in managing sustainability in building projects

#	Critical success factors for managing sustainability in building projects	Mean	S.E	S.D	Rank
Enha3	Workers' health, safety and working conditions in a construction site	4.54	0.07	0.83	1
Asse6	Building commissioning is carried out	4.22	0.07	0.85	2
Enha4	Project team's skills and knowledge in executing project activities	4.17	0.07	0.88	3
Stak5	Stakeholders are involved in the early stages of projects	4.08	0.09	1.01	4
Stak4	Effective communication with clients and other stakeholders	4.06	0.08	0.96	5
Enha1	Responsibility and power for project team members to do their jobs	4.05	0.06	0.76	6
Enha6	Collaboration and communication among project team members	4.04	0.08	0.90	7
Stak2	Key stakeholders' vision, strategies & objectives are determined to align them with project goals	4.03	0.07	0.88	8
Enha5	Project managers' competences and experience about sustainability in construction projects	4.02	0.07	0.88	9
Stak3	Engagement of internal and external stakeholder to project activities	3.95	0.07	0.86	10
Stak1	Long-term value creation by all stakeholders is fully considered	3.94	0.08	0.91	11
Plan4	Waste reduction, reuse and recycle in the project is considered in the project plan	3.90	0.09	1.09	12
Enha7	Information transparency among project team members	3.90	0.08	0.94	12
Asse1	Green building or energy performance certificates targeted	3.88	0.08	0.96	14
Plan5	Natural environment conservation is considered in project plan	3.86	0.09	1.04	15
Asse5	Sustainability performance/progress is monitored and measured the project	3.83	0.08	0.94	16
Plan7	Effectiveness in allocating project resources	3.82	0.08	0.97	17
Asse2	Project management team considered sustainability-related standards to apply in project	3.81	0.07	0.86	18
Asse3	The project management team had sufficient understanding about SD regulations	3.81	0.07	0.85	18
Goal2	A sustainability ambition is created among project team members at the beginning of the project	3.78	0.08	0.95	20
Plan8	Efficient and environmental-friendly technologies and materials are used	3.77	0.09	1.03	21
Plan1	Identification, assessment and planning of sustainability-related risks	3.76	0.08	0.99	22
Enha1 0	The continuous learning process is implemented among the project team	3.76	0.09	1.02	22

Table 5.1. Mean rating and ranking for the performance of critical success factors in managing sustainability in building projects (cont)

#	Critical success factors for managing sustainability in building projects	Mean	S.E	S.D	Rank
Asse4	Environmental, economic and social impacts assessment in design and early stages	3.75	0.07	0.85	24
Asse7	Post-occupancy evaluation (POE) is carried out	3.74	0.09	1.01	25
Plan3	Considering sustainability achievement when selecting the project delivery method	3.73	0.09	1.11	26
Goal1	Promotion of stakeholders' awareness, knowledge and commitment to invest in sustainability	3.70	0.08	0.94	27
Enha2	Innovative solutions from project team members proposed (and discussed)	3.69	0.08	0.93	28
Enha8	Special advisors' involvement in a project to support for achieving sustainability targets/goals	3.69	0.08	0.98	28
Goal4	A sustainability mission statement with tangible objectives in project brief or project plan	3.67	0.09	1.07	30
Plan6	Planning a realistic schedule	3.67	0.09	1.04	30
Goal3	A declaration of the owner regarding sustainability goals is announced to all relevant stakeholders	3.66	0.09	1.04	32
Plan2	Identification and prioritization of sustainability issues	3.65	0.09	1.02	33
Plan9	Proposing and prioritizing sustainability-related activities	3.62	0.09	1.04	34
Enha9	Project team members are motivated towards sustainability at the beginning of the project	3.47	0.10	1.14	35

Furthermore, except for the performance of "Building commissioning" as the second highest ranking, other factors related to sustainability assessment (ASSE) were in the middle of the list (Ranks from #14 to #25). However, they were still in upper ranks of the two other issues: The evaluated performance of factors related to the definition of sustainable goals (GOAL with all 4/4 in 16 lowest ranks) and the planning for sustainability (PLAN with 6/10 in 16 lowest ranks). This result supports the argument that sustainability is a new and complex issue where related activities of management have lower performance than managers' expectations.

The assessment of factors by respondents does not only examine the performance of these factors in real projects, it also suggests the prioritisation of these activities in actual projects. This argument is set on the grounds that the performance of an activity could be higher if the project team puts more efforts on it, in other words, they treats it in higher priority than other ones. Therefore, the results of factors assessment above suggest that activities related core principles of traditional project management (such as obeying regulations, managing stakeholders, and developing project team's ability in controlling and delivering the project to meet required performance) receive more attention, whereas activities related to sustainability might get less attention. It might be the reasons that made actions related to defining sustainability goals, planning, assessing for sustainability, and developing project team's awareness and knowledge on issues of sustainability in current projects are not ranked highly. The framework developed in Chapter 6 ensures that more attention is paid to these issues.

5.4. Structural Equation Modelling (SEM) analysis

5.4.1. The use of a reflective measurement model

All latent variables in the testing model were assigned with multiple reflective indicators. In other words, these latent variables were measured through some indicators, related to the different aspects of the variables. The main aim of the reflective model is to maximize the overlap between indicators in the same construct; therefore, indicators in the same variable should be highly correlated and interchangeable with each other (Hair et al., 2017, p. 47). Table 5.2 and 5.3 illustrated medium to high correlations of indicators (blue parts), indicating that all indicators used are potentially good indicators for a reflective measurement model.

5.4.2. Metrics used for assessing measurement model and their threshold levels

To assess the quality of the measurement model, internal consistency reliability, convergent validity, and discriminant validity are all critical metrics in SEM (Hair et al., 2017). The results for assessing measurement model below (see Section 5.4.4) will prove that the conceptual model satisfies all these metrics.

- *Internal consistency reliability* is evaluated by Cronbach's alpha and Composite reliability that a model is accepted if both of the two metrics are more significant than 0.7 (Hair et al., 2017; Henseler, Ringle, & Sinkovics, 1992).

- *Convergent validity* considers the outer loading of indicators as well as Average Variance Extracted (AVE). The recommended threshold for outer loading of each indicator is 0.7; but a value between 0.4 and 0.7 could retain in the model if it has significant meaning to the construct/latent variable that it is presenting or in case that the elimination of that indicator results in a reduction of internal consistency and/or AVE value (Hair et al., 2017). AVE indicates the communality of a variable when it is larger than 0.5 (Fornell & Larcker, 1981; Henseler et al., 1992).

- *Discriminant validity* aims to ensure the distinction of each variable by empirical standards. Then, it requires an indicator's outer loading to be the highest in the line of the cross-loading table with other constructs. Another metric for discriminant validity is the Heterotrait-monotrait ratio (HTMT) by Henseler, Ringle, & Sarstedt (2015), which requires that the confident interval level of a variable does not overlap "value 1".

5.4.3. Modification of the measurement model

Based on essential assessment metrics for the measurement model stated above, the measurement models for latent variables are modified to increase reliability and validity, including necessary steps of combining indicators to get rid of semantically redundancy, removing indicators with low loadings and latent variables with unqualified observed results. The final revised testing model is illustrated in Figure 5.5.

Firstly, semantically redundant items (indicators with a very slight different in meaning) were identified. Although the reflective model was designed to maximize the overlap between indicators in the same latent variable/construct, redundant items could have the reverse effect on content validity and increase error term correlations in bootstrapping procedures. So the elimination of them would help to ensure the higher validity of the model. Indications of redundant items were found from not only the resemblance of questions in the survey but also by the very high Spearman's coefficient correlation of indicators, variance inflation factor (VIF), Cronbach's alpha and composite reliability (Tavakol & Dennick, 2011). Couples of indicators Plan1 and Plan2, Enha6 and Enha7, Asse6 and Asse7, SoS1 and SoS3 were detected as potential redundant items in pairs. Therefore, these indicators were merged using factor score. The calculation of factor score was carried out by factor analysis in SPSS where all the new combined indicators could explain more than 80% variance of data. These combinations of indicators also increase Cronbach's alpha, composite reliability, AVE as well as reduce VIF; in other words, the validity and reliability of the measurement model are increased. The new names and codes of merged indicators are shown in Table 5.4.

Table 5.2. Spearman's rank of correlation among indicators of sustainable project success (all values are significant at 1% level)

	Ppss1	Ppss2	Ppss3	StS5	StS6	StS7	EcS1	EcS2	EcS3	EcS4	EnS1	EnS2	EnS3	EnS4	EnS5	SoS1	SoS2	SoS3	SoS4
Ppss2	.354																		
Ppss3	.289	.574																	
Ppss4	.395	.206	.270																
StS6				.629															
StS7				.684	.556														
StS8				.384	.438	.485													
EcS2							.503												
EcS3							.287	.409											
EcS5							.281	.451	.439										
EnS1										.470									
EnS2										.421	.540								
EnS3										.391	.517	.590							
EnS4										.412	.510	.514	.597						
EnS5										.459	.473	.437	.572	.583					
EnS6										.259	.259	.315	.318	.388	.570				
SoS2																.612			
SoS3																.467	.483		
SoS4																.296	.446	.419	
SoS5																.424	.445	.360	.553

Table 5.3. Spearman's rank of correlation among indicators of MaSBuP model (all values are significant at 1% level)

	S1	S2	S3	S4	G1	G2	G3	P1	P2	P3	P4	P5	P6	P7		P8	A1	A2	A3	A4	A5	A6	E1	E2	E3	E4	E5	E6	E7	E8	E9
S2	.518																														
S3	.447	.509																													
S4	.481	.495	.542																												
S5	.349	.390	.586	.534																											
G2					.639																										
G3					.496	.741																									
G4					.558	.698	.724																								
P2								.816																							
P3								.582	.682																						
P4								.585	.561	.435																					
P5								.560	.567	.429	.678																				
P6								.552	.525	.389	.415	.420																			
P7								.474	.513	.420	.357	.292	.719																		
P8								.598	.611	.605	.660	.547	.478	.514																	
P9								.657	.681	.636	.508	.554	.453	.504		.753															
A2																	.655														
A3																	.469	.508													
A4																	.580	.526	.614												
A5																	.673	.618	.559	.679											
A6																	.399	.341	.438	.387	.353										
A7																	.333	.279	.426	.402	.366	.632									
E2																							.553								
E3																							.500	.425							
E4																							.683	.507	.479						
E5																							.601	.473	.500	.589					
E6																							.559	.442	.424	.616	.670				
E7																							.506	.354	.349	.500	.528	.739			
E8																							.457	.392	.247	.465	.461	.475	.553		
E9																							.434	.455	.280	.460	.459	.417	.544	.725	
ET10																							.415	.443	.361	.401	.415	.524	.538	.605	.682

**G: Goal; E: Enha; P: Plan; A: Asse; S: Stak*

Table 5.4. Combination of indicators for a better measurement model

Old code and name of indicators		*New code and name of indicators*	
Plan1	Identification, assessment, and planning of sustainability-related risks	Plan12	Identification, assessment, prioritization, and planning of sustainability-related risks and issues
Plan2	Identification and prioritization of sustainability issues		
Enha6	Collaboration and communication among project team members	Enha67	Collaboration, communication and information transparency among project team members
Enha7	Information transparency among project team members		
Asse6	Building commissioning is carried out	Asse67	Building commission and post-occupancy evaluation are carried out
Asse7	Post-occupancy evaluation (POE) is carried out		
SoS1	Health and safety in construction sites	SoS13	Safety, healthy and good working conditions for employees of the project
SoS3	Good working conditions for all employees		

It is advised that indicators with low outer loading should be considered for removal from the model to increase convergent validity (Hair et al., 2017). The desired outer loading is recommended to exceed 0.7 but an outer loading from 0.4 – 0.7 may be retained in the model if it has significant meaning to the construct, or in case that the elimination of that indicator results in a reduction of internal consistency and/or AVE value (Hair et al., 2017). There were nine indicators in this range, including:

Plan6 (l=0.507)	Asse67 (l=0.665)	EcS1 (l=0.541)
Plan7 (l=0.567)	Ppss2 (l=0.608)	EcS4 (l=0.603)
Enha3 (l=0.685)	Ppss3 (l=0.627)	EnS6 (l=0.681)

As the reflective model promotes the overlap of indicators, then more indicators could help to build up the latent variable better, and more indicators can have a positive effect on the R^2 value of the model. Hence, indicators with outer loading lower than 0.7 were only removed when its elimination led to a remarkable increase of composite reliability or AVE. Following that principle, two indicators P6 and P7 were eliminated from the model. Other indicators remained since removing them reduced the reliability and validity of the variables (i.e. values of Cronbach's alpha and Composite Reliability and AVE).

5.4.4. Evaluation of the measurement model

To determine the quality of the model, individual indicator validity and reliability, internal

consistency reliability, convergent validity, and discriminant validity were critical metrics in SEM analysis (Hair et al., 2017; MacKenzie, Podsakoff, & Podsakoff, 2011). The result of assessing measurement models are summarised in Table 5.5, which have satisfied all the requirements.

Table 5.5. Results for assessing the reliability and validity of the measurement model

Latent variables	Individual validity and reliability	Internal Consistency Reliability		Conver-gent validity	Discriminant validity
	Outer loading > 0.5	CA > 0.6	CR > 0.6	AVE > 0.5	HTMT (confidence interval ≠ 1)
GOAL	0.776 - 0.906	0.886	0.922	0.747	Yes
ENHA	0.685 - 0.804	0.906	0.923	0.573	Yes
PLAN	0.771 - 0.871	0.904	0.926	0.676	Yes
ASSE	0.665 - 0.844	0.873	0.905	0.615	Yes
STAK	0.699 - 0.827	0.846	0.890	0.619	Yes
PPSS	0.627 - 0.873	0.879	0.904	0.545	Yes
EcS	0.541 - 0.819	0.759	0.840	0.518	Yes
EnS	0.681 - 0.807	0.861	0.896	0.591	Yes
SoS	0.744 - 0.876	0.836	0.891	0.672	Yes
SPS	0.827 - 0.873	0.930	0.938	0.710	No, but accepted

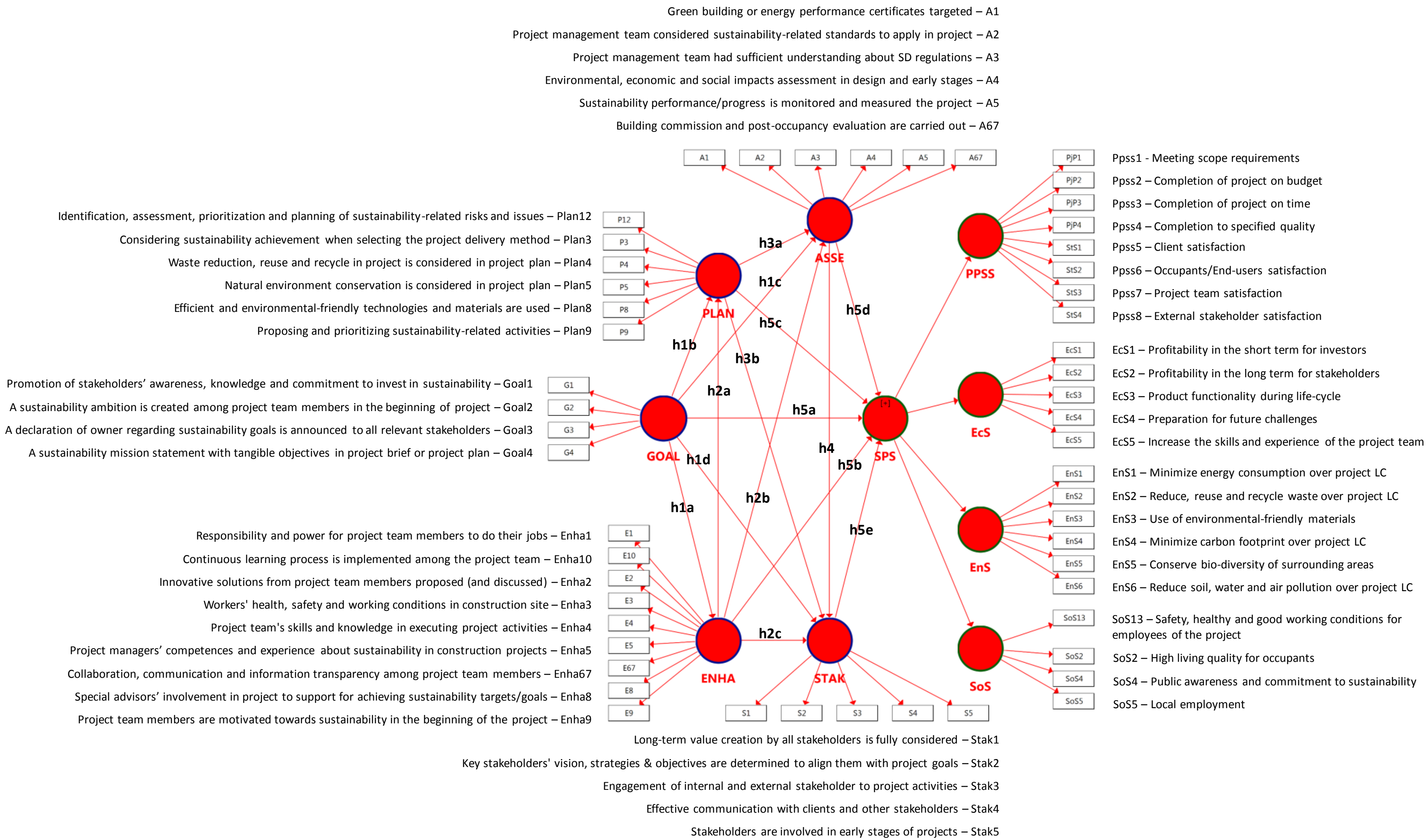


Figure 5.5. Final measurement model

5.4.4.1. *Individual indicator validity and reliability*

Individual indicator validity and reliability are reflected by outer loadings. The recommended threshold for outer loading of each indicator is 0.5 (Fornell & Larcker, 1981; MacKenzie et al., 2011). In this model, the smallest value of outer loading was 0.541 and more than 86% of them were more significant than 0.7.

5.4.4.2. *Internal consistency reliability*

Internal consistency reliability was evaluated by Cronbach's Alpha (CA) and Composite Reliability (CR). The actual reliability value is between CA and CR because CA tends to underestimate the reliability whereas CR ratio is an overestimated ratio (Hair et al., 2017). A model is acceptable if both of the two metrics are more substantial than 0.6 (Hair et al., 2017; Henseler et al., 1992). All latent variables of the model achieved a very high internal consistency reliability, where the minimum CA and CR value of obtained variables was 0.759, and the average values of them were 0.87 and 0.90, respectively.

5.4.4.3. *Convergent validity*

Convergent validity for variables considers Average Variance Extracted (AVE). A high AVE value means that the latent variable can account for a majority of the variance of its indicators (MacKenzie et al., 2011). In this case, the AVE value of each variable exceeded the threshold of 0.5 (i.e., more than 50% of variance was captured by latent variables). It is worth to note that the AVE value of the second-order variable (i.e., Sustainable Project Success - SPS) was calculated by averaging the squared multiple correlations for its first-order variables (PPSP, EcS, EnS, and SoS) as suggestion from MacKenzie et al. (2011).

5.4.4.4. *Discriminant validity*

Discriminant validity aims at ensuring the distinction between each variable by empirical standards, i.e., every variable is unique, and the phenomena captured is not characterised by other variables in the same model. There are three approaches in assessing discriminant validity, including cross-loadings, Fornell-Larcker criterion, and the Heterotrait-Monotrait ratio (HTMT) (Hair et al., 2017). The detailed results for all three approaches described below show that the discriminant validity of the model was fulfilled.

a. Cross-loadings analysis

Cross-loadings analysis compares outer loadings' values as demonstrated in Table 5.6. If an indicator is associated with a construct, its outer loading on that variable should be larger than all other outer loadings of the indicator on other variables (Hair et al., 2017). In this case, all indicators associated with its corresponding variables (in blue cells) had the largest outer-loading in the line. Therefore, the model was accepted by cross-loading analysis.

Table 5.6. The result of cross-loading analysis

	GOAL	ENHA	PLAN	ASSE	STAK	PPSS	EcS	EnS	SoS
Goal1	0.776	0.436	0.510	0.564	0.507	0.386	0.385	0.474	0.443
Goal2	0.906	0.539	0.563	0.663	0.478	0.363	0.475	0.559	0.476
Gola3	0.882	0.542	0.632	0.652	0.551	0.304	0.446	0.539	0.448
Goal4	0.889	0.589	0.729	0.689	0.524	0.309	0.414	0.548	0.503
Enha1	0.458	0.790	0.435	0.523	0.445	0.388	0.318	0.376	0.503
Enha10	0.470	0.745	0.477	0.450	0.344	0.186	0.283	0.355	0.388
Enha2	0.414	0.722	0.452	0.509	0.372	0.370	0.362	0.406	0.500
Enha3	0.360	0.685	0.402	0.474	0.501	0.276	0.362	0.353	0.558
Enha4	0.409	0.804	0.438	0.557	0.421	0.372	0.356	0.370	0.451
Enha5	0.424	0.775	0.465	0.504	0.392	0.293	0.295	0.398	0.367
Enha67	0.405	0.793	0.453	0.516	0.508	0.371	0.300	0.389	0.435
Enha8	0.543	0.725	0.575	0.587	0.304	0.257	0.278	0.420	0.364
Enha9	0.640	0.765	0.654	0.639	0.391	0.220	0.348	0.525	0.445
Plan12	0.727	0.629	0.877	0.778	0.549	0.352	0.464	0.637	0.559
Plan3	0.554	0.509	0.771	0.563	0.362	0.192	0.389	0.487	0.455
Plan4	0.483	0.455	0.782	0.572	0.389	0.276	0.393	0.604	0.484
Plan5	0.497	0.458	0.797	0.604	0.462	0.159	0.305	0.524	0.429
Plan8	0.560	0.541	0.850	0.622	0.336	0.256	0.335	0.588	0.466
Plan9	0.635	0.568	0.851	0.679	0.334	0.205	0.343	0.587	0.427
Asse1	0.627	0.445	0.570	0.795	0.336	0.335	0.401	0.559	0.414
Asse2	0.640	0.543	0.633	0.768	0.353	0.319	0.380	0.559	0.402
Asse3	0.515	0.554	0.651	0.787	0.495	0.385	0.474	0.538	0.479
Asse4	0.611	0.601	0.674	0.844	0.500	0.339	0.407	0.600	0.497
Asse5	0.611	0.597	0.672	0.833	0.375	0.340	0.376	0.561	0.467
Asse67	0.502	0.560	0.459	0.665	0.529	0.373	0.443	0.407	0.487
Stak1	0.456	0.294	0.430	0.420	0.699	0.302	0.363	0.289	0.462
Stak2	0.371	0.363	0.377	0.375	0.790	0.279	0.414	0.346	0.419
Stak3	0.478	0.454	0.385	0.449	0.823	0.405	0.468	0.377	0.456
Stak4	0.485	0.421	0.395	0.431	0.827	0.453	0.401	0.350	0.484
Stak5	0.528	0.544	0.384	0.486	0.789	0.422	0.518	0.483	0.554
Ppss1	0.192	0.269	0.144	0.313	0.247	0.716	0.458	0.361	0.450
Ppss2	0.236	0.217	0.131	0.142	0.331	0.608	0.339	0.234	0.351
Ppss3	0.219	0.253	0.153	0.193	0.247	0.627	0.318	0.175	0.216
Ppss4	0.195	0.222	0.185	0.285	0.183	0.733	0.465	0.366	0.342

	GOAL	ENHA	PLAN	ASSE	STAK	PPSS	EcS	EnS	SoS
Ppss5	0.319	0.289	0.211	0.374	0.375	0.873	0.536	0.398	0.478
Ppss6	0.367	0.345	0.331	0.519	0.470	0.776	0.592	0.478	0.560
Ppss7	0.369	0.412	0.296	0.359	0.494	0.828	0.514	0.313	0.497
Ppss8	0.364	0.326	0.253	0.335	0.438	0.704	0.547	0.367	0.490
EcS1	0.194	0.056	0.040	0.113	0.242	0.382	0.541	0.217	0.333
EcS2	0.340	0.219	0.285	0.406	0.386	0.556	0.809	0.485	0.485
EcS3	0.367	0.368	0.376	0.469	0.423	0.527	0.780	0.550	0.485
EcS4	0.462	0.395	0.519	0.455	0.402	0.264	0.603	0.577	0.384
EcS5	0.411	0.434	0.373	0.401	0.510	0.566	0.819	0.557	0.643
EnS1	0.545	0.460	0.574	0.563	0.471	0.422	0.619	0.781	0.506
EnS2	0.363	0.408	0.580	0.474	0.313	0.327	0.493	0.761	0.406
EnS3	0.533	0.401	0.565	0.552	0.259	0.339	0.438	0.771	0.449
EnS4	0.550	0.415	0.558	0.551	0.343	0.322	0.497	0.805	0.480
EnS5	0.458	0.398	0.540	0.534	0.338	0.338	0.537	0.807	0.513
EnS6	0.374	0.367	0.398	0.489	0.453	0.405	0.519	0.681	0.592
SoS13	0.346	0.425	0.404	0.424	0.470	0.565	0.579	0.501	0.871
SoS2	0.436	0.494	0.450	0.533	0.565	0.591	0.634	0.591	0.876
SoS4	0.575	0.564	0.591	0.528	0.485	0.366	0.466	0.540	0.744
SoS5	0.448	0.464	0.468	0.443	0.475	0.373	0.472	0.469	0.780

b. Fornell-Larcker criterion analysis

Fornell-Larcker criterion analysis is satisfied if the square root of AVE ($\sqrt{\text{AVE}}$) of a variable is larger than any other latent variable correlations (of that variable to other constructs). The logic behind the Fornell-Larcker criterion is that a variable should share less variance with another variable than with its associated indicators (Hair et al., 2017). Table 5.7 shows $\sqrt{\text{AVE}}$ in blue cells and the corelation between variables in grey cells. The measurement model was accepted because the value in the blue cells were the largest in their corresponding rows and columns.

Table 5.7. The result of Fornell-Larcker criterion analysis

	GOAL	ENHA	PLAN	ASSE	STAK	PPSS	EcS	EnS	SoS
GOAL	0.865								
ENHA	0.613	0.757							
PLAN	0.709	0.646	0.822						
ASSE	0.745	0.705	0.781	0.784					
STAK	0.596	0.539	0.499	0.554	0.787				
PPSS	0.391	0.400	0.298	0.445	0.481	0.738			
EcS	0.497	0.427	0.455	0.528	0.556	0.652	0.720		
EnS	0.614	0.533	0.697	0.688	0.477	0.470	0.677	0.769	
SoS	0.541	0.588	0.575	0.586	0.609	0.589	0.662	0.642	0.820

c. Heterotrait-Monotrait ratio (HTMT)

Heterotrait-Monotrait ratio (HTMT) has been considered as the most powerful metric to measure the "true correlation between two variables if they are perfectly measured" (Henseler et al., 2015). In SmartPLS, HTMT is examined through a bootstrapping procedure to test whether HTMT is significantly different from 1 (Hair et al., 2017). If the confidence interval (from 2.5% to 97.5%) does not include 1, the discriminant validity of the model is satisfied – meaning that each variable in the model is genuinely distinct from the rest of variables. Table 5.8 shows the HTMT values along with their 95% bias-corrected and accelerated bootstrap confidence intervals. It can be seen that all HTMT values between any two variables are all significantly different from 1, except for SPS and EcS. Besides, the HTMT values between SPS and EnS, SPS and PPSP, and SPS and SoS in pairs are also very high. However, this is considered reasonable because SPS was the high-order variable, so it took all indicators of its lower-order variables (including PPSP, EcS, EnS, and SoS) as its measurement unit. Sharing the same indicators, it is obvious that lower-order variables (including PPSP, EcS, EnS, and SoS) and their higher-order variable (SPS) could not be distinguished from each other. Discriminant validity, therefore, was not necessary for a hierarchical component model of SPS and its second-latent variables.

Table 5.8. The result of the confidence interval for HTMT (bias corrected)

Constructs	Original Sample	Sample Mean	Bias	Interval		**Confidence interval ≠ 1**
				2.5%	**97.5%**	
GOAL -> ENHA	0.673	0.672	-0.001	0.524	0.792	Yes
GOAL -> ASSE	0.848	0.849	0.001	0.765	0.913	Yes

GOAL -> EcS	0.607	0.608	0.001	0.432	0.753	Yes
GOAL -> EnS	0.701	0.702	0.001	0.534	0.823	Yes
ENHA -> ASSE	0.784	0.784	-0.001	0.664	0.870	Yes
PLAN -> ENHA	0.701	0.700	-0.001	0.546	0.816	Yes
PLAN -> ASSE	0.870	0.871	0.001	0.787	0.930	Yes
PLAN -> EcS	0.548	0.559	0.012	0.388	0.664	Yes
PLAN -> EnS	0.789	0.791	0.002	0.621	0.901	Yes
PLAN -> GOAL	0.779	0.780	0.001	0.661	0.864	Yes
STAK -> ENHA	0.604	0.602	-0.002	0.440	0.729	Yes
STAK -> ASSE	0.637	0.636	-0.001	0.478	0.753	Yes
STAK -> EcS	0.679	0.676	-0.003	0.505	0.815	Yes
STAK -> EnS	0.544	0.543	-0.001	0.368	0.694	Yes
STAK -> GOAL	0.682	0.682	0.000	0.535	0.790	Yes
STAK -> PLAN	0.567	0.563	-0.003	0.382	0.710	Yes
STAK -> PPSS	0.539	0.545	0.006	0.369	0.691	Yes
STAK -> SPS	0.686	0.688	0.001	0.518	0.801	Yes
SPS -> ASSE	0.726	0.729	0.002	0.595	0.822	Yes
SPS -> ENHA	0.619	0.626	0.007	0.477	0.726	Yes
PPSS -> ASSE	0.490	0.494	0.005	0.319	0.637	Yes
PPSS -> ENHA	0.446	0.455	0.009	0.288	0.594	Yes
PPSS -> EcS	0.775	0.771	-0.005	0.590	0.883	Yes
PPSS -> EnS	0.524	0.525	0.001	0.321	0.677	Yes
PPSS -> GOAL	0.440	0.444	0.004	0.290	0.584	Yes
PPSS -> PLAN	0.320	0.334	0.014	0.178	0.465	Yes
EcS -> ASSE	0.636	0.639	0.003	0.472	0.766	Yes
EcS -> ENHA	0.506	0.519	0.013	0.328	0.629	Yes
EnS -> ASSE	0.792	0.791	0.000	0.673	0.879	Yes
EnS -> ENHA	0.596	0.595	-0.001	0.409	0.735	Yes
EnS -> EcS	0.824	0.821	-0.003	0.692	0.922	Yes
SoS -> ASSE	0.688	0.684	-0.004	0.535	0.795	Yes
SoS -> ENHA	0.683	0.682	-0.001	0.536	0.791	Yes
SoS -> EcS	0.813	0.804	-0.009	0.628	0.930	Yes
SoS -> EnS	0.753	0.748	-0.005	0.594	0.856	Yes
SoS -> GOAL	0.640	0.638	-0.002	0.484	0.760	Yes
SoS -> PLAN	0.669	0.665	-0.003	0.522	0.785	Yes
SoS -> PPSS	0.659	0.656	-0.003	0.454	0.794	Yes
SoS -> STAK	0.718	0.713	-0.005	0.505	0.858	Yes
SPS -> GOAL	0.662	0.665	0.002	0.543	0.757	Yes
SPS -> PLAN	0.635	0.643	0.009	0.518	0.727	Yes
SPS -> EcS	1.029	1.028	0.000	0.989	1.085	No, but accepted
SPS -> EnS	0.910	0.911	0.001	0.843	0.955	Very high, but accepted
SPS -> PPSS	0.926	0.927	0.001	0.865	0.964	
PSP -> SoS	0.931	0.929	-0.002	0.846	0.984	

5.4.5. Evaluation of the structural model

After several steps to check the validity and reliability of measurement models, the analysis was continued with an assessment of the structural model regarding collinearity issues and predictive power, results of hypotheses test, and mediation effect by SEM.

5.4.5.1. Collinearity

Collinearity represents for the very high correlations between variables because they share a very similar variances. The existence of collinearity leads to the boost of standard errors, and the reversed impact to the estimation of coefficients as well as their significance (Hair et al., 2017). Variance inflation factor (VIF) ratio is used to assess the collinearity issue. As all the inner VIF values of this model (the left part of *Table 5.9*) were less than the threshold of 5, the whole model, therefore, was not considered as a potential collinearity problem (Hair et al., 2011; Wong, 2013).

Table 5.9. Tests for co-linearity, predictive power and effect size of the structural model

Variable	**VIF ratios**					**R^2**	**Q^2**
	ENHA	***PLAN***	***ASSE***	***STAK***	***SPS***		
GOAL	1.000	1.601	2.193	2.520	2.748		
ENHA		1.601	1.871	2.118	2.210	0.376	0.183
PLAN			2.350	2.916	2.916	0.574	0.337
ASSE				3.584	3.608	0.721	0.386
STAK					1.690	0.408	0.211
PPSS						0.686	0.309
EcS						0.762	0.342
EnS						0.683	0.354
SoS						0.708	0.422
SPS						0.550	0.185

5.4.5.2. Predictive power and predictive relevance

In PLS-SEM, the predictive power of the model is evaluated by the coefficient of determination (R^2) and predictive relevance is assessed by Stone-Geisser's Q^2 value. In general, as demonstrated in Table 5.9, the model was relevant and accuracy for understanding the relationships between the latent variables. The predictive power and predictive relevant measure the reliability of path coefficients (which indicate the strength of relationships between variables). In detail:

- *Predictive power (R^2)* measures the percentage of the variation in the dependent variable which can be attributed to variation in the independent variable (Hair et al., 2017). In this model, R^2 values for endogenous variables were in the range from 37.6% to 76.2%, illustrated in the circles of Figure 5.10. ENHA had no R^2 value because it did not have any flowing arrows. As noted by Cohen (1998) in social research, an R^2 value above 26% is considered substantial. Therefore, all the variables in the model have high predictive power.
- *Predictive relevance (Q^2)* measures the out-of-sample predictive power, and it is calculated by blindfolding process to evaluate the predictive relevance for a specific endogenous variable (Hair et al., 2017). All Q^2 values were far exceeded zero, so the model had predictive relevance for all endogenous constructs.

5.4.5.3. Strength and significance of correlations - Testing results for hypotheses

PLS-SEM used a bootstrapping procedure to generate 5000 samples from the observed data, and then all these samples were used to test the significance of the path coefficients between variables (Hair et al., 2017). All hypotheses were tested at a significance level α=5%. Table 5.10 and Figure 5.7 summaries the hypotheses testing about the significance of path-coefficient. A higher value of path-coefficient presents for a stronger association between the two variables. Detailed results showed that ten out of fifteen sub-hypotheses were fully supported at a significance level of 5% or less; and five sub-hypotheses of the relationship between variables were not supported by the data collected.

Table 5.10. The result of significance tests for the path coefficients

Ref	*Hypotheses*	*Path coefficient*	*T-value*	*P-value*	*Inference*
h1a	GOAL → ENHA	0.613	10.116	0.000	Supported
h1b	GOAL → PLAN	0.502	6.599	0.000	Supported
h1c	GOAL → ASSE	0.302	5.014	0.000	Supported
h1d	GOAL → STAK	0.367	3.209	0.001	Supported
h2a	ENHA → PLAN	0.339	3.828	0.000	Supported
h2b	ENHA → ASSE	0.263	4.037	0.000	Supported
h2c	ENHA → STAK	0.234	2.085	0.037	Supported
h3a	PLAN → ASSE	0.397	5.650	0.000	Supported
h3b	PLAN → STAK	-0.007	0.045	0.964	*Not supported*
h4	ASSE → STAK	0.121	0.961	0.337	*Not supported*
h5a	GOAL → SPS	0.065	0.592	0.554	*Not supported*
h5b	ENHA → SPS	0.085	0.965	0.334	*Not supported*
h5c	PLAN → SPS	0.094	0.918	0.359	*Not supported*
h5d	ASSE → SPS	0.305	2.919	0.004	Supported
h5e	STAK → SPS	0.324	3.901	0.000	Supported

The result illustrates that all these five variables of SPM are interrelated. Four hypotheses (h1, h2, h3, and h4) addressed the interrelationship among the five components of SPM. The coefficient paths in Figure 5.7 show that GOAL supports for the implementation of other constructs, including ENHA, STAK, PLAN, and ASSE (h1 was fully supported). Also, the enhancement of the project team toward sustainability (ENHA) has a positive impact on the implementation of other processes (h2 was fully supported), including STAK, PLAN, and ASSE. Furthermore, the higher effort on the PLAN was made, the more facilitation ASSE can have (h3a was supported).

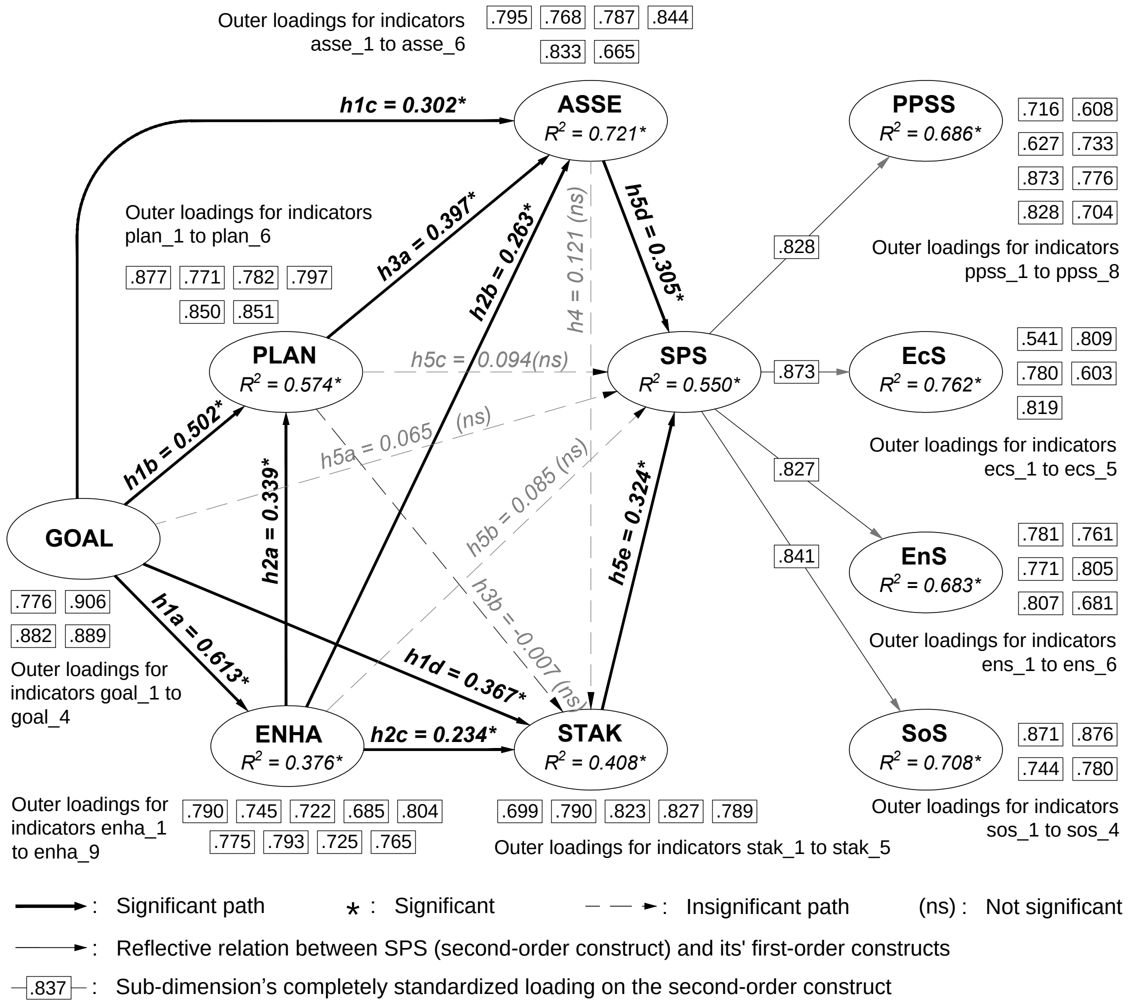


Figure 5.6. Types of relationships among latent variables of the testing model

Two of the five key variables of SPM, STAK and ASSE, were found in significant relationships with SPS. This finding implies that a higher level of stakeholder management and sustainability assessment are associated with the achievement of sustainable project success. Interestingly, STAK had slightly higher direct influence on SPS than ASSE ($p_{STAK\text{-}SPS} = 0.324 > p_{ASSE\text{-}SPS} = 0.305$). In addition, project team enhancement (ENHA), sustainability goals definition GOAL, and sustainability planning (PLAN) did not have significant direct relationships with SPS (drop of h1a, h1b, and h1c). However, because of their high correlations with stakeholder management STAK and sustainability assessment ASSE, they can potentially support the achievement of sustainable results indirectly.

However, it is important to note that within a complex interrelationship network among variables, complementary mediation effects appear that enhance the strength of the relationship with indirect effects (Hair et al., 2017). Therefore, the total impact of variables such as GOAL or ENHA to other variables, especially ASSE, might be sturdy. The following part would examine this mediation effect.

5.4.5.4. Mediation effect

Because the model contained an inter-relationship among variables (i.e., a complex network of variables), then the meditating effect might appear. Mediation happens when a third variable (mediator) intervenes between two other variables, and its impacts (enhance or reduce) the relationship between the two variables (Hair et al., 2017). For example, in Figure 5.7, sustainability goal definition (GOAL) has a moderate impact to sustainable planning (PLAN), the path coefficient ($p_{GOAL->PLAN}$=0.502) shows a direct and postive effect of the relationship between GOAL and PLAN. This relationship is intervened by enhancement of project team toward sustainability (ENHA), which has significant relationships with both of GOAL and PLAN (path coefficient/direct effect of $p_{GOAL->ENHA}$=0.613 and $p_{ENHA->PLAN}$=0.339. As a result, ENHA has an indirect effect or mediating effect between GOAL and PLAN. The strength of this indirect effect is calculated as:

$$p_{GOAL->PLAN}^{indirect} = p_{GOAL->ENHA}^{direct} * P_{ENHA->PLAN}^{direct} = 0.613 * 0.339 = 0.208$$

By a bootstrapping procedure, SmartPLS can identify the significance of all the indirect effects between latent variables in pairs. The result of a significance test for indirect effects is illustrated in the fourth column of Table 5.11. It is important to note that to run the bootstrapping process for mediation analysis, insignificant paths from original model (as demonstrated in Figure 5.6) were removed to reduce the impact of insignificant weights in the model. Therefore, the result of direct effect in this Table would be slightly different from the result shown in Table 5.10, however, the significance and the meaning of values are not different.

Based on the significance of direct effect and indirect relationships among latent variables, there are four types of mediation effects in this research:

- No effect (*no-relationship*): Both direct and indirect effect are not significant;
- The indirect effect only (*full-mediation*): The indirect effect is significant, but the direct effect is not. There is no direct relationship between the two variables (as hypothesis tested), but all significant direct relationships of variables intervene between them created the full mediation effect;
- The direct effect only (*no-mediation*): Only the direct effect is significant, the indirect

effect is not significant;

- Complementary (*partial-mediation*): Both direct and indirect effect are significant, and then intervening variables play as complementary variables.

Table 5.11. Direct effect, indirect effect and total effects of all relationship hypotheses

Hypo-theses	Relationships	Direct effect	Indirect effect**	Total effect	Types of meditation effect
h1a	GOAL → ENHA	0.615*		0.615*	**No-mediation**
h1b	GOAL → PLAN	0.502*	0.209*	0.711*	*Partial-mediation*
h1c	GOAL → ASSE	0.305*	0.442*	0.746*	*Partial-mediation*
h1d	GOAL → STAK	0.425*	0.170*	0.596*	*Partial-mediation*
h2a	ENHA → PLAN	0.340*		0.340*	**No-mediation**
h2b	ENHA → ASSE	0.257*	0.136*	0.393*	*Partial-mediation*
h2c	ENHA → STAK	0.277*		0.277*	**No-mediation**
h3a	PLAN → ASSE	0.399*		0.399*	**No-mediation**
h3b	PLAN → STAK				**No-relationship**
h4	ASSE → STAK				**No-relationship**
h5a	GOAL → SPS		0.565*	0.565*	**Full-mediation**
h5b	ENHA → SPS		0.283*	0.283*	**Full-mediation**
h5c	PLAN → SPS		0.183*	0.183*	**Full-mediation**
h5d	ASSE → SPS	0.460*		0.460*	**No-mediation**
h5e	STAK → SPS	0.372*		0.372*	**No-mediation**

** Significance at <0.1%; ** For variables with multiple mediation effect, all specific indirect effects among paths were also found significant*

The result of mediation analysis further explained the result on strength and significance of the identified relationships in Section 5.4.5.3. The roles of GOAL and ENHA were crucial because of their notable total impacts to other variables. For instance, the total effects of the GOAL to ENHA, PLAN, ASSE and STAKE (h1) are all substantial (from 0.596 to 0.746). Similarly, ENHA also has partial-mediation effect on ASSE (h2b with total effect equal to 0.393). Moreover, these two variables (GOAL and ENHA) were found as bearing indirect-only effect on the achievement of SPS (full-mediation found in h5a: $p^{total}_{GOAL\text{->}SPS}$=0.565 and h5b: $p^{total}_{ENHA\text{->}SPS}$=0.283).

In conclusion, the finding of meditation analysis emphasized the crucial role of sustainability goals definition (GOAL) and project team enhancement (ENHA) in enabling processes of stakeholder management (STAK), sustainability planning (PLAN) and sustainability assessment (ASSE) more effectively. Through the action of boosting up these variables, GOAL and ENHA can affect the achievement of SPS, indirectly but remarkably.

5.5. Further detail on the impact of SPM to SPS (expanded model)

To understand the detail impacts of SPM's components to the four pillars of the SPS, all insignificant relations in Figure 5.6 were removed from the model, and the two variables of SPM that have direct impact to SPS (including STAK and ASSE) were tested to understand their impacts on each component of SPS (including PPSP, EcS, EnS, and SoS). Therefore, hypotheses h5d and h5e were broken into eight sub-hypotheses in the expanded SEM model:

- *Hypothesis h5d.1 (ASSE -> PPSP): Sustainability assessment supports the achievement of project performance and stakeholders' satisfaction in building projects*
- *Hypothesis h5d.2 (ASSE -> EcS): Sustainability assessment supports the achievement of economic sustainability in building projects*
- *Hypothesis h5d.3 (ASSE -> EnS): Sustainability assessment supports the achievement of environmental sustainability in building projects*
- *Hypothesis h5d.4 (ASSE -> SoS): Sustainability assessment supports the achievement of social sustainability in building projects*
- *Hypothesis h5e.1 (STAK -> PPSP): Stakeholder management supports the achievement of project performance and stakeholders' satisfaction in building projects*
- *Hypothesis h5e.2 (STAK -> EcS): Stakeholder management supports the achievement of economic sustainability in building projects*
- *Hypothesis h5e.3 (STAK -> EnS): Stakeholder management supports the achievement of environmental sustainability in building projects*
- *Hypothesis h5e.4 (STAK -> SoS): Stakeholder management supports the achievement of social sustainability in building projects*

The new parsimonious model was assessed, and it met all requirements of validity, reliability, collinearity, predictive power, and relevance. The process of this assessment is similar to the one demonstrated in section 5.4.4 and 5.4.5. The summary of results for measurement and structure of the expanded model is demonstrated in Table 5.12; the expanded model and results of hypotheses are illustrated in Figure 5.7.

Table 5.12. SEM results for assessing the expanded model

Latent variable	Individual validity and reliability	Internal Consistency Reliability		Conver-gent validity	Discriminant validity	R2	Q2
	Loading > 0.5 (min - max)	CA > 0.6	CR > 0.6	AVE > 0.5	HTMT (confidence interval ≠ 1)	R >26%	Q2 ≠ 0
GOAL	(0.773 - 0.905)	0.886	0.922	0.747	Yes		
ENHA	(0.681 - 0.801)	0.906	0.923	0.573	Yes	37.9%	Yes
PLAN	(0.776 - 0.857)	0.904	0.926	0.676	Yes	57.7%	Yes
ASSE	(0.658 - 0.842)	0.873	0.905	0.615	Yes	72.1%	Yes
STAK	(0.699 - 0.827)	0.846	0.854	0.890	Yes	40.2%	Yes
PPSS	(0.606 - 0.844)	0.879	0.908	0.903	Yes	29.6%	Yes
EcS	(0.575 - 0.817)	0.759	0.789	0.836	Yes	39.6%	Yes
EnS	(0.672 - 0.810)	0.861	0.863	0.896	Yes	48.7%	Yes
SoS	(0.771 - 0.862)	0.836	0.841	0.891	Yes	46.7%	Yes

The result of tested hypotheses in Figure 5.7 shows that the two components of SPM (ASSE and STAK) all have significant impacts to the achievement of sustainability, project performance, and stakeholders' satisfaction, but the strength of the relationships are slightly different, most of them are ranging from 0.255-0.376.

The strongest relationship is the support of sustainability assessment to the achievement of environmental sustainability (h5d.3: ASSE → EnS with p=0.613), whilst the weakest relationship is the impact of stakeholder management to this variable (h5e.3: STAK → EnS with p=0.137).

Besides, the achievement of social sustainability is impacted slightly more from stakeholder management (p=0.411) than the application of sustainability assessment (p=0.365). This finding implies that sustainability assessment tends to focus more on environmental factors whilst stakeholder management can be a useful tool to improve the social factors of sustainability. Besides, this explains the result of no significant relationship found between PLAN/ASSE and STAK (h3b and h4, respectively). It could be seen as two separated approaches, the first approach followed by planning process and sustainability assessment that focused more on environmental factors, and the second approach of management emphasised the satisfaction of stakeholders and social factors of sustainability. However, these two approaches should be in link together as sustainability is not separated targets, it is met in the unity of them. For example, the enhanced communication about planning and result of sustainability assessment could help to engage and motivate stakeholders in contributing to the project. However, in practice, stakeholders are not commonly provided this information.

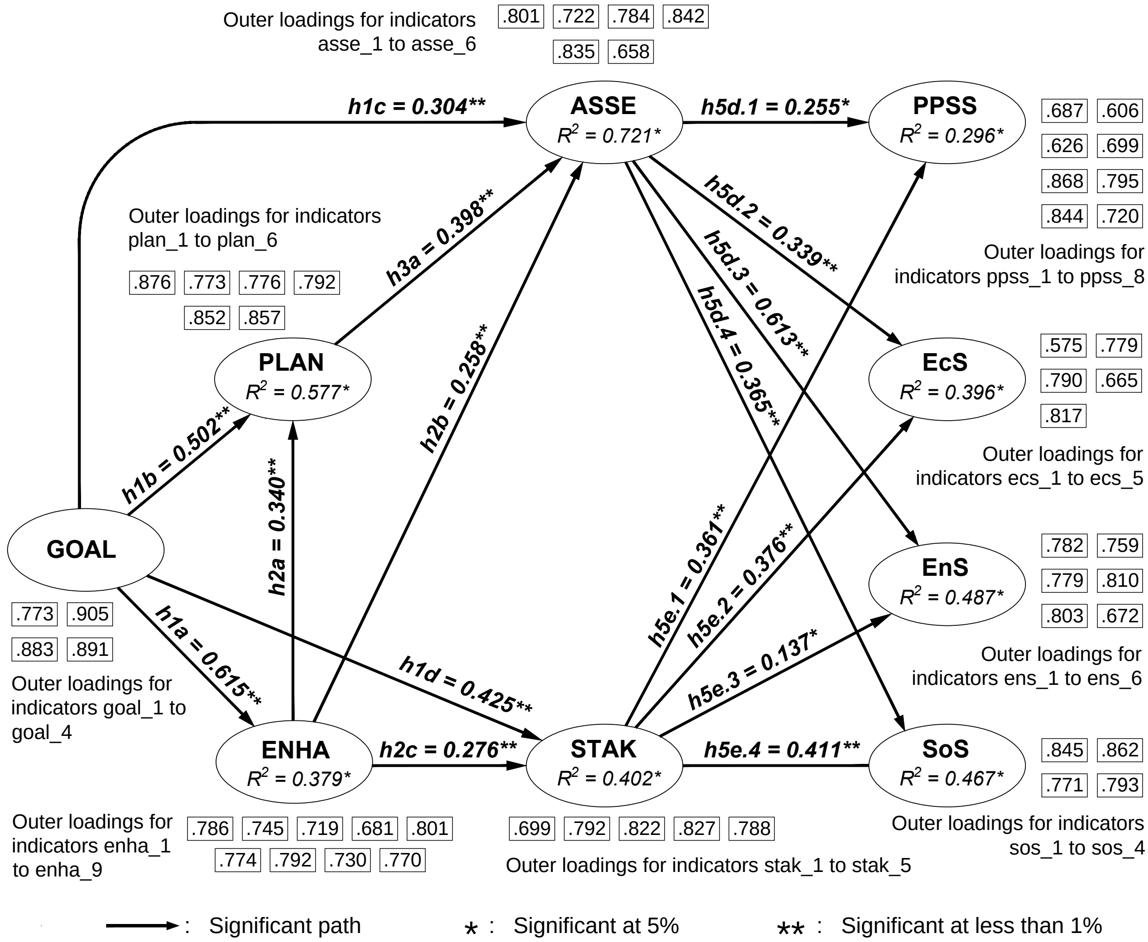


Figure 5.7. The result of further detail impact analysis between SPM and the four representative variables of SPS

5.6. Discussion of results

The findings of this chapter support for the forming of Sustainable Project Management (SPM) with five key components, including sustainability goals definition, project team enhancement, sustainability planning, sustainability assessment, and stakeholder management.

This research sees the relationship between SPM and SPS with a metaphor of a tropical tree. From a first viewpoint, all the trees are in green, which is SPS. The value of sustainability assessment (ASSE) and stakeholder management (STAK) are the core trunks of the tree. They need strong roots to work effectively. The roots in this study are highlighted by the definition of sustainability goals (GOAL), enhancement of the project team toward sustainability (ENHA), and the planning of sustainability in the project

(PLAN). Therefore, all approaches that focus solely on using a building rating system to achieve the building's sustainability might be insufficient. Indeed, it might need a whole system behind. In this part, each variable of SPM will be discussed in detail.

5.6.1. Sustainability goal and competent project team - An crucial initiation for achieving sustainability

Both sustainability goals definition and project team enhancement have a positive and remarkable influence on all the three other components of SPM; this finding highlights the importance of these two components in the model. Among the five variables of SPM, the definition of sustainability goals has the most considerable total effect on SPS. However, this is a full-mediation – which means that it has no meaning without the appearance of sustainability assessment and stakeholder management. Therefore, the result is found unable to fully support a common thinking like Gareis (2013) that the project initiation process is more important than the project delivery process to achieve sustainability, it shows that activities in project initiation process are not less important than those in following stages. The further implementation of the processes in project delivery (including planning, assessing of sustainability, managing stakeholder) needs a clear vision of project goals and a proper team to carry them out.

Moreover, path coefficient values pointing from GOAL are all higher from those toward the same variables pointing from ENHA (See Table 5.10). It means that the performance of stakeholder management, sustainability planning, and assessment rely more on a project goal definition that facilitates sustainability than on the ability of the project team. Besides, GOAL has very substantial total effects to variables ENHA, PLAN, GOAL, ASSE, and SPS (See Table 5.11). It means that the definition of sustainability has a critical meaning in the SPM model, in other words, a crucial starting point of a sustainable project. This finding is also in line with a recommendation from Eid (2004) to integrate sustainability into scope and objectives in the initial stages of the project. Besides, it is also a statistical proof for argument of Gareis (2013) that initiation processes are more important than the following management processes.

Furthermore, the definition of sustainability goals also has a substantial high impact on the enhancement of project team ability toward sustainability. On the one hand, it implies that the definition of a sustainability goal at the beginning of the project enables the employment of a competent project team. On the other hand, the team with rich experience, high motivation, innovative thinking, learning ability, and collaboration can contribute to the success of sustainable projects. Therefore, the relationship between a sustainability goal and an enhanced-competent project team is a two-way relationship where they support each other. Project managers are used to being restricted with traditional project constraints (mainly for cost budget and time) as well as limited power. Therefore, an explicit goal of sustainability can free them to use all of their potential ability in managing stakeholder and in planning project toward sustainability.

In order to ensure proper sustainability goals or objectives are set up in the project brief, it is highly recommended to start enhancing the project team by the appointment of an experienced project manager in sustainable buildings in the earliest stage of the project. In many cases, clients of building projects do not have intensive experience and knowledge in the area of construction and sustainability. Therefore, the early involvement of the project manager can help to bridge clients with the experience and knowledge of project managers in the sustainable construction of buildings. Through a discussion of benefits, opportunities, and constraints of sustainability in the strategic definition stage, project managers can advise clients on sustainability features in their buildings. Besides, clients might use sustainability champions (sustainability advisor, accredited professional or sustainability consultant) as their advisors on technical aspects of sustainability as another way to enhance the project team toward sustainability.

5.6.2. The critical value of stakeholder management and sustainability assessment to the achievement of sustainable project success

Regarding the relationship between SPM and SPS, the result indicates that a higher level of stakeholder management and sustainability assessment are associated with achievement of SPS; in detail, they have a significant impact to all pillars of SPS. The positive relations between sustainability assessment and SPS is not surprising because the measurement is designed to ensure that final targets are met. However, it is interesting to note that stakeholder management does not have less critical meaning than sustainability assessment in achieving the sustainable results of the building. Sustainability assessment is found with a strong focal point on environmental factors, but it also considers economic and social factors; whereas stakeholder management can potentially solve the issue of social sustainability. As the social sustainability is disappearing in sustainable building projects (Ole Jensen, Søgaard Jørgensen, Elle, & Hagelskjær Lauridsen, 2012), the gap can be solved by putting more assessment factors of social impacts and by focusing more on stakeholder management at the same time. In other words, this finding highlights the value of stakeholder management and that project managers should also pay more attention to this new area of project management knowledge in their sustainable buildings besides following a mean of sustainability assessment.

5.6.3. Sustainability planning can be underestimated in supporting SPS

From the significant relationship between PLAN and ASSE (hypothesis h3a), it can be concluded that the sustainability assessment requires a sustainability management plan that could provide further direction to activities in the delivery process of the project. However, the result from the bootstrapping procedure showed that sustainability planning does not have direct relationship to SPS (hypothesis h5c), but through the sustainability assessment (mediation effect as demonstrated in Table 5.11), this variable contributed an indirect effect to the achievement of SPS, although this effect was found relatively small in this research. This suggested that the value of sustainability planning might be recognised by practitioners, but its value could be underestimated.

The finding of hypothesis h5c supports a multi-case study research in the Netherland by Silvius, Neuvonen & Eerola (2017), which demonstrated that the use of a sustainability management plan could potentially improve the project product and process. The only indirect effect result could be sourcing from the fact that almost none of the participants in this research use an official and separated sustainability management plan. On the one hand, almost all of projects in this research succeeded in achieving certification of the green building rating, so that the planning for sustainability might be mainly focused on achieving targeted criteria of that rating certification. The sole use of a mean of sustainability assessment, as demonstrated in the previous part, might not be sufficient for achieving sustainability of the project; in fact, planning for sustainability requires more than just a consideration of a measure. On the other hand, the use of a separated/specific sustainability management plan is not widespread in construction projects. Sustainability planning may have been integrated into a regular project management plan; which might put targets of sustainability behind the targets of financial benefits (like saving initial investment and reducing backpack time) from the investors' point of view on the traditional approach. Therefore, it is believed that the sustainability of building projects can be emphasized if a sustainability management plan is made separately as an official plan before the project plan/project management plan is created.

5.7. Summary

This chapter introduced the testing and discussion on the results of the five hypotheses, which were broken down into 15 sub-hypotheses and introduced in Chapter 3. From the collected data, SEM analysis was carried out to understand the relationship between the five components of SPM and how they could impact the achievement of SPS. The results confirmed the validity and reliability of the conceptual model and its measurement indicators.

The bootstrapping procedure showed that 10/15 sub-hypotheses were significant. The findings identified the positive impact from “sustainability assessment” and “stakeholder management” to the achievement of sustainability. A mediation analysis was further conducted to understand the actual relationships among variables of MaSBuP model and hypotheses. The finding showed that 3 sub-hypotheses were significant indirectly besides 10 directly significant sub-hypotheses found. The two unsupported relationships were found due to the separation of management approaches in achieving project success, which resulted no relationship found between stakeholder management and sustainability planning/assessment.

In conclusion, the results showed the inter-relationships between the five key variables/components of SPM, where they can support each other in achievement of higher performance of management. Therefore, the sole application of one or more sustainability certifications is not enough for the achievement of project success and sustainability in building project. Understanding these key relationships, the study was followed with a practical framework in Chapter 6. This framework was developed to support project management team in initiating and delivering sustainability in building projects.

CHAPTER 6. DEVELOPING GEPAS FRAMEWORK FOR SUSTAINABILITY MANAGEMENT IN BUILDING PROJECTS

6.1. Introduction

The literature review has found that the current project management standards have paid insufficient attention to the issues of sustainability. It has pointed out there is a critical need for a method that enables project management to support sustainability achievement in construction projects. The results of the SEM analysis presented in Chapter 5 showed that sustainable project management should not only focus on assessing sustainability, but should also consider matters related to stakeholder management, planning process, and the enhancement of human resource's capacity to handle the uncertainty and complexity of sustainable projects.

This chapter presents the GEPAS framework as the framework for managing sustainability in construction (the main research aim), which was developed to address this need. GEPAS is an abbreviation that is formed by the combination of the first letters of the critical word in each of the five component processes: *define sustainability* ***G****oals* (A1), ***E****nhance project team* (A2), ***P****lan for sustainability* (A3), ***A****ssess sustainability* (A4) and ***S****takeholder management* (A5). The framework aims at providing a clear guidance for Project Managers (PM) and their team to initiate, direct, and manage building projects towards sustainable success through the five demonstrated processes (A1 to A5).

6.2. Overview of GEPAS framework

6.2.1. Foundation of GEPAS

The GEPAS framework was developed based on the empirical analysis results of the MaSBuP model, which was introduced in previous chapters. The development of this framework took into account of the five key components of Sustainable Project Management (SPM), indicators that had formed these components (Chapter 3); the inter-relationships among the five key components (results of hypotheses testing in Chapter 5); and the available tools and techniques to carry out processes and activities (or sub-processes) that were demonstrated in Chapter 3.

Furthermore, the framework processes are developed to be compatible with the existing guidelines and best practices of project management in the UK, including: RIBA (2013b - Plan of Work) CIBSE (2007 - Guild L on Sustainability), BS:6079 standards (BSI, 2010a, 2012). GEPAS also matches with principles of sustainability in building construction from BS ISO 15392:2008 - Sustainability in Building Construction: General principles (BSI, 2008).

6.2.2. The rationale for GEPAS framework development

The justification for the GEPAS framework development considered several problems of sustainability achievement in building projects, explained as follows:

- Recent research shows that many *project management standards* does not pay sufficient attention to the problems of sustainability. The development of GEPAS framework is based on the standard BS 6079-1:2010 on project management; and is designed as supplementary processes to fulfil the gap of this UK standard in managing sustainability issues of projects. However, the principles and processes of the framework are not only limited to BS 6079; they can be potentially applied in other project-management standards.
- The literature review revealed that the current project management approach still *heavily concentrates the effort on delivering the project within the time, cost and quality expectations*. GEPAS focuses not only on the delivery processes but also on the initiation processes to define project objectives in a sustainable approach. It supports PM whilst discussing and advising clients on issues related to sustainability before drafting initial requirements and constraints of resources to projects. Therefore, project goals/objectives are called sustainable objectives in GEPAS, which means that financial benefits would not be prioritized over the other objectives, which take into account the impacts of TBL.
- Recent research indicates that *sustainability is considered as an additional cost to projects due to its uncertainty*. Therefore, GEPAS highlights the use of an Integrated Project Team (IPT) in the project's design stages. The involvement of this multidisciplinary team can help to reduce changes in further stages, and hence waste of change (cost and time) could be avoided.
- The definition of sustainability stresses on the balance of benefits among stakeholders. This makes achieving sustainability a difficult task as it requires to succeed in both short and long term orientations, and get the satisfaction of a large group of stakeholders. To solve this problem, GEPAS has put a great effort into enhancing project team ability toward sustainability. A highly competent project manager (PM) is necessary for success; however it is not enough. The framework highly promotes

the collaboration and ongoing training process to achieve continuous improvement of awareness, knowledge, and skills for the team during the meetings and implementation of the IPT.

- Due to the current procurement methods, especially in the traditional contracting, projects bear a risk of *dropping sustainability values* from the design stage to construction stage, and then to in-use stage due to the lack of transparent information from designers to contractors, and to building operators and users. GEPAS addresses this by emphasising teamwork communication, IPT meetings, and the transparency of project documents. Project logbook and user guide are highlighted as a way to prepare for sustainability assurance of building operation. Besides, GEPAS also pays attention to post-construction evaluation to ensure the actual value of sustainability can be achieved as in design.

- Recent research also points out that *stakeholders' low awareness, willingness, and collaboration toward sustainability* are recognised as a big barrier to sustainable projects. GEPAS faces the issue by enhancing the existing guide of project management and communication from BS 6079:1-2010. In detail, the framework recommends forming an IPT and hence brings stakeholders to engage in the project earlier and regularly through out the project. GEPAS considers this issue by motivating the whole team toward sustainability. Project manager's role is highlighted in educating and raising awareness by acting as an example to their project team.

- The framework is also beneficial to the clients in the strategic definition stage; they would get an early consultant from advisors/design managers/project managers about sustainability issues, which helps them to have a more confident decision on investing in sustainable values

- BS ISO 15392:2008 (BSI, 2008) showed nine general principles of sustainability in construction. All these principles were embedded in the processes and sub-processes of the framework. For instance, the use of IPT meets the requirement of “equity“ principle - when the participation of this multidisciplinary team can help PM be aware and keeps the balance of environmental, social and economic requirements from different stakeholders. It is a chance for a PM to achieve “continuous improvement” of project team ability through on-going training and communication on project sustainability issues; it also promotes the project team to record and use the lesson-learnt log and project report system for further projects. Moreover, GEPAS pays high attention to the principle of “involvement of interested parties” and “transparency” with an adaption of the stakeholder management process. Furthermore, with a focus on life-cycle sustainability assessment perspective, “long-term consideration” and “holistic approach” are all embedded in the framework.

- From the theoretical point of view, GEPAS is developed as a *holistic approach* (from the strategic definition stage to in-use stage), and project team is required to make particular efforts in assessing and monitoring project's life-cycle impacts in design, construction and operation stage. The framework is expected to help clients overcome short-term financial concern and take into account life-cycle thinking.
- From the theoretical point of view, GEPAS’s five main *processes represent the five key components* of MaSBuP model; and the *sub-processes of the framework rely on the 30 success factors* of MaSBuP model with adjustments toward rationale mentioned above.
- Finally, *key connections of GEPAS’s processes follow the inter-relationship of components in MaSBuP model*, which are identified in Chapter 5, The definition of sustainability goals promotes the formation of a project team with high competency; it also provides the team a sufficient power and allows them to use proper abilities in managing stakeholder, in planning and assessing project toward sustainability. Moreover, a highly competent and motivated project team is more suitable to facilitate all project management processes. Finally, a sustainability plan provides principles and direction to the assessment of the sustainability of buildings, the continuous development of the integrated project team and the management of stakeholders in a sustainable way.

6.2.3. Aims and targets of GEPAS

GEPAS aims at providing a comprehensive and step-by-step guidance for the PM and their team in directing and managing building projects toward sustainable project success. It is presented in the form of a holistic process map (from strategic definition stage to in-use stage) that is compatible with project management processes of BS: 6079-1:2010 standard. GEPAS has the following specific targets:

- To promote client team in defining sustainability objectives in the beginning stage of the project with the involvement of project advisors/managers, who could discuss and provide early advice to the clients and investors on the potential benefits, opportunities, and constraints of sustainability (letter G);

- To facilitate the forming and implementation of an Integrated Project Team (IPT) for benefits of constructive contributions from a multidisciplinary team, which could help to reduce waste, improve general quality, boost up innovative thinking, and enhance collaboration among the project team. The IPT implementation is a chance for continuous improvement of project team's ability, knowledge, and awareness toward sustainability (letter E);
- To guide the planning process that supports the achievement and maintenance of sustainability values over different stages of projects (letter P);
- To guide for the process of monitoring and assessing the sustainability of projects, from concept design to the in-use stage (letter A);
- To enhance the stakeholder management in a way that stakeholders are engaged in the project in the early stages, and their positive/negative performance are measured and controlled to support the achievement of sustainability goals (letter S);
- To suggest available tools, techniques, documentation, and further advice that can support project managers in initiating and delivering sustainable-building projects (letters G, E, P, A, & S).

6.2.4. Project Manager role in different procurement routes

As the literature review identified a lack of clear guidance for the project managers (PM) in managing their sustainable projects, GEPAS framework is designed with a particular focus on Project Managers. All processes and activities covered in the framework are intended as a step-by-step approach that PM can apply in their projects.

In this research, project manager is understood as a profession rather than a person. It is worthy to emphasise that "Project Manager" in construction projects may not be the same person during the whole life cycle of projects. The number of people holding the responsibility of "project manager" depends on the choice of procurement route. In all types of procurement route, the responsibility of encouraging sustainability in client's initial brief (i.e., strategic definition, preparation, and brief stage) is put on the shoulders of project director/advisors in the client team. Progressive clients with sustainability agenda could get an experienced professional (hired temporarily) in managing sustainable projects as a member of the advisory board before deciding the objectives and aspirations of the project. Then, the role of the main project manager could be taken by design managers, construction managers, or prime contractor (all depends on the selected procurement route) before it is taken by building managers (operators). The detail responsibility for leading the role of project management in different procurement routes is demonstrated in Figure 6.1.

6.2.4.1. GEPAS's project managers in the traditional route

Traditional procurement route requires full completion of the design before a tender is selected to do the construction works. Sometimes, the role of a project manager is transferred among several key participants: from the client (in strategic definition stage) to the designers (in design stage), and then to the contractors (in construction stage) before it is turned to the building/assets managers (in operation stage). In this case, it is highly required to maintain sufficient communication and transference of knowledge and project documents among the project-management participants.

A large number of people acting as "project manager" could be a barrier to the achievement of sustainability, especially when each of them has a different understanding, level of awareness and commitment to sustainability. As a result, a drop in sustainability could happen in any transfer points of responsibility between these project managers. Furthermore, the traditional route is associated with a longer time for the completion of the project (as it requires a full detailed pre-tender process, no chance to overlap design and construction), potential higher cost (in cases that many changes made), and lack of communication/collaboration between the design and build team. All these disadvantages are believed that traditional contracting is not highly recommended for sustainable projects.

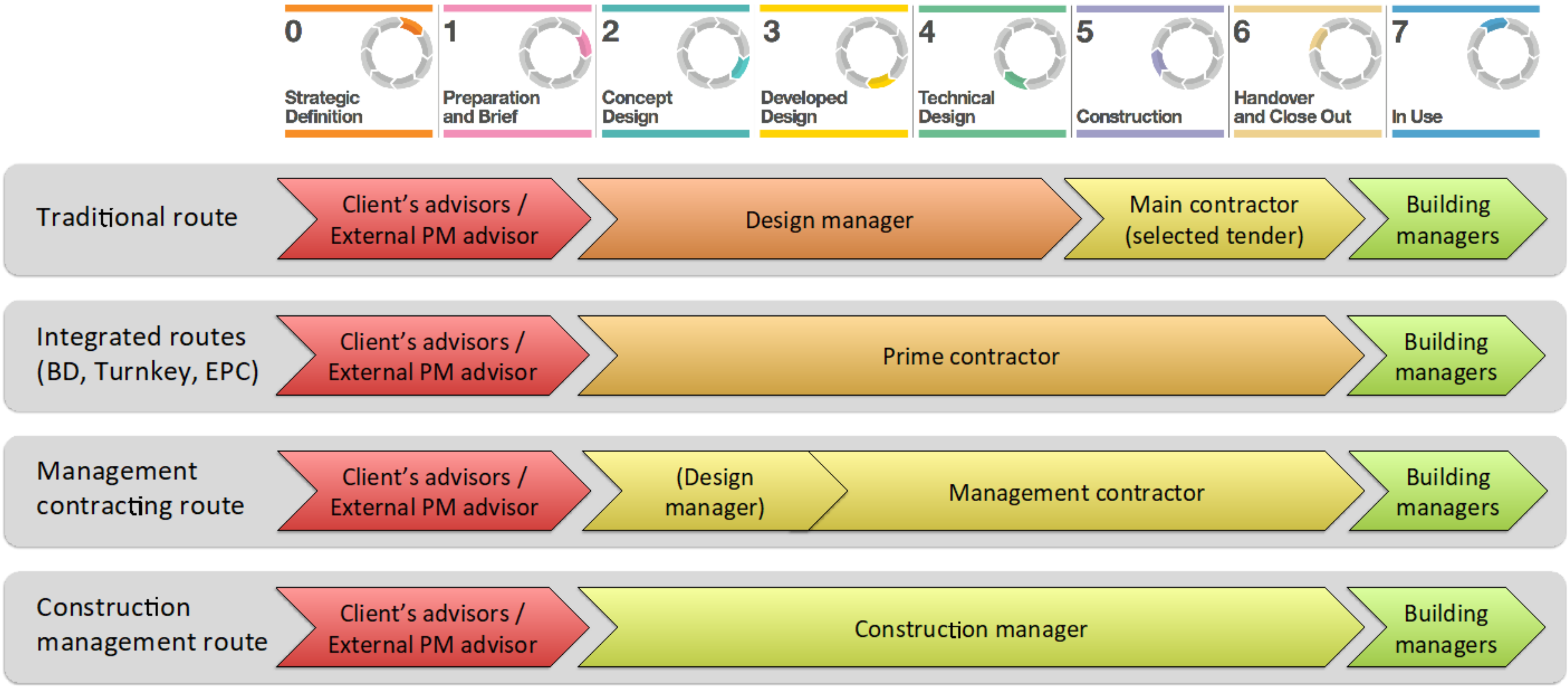


Figure 6.1. Responsibility for leading the main role of project management in different procurement

However, if the traditional route is selected, there are ways to get earlier involvement and strong commitment of the builder, such as using negotiated contract (the preferred bidder), two-stage tendering or restricted tendering (2-4 tenders). Tenders are willing to contribute more if they see a high chance of winning. Clients can also boost the collaborative environment of key participants by issuing a partnering agreement among internal stakeholders, especially between the designers and builders.

6.2.4.2. *GEPAS's project managers in integrated routes*

In integrated routes like Design-Build (DB) contract, the building is designed and built by the same contractor, however different sub-designers and sub-contractors can also be involved. This model of project delivery enables greater communication and collaboration among the project team than the traditional route. Moreover, it guarantees the participants and contributions of the builders/contractors in the design stage. Integrated contracting transfers more risk to the prime contractor (who might be able to manage risk better) and the inexperienced client takes a lower risk at good price certainty. Project manager from the concept design to the handover & close-out stage is appointed by this prime contractor. Other integrated routes (like Turnkey, Engineering, Procurement, and Construction – EPC contracts) have a similar structure about the role of the project manager in the delivery of projects.

6.2.4.3. *GEPAS's project managers in management-oriented routes*

The two prevalent types of management-oriented contract - management contracting and construction management - are often used in complex construction projects with the employment of a professional organization responsible for the management tasks.

In management contracting route, the builders are appointed and contracted directly with the management contractor, who provides the general management of the project; but the designers are procured separately and contracted directly with clients (Marsh, 2002). If the management contractor is appointed from the pre-construction stage, the design manager should take responsibility in leading the project design toward sustainability. Generally, the management contractor is employed in a very early stage to provide their construction expertise on the design. In this case, the construction manager should be the PM for the design and construction stage of the project.

In construction management route is applied when clients have direct contracts with a number of trade contractors (including designers and builders), and then uses the expertise of a construction manager to coordinate them (Marsh, 2002). In this procurement route, the construction manager should take responsibility of the main PM in leading the team to sustainability.

6.2.5. Scope of use of GEPAS

As mentioned above, GEPAS principles and processes can be used in almost all of the procurement routes, especially in integrated contracting (such as IPD, D&B, or Turnkey) and management-oriented routes. The traditional procurement route is not highly recommended due to its limitations on delivering sustainable projects.

Besides, an application of all processes and sub-processes of GEPAS should be more applicable to medium-large size projects because it requires a high capacity of the project management team and stakeholder involvement. In small projects, some features of framework might be unsuitable because the benefits they bring to project could not be able to compensate the costs related to efforts of the project team in management activities such as IPT meetings, training sessions, or multi-stage sustainability assessments. Therefore, the use of this framework in a small size project might need further consideration of cutting some of the processes/sub-processes. However, some critical sub-processes the achievement of sustainability should not be illuminated (such as A11, A12, A31, A33, A42, A44, A51 to A55 - where the knowledge and awareness training of key participants should be carried out through the communication - A54). Moreover, the application of this framework to a megaproject might need further consideration as its development background is not built on this type of project; however, the idea from this framework can be useful for the management of mega projects with sustainable-buildings, sustainable community, or sustainable city.

Furthermore, GEPAS is expected to work effectively in a wide range of building purposes (commercial, residential, educational, medical and governmental buildings), and different construction types (new-build, renovation, refurbishment, and retrofit).

6.2.6. The choice of the modelling language

To introduce and explain the GEPAS model, Integration Definition Function Modelling (IDEF0 or IDEF∅) was selected. IDEF0 is a modelling method useful in introducing a structured function model with activities and processes. For the new system, it helps to define the requirements, specify the function, and design implementation to perform the function (NIST, 1993).

IDEF0 is composed of a hierarchical series of syntactic and semantic diagrams. A diagram might include one or a few numbers of processes, and each process (and each activity) is visualised under the form of a rectangle box and its belonging arrows. Process/activity name and ID code are presented inside the box while arrows of controls, inputs, outputs, and mechanisms are put on the top, left, right, and bottom side of the box, respectively. The expression and explanation of the diagram's elements are demonstrated in Figure 6.2.

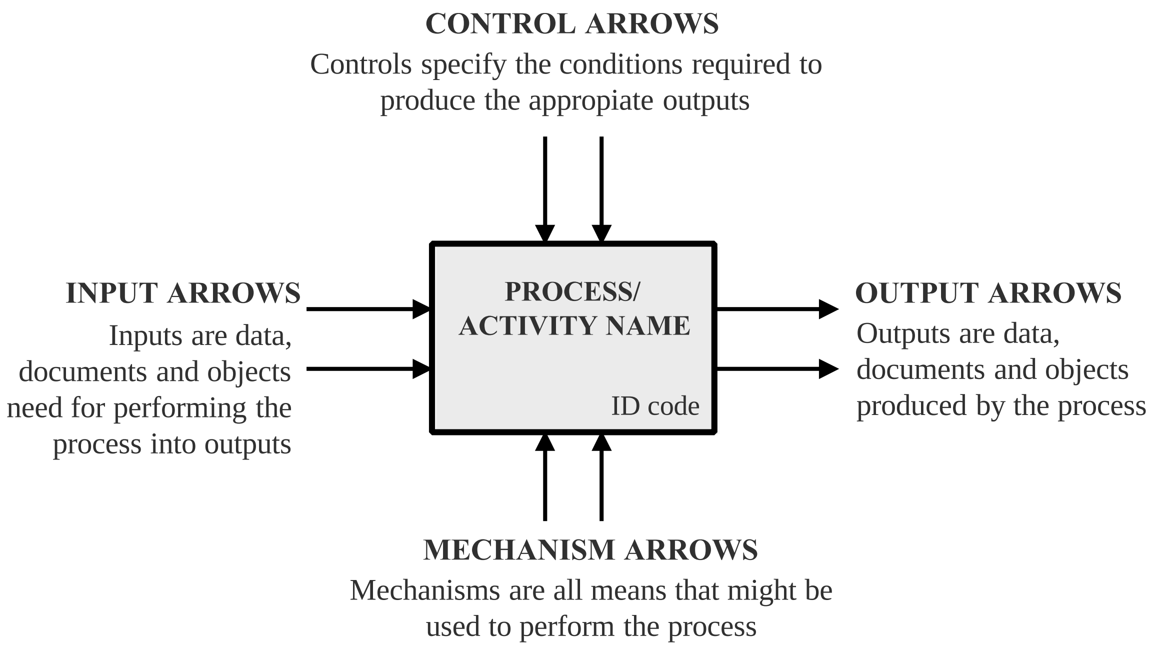


Figure 6.2. Process box with input, output, control and mechanism arrows (Adapted from NIST, 1993)

A process in a diagram can be broken down into detail activities (or sub-processes). These activities are illustrated in another diagram, which is called a child diagram; and the diagram of the original process is called a parent diagram. Figure 6.3 demonstrates the relationship between IDEF0 diagrams. In this figure, the top-level process is illustrated in a single box A-0; A-0 diagram shows the top-level function of the whole framework. Then, A-0 diagram is broken down into A0 diagram; A0 diagram is the context diagram that presents all processes of the model (e.g., processes A1, A2, and A3) and their relationships. Afterward, process A2 is further broken down into a separated diagram with its detailed activities named as A21, A21, and A22.

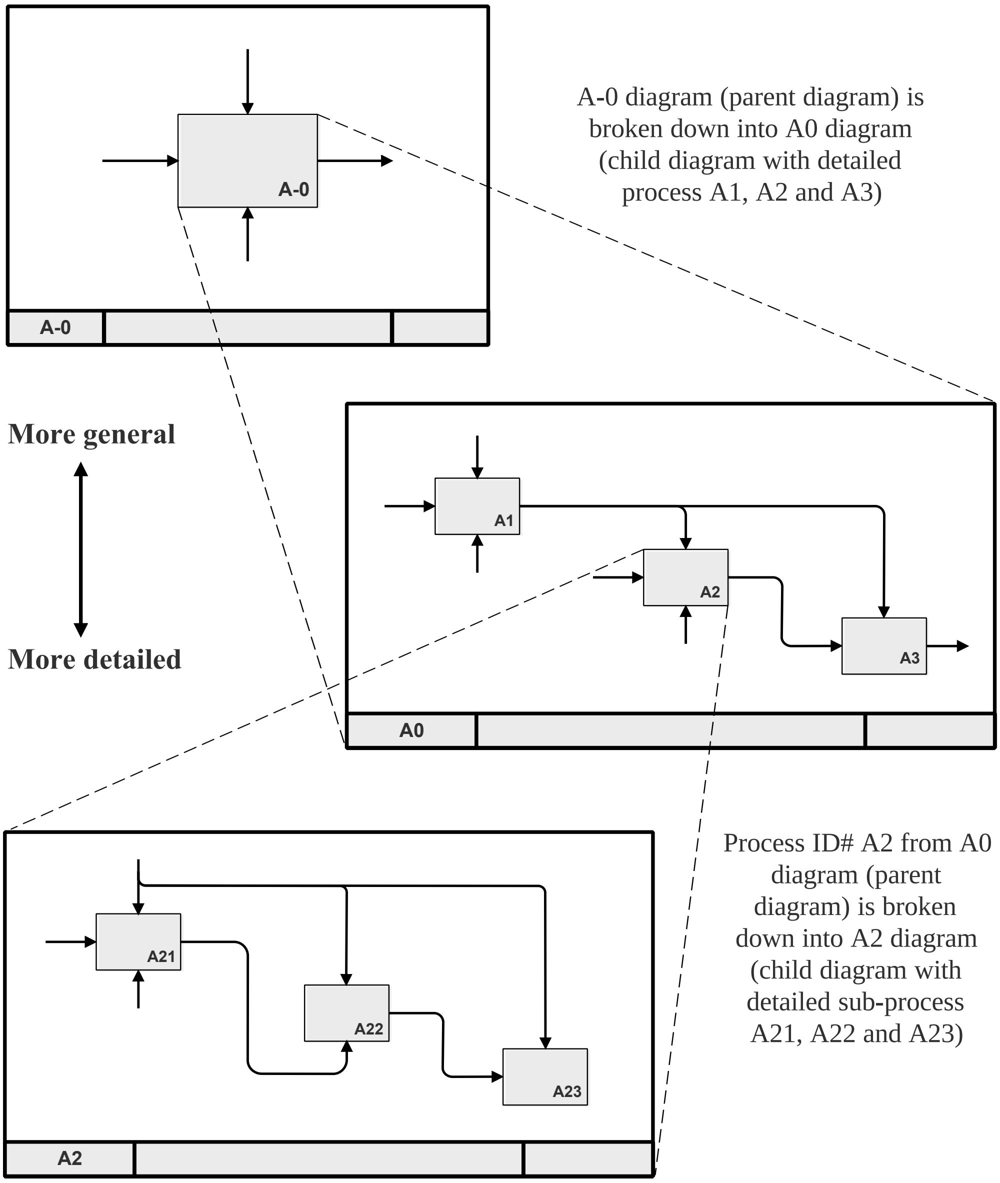


Figure 6.3. The hierarchical system of IDEF0 diagrams (Adapted from NIST, 1993)

Because IDEF0 is an expressive, coherent, and easy-to-read language (NIST, 1993) which is well-suited for developing operational and strategic management (Waissi, Demir, Humble, & Lev, 2015), it is the most suitable modelling method to demonstrate the function of GEPAS framework. Furthermore, this technique is well-known in building research (Luiten, Tolman, & Fischer, 1998), and the use of it can help to enable project managers to understand and apply the GEPAS framework easily.

6.3. Features of the GEPAS framework

6.3.1. Conceptual framework

GEPAS framework is based on the results identified in Chapter 5; that a sustainable project management approach supports the achievement of sustainable project success. Project manager (PM) should take the main responsibility of setting up a reasonable sustainable-project-management approach in their project, according to special conditions of that project. PM can get support from sustainability champions (SC), who are advisory professionals with intensive knowledge on sustainability and practical experience in similar building type. However, the achievement of project success also requires the involvement and contributions from all internal stakeholders. The collaboration among them is one of the most important success factors to sustainable projects.

GEPAS framework is developed as a process-map with five processes as demonstrated in Figure 6.4, including 1 - Define sustainability goals (GOAL in MaSBuP model), 2 - Enhance project team toward sustainability (ENHA), 3 - Plan for sustainability (PLAN), 4 - Assess sustainability (ASSE), and 5 - Manage stakeholder & communication (STAK). These processes are justified in Chapter 3 and validated in Chapter 5 with the test of the SEM analysis technique.

In the first process, PM and SC can advise clients on potential issues related to sustainability and support them in ***defining sustainability goals***. The definition of the sustainability goals (red arrows in Figure 6.4) promotes the forming of a project team with high competencies and rich experience; it also provides the important target and strategic direction to following processes of projects.

The second process aims to ***enhance the project team toward sustainability***, where a competent and seamless Integrated Project Team (IPT) is formed and coordinated. The use of this multidisciplinary team can help to reduce changes in further stages, and then cost, time and waste of change will be avoided; in other words, the uncertainty of sustainable project can be reduced through contributions of participants. In this process, an active collaboration of all internal stakeholders is promoted. GEPAS highly encourage starting the IPT by one or a few training sessions on sustainability. Project manager's and sustainability champion's role are highlighted in educating and raising awareness of stakeholders on sustainability by acting as an example to their project team. The knowledge, improved competences, and high motivation of the team will bring back the efficiency of the following processes (blue arrows in Figure 6.4).

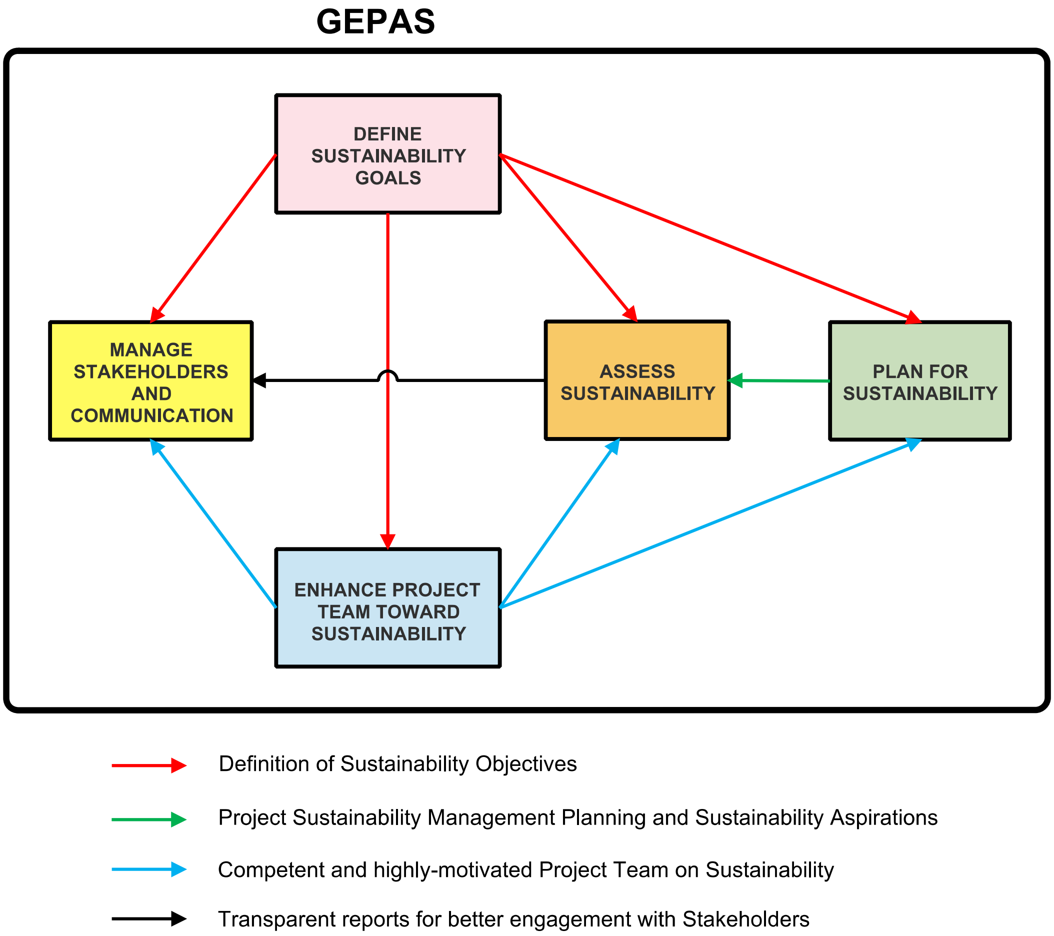


Figure 6.4. A conceptual framework for sustainability management in building projects

The third process is designed to ***plan for sustainability***. This is the process of creating core principle and direction for further actions (through a document called as Project Sustainability Management Plan - PSMP), of comparing and selecting the final sustainable design solution, and of proposing sustainability assurance to prevent sustainability drop in building operation stage. PSMP is an important plan and should be compatible with a project management plan, including stakeholder and communication plan; this document should clarify the choice of sustainability assessment methodology; i.e., measuring tools, techniques, standards, building certification, quality metrics or KPIs (green arrows in Figure 6.4).

The fourth process, ***assess sustainability***, considers the assessment of sustainability during the life-cycle of the project, including evaluations and monitorings of building life-cycle impacts in the design, construction, and operational stage. Assessment results and sustainability-related reports are useful information for communicating, engaging stakeholders, and for keeping their commitment to sustainability (black arrows in Figure 6.4).

Finally, the fifth process puts a focal point on ***managing stakeholder's engagement and communication***. This process aims to support the early engagement of stakeholders in the project; it also targeted at engaging stakeholders in the relations with sustainability goals, and to monitor their contributions to sustainability targets.

6.3.2. Actors in the framework

GEPAS framework covers a wide range of actors, including all key and internal stakeholders to project success, including:

(a) Project manager (PM)

PM plays a vital role in advising clients to define sustainability objectives in initiating stages, and then, in leading the whole project team to achieve these objectives. PM also takes the main responsibility of managing and directing activities of enhancing project team's ability (through the implementation of the IPT), creating a sustainability plan, assessing sustainability, and managing stakeholders' engagement during the project life cycle. Depending on the choice of procurement routes, the responsibility in managing project falls to project director, client advisors (in client team), design manager, construction manager, management contractor, or turnkey/prime/DB contractor. If clients of project do not have an involvement of an experienced project manager in strategic definition of project, they could also benefit from hiring an external professional on sustainable project management (with daily-pay wage for a short period of time), who acts as an advisor to the client on benefits, opportunities, and constraints of sustainability target options (see A11).

To select the proper PM, besides the intensive working experience in sustainable buildings, it is important to pay attention to intellectual competencies. Because of uncertainty and complexity of sustainable projects, skills like system thinking (ability in critical analysis, judgement and understanding causes of problems), anticipatory (ability in development of possible future visions) and strategic perspective (ability in planning and implement interventions) are considered as key skills for PM (Silvius & Schipper, 2014a; Tabassi et al., 2016). Regarding ethical aspect, the sustainable project also requires a strong leadership of the PM in setting an example to the whole project team, in educating and raising awareness among the team (Robichaud & Anantatmula, 2010).

(b) Sustainability champion (SC)

Sustainability champion (SC) is also sometimes referred to as sustainability advisor, accredited professional or sustainability consultant. SC is an advisory professional with intensive knowledge on sustainability and practical experience in similar building type. In GEPAS, SC is appointed to support PM, clients, designers, contractors, and the IPT in achieving the maximum benefits of sustainability – which includes but not limited to strategies development, modelling, assessment, and auditing sustainability-related issues. In some special cases, that client team might have a similar advisory professional, so this sustainability advisor should work closely with project managers in project initiating and delivery processes. However, if both the PM team and client team are limited experience and knowledge on sustainability, the appointment of SC(s) is critical for the project to achieve sustainability values.

The issues faced by SC is mainly technical problems in a wide range from environmental protection (waste, greenhouse gases, carbon footprint or pollution), resources consumption (energy, water), green material & technology selection, to building certification achievement (like LEED or BREEAM). In GEPAS, SC joins in most of the processes, such as helping clients to define sustainability goals, providing necessary training on sustainability to the IPT, joining the IPT implementation as a special advisor, supporting PM to develop the project sustainability management plan (PSMP). On top of that, this person holds a vital role in assessing and monitoring sustainability objectives achievements and life-cycle impacts.

The early involvement of *sustainability champion (SC)* in beginning stages could be beneficial to the project. Construction buildings are often large-scale projects with the influence to/from a significant amount of stakeholders; therefore, leadership and interpersonal skills are becoming more important than technical skills for PM. To overcome the lack of intensive technical skills, PM can rely on his/her management team; and technical skills related to sustainability is not exceptional. The selection of SC may not rely on accredited professional qualification, but it must satisfy the requirements of intensive experience in sustainability advice of similar type of building. Especially in large-scale projects with significant impacts to the society and environment, or high complexity of technical requirements, or particular requirements related to sustainability certification/features, project management may employ one or a few *SCs* to his/her management team. In small-size projects, SC and PM can be the same person because of the lower level of complexity and limited budget allocated.

To save up the cost of management, SC could be hired temporarily in the small-medium scale project. On a larger scale of the project, the client could also get the involvement of SC as a third-party, who takes responsibility on giving advice on sustainability issues. Large contractors could use a (or a group of) permanent SC for all their projects.

(c) *Client team*

Clients in construction are an organization funding the project. Client team might include investment decision maker, senior responsible owner, project advisory board, independent client advisor, and project sponsor. In GEPAS, clients take the main responsibility of defining and declare project sustainability goal with advice and support from PM and SC.

(d) *Designers (Design team)*

The design team includes design managers, architects, engineers, technology specialists, design auditor, and sub-designers responsible for the concept, developed and technical design of buildings. The role of the design team is vital in the IPT; they participate in assessing life-cycle impacts and take the primary responsibility of developing sustainable design options and sustainable design solution to the final drawings, specification, and instruction (including log book and user guide for operation stage).

(e) *Suppliers*

Suppliers are organisations contracted to provide building material, components, and technology required for building delivery process. The importance of suppliers is increasing in prefabricated buildings if a large part of the building is pre-generated by suppliers in their factories. Moreover, as sustainable projects might consume a certain amount of new and environmental-friendly materials and technologies, the appearance of suppliers should be beneficial to the performance of the IPT. Besides, their technical knowledge and information about materials (such as embodied carbon, greenhouse gas emission or energy consumption) will help to assess the environmental impacts of building projects easier.

(f) Contractors

Contractors include both main contractors and sub-contractors, who are responsible for the construction and completion of the building. Contractors join in the IPT for increasing the buildability of the sustainable building; for instance, their experience and knowledge can help to reduce further technical issues and to maximise the performance of sustainability features. The motivation for contractors to participate in the IPT could be rewards, bonus or incentives in further contracts. The main contractor should cooperate with subcontractors and suppliers with smooth communication and information transparency, especially for new technologies or materials related to sustainability. During the construction stage, the main contractors are also required to work with SC in monitoring sustainability objectives achievement / life-cycle impacts, as well as to do necessary actions to remedy errors and reduce risks of sustainability drop.

(g) End-users (Occupant)

End-users are those who use, live or work in the building. In cases that they are not clients, their opinions should be critical to the IPT for designing a building with functions that could enhance the living quality and working performance of users.

(h) Building maintainers & operators

Building maintainers and operators are responsible for the smooth operation of buildings during the in-use stage. Therefore their experience in the operational stage is necessary valued input for the multidisciplinary IPT. Moreover, the maintainer and operator are highly required to corporate with the designer and contractors to minimise all unwanted building-related knowledge and drop of sustainability from construction completion to operation.

(i) Integrated Project Team (IPT)

IPT is a group of all essential and supportive stakeholders that PM can engage in the design stage to contribute to the success of projects. The definition of IPT in this study is different from the integrated project delivery approach and it does not require a multiparty contract. Ideally, IPT should include members from project client side (occasional and regular clients, and project sponsor), potential end-users/occupants, building professionals (PM, project management team, sustainability champions, potential designers, contractors, consultancies, suppliers, building maintainers, and operators), and it might also cover external stakeholder's side (local authorities and communities). The meeting of this multidisciplinary project team aims at reducing the cost of further change, handling with complexity and diversification of sustainability issues, increasing the quality and constructability of sustainable buildings, the satisfaction of stakeholders, and the collaboration among project team toward objectives of sustainability.

6.3.3. GEPAS – IDEF0 process modelling overview

GEPAS is presented using the IDEF0 modelling method. Actors in the framework are shown as mechanisms of the IDEF0 model as mentioned above. The A-0 diagram of the overall framework is presented in Figure 6.5.

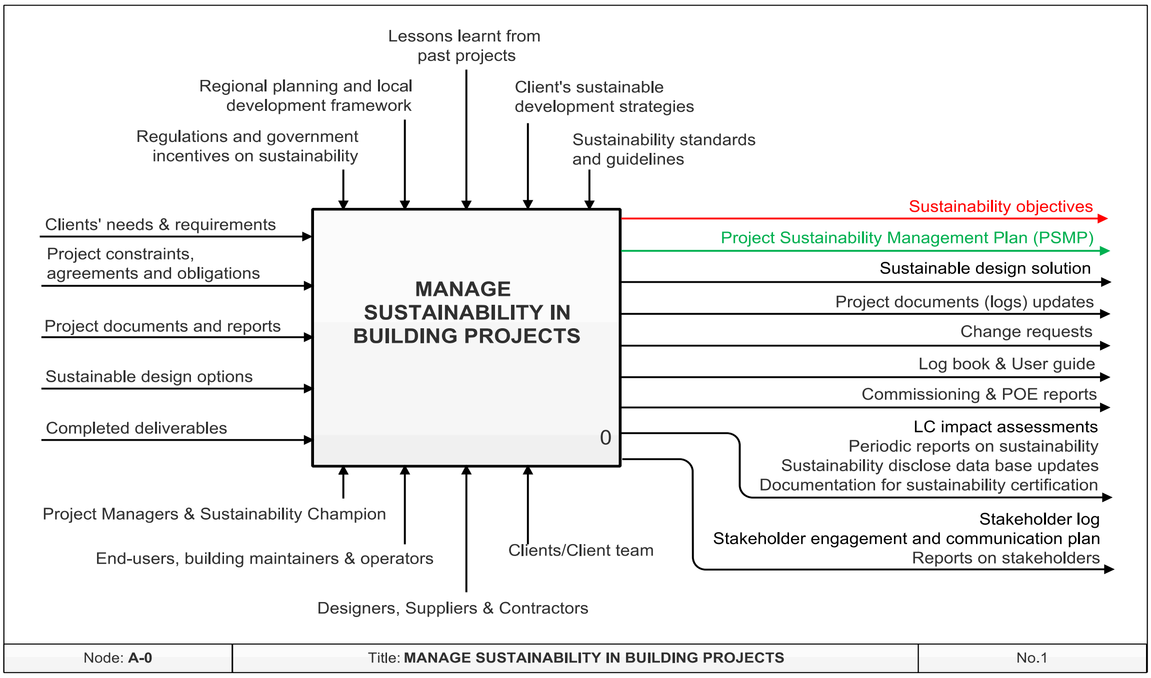


Figure 6.5. GEPAS Framework: A-0 Diagram

The A-0 process is broken down to five processes (see Figure 6.6). The five processes are then further broken into 16 sub-processes. All these sub-processes and their unique node index are shown in Table 6.1. The rule of coding these node indexes follows principles of the node tree in IDEF0 terminology.

Moreover, as GEPAS covers a large number of processes, sub-processes and flows among them, different colours are used to distinguish these processes and the flow between them. It is aimed at enabling readers to understand the relationship of GEPAS framework easier. For this purpose, the process "A1 – Define sustainability goals" is shown in light red/pink, and "sustainability objectives" (main outcome from process A1) is drawn in the red line.

The process A2 – "Enhance project team toward sustainability" is in light blue, and its main output (the IPT) is also shown in blue. The process "A3 – Plan for sustainability" and its outcome PSMP are all in green. Finally, the process "A4 – Assess sustainability" and "A5 – Manage stakeholders and communication" are shown in orange and yellow, respectively. Sub-processes are shown in the same colour as their parent process.

Table 6.1. Node indexes for GEPAS framework

Node	GEPAS's processes and sub-processes
A1	**Define sustainability goals**
A11	Advise clients on benefits, opportunities, and constraints of sustainability
A12	Establish and declare sustainability objectives
A2	**Enhance project team toward sustainability**
A21	Prepare for the integrated project team (IPT)
A22	Train the IPT on sustainability
A23	Coordinate and motivate the IPT toward sustainability
A3	**Plan for sustainability**
A31	Strategic plan for the project's sustainability
A32	Compare design options and select sustainable solution
A33	Prepare for sustainability assurance of building operation
A4	**Assess sustainability**
A41	Assess life-cycle sustainability impacts of each design options
A42	Assess life-cycle sustainability impacts of the final design solution
A43	Monitor sustainability objectives achievement and life-cycle impacts
A44	Carry out post-construction evaluation
A5	**Manage stakeholders and communication**
A51	Identify stakeholders
A52	Relate stakeholders with sustainability objectives
A53	Plan stakeholder engagement & communication
A54	Communicate with stakeholders
A55	Monitor stakeholder engagement and measure their performance

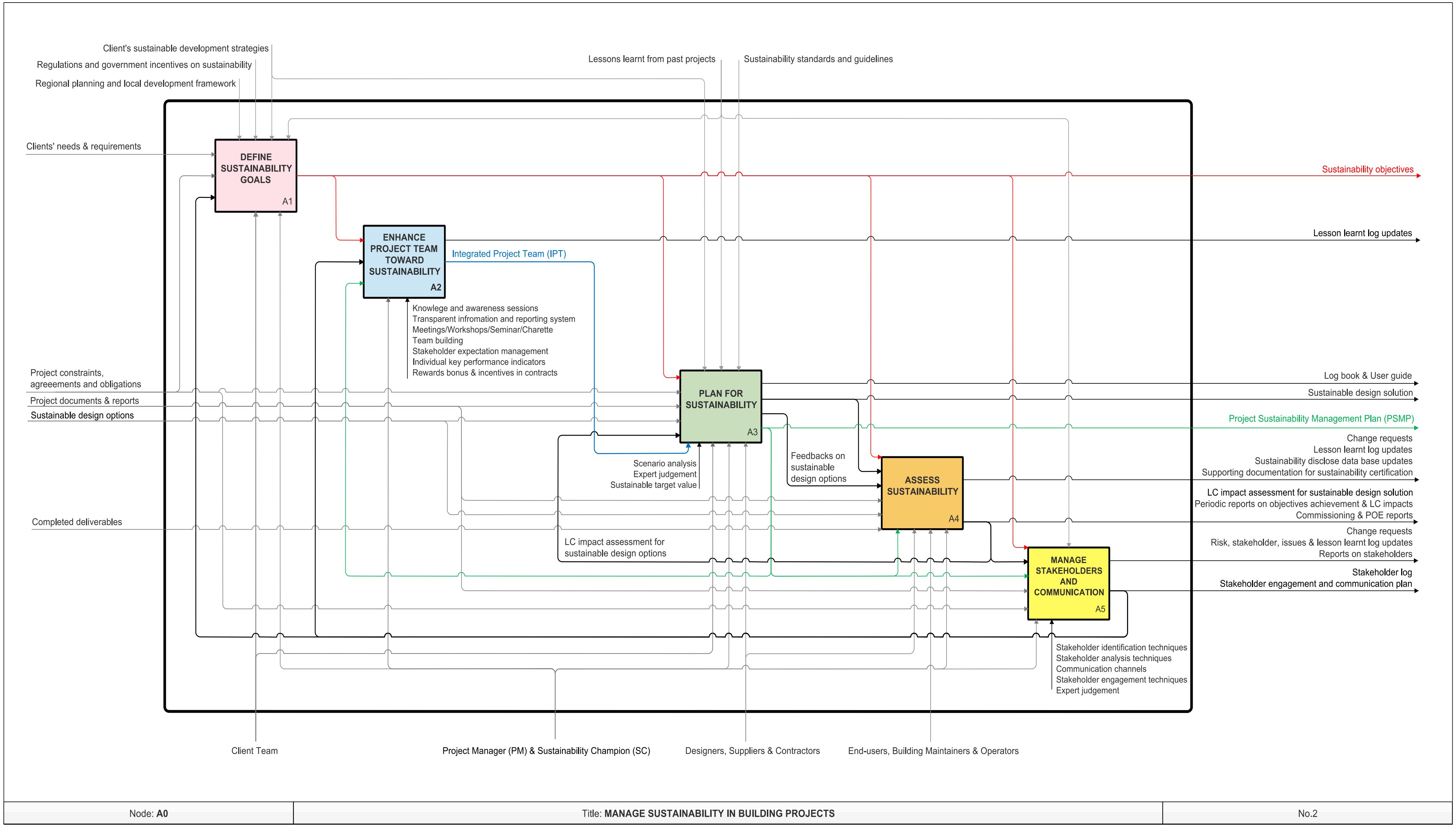


Figure 6.6. GEPAS – A0 context diagram

6.3.4. A1 - Define Sustainability Goals

GEPAS differs from the traditional management approach by its activity of advising clients on benefits, opportunities and constraints of sustainability (A11) before they decide and declare project objectives (A12). GEPAS refers to the overall project objectives as *sustainability objectives* since sustainability is embedded in project objectives. This ensures the objectives are not driven by financial benefits but looks at the overall benefits considering environmental and social aspects as well. IDEF0 diagram for the A1 process is shown in Figure 6.7.

6.3.4.1. A11 - Advise clients on benefits, opportunities, and constraints of sustainability

In this step, project manager (PM) and sustainability champion (SC) act as advisors for clients/investors in defining their *initial business case, strategic brief, sustainability aspirations, and other core project requirements*. The PM in this stage of the project could be from the client team (project director/manager, project advisor), or an external professional hired temporarily to advise on sustainable project management.

In many cases, clients of building projects do not have intensive experience and knowledge in the area of construction and sustainability. Therefore, this activity is designed to inform and advise clients on sustainable construction of buildings discussing the benefits, opportunities and constraints of sustainability with PM and SC(s). To prepare for the discussion with clients, PM and SC could start from the *client's needs and requirements*; and also take into account clients' corporate *sustainable development strategies,* and regulation documents (such as *regulations and government incentives on sustainability, regional planning, and local development framework*). They might need to review the *lesson learnt from past projects.* These lessons learnt could be in a formal form (record log files or real cases) or informal form (i.e., personal experience). Lessons learnt in the form of a case study or statistical data from successful projects will help to clarify new ideas and concepts to the client team. The presentation of supporting documents is critical to influence the decision of clients, so they should be well prepared before meeting with clients. Information related to the cost should be considered from a life-cycle-costing viewpoint.

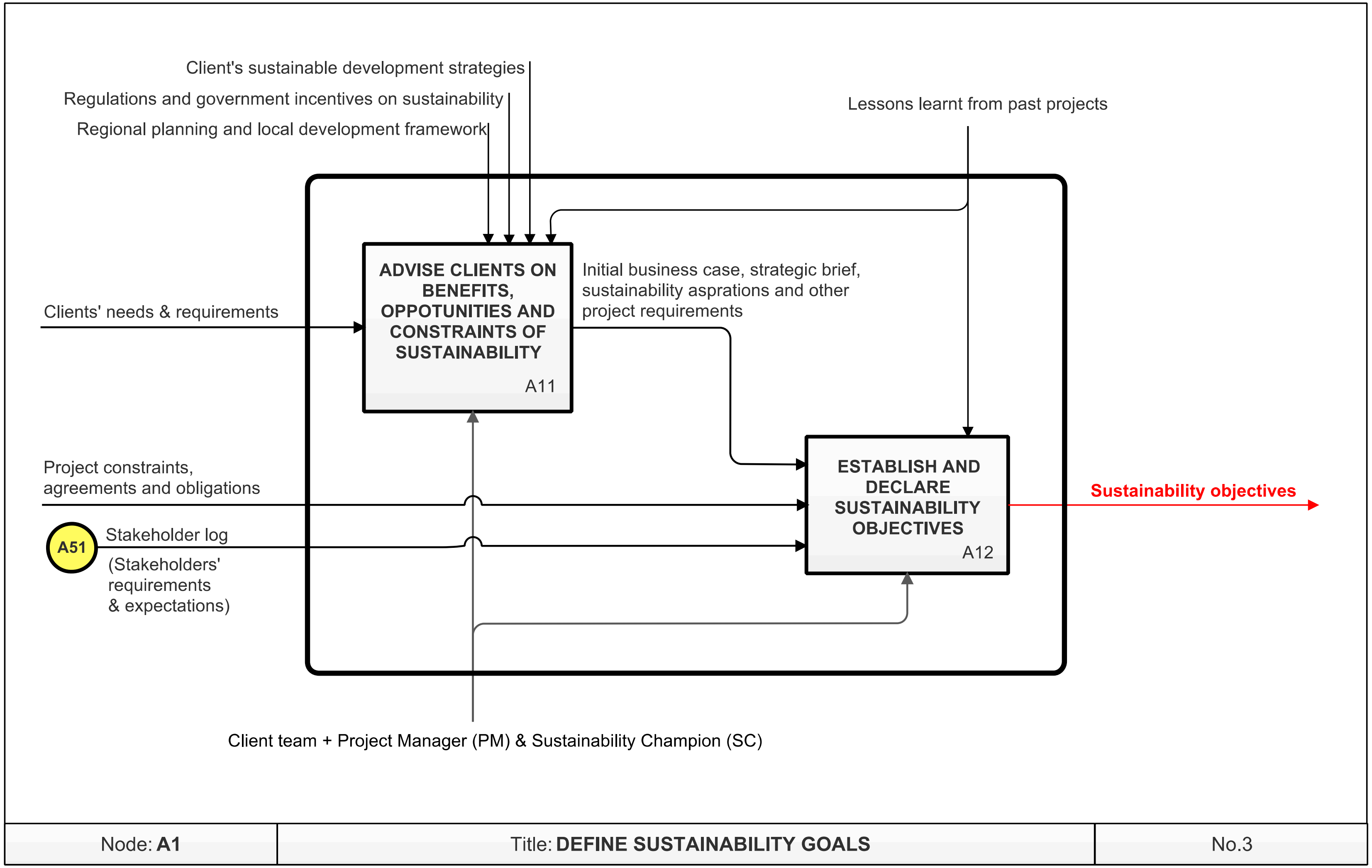


Figure 6.7. GEPAS – A1 Define Sustainability Goals

6.3.4.2. A12 - Establish and declare sustainability objectives

After the *initial business case, strategic brief, sustainability aspirations, and other core project requirements* developed (output from A11), PM and SC(s) are required to support clients in developing *a list of project sustainability objectives*, which is an official statement of project goals with consideration of economic, environmental and social impacts of the building and its construction process. To define the project objectives, the team also needs to consider the stakeholders' requirements recorded in the *stakeholder log* as well as *project constraints, agreement, and obligations*. Moreover, the *lesson learnt from past projects* can help in reviewing goals before official ones are approved. Then, to make the project objectives to be more transparent to all stakeholders, PM should clarify sustainability objectives through a set of value criteria for project objectives and targeted outcomes (including but not limited to criteria of functionality, budget/cost, design and quality standards, health, and safety, community and environment). This set of criteria needs approval from clients before getting accepted as part of the project brief.

6.3.5. A2 - Enhance Project Team toward Sustainability

GEPAS framework emphasizes the need for a strong focal point on the development of the project team's ability and their commitment to sustainability. It starts with the responsibility of forming and preparing the *Integrated Project Team (IPT)* (see A21). PM also needs to make sure that the implementation of the IPT (see A23) can contribute to increasing project value, to reduce total cost, as well as to improve quality, innovation, and collaboration of the project. To prepare for effective working of IPT meetings, a proper training session on sustainability (See A22) is necessary to head participants toward the same direction of sustainability objectives. IDEF0 diagram for the process A2 is shown in Figure 6.8.

6.3.5.1. A21 - Prepare for the Integrated Project Team (IPT)

GEPAS framework supports the forming and implementation of an Integrated Project Team (IPT), who would contribute to the success of projects from the design stage. Following the *sustainability objectives* (from A12), *project sustainability management plan (PSMP), stakeholder engagement & communication plan*, PM needs to consider who in the *stakeholder log* should be selected to become members of IPT and how to invite them to the IPT meetings. Initially, the selection must be carried out carefully to make sure that they are all best suited to the IPT working culture and have progressive contributions to help to achieve defined sustainability objectives. The normally accepted criteria for this selection are experience, location, safety record, qualification, and available resources. Besides, potential members' performance in previous projects (i.e., records of the budget, schedule, quality, safety, client satisfaction, compliance with regulations, and other issues related to sustainability aspects) could be considered if this information is available.

Furthermore, to run a successful IPT, potential partners should show that they have sufficient teamwork skills, flexible and constructive thinking to work in a collaborative team. To invite and keep the right people in the IPT, it is essential to have suitable *rewards, bonus or incentives* as a promise of future construction contracts. If the project is carried out through the traditional procurement routes, using negotiated contract (the preferred bidder), two-stage tendering or restricted tendering (2-4 tenders) could help to get active participants from the potential contractors, who are willing to contribute if they see a high chance of winning the bid. Besides, issuing a partnering agreement among internal parties could help to boost up the collaborative environment of the project team.

After best-added-value members accept to participate in the IPT, in the first kick-off meeting, PM should manage to achieve *agreements on IPT implementation* among all members on working culture, the timing of meetings, role, share of risk and responsibility, and processes of IPT implementation (especially in the process of resolving problems/dispute and making decisions).

6.3.5.2. A22 - Train the IPT on sustainability

Sustainability in construction buildings is a new terminology that people might not be familiar with the concept or might have a different understanding about it. The lack of knowledge on sustainability can prevent project team and stakeholders in contributing on the sustainable success of the project; whereas, the lack of a common and sufficient understanding about sustainability goals among them might lead participants to a different orientation, which could result to unwanted damage or waste to the project.

Therefore, this activity aims at providing a necessary training on *IPT* and project's common sustainable values. The *PM* should organize the meeting of IPT aligned with *agreements among IPT members* such as working culture, the timing of meetings, role, share of risk and responsibility, and processes of IPT implementation (See A21). *SC* takes main responsibility in delivery of the training *sessions on awareness and knowledge* on sustainability. These training sessions must focus on introducing all related knowledge to *sustainability objectives* of the projects as well as motivating the IPT on sustainable behaviour thanks to benefits they can bring to the project. SC should clarify the IPT members about sustainable criteria (KPIs and quality metric) and expected responsibility of IPT in initiating and delivering sustainability of the project (which is demonstrated in the PSMP). This activity has no tangible output, however, it is important for further IPT implementation. When members have sufficient knowledge and motivation, they would potentially contribute more innovative ideas in the following meetings of the IPT. Moreover, these training sessions also bring IPT members closer through a common knowledge background they are introduced, which can then lead to an indirect support of the collaboration of the team.

6.3.5.3. A23 - Coordinate and motivate the IPT toward sustainability

In the following meetings, PM should coordinate the IPT in identifying, developing, reviewing and selecting the sustainable solution. The sustainable solution is the selected sustainable design option; the sustainable solution should be the most suitable option in consideration of project conditions. The selection of the sustainable solution might need to consider issues related to stakeholders', clients' and regulatory requirements and constraints, project risks, and analysis of life-cycle impacts that proposed sustainable options bring to the economy, environment, and society.

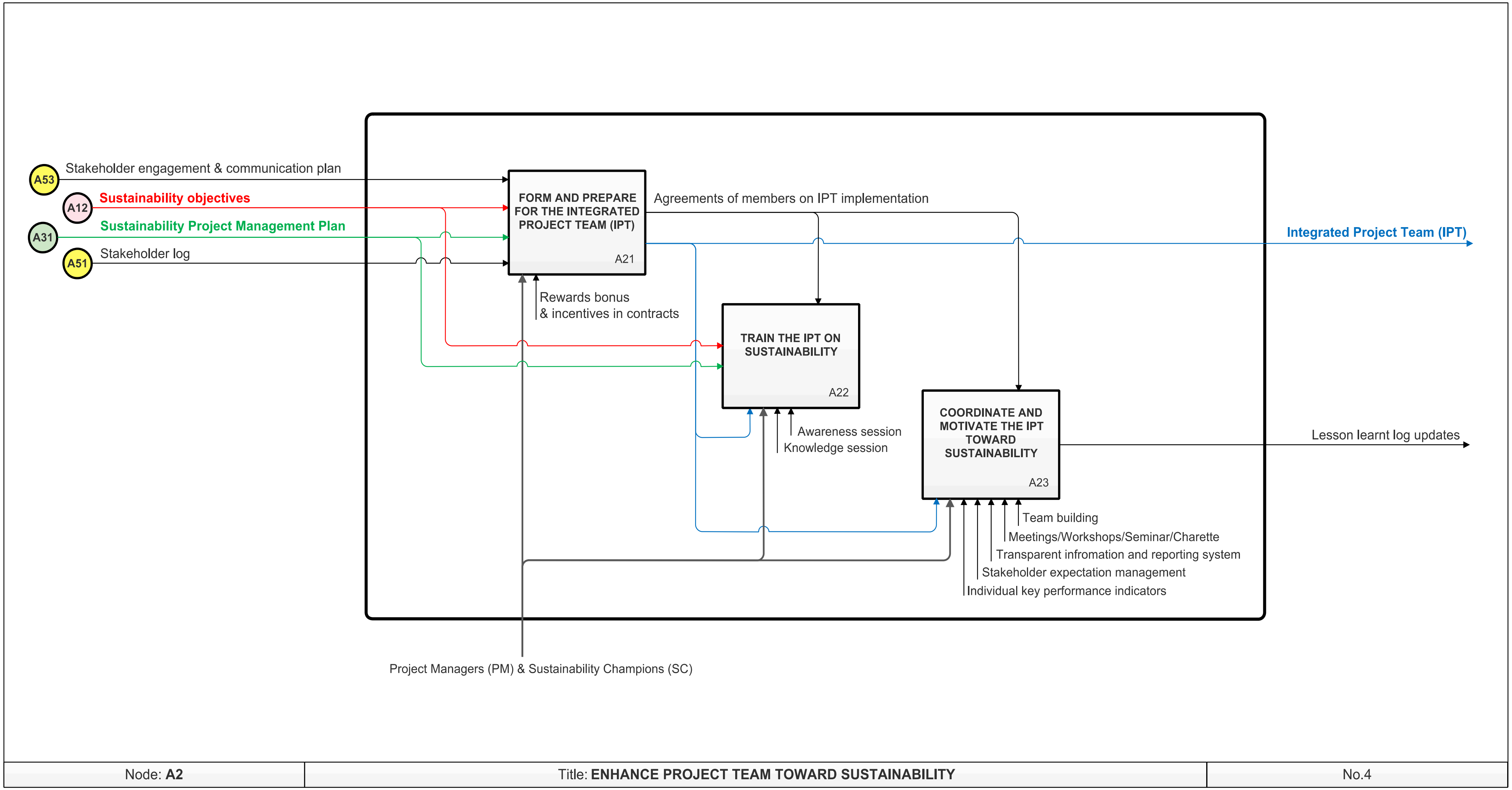


Figure 6.8. GEPAS – A2 Enhance Project Team toward Sustainability

To coordinate the IPT, PM can benefit from *communication technologies*, *transparent information and reporting system* to improve the effectiveness of the meetings. The meetings are not limited to official *face-to-face meetings/seminar/workshop*, but include potential virtual reality (online) meetings and other *communication technologies*. Besides, it is necessary for a PM to take into account issues of *team building*, *stakeholders' expectation management*, and IPT performance evaluation through *individual key performance indicators (KPIs)*. GEPAS highlights the implementation of IPT as an opportunity for continuous *training and education* for stakeholders on sustainability. PM should also pay attention to motivate sustainability among the team and to provide sufficient training on sustainability for the whole team or a group of members. The enhancement of team motivation on sustainability, inter-personal and teamwork skills will help to implement further processes effectively.

Finally, it is essential to *update lessons learnt log*, this document records the category and description of the situation. It may include the impact, challenges, problems, realised risks and opportunities, recommendations, and proposed actions associated with the situation, or other content as appropriate. The document strongly supports the on-going development of the whole IPT implementation in following meetings/further projects.

6.3.6. A3 - Plan for sustainability

In GEPAS, planning for sustainability is not a single or one-off document, it is the process of creating core principle and direction for further actions (through a document called as Project Sustainability Management Plan - PSMP from A31), comparing and selecting the best solution (A32), and proposing sustainability assurance to prevent sustainability drop in building operation stage (A33). IDEF0 diagram for the A3 process is shown in Figure 6.9.

6.3.6.1. A31 - Strategic plan for the project's sustainability

In all prevalent procurement routes, this step is one of the first actions done by a PM from designers'/contractors' side. Before a sustainability plan is created, designers/contractors would have a chance to influence clients on carrying out sustainability aspirations or further-developing sustainability objectives with their expertise in the concept design stage. If PM and SC are successful in influencing the client, additional criteria and some changes should be made to project documents and informed to stakeholders.

In this sub-process, benefiting from the *lessons learnt from past projects*, experienced PM with the support of SC takes the main responsibility to develop a *Project Sustainability Management Plan* (PSMP). A PSMP helps to manage and direct the activities and tasks needed for the achievement of *sustainability objectives* (and additional objective/sustainability aspiration if applicable), and it needs to be in line with the *client's sustainable development strategies*. GEPAS supports for the issue of a separate plan as a recommendation from Silvius, Neuvonen, & Eerola (2017) in cases that sustainability is not explicitly addressed, like in building projects; and then PSMP can work as an effective channel to address sustainability. This approach is also in line with the approach of Project Sustainability Logbook in engineering and infrastructure industry from FIDIC (2013).

There are three templates for developing PSMP that user can rely on: from Carboni (2013), FIDIC (2013) and Silvius (2015). In GEPAS, a PSMP is highly recommended to design in the orientation of both product and project management delivery processes; then it should cover but not limited to the contents below.

- *Project introduction*: Summary of project definition, sustainability objectives, approved set of value criteria for project objectives and targeted outcomes (See A12), scope definition and, scope exclusions;
- *Organisational context*: Summary of organisational sustainable development strategy, the list of stakeholders, their interests and level of requirements on sustainability.
- *Sustainability strategy* on impact, risk, and opportunities related to waste, energy, water, carbon footprint, green materials & technology, sub-contracting communication, site negative impact control, or workforce conservation. The environment management plan and waste management plan, therefore, could be combined as parts of PSMP.
- *Sustainability assessment methodology*: The choice of measuring tools, techniques, standards, building certification, quality metrics or KPIs.
- *Governance of sustainability*: The description of who should take responsibility, be involved and reported throughout the project.

Therefore, to develop a management plan for delivering sustainable features of projects, PM might need *risk log* (for potential risk related to sustainability) and *stakeholder log* (particularly the relationship between stakeholders and sustainability objectives).

6.3.6.2. A32 - Compare design options and select sustainable solution

The first design drafts and potential *sustainable design options* (i.e., potential options that can be considered to achieve sustainability objectives) created by the design team taken into consideration by *IPT* to decide which option should be chosen for the project. The selection of the sustainable solution might need to consider issues related to *project requirements, constraints, and obligations*, *project risks*, and analysis of *life-cycle impacts that proposed sustainable options* bring to the economy, environment, and society. In most of the cases, the selection might take a few meetings before coming to the selection of the final *sustainable design solution* (the selected design option to be implemented), then *feedback on sustainable design options* after each meeting can help designers to develop them further. The feedback would require designers to redevelop a better potential design option and reassess their LC impacts (See A41). Therefore, this activity and activity A41 might need to be repeated until the IPT team agree on a final sustainable design solution.

To facilitate this activity, the IPT can use *scenario analysis, sustainable target value* to investigate and review each different design option developed by the designer. Inviting new IPT member can be carried out as a potential way to get a valuable *expert judgment* in particular cases, for example, a new energy technology or cooling system that the current team is not specialised.

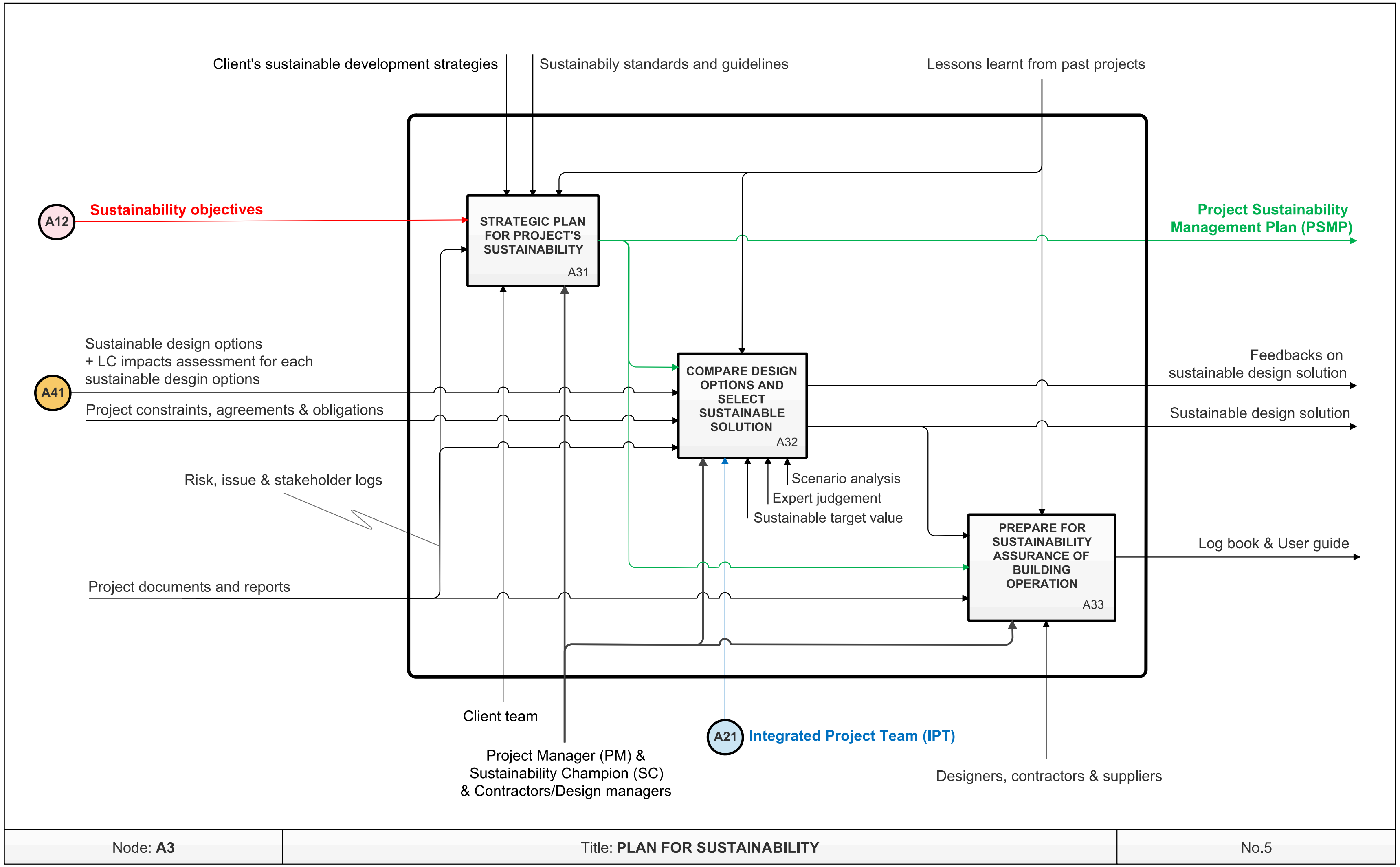


Figure 6.9. GEPAS – A3 Plan for Sustainability

6.3.6.3. *A33 – Prepare for sustainability assurance of building operation*

This activity aims at maintaining sustainable features and value through the long-term operation of the building and at preventing the drop of sustainability due to lack of communication and transparency from the project team to building users, operators, and maintainers. In this activity, PM, *SC*, *designers*, *suppliers*, and *contractors* will work together to prepare a detail *building logbook and guide for users*. These operational guides should be aligned with the principles of *PSMP* and *sustainable design solution* and cover all necessary *project documentation and reports*. Eventually, it can demonstrate potential risks and problems that operators and maintainers might meet in the future as well as possible solutions to prevent them. Furthermore, in some sophisticated system, user guide should be made as a video with a clear step-by-step approach to avoid misunderstanding from users and troubles in the operation of that system.

6.3.7. A4 - Assess sustainability

GEPAS sees the assessment of sustainability during the life-cycle of project, including two significant impact evaluations of building life-cycle in design stages (A41 & A42), continuously monitoring of sustainability objectives achievement and life-cycle impacts in construction stage (A43), and checks for achievement of sustainability outcomes after construction of deliverable finished (A44). All the activities of A4 process are profoundly influenced by factors like *sustainability standards and guidelines* as well as *lessons learnt from past projects* to carry out the assessments. IDEF0 diagram for the A4 process is shown in Figure 6.10.

6.3.7.1. *A41 - Assess life-cycle sustainability impacts of each design options*

Sustainable design options are potential and alternative options from designers to delivery *sustainability objectives*. Before *sustainable design options* are reviewed by the IPT, *designers, and SC* (assessment team) are required to take responsibility of evaluating economic, social and environmental impacts of each design options with criteria and methods defined in *PSMP*. After the IPT meetings in selecting the sustainability solution (See A32), designers might need to redevelop design options, and then SC also needs to reassess LC impacts. Activity A41 and A32 might need to be repeated until the IPT team agree on a final sustainable design solution.

The assessment team can also benefit from suppliers with intensive information about the environmental and social impacts of supplied materials/ building components. The output of this activity is a detail *life-cycle impact assessment for each design options*, which will support the IPT in deciding the sustainable solution (See A32).

6.3.7.2. A42 - Assess life-cycle sustainability impacts of the final design solution

After the IPT approves *sustainable design solution* (which is then integrated into the final design solution), it is the time for a more in-depth assessment of the final design with criteria and methods defined in PSMP. The assessment team (designers and SC) can also benefit from the information in *life-cycle impact assessment for each design options* (See A41). The output of this activity is a *life-cycle assessment report of the sustainable design solution*, which can become a supporting document for registering sustainability certifications for the building. It is essential to double-check the compatibility between *life-cycle assessment results of sustainable design solution* and *sustainability objectives* (in detail, the set of value criteria for project objectives and targeted outcomes – See A12); in cases that they are not compatible, PM might need to organise another IPT meeting for reviewing the sustainable design solution.

6.3.7.3. A43 - Monitor sustainability objectives achievement and life-cycle impacts

During the construction stage - where most of the physical work-packages of the project are built up, the monitoring of sustainability objectives' achievement and life-cycle impacts is critical to prevent the unwanted drop of sustainability from the design drawings to real building components.

In fact, a complete assessment of sustainability, such as Life-Cycle Assessment (LCA), requires a large amount of information and efforts of all team members – which might take time to have a reliable result. Therefore, such a full-set assessment is not suitable in the construction stage. To face with this problem, GEPAS suggests to first identify a short list of key measureable metrics/KPIs, which can be checked regularly during the construction stage. These metrics would be monitored with support of information from *project documents and reports.*

This activity might be designed differently depending on the size of the project. In large projects with significant impacts, the primary output of this activity is *periodic reports on sustainability objectives' achievement and life-cycle impacts,* which should be informed to all relevant stakeholders. In case that monitored metrics/KPIs exceeds warning limit, *change request* should be made to remedy consequences, and the *lesson-learnt log* should be recorded for preventing a similar problem in the future. In a small project with an insufficient budget for the project management team, such metric/KPI can be embedded in quality metrics, and this activity will be integrated into quality management.

6.3.7.4. A44 - Carry out post-construction evaluations

This activity includes two main checks: commissioning and post-occupancy evaluation (POE). First, after project *(completed) deliverables* are completed, *main contractors* will be responsible for carrying out tests and issue *commissioning reports* to make sure that building systems function as designed and all errors are remedied. Secondly, after the building is operated for a specified period, POE with the involvement of *end-users, building maintainers,* and *operators* can help diagnose operational problems. Depends on the problem identified, request changes might be made to improve the performance of buildings. The output of the activity, *POE report*, can also support the continuous learning process of architectures and all other project team members (through records in a *lesson learnt log*). If the client requires for sustainability certification in operation, all POE report results can be *supporting documentation for registration*. This report's findings can be a part of *sustainability disclose database updates*, which then form the corporate sustainability reporting. Moreover, PM, designers, and contractors might benefit from comparing commissioning, and POE reports with LC impact assessment of sustainable design solution (From A42), finding differences, and reflecting themselves for avoiding unwanted failure in further projects.

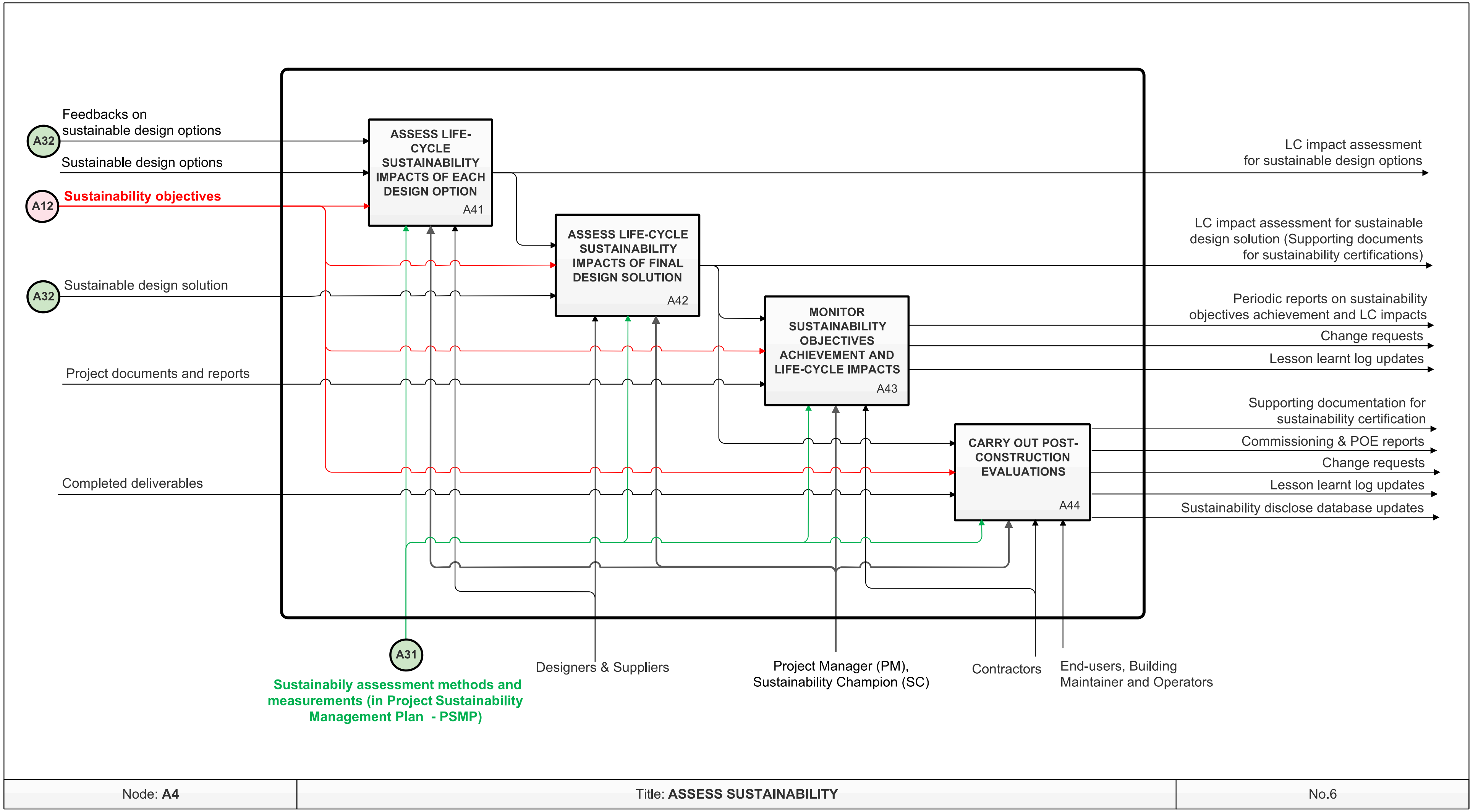


Figure 6.10. GEPAS – A4 Assess Sustainability

6.3.8. A5 - Manage stakeholders and communication

Regarding stakeholder and communication management, GEPAS inherits all elements demonstrated in BS 6079:1-2010 – including activities of identifying stakeholder (A51), planning stakeholder engagement and communications (A53), communication (A54) and monitoring stakeholder (A55). Moreover, it combines the stakeholder engagement process from Bal, Bryde, et al. (2013) to the BS standard. In detail, stakeholders are related to sustainability objectives in the concept design stage (A52) and measured individuals' performance during project delivery (Additional task to A55). IDEF0 diagram for the A5 process is shown in Figure 6.11.

6.3.8.1. A51 - Identify stakeholders

This activity is carried out by the *PM and their management team*; it aims at identifying a full list of stakeholders and a detailed information sheet of each stakeholder (*stakeholder log*). Stakeholder log contains information about identified stakeholders, including but is not limited to their general and contact information, role on the project, requirements and expectation, and analysis (classification and prioritization) of their impact/power/influence, interest, urgency or attitude to the project, as well as their inter-connections that might impact to the project activities.

After stakeholder log is created, it should be kept updating periodically (especially when the project moves to another stage) to avoid risks related to stakeholders. Moreover, as GEPAS put a focal point on engaging stakeholder earlier than the traditional approach of project management, PM is expected to be aware of future stakeholders of the project, which have not to affect or visible at the moment of identification. To carry out this activity, PM and his/her management team can rely on *stakeholder identification techniques* (brainstorming, expert judgment, or snowballing) and *stakeholder analysis techniques* (stakeholder circle, salience, socio-dynamic, influence map, interest-power matrix, or social network analysis).

6.3.8.2. A52 - Relate stakeholders with sustainability objectives

After sustainability objectives are defined (See A12), they are updated in the stakeholder log (See A51). This enables relating the sustainability objectives to stakeholders' responsibility and skills. Different stakeholders have different skills and knowledge that can contribute to one or a few particular part of project objectives. Therefore, PM and management team should manage stakeholders in the relations with these objectives, so that their skills and knowledge can be utilised to achieve high performance and targeted sustainability outcomes.

6.3.8.3. A53 - Plan stakeholder engagement & communication

Having *stakeholder log* determined, a means of engaging them to project should be planned. Based on data collected and analysed in *stakeholder log*, PM can prioritise them through their positive/negative attitude, power and the potential contribution they can provide to projects. This prioritisation will help PM to develop a detailed *stakeholder engagement and communication plan* – which should define the target level of engagement and how to engage each stakeholder with the project to minimize their negative feelings and promote positive attitudes. The plan should also clarify time, budget and human resource required to do the communication and monitor stakeholders; it also needs to define metrics/KPIs for monitoring stakeholder performance and contribution. Therefore, the development of this plan should be aligned with *sustainability objectives*, *PSMP,* and *agreements and obligations* that project committed with stakeholders. To facilitate this planning, the PM can rely on *expert judgment*, *stakeholder engagement techniques,* and available *communication channels*. Furthermore, it is worthy to note that a successful stakeholder engagement and communication plan requires PM's ability in predicting stakeholder relations and in proposing proactive actions to build trustful and long-term relationships with stakeholders.

6.3.8.4. A54 - Communicate with stakeholders

Depending on the target audiences (and their profile defined in *stakeholder log*) as well as core principles of communication and stakeholder engagement illustrated in the *stakeholder engagement and communication plan,* PM can be flexible in selecting *communication channels*. For some stakeholders, push communication approaches (like emails, reports, posters/press releases or memos) can be used; but interactive or two-way communication approaches like face to face meetings are highly recommended to boost up mutual understanding and effectiveness of communication between the two sides of project and stakeholders. Besides, PM should also make sure that *reports on life-cycle impact assessments, reports of sustainability objectives achievements, life-cycle impacts, commissioning and POE* could be informed to proper stakeholders as a way to maintain their engagement to the project. The primary output of this activity is *project communication records* (including stakeholders' feedbacks), which is monitored in activity A55. Moreover, depending on feedbacks of stakeholders on project activities, *change requests* might be created and some updates need to be made (*stakeholder, risk, and lesson learnt log updates*).

6.3.8.5. *A55 – Monitor stakeholder engagement and measure their performance*

This activity aims at validating and reporting stakeholders' attitude, satisfaction, and performance in supporting sustainability objectives' achievement using *project communication records.* The project management team can measure stakeholder satisfaction and their performance in fulfilling responsibilities through a set of *KPIs/metrics for stakeholder performance evaluation*. The PM and the management team are also required to keep an eye on identifying issues related to stakeholders that might damage project outcomes. In case of stakeholder demands (such as additional requirements, or the appeal of unknown requirements) that can affect the project, *change requests* with proposal of corrective actions should be sent to clients for approval (which often be carried out with support of risk and issue management); and *updates* (*project plan, stakeholder, risk, issue, and lessons learnt log*) need to be made to prevent similar problems from happening in the future.

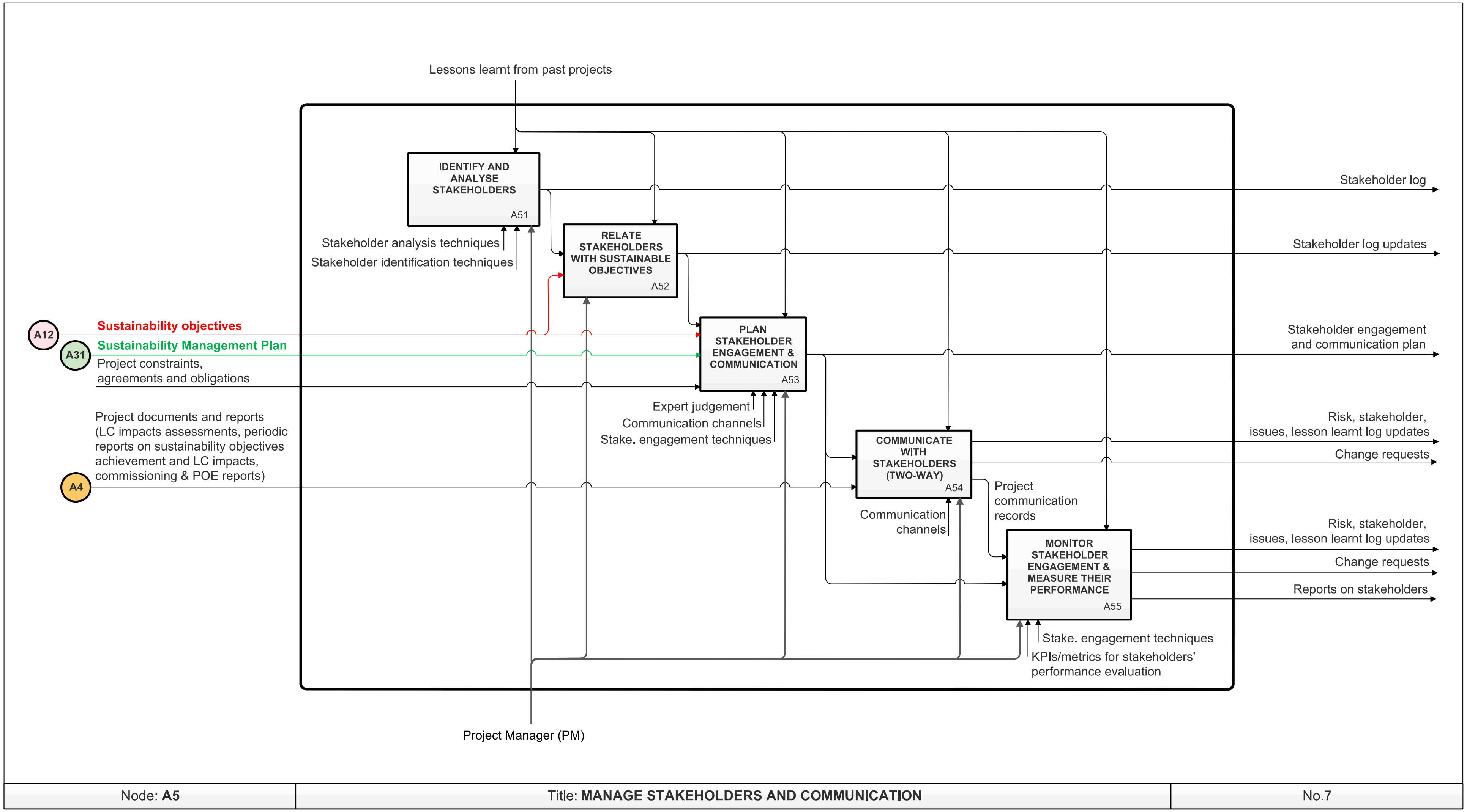


Figure 6.11. GEPAS – A5 Manage Stakeholder and Communication

6.4. Inter-relationships among GEPAS's activities and with other project management supporting areas of BS 6079-1:2010

It is essential to present the dependencies and flows between the activities of the model. Figure 6.12 shows the interrelationships among these activities and Figure 6.13 further details them with the sequence of appearances in the project life cycle. Finally, figure 6.14 explains the relationship between the five main processes of GEPAS and current supporting project management areas in the standard BS6079-1:2010.

6.4.1. Inter-relationships among the five processes of GEPAS

This part demonstrates the inter-relationships of GEPAS's activities in the time frame from strategic definition to the in-use stage of the project life cycle. The procedure of GEPAS's activities by the project's life-cycle stages is illustrated in part below. Table 6.2 summaries the activities, inputs, and outputs in each stage.

(1) Strategic definition

PM with the support from the SC will take responsibility in identifying and analysing project's stakeholders (A51) to develop the first version of stakeholder log (which then should be kept update periodically). After that, the PM and SC are required to advice clients on issues related to the legal aspect, benefits, opportunities, and constraints (including barriers and bad-side risks) of sustainability that project might get before forming the initial business case, strategic brief and other core requirements of clients on the project.

(2) Preparation and brief

In this stage, PM and SC will support the clients in deciding the sustainability objectives of the project (A12). These objectives should cover not only the economic aspect but also the social and environmental aspects of sustainability. It is also expected to keep a balance between the client's needs and requirements and other stakeholders' requirements (in stakeholder log from A51). After sustainability objectives are established, they should be written clearly in a suitable language to avoid misunderstanding, and then declared formally to all stakeholders (A12).

(3) Concept design

This is the stage where planning activities occur. First, PM needs to related stakeholders with sustainability objectives (A52). This update of stakeholder log would help for further management of stakeholders; for example, in cases, if a problem damages a project objective, all related stakeholders can be informed quickly and support to troubleshoot it. Second, a strategic plan should be made for project sustainability named as Project Sustainability Management Plan - PSMP (A31), which would provide further direction for the collaborative working of the project team, the assessment, and monitoring of sustainability, and the engagement and communication with stakeholder. Besides, a stakeholder engagement and commutation plan (A53) should be made in this stage.

(4) Developed and technical design

As recommended by GEPAS, the collaborative working the project team is carried out by the forming, training and coordination of an Integrated Project Team - IPT (A21, A22, and A23). On the one hand, PM could benefit from IPT meetings as a chance to motivate and train the whole team to raise their knowledge and awareness on sustainability. As a result, their commitments to the project and sustainable objectives could be enhanced. On the other hand, the IPT is employed to support a whole-team design, particularly to contribute potential options and select the most suitable solution to delivery sustainable objectives of the project (A32). The selected design solution needs to balance the life-cycle impacts of the project (A41) and project constraints, but able to achieve sustainability objectives embedded in the PSMP. Therefore, activity A41 and A32 might need to be repeated with feedbacks of the IPT on sustainable design options until decision makers of the IPT team agree on a final sustainable design solution. During and after the working of IPT, it is necessary to keep in touch with stakeholders (A54) to maintain their updates on results and reports related to the sustainability of the project. This activity aims at keeping continuous engagement and support from stakeholders to the project. Therefore, the monitoring of stakeholder's satisfaction/attitude and measurement of their performance (A55) is crucial to have a proper and on-time interaction that avoids adverse impacts and promotes supportive actions from stakeholders.

After the final design solution is approved by the IPT, it is time for SC and designers to evaluate the intensive life-cycle impacts of the project (A42). The result of this evaluation should be reviewed in comparison with sustainability objectives. After it is approved, it will play as a targeted set of life-cycle impacts of the project to be monitored and can also be used as a supporting document for sustainability certifications. Besides, the meetings of IPT could be continued in this stage if designers need further support from key internal stakeholders on issues related to the constructability or clash detection of the design.

Therefore, the number of IPT members in this stage might be limited to contractors, maintainers, supplier, and operators.

(5) Construction

During the construction stage - where most of the physical work-packages of the project are built up, the monitor of sustainability objectives achievement and life-cycle impacts (A43) is critical to prevent the unwanted drop of sustainability from the design drawings to real building components. Designers and SC need to identify a short list of measurable metrics/KPIs so that PM and construction manager (of main contractors) can check them regularly during the construction phase. If there is an insufficient budget for the project management team, such metric/KPI can be embedded in quality metrics, and this activity will be integrated into quality assurance.

(6) Handover and close-out

When almost all of the construction works have finished, GEPAS suggests that the two activities should be carried out: First, designers, contractors, and suppliers are required to prepare a comprehensive logbook and guide (A33) for operating, maintaining and using the building. This activity aims at assuring the durability of sustainable features and value through the long-term operation as well as at preventing the drop of sustainability due to lack of communication and transparency from the project team to building users, operators, and maintainers. Second, PM and contractors should manage to do all necessary commissioning (A44) to make sure that building systems function as designed and all errors are remedied. The commission of building components could start earlier from the construction stage, but it should be finished before the building is transferred from contractors to users and operators.

(7) In-use

After the building is operated for a specified period, Post-Occupancy Evaluation - POE (A44) with the involvement of end-users, building maintainers and operators can help diagnose operational problems. POE can also support the continuous learning process of architectures and all other project team members.

Table 6.2. Summary of GEPAS's activities, inputs, and outputs in different stages of a project

Stage	Inputs	Sub-processes / Activity involved	Main outputs **(and project document updates if applicable)**
Strategic definition		A51 Identify and analyse stakeholders A11 Advise clients on benefits, opportunities, and constraints of sustainability	- Stakeholder log - Initial business case strategic brief, sustainability aspirations, and core project requirements
Preparation and brief	- Stakeholder log	A12 Establish and declare sustainability objectives	- Sustainability objectives
Concept design	- Sustainability objectives - Stakeholder, risk and issue log (& other project documents) - Project constraints, agreements, and obligations	A52 Relate stakeholders with sustainability objectives A31 Strategic plan for project sustainability A53 Plan for stakeholder engagement and communication	- Project sustainability management plan (PSMP) - Stakeholder engagement and communication plan
Developed and technical design	- Sustainability objectives - Sustainable design options - Stakeholder engagement and communication plan - PSMP	A21 Form and prepare for the IPT A22 Train the IPT on sustainability A23 Coordinate and motivate the IPT toward sustainability A32 Compare design options and select sustainable solution A41 Assess life-cycle sustainability impacts of each design options A42 Assess life-cycle sustainability impacts of the final design solution A54 Communicate with stakeholders	- The integrated project team (IPT) - Agreements of members on IPT implementation - Feedbacks on sustainable design options - Lesson learnt log updates - Life-cycle impact assessment for sustainable design options - Sustainable design solution - LC impact assessment for the sustainable design solution - Risk, stakeholder, issue, lesson learnt logs updates - Change requests

		A55 Monitor stakeholder engagement and measure their performance	- Project communication records - Reports on stakeholders
Construction	- Sustainability objectives - PSMP - Project documents and reports - Stakeholder engagement and communication plan - Completed deliverables	A43 Monitor sustainability objective achievement and life-cycle impacts A44 Carry out post-construction evaluations A54 Communicate with stakeholders A55 Monitor stakeholder engagement and measure their performance A33 Prepare for sustainability assurance of building operation	- Periodic reports on sustainability objective achievement and life-cycle impacts - Lesson learnt log updates - Risk, stakeholder, issue logs updates - Change requests - Project communication records - Reports on stakeholders - Sustainability disclose database updates - Supporting document for sustainability certification - Commissioning reports - Logbook and user guide (Draft)
Handover and close-out	- Sustainability objectives - PSMP - Stakeholder engagement and communication plan - Project documents + reports - Completed deliverables	A33 Prepare for sustainability assurance of building operation A44 Carry out post-construction evaluations A54 Communicate with stakeholders A55 Monitor stakeholder engagement and measure their performance	- Logbook and User guide (Final version) - Risk, stakeholder, issue, lesson learnt logs updates - Change requests - Project communication records - Reports on stakeholders - Commissioning reports
In-use	- Sustainability objectives - PSMP - Stakeholder engagement and communication plan - Completed deliverables	A44 Carry out post-construction evaluations A54 Communicate with stakeholders	- POE report - Lesson learnt logs updates - Change requests - Supporting document for sustainability certification - Sustainability disclose database updates

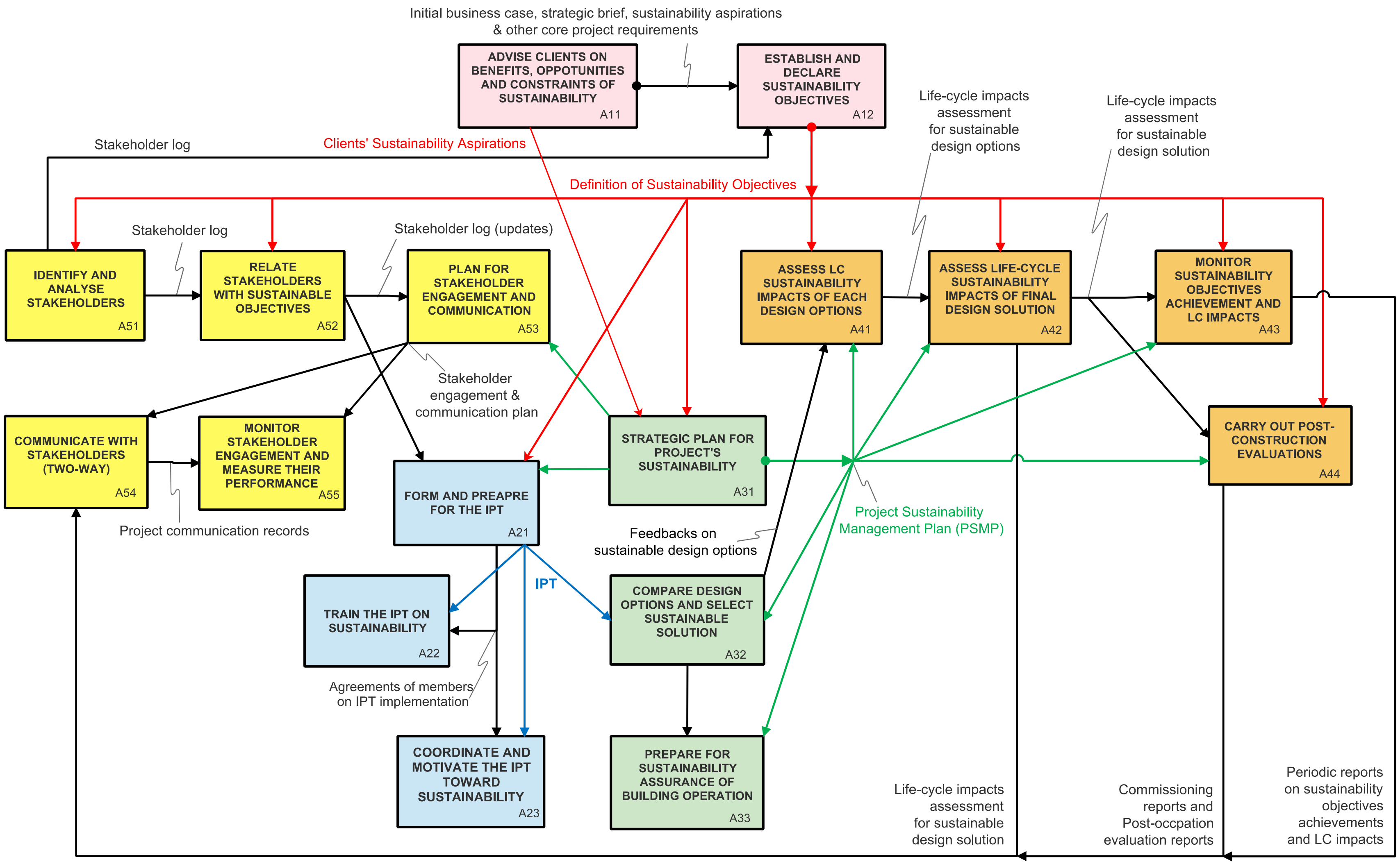


Figure 6.12. Interrelationships among GEPAS's sub-processes

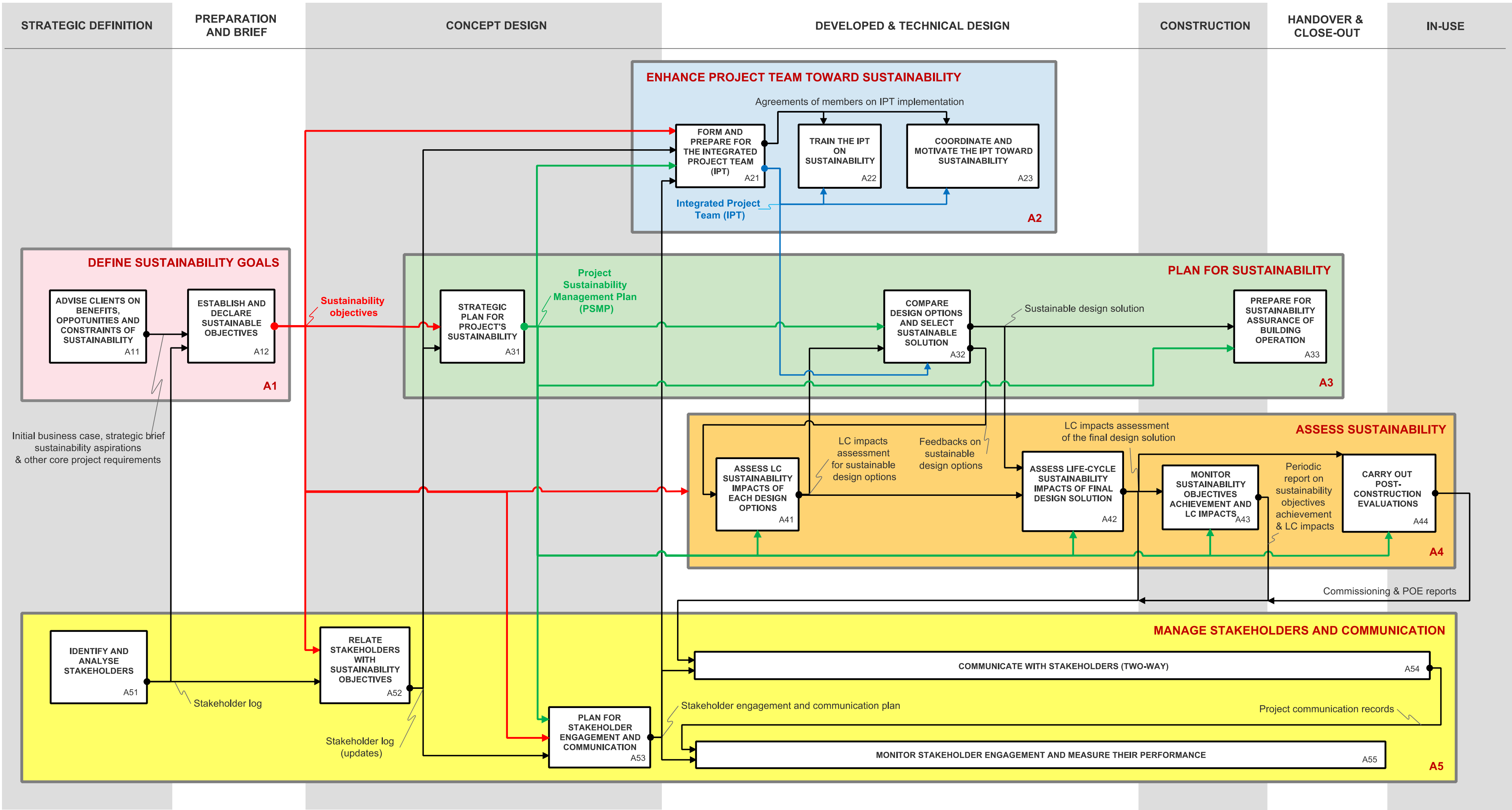


Figure 6.13. Interrelationships among GEPAS's sub-processes and their sequence of appearances in the project life cycle

6.4.2. GEPAS as supporting the process of "Manage Sustainability" and its relationships to other supporting processes in BS 6079-1:2010

This part explains the relationships between the GEPAS framework and other processes of project management in BS 6079-1:2010 standard. To embed GEPAS into the standard, the four processes A1, A2, A3, and A4 are combined as a group called "manage sustainability" - a new additional "project support process" with ID no 7.2.17 of the standard. Process A5 already exists as the process ID no 7.2.16 of this standard, but sub-processes of A5 are designed to enhance the "stakeholder & communication management" toward the achievement of sustainability. The overall view of these relationships is demonstrated in Figure 6.15.

The outputs of GEPAS's processes are linked with other existing processes of BS 6079-1:2010 as below:

- A list of sustainability objectives (red line resulting from the A1 process) is an essential document for not only the *Preparation for a project* (process 7.1.2 - which issues the *project brief*) but also the planning activities (i.e., the recognition of project scope and benefits);
- PSMP is made before the Work-Breakdown-Structure (See Figure 6.14). Therefore, the content of PSMP would affect the project schedule (7.2.5), resources (7.2.6) and costs plan (7.2.7). Furthermore, the sustainability assessment methodology mentioned in PSMP would also have impacts on the development of quality metrics and KPIs, which are further managed by project quality management (7.2.14);
- GEPAS encourages the record of lessons learnt log from related processes such as experience from the collaboration and implementation of IPT meetings (A23) and stakeholder engagement (A54 and A55), lessons from the monitoring of sustainability objectives achievement & life-cycle impacts (A43) as well as actions when the actual results go to lousy direction. Besides, the project team, especially builders and designers, can learn from the results of commissioning and post-occupancy evaluation reports (A44) so that their further project could avoid mistakes and misunderstanding end-users' demand;

- During the implementation of GEPAS, change requests might be considered, for example, in cases that a monitored metric of sustainability objectives achievement or impact (A43) is found as far exceed the pre-evaluation of the final design solution in design stages. Some changes might need to be done if the results of post-construction evaluations (A44) are not like in design. Besides, the project management team can think about asking chance approval from clients to satisfy the requirements of stakeholders that PM finds when he/she interacts closer with them (A54);
- The processes of GEPAS also contribute to reporting (7.2.12) and documenting (7.2.15) system of project with user guide and log book (A34), project life-cycle assessments (A41+A42), periodic reports on sustainability objectives achievement and life-cycle impacts (A43), commissioning, POE reports (A44) and reports related to stakeholders (A5);
- On the contrary, GEPAS also need project documentation and stored information for its processes, including risk log from project risk management (7.2.8), issue log from project issues management (7.2.9).

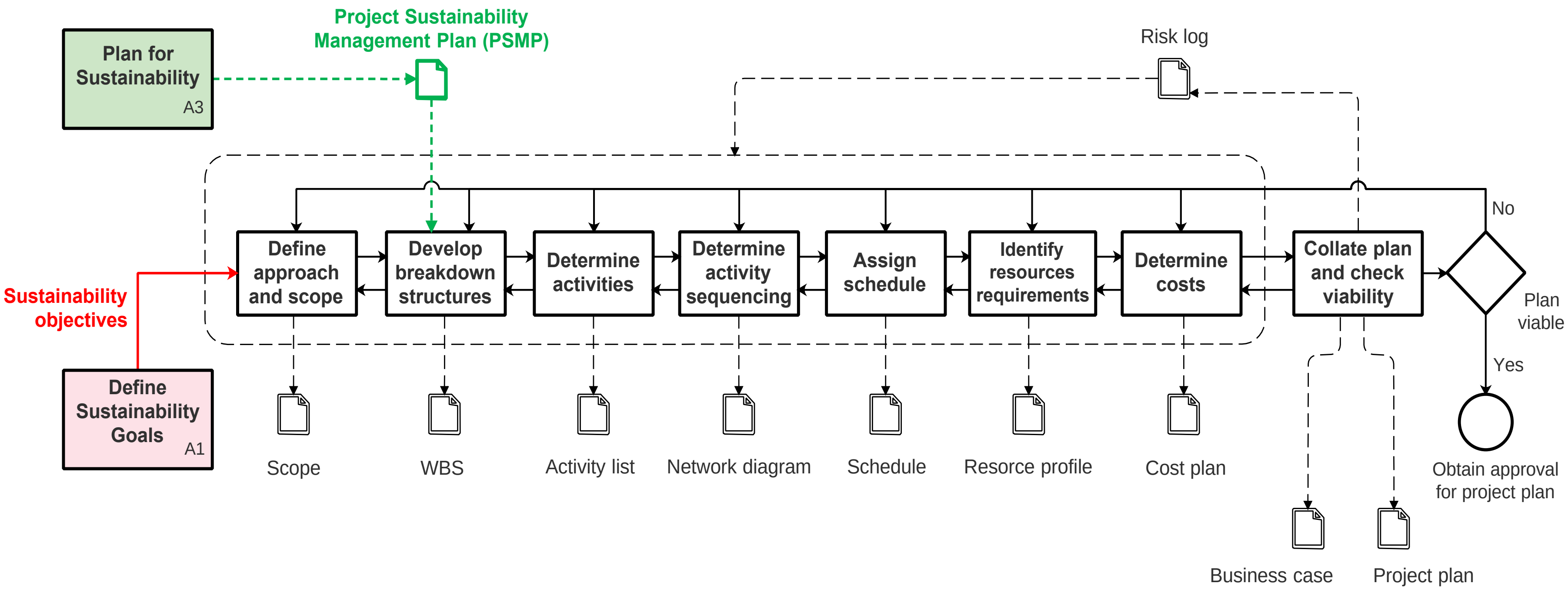


Figure 6.14. Sustainability objectives and Project Sustainability Management Plan (PSMP) with planning activities (Adapted from BS 6079-1:2010)

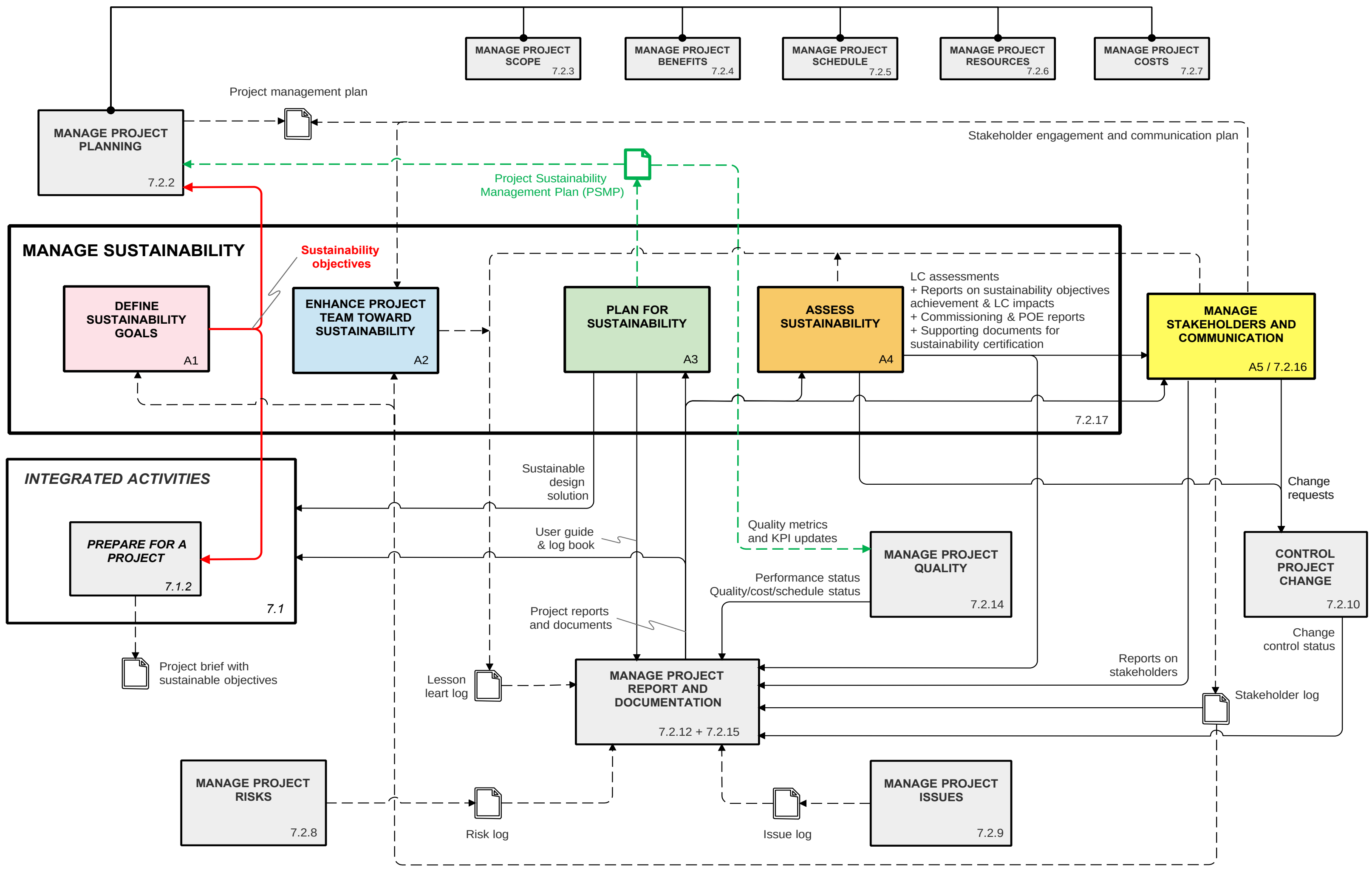


Figure 6.15. Relationships between the new "Sustainability Management" and other existing supporting project management areas in BS 6079-1:2010

6.5. Chapter conclusion

This chapter has presented the GEPAS framework, which was developed as a step-by-step sustainability management approach for building projects. GEPAS is designed to define sustainability goals (A1), to enhance project team toward sustainability (A2), to plan for sustainability (A3), to assess sustainability (A4), and to manage stakeholder & communication (A5). These processes aim at facilitating the sustainability management process in building projects in a way that competencies, knowledge, awareness, and motivation of the project team on sustainability are improved through IPT meetings. It also helps to guide for the process of sustainability planning, assessment and stakeholder management in consideration of strong sustainability objectives. Moreover, it equips PM with useful tools, techniques, and documentation that can support them in initiating and delivering sustainable building projects.

Although all five processes and 16 sub-processes of GEPAS framework have been clarified in detail by the use of IDEF0 modelling language, it is not completed until it is validated by construction industry professionals. The validation results of this framework are presented in the next chapter, Chapter 7.

CHAPTER 7. EVALUATION OF THE GEPAS FRAMEWORK

7.1. Introduction

This chapter presents the evaluation of the GEPAS framework introduced in Chapter 6. It clarifies the aims and objectives of the evaluation, and the choice of evaluation methods. They are then followed by a demonstration of the quantitative and qualitative data obtained from the research evaluators. The chapter ends with a discussion on the data collected and suggestions for further development of the framework.

7.2. Aims and objectives of framework evaluation

The evaluation was carried out to determine the validation and credibility of the framework. This chapter aims at determining the level of appropriateness and the extent of GEPAS framework and its processes in building projects. The specific objectives of the research evaluation include:

1. Assessing the applicability of GEPAS framework;
2. Assessing the overall effectiveness of GEPAS framework, including:
    - The extent to which GEPAS is able to support the definition of sustainability goals/objectives (letter G);
    - The extent to which GEPAS is able to improve project team in enhancing their communication, competencies, knowledge, and awareness on sustainability (letter E);
    - The extent to which the framework is able to support the planning process toward sustainability of projects (letter P);
    - The extent to which the framework is able to support the sustainability assessment of projects (letter A);
    - The extent to which GEPAS is able to support the stakeholder management (letter S);
3. Obtaining suggestions from the end-users on issues related to benefits, barriers and how to further develop the framework.

7.3. Adopted evaluation methodology

Research evaluation in social science deals with studying, appraising and improving social programs in their conceptualization, design, implementation, administration, outcomes, and efficiency (Rossi, Freeman, & Lipsey, 1999). The aim of evaluation is to ensure the total quality of model/framework (formative evaluation), including but not limited to key criteria of accuracy, execution efficiency, profitability, and usability (Balci, 1997). Furthermore, research evaluation could be able to assist the improvement or development - summative evaluation (Robson, 2011, p. 179).

Evaluation of this research focuses on assessing the validation and credibility of the model. Firstly, model validation assesses whether the model is reasonable and behaves consistently with its objectives (Sargent, 2007). In other words, GEPAS framework with its domain of applicability should meet its intended use stated in the beginning of Chapter 6. Second, model credibility targets at increasing users' confidence to use the model (Sargent, 2007); i.e., the applicability of the framework in building projects.

7.3.1. Implementing approaches for evaluation

In terms of implementing the approach for research evaluation, Sargent (2007) categorized four basic ways to do so, including:

- *Self-assessment:* Researchers or model development team will investigate the model themselves to decide the validity of the model. This method might work effectively in cases where they can compare the model testing results with a standardized data set.
- *End-user assessment*: As the model is designed to support end-users, it is necessary to involve them in its assessment. The model can then be considered as credible (i.e., the achievement of users' confidence in using the model) after it proved as valid.
- *Independent assessment*: This approach uses a third-party to assess the model. This party must not cover model developers and users to guarantee independence. However, this approach requires a deep level of knowledge and understanding of the framework.

- *Scoring assessment*: A set of criteria (with or without weight) is used to evaluate the model, and it is considered valid if it can pass an overall score. The approach is criticised by Sargent's (2007) as it could have an adverse result in one aspect but still pass the overall test. However, every model has its weaknesses, and should be accepted if the negative aspect has a minor impact on the overall working of that model. The identification of these weaknesses is also a useful finding that can support further development and a notification for users.

After considering the advantages and disadvantages of each approach, this study employed a mixture of end-user assessment and scoring assessment. The first approach (self-assessment) is not suitable because it has not much meaning in the validation of the model. Regarding the third approach (independent assessment), as GEPAS is a new and comprehensive framework in a very new area of knowledge, it is impossible to find such a third party to assess it; in other words, the independent value cannot be obtained. In contrary, GEPAS framework is designed for the use of project managers; therefore, the second approach (end-users assessment) is fitting with the original purpose. Besides, the scoring assessment is advantageous as it can assess various aspects of the model. Because the target of research evaluation, in this case, is to verify and validate the model at the same time, this approach has a great potential to support the evaluation.

In accordance with the aforementioned mixed approach to evaluate the model, the research was conducted to gather both quantitative and qualitative data. The triangulation of the two types of data would be helpful at not only increasing the validity of results, but also at deepening and widening the understanding of results (Olsen, 2004).

7.3.2. Adopted evaluation techniques

In terms of evaluation technique, it should be considered with the constraints of cost and time consumed to determine that model. In this case, it is impossible to do a proper execution of the framework in a real project, which might take years to develop from the initial concept to the completion of a building. Therefore, an *informal technique* is selected among the four types of techniques (informal, static, dynamic and formal technique), summarized by the Defense Modeling and Simulation Office (2001). The informal technique relies only on human subjective analysis and interpretation without any mathematical formalism (Debbabi, Hassaïne, Jarraya, Soeanu, & Alawneh, 2010). The technique uses experts (in this case, the expert and end-user could be the same targeted evaluator) to examine the process flowchart/graphical model; and then to determine if the model is appropriate and reasonable (Sargent, 2007).

7.3.3. Framework evaluators

As the GEPAS framework was designed for project managers in the UK to manage their sustainable building project, the targeted evaluators for framework evaluation should be the same industry practitioners. In detail, participants must be professional project managers with more than five years of working experience in managing and directing building projects with sustainability certification in the UK. These requirements are set to ensure that participants have sufficient knowledge and experience to make evaluation results reliable and valid.

The research has successfully gathered the participation of twelve evaluators, who came from a wide range of company sizes, types, and also who have expertise in managing project from clients' side, designers' side and contractors' side. Table 7.1 shows the details of these participants. The validation included 12 participants as recommended by Guest, Bunce, & Johnson (2005), which showed that data saturation occurred within twelve interviews. After the first stage of validation, four extra interviews were conducted with two old participants (evaluator #9 and #10) and two new participants (evaluator #13 and #14) to investigate further the applicability and scope of use of GEPAS in practice.

7.3.4. Meetings with evaluators

Before the formal evaluation procedure, the designed evaluation method and questionnaire survey were piloted with support from two research associates in the Institute of Sustainable Building Design at Heriot-Watt University. After the pilot, some of the questions and slides were reworded and changed to make it easier for participants to understand.

The evaluation was carried out with face-to-face meetings. Meetings with evaluators were designed to last about 60 minutes. In practice, however, most of the meetings were between 45 to 70 minutes; three meetings were extended to more than 100 minutes at the request of participants. The evaluation meeting consisted of the following four sessions, as demonstrated in Figure 7.1.

- An introduction of the research was presented to the evaluators for about 5 minutes. It covers the objectives of the research, and development background of the framework.

- The framework for sustainability management in building project (GEPAS) is presented in 20 minutes. It started with an explanation of the conceptual framework, followed by the demonstration of IDEF0 modelling language, five processes of the framework, their detail sub-processes and how they are linked together in the timeline of project life cycle, from strategic definition to in-use stage. Evaluators can interrupt the first two presentations to ask questions.
- The next 15 minutes were spent on discussing the framework, with questions from evaluators and answers from the researcher. Discussions were recorded with evaluator consent, or in the case of no consent note were taken.
- The last 20 minutes were reserved for an evaluation questionnaire consisting of both close-ended and open-ended questions.

Table 7.1. Summary of evaluators

No	Company type	Job title	Specialty	Exp (year)
1	Property consultancy	Project director	Chartered surveyor	22
2	Real estate investment manager	Construction director	Construction management	20
3	Contactor	Project manager	Project management, building energy, and sustainability	20
4	Main Contractor	Senior project manager	Project management	33
5	Project consultancy	Director & Project manager	Programme and Project Management	22
6	Construction consultancy	Senior associate	Project management	15
7	Construction services	Senior project manager	Project management	25
8	Main Contractor	Partnership & programme manager	Project management	19
9	Project & programme management consultancy	Project Manager	Architect, project management	5
10	Engineering consultancy	Associate director	Sustainability management	23
11	Asset management and construction consultancy	Director	Project management	43

12	Design & Consultancy	Design manager	MEP design, project management	25
13	Design, Consultancy and Contractor	Project manager	Architect, BIM, project management	13
14	Construction consultancy	Senior manager	Project management, Structural design	10

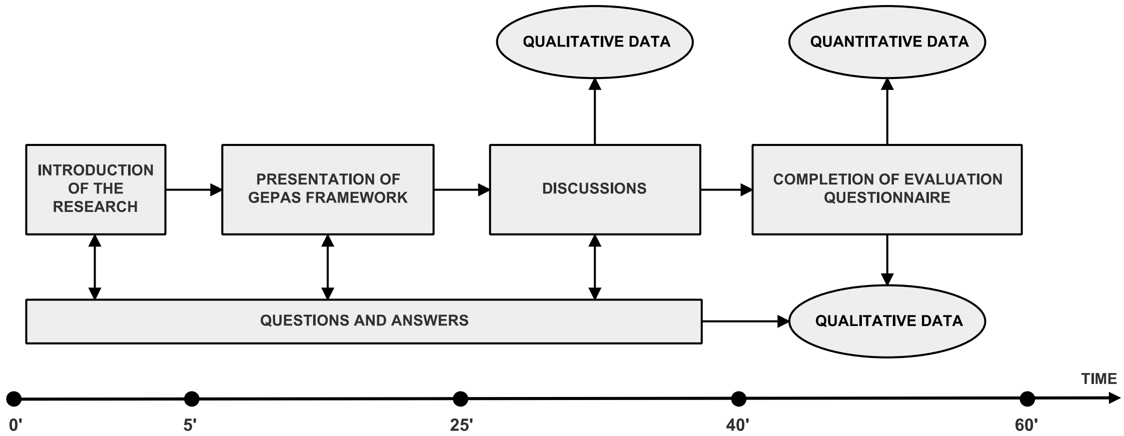


Figure 7.1. Scheduled meeting for evaluating the GEPAS framework

A power-point presentation was prepared for each meeting for the first two sessions of the evaluation (introduction of the research and presentation of the GEPAS framework). An A3 hard copy of the slides was used as the main material of the meetings. This hard copy of slides was also reused in all evaluation meetings.

7.3.5. Framework evaluation questionnaire

At the end of the meeting, evaluators were asked to return the framework evaluation questionnaire. The questionnaire survey was designed to answer the aim and objectives demonstrated at the beginning of this chapter; there were three main parts in this survey as below. The detail of this questionnaire is presented in the appendix of this thesis.

- *Background information:* The questionnaire survey started with questions regarding evaluator's background information, including job title, experience in construction, and experience with sustainable building.
- *Framework evaluation questions*: This part had eleven questions in Likert scale, which assess the logic and clarity, overall effectiveness and detail functions of the framework.
- *Further evaluation questions*: The last part of the survey covers five open-ended

questions about the main advantages of the framework, the potential applicability, and barriers to the implementation in practice, a suggestion for further development. Participants were also given space to provide other comments.

7.4. Evaluation results and discussion of results

This section of the chapter presents the analysis of quantitative and qualitative obtained from the evaluation questionnaire introduced in section 7.3.5.

7.4.1. Results obtained from Quantitative Data

Quantitative data was obtained from the answers to 11 close-ended questions in the second part and one closed-end question in the third part of the questionnaire. The interviewees were asked to score the logic and clarity, overall performance, detail functions, and applicability of the frameworks on a five-point Likert-scale. Number 1 to 5 presents "Poor", "Fair", "Satisfactory", "Good" and "Excellent", respectively. The statistical summary of quantitative results is demonstrated in Table 7.2, which shows that the GEPAS framework was found successful according to the aim and objectives stated at the beginning of this chapter.

All evaluators provided overall positive responses to the structure of the framework, its potential performance, and detail functions that it focused. None of the responses were scored 1 (poor) by participants, but all of them had a certain number of 5 ratings (excellent). The mode of answers in 11/12 questions was at 4 (good) – with the exception of the mode of answers in question #8, which was at 3 (satisfactory); and 98% of the selections given by evaluators are at and above the satisfactory level of participants (from level 3 to level 5 out of 5). The mean scored of answers for all questions was also high, ranging from 3.42 to 4.33, all exceeded the satisfactory level.

The highest mean score of 4.33 out of 5 was found in question regarding the logical structure of the framework. Conversely, apart from 10/12 questions experiencing a mean score at above 3.92, the lowest calculated mean scores were observed for the answers of the fifth and eighth questions, which both equates to 3.42. First, the fifth question relates to the extent to which the framework could support improvements of the overall efficiency of project management. This result is not surprising because the framework focuses more on the sustainability achievement of the project rather than the overall enhancement of project management efficiency; and in many cases, sustainability was considered a contradictory factor to the achievement of cost and time constraints of projects, and then was traded off with initial "cost-saving". Second, the eighth question required evaluators to answer the extent to which the framework could motivate the project team on issues of sustainability. Although GEPAS was designed with sub-process of training the IPT on sustainability (A23) and coordinating and motivating the IPT toward sustainability (A24), these IPT meetings only occur in a short period of the project (in the design stage). As such, it might not be able to create a significant change in awareness and motivation of project participants and IPT members toward sustainability. However, research evaluators were also highly appreciated the effort of giving sufficient training of the team on sustainability, which was called a "very necessary activity".

Table 7.2. Overall view of evaluation responses for quantitative questions

No	Evaluation questions	Percentage scores					Mean score
		Poor	Fair	Satis-factory	Good	Excel-lent	
Logic and clarity of the framework							
1	How easy is it to follow the processes and sub-processes of the framework?	-	-	17%	58%	25%	4.08
2	How would you rate the logical structure of the framework?	-	-	-	67%	33%	4.33
Overall performance of the framework							
3	How useful would you rate the overall framework for sustainability management in building projects?	-	-	8%	83%	8%	4.00
4	To what extent can the framework help in managing the overall sustainability of building projects?	-	-	25%	58%	17%	3.92
5	To what extent can the framework help in improving the overall efficiency of project management?	-	17%	33%	42%	8%	3.42

Table 7.2. Overall view of evaluation responses for quantitative questions (cont)

No	Evaluation questions	Percentage scores					Mean score
		Poor	Fair	Satis-factory	Good	Excel-lent	
Core functions of the framework							
6	To what extent is the framework able to support the definition of sustainability goals?	-	-	17%	50%	33%	4.17
7	To what extent is the framework able to guide the project team on issues of sustainability?	-	-	33%	33%	33%	4.00
8	To what extent is the framework able to motivate the project team on issues of sustainability?	-	8%	50%	33%	8%	3.42
9	To what extent is the framework able to support the planning of sustainability throughout the life cycle of buildings?	-	-	8%	67%	25%	4.17
10	To what extent is the framework able to support the sustainability assessment of buildings?	-	-	25%	58%	17%	3.92
11	To what extent is the framework able to support stakeholder engagement and communication?	-	-	25%	42%	33%	4.08
Applicability of the framework							
12	To what extend is the framework able to apply in your projects?	-	-	17%	75%	8%	3.92

7.4.2. Results obtained from Qualitative Data

7.4.2.1. Main benefits of the framework

The first question in the third part of the evaluation questionnaire asked the participants what was considered the main advantages/benefits of the GEPAS framework. The main advantages mentioned by the evaluators mainly focus on its step-by-step processes - with "detailed path and appropriate juncture" - to achieve sustainability targets in a logical/robust/structured layout, which currently lack in the current project management practice. Other detailed benefits of the framework that stated by evaluators are listed down as follows:

- The framework highlighted sustainability in the early stages. In normal projects, the contract was already part way through when the client starts looking at sustainability. As a result, it might be quite late to make some changes.
- The framework was integrated with familiar standards/guidelines such as BS 6079-1:2010 and the RIBA Plan of Work.
- The framework introduced sustainability as a core consideration in the early stage of the project while most of project management methodologies fail to address sustainability in the same manner. Therefore, the use of GEPAS should ensure "a proper integration of sustainability into a project".
- Evaluators agreed that trying to drive a life-cycle approach as suggested by the framework would "make a great difference to change the thinking of current construction project teams," for example, from focusing on short-term capital investment to more attention on long-term running costs.
- The framework can be applied to many types of projects, and in different countries, therefore wider adoption of its principles should be promoted.
- The framework had formalized the adoption of sustainability principles into the management of the project, so the core aspects of sustainability can be communicated with stakeholders formally.
- The framework allowed for training of project participants, which was essential in many cases. 2/12 of evaluators, who worked in large companies, shared that many activities of the framework were embedded in the top tier contractors' processes, but not in a logical order like in this framework. Moreover, while it would be difficult for these top companies to share their processes widely, the publication of the GEPAS could be beneficial to lower-tire organizations, which are the majority of the

construction market, in a way that helps to increase their competitiveness in a changing competitive environment.

7.4.2.2. Obstacles to the use of the framework in practice

The part below provided and discussed the seven potential obstacles identified by 12 evaluators to the implementation of the GEPAS framework in practice.

- *Lack of support from clients:* According to the majority of evaluators (8/12), the biggest obstacle to the implementation of GEPAS framework in practice was the lack of support from clients. This obstacle is not surprising as it is the result of prevalent barriers of sustainable construction (as introduced in chapter 2), named as a lack of client's awareness, demand and financial and risk disincentive. For progressive clients, for example, like the pharmaceutical industry, with high expectation on their sustainability agenda and social responsibility policy, the framework was highly appreciated by evaluators because it would be able to "push forward and promote the sustainability agenda throughout the lifecycle of their project". For clients with low aspirations for sustainability targets or focus on short-term goals, such as speculative property developers, the evaluators believed that it was not easy to persuade, educate or promote them to invest an additional upfront cost for a long-term and questionable gain (which is hard to quantify and has controversial accuracy of prediction). On one hand, it depends on the ability of project managers to provide proper advice to clients with clear proof/examples/case studies before deciding the project objectives. One of the evaluators found that "not all of the clients have a clear definition about the sustainability of the buildings, and often designers are pushing them rather than the clients are asking", and he/she also believed that advice of project managers and sustainability champion could have a "certain impact to decision of clients" in early stage of project. On the other hand, some real circumstances might be out of project managers' control, and it is worth reminding that GEPAS's suggestion is not a universal key for all cases. For example, when the actual cost rises sharply, sustainability measures might be the first to be cut, as most projects will struggle to keep on budget. Clients would ask designers and project team to do the minimum to comply with regulations.

- *Cost and time for management:* 6/12 of evaluators were afraid that the framework could lead to additional cost and delay. They considered that the use of framework should be beneficial in large size/scale projects. This obstacle is not significant to the use of the framework because it is designed as a comprehensive framework, and therefore, smaller-size projects are not required to follow all processes and sub-processes of the framework. This obstacle also leads to a further suggestion of creating different versions of the framework for projects with different sizes. This suggestion is discussed further in the following section of this chapter.
- *The limited use of POE and lesson learnt in practice:* Participant #8 and #10 showed their concern on the use of POE reports and lesson learnt log. Although they agreed that the value of these materials is undeniable in principle, they were not widely and formally applied in practice. The two participants both stated that the client might refuse to share the result of POE reports widely, as it could damage the image of their company. Likewise, some project team members (designers) were not interested in reading the results of old projects. This obstacle might be biased under the subjective viewpoint of the two participants, but it showed that this is happening in the industry. However, with higher awareness on after-carer service and higher competitiveness among companies, this would be more and more popular in practice, however, it might take time for the industry to change gradually.
- *Lack of support regulations background:* The use of GEPAS framework might need support from stricter regulations on sustainability, which is only available in few areas, such as in Wales or London. It is the second-mentioned barrier to the use of GEPAS framework. For instance, Welsh Government (2017) issued a decisive policy on sustainable building standard; this policy requires a non-domestic building with floor area from 1000-2000m^2 to achieve a BREEAM rating “Very Good" and " energy credits rating of excellent, whereas, floor area above 2000m^2 need to have BREEAM rating of “Excellent". London is now also heading the construction industry to "Zero carbon London: A 1.5^oC compatible plan" (Mayor of London, 2018). The emerging trend of putting more onerous regulations on sustainability by the local and central government is promising for a future with more and more sustainable buildings, and GEPAS could be one of the first steps for actualizing that vision.
- *The problem of every new process - Changing the behaviour of project managers:* Like all new frameworks, the evaluators anticipated an obstacle in changing management processes, especially in the construction industry – “which is very staid and does not have a good track record of implementing new procedures”. Besides, an

evaluator considered that the adoption of GEPAS framework might be difficult for top contractors who have similar processes utilized in their organizations. However, GEPAS framework was not designed to compete with these existing internal frameworks; the principles and suggestions of GEPAS could be helpful for these organizations to improve their current processes. For all organizations, the framework could be applied with some modifications depending on their strategies, corporate policies, and current processes.

- *Obstacles related to the implementation of the IPT:* An evaluator expressed his/her anxiety about the implementation of the IPT. The idea of IPT was seen as a right approach, but it was also "a big change" to how the design team worked and procured. He/she felt that meetings of the IPT were hard to manage and reach agreement in sustainable requirements among a large group of stakeholders, who were expecting conflicting objectives. Inviting the contractors to join the IPT was stated as "possible", but "not an easy task". Therefore, it would require a highly competent project management team, especially the project manager.

7.4.2.3. Applicability of the framework in practice

The framework has not had a chance to apply in a real project yet, but this evaluation asked participants how the framework could be used in practice based on their experience. According to the evaluators, the framework was assessed as "can be applied to the majority of the projects". It was also viewed "significant potential for enshrining sustainability at the core of projects". The question 12 in Table 7.2 showed high potential applicability of GEPAS in answers of all 12 evaluators, majority of them (85%) considered the applicability at good level, respectively; and none of the answers is in negative consideration. This result might not be guaranteed for success, but it revealed promising applicability of the framework.

In general, all evaluators agreed that all principles of the framework should be highlighted in practice, especially for the enhance of a collaborative working that could make stakeholders understand more about each other's and increase the chance of success. The evaluators also agreed that the adoption of this framework should be tailored by the project managers. Depending on the particular context of that project, so that it could be adopted wholly or partly.

Almost all of the evaluators saw that the adoption of GEPAS would be accepted by project managers, but they might not the decision-maker to adopt this because the client could stop many processes from the beginning, such as the use of IPT meeting, the use of extra consultancy, or several steps of assessment, which might result a higher cost. This issue recalls the first and most significant barrier of GEPAS as discussed in the section above. In majority of projects, clients are "unwilling to implement systems that will incur additional cost and deviate from the normal practices". Therefore, when asking about how GEPAS can be used in their projects, the evaluators considered more about conditions to adopt the framework. In details, they saw the scope of this framework in large-scale projects, or government schemes that are looking to champion sustainable construction (schools, hospital, banks, or other similar types of projects). On the one hand, the consideration of "large-scale" is actually the consideration of costs and benefits that GEPAS could bring to, and sustainable benefits would be easier recognised in larger projects. Large projects also understood as more substantial impacts and higher risk so that it would gain more attention from the authorities on social and environmental issues. Besides, larger projects allow a larger amount of funding for management, so actions suggested in this framework could be covered. It is essential to note that large projects mainly use design-and-build contracts, then, it would be more compatible with the principles of IPT than the traditional route. On the other hand, clients with a focus on their short-term benefits could ignore their social, economic and environmental responsibility, but they are not able to ignore the regulations. With the great effort of some governments in encouraging sustainability in buildings the adoption of GEPAS would be "a mechanism for achieving this", such as Welsh Government's (2017) policy on sustainable buildings or "Zero carbon London plan (Mayor of London, 2018). In addition, evaluators working with design teams experienced the fact that "not all clients have a clear definition of sustainability, and often designers are pushing them rather than directly from client". Therefore, with additional support from sustainability champions and project managers, as suggested in this framework, it would be more encouraging for clients to overcome sustainability-related barriers.

Evaluators considered the potential benefits of GEPAS in projects with complex technical systems. The evaluators in their experience found that that end-users or operators were hard to operate and maintain such sophisticated systems. Therefore, their early involvement into the design process can help them to prepare better for the future operation of the building. On the one hand, this activity can promote a design solution that matches ability and actual need of the user, and then waste due to investing unnecessary functions of facilities could be avoided. The sophisticated design is not always useful and necessary, but it seems to be a trend in the modern buildings. Designers need to know about the real demand and capacity of operators and maintainers to have an effective design. Operators would also take benefits from this when they know about facilities they are going to manage and have sufficient time for trainings and learning process. On the other hands, sophisticated systems are normally delivered with BIM, and team-work activities suggested by GEPAS are compatible with BIM communication.

Furthermore, some of the evaluators queried on further details on how to implement the framework in their project, such as how to develop a sustainability management plan, the responsibility of each individual in the management process, as well as afraid of changes among participants. After discussion and explanation about the scope as well as rationales of the framework and its processes, evaluators assessed that the success of GEPAS depended on "how it is well understood", meaning that educating users/practitioners would "decide and ensure effective application". So that users of this framework "need to be trained to present in the right way", and this might depend on company strategies. An evaluator working in tier-one contractor shared that his/her company was trying to implement a sustainability process; and suggested that other top companies might have their own approaches to deal with sustainability. However, these processes were kept as internal documents hence no comparisons could be made. GEPAS might work as an inspiration for these existing processes. However, the majority of small-and-medium enterprises (SMEs) are not operating a process designed for managing sustainability. SMEs accounted for 99.9% of construction sector business (Department for Business Information & Skills, 2013) would greatly benefit from a framework like GEPAS.

7.4.2.4. Recommendation for further development of the framework

The evaluators provided some recommendations for further development of the GEPAS framework as the list and discussion below.

- *The framework should be considered in different contexts*, such as the type of procurement routes or the size/scale of the project, to make it flexible for use in practice. The researcher had added a further explanation for the use of this framework in four prevalent types of construction contracts in the UK to Chapter 6, including the traditional, integrated (DB, Turnkey, EPC), management contracting and construction management route. Chapter 6 also suggested the responsibility of project managers on the clients' side, the designers' side, and the contractors' side in different types of procurement routes. However, the use of the framework in small-size projects and megaprojects might need further consideration, depending on specific requirements of that project and capacity of the project team.

- The framework could be a detailed step-by-step approach if it *is linked to a particular sustainability standard, such as LEED or BREEAM*. This suggestion showed the dominant role of such green-building standards like LEED or BREEAM in the construction market. However, as this research aimed at developing a comprehensive framework for the management of sustainability in building projects, the use of the framework should not be limited to a single green-building standard, as it was designed to use in every sustainability standards.
- Evaluators agreed that the structure of the framework was logical, but still quite complicated due to a large amount of processes, sub-processes and their interaction links/documents. The framework "will only be successful where it is well understood". Therefore, users might need *more explanation on process map to use the framework in their projects*.
- Some evaluators suggested the *integration of GEPAS in other project management standards*, such as the NEC suite of contracts or CIOB. This is also a further direction of this research.
- To persuade the users, *GEPAS should have evidence-based research for adopting the framework*. The researcher expects that the framework could be implemented in real projects after it is published. However, due to the time limit of this study, no actual application could be made at this point.

7.5. Chapter summary

The chapter presented the evaluation of GEPAS framework. The evaluation research was carried out with the participation of twelve experienced professionals in the UK with more than five years working in initiating, managing and directing building projects. The results showed that GEPAS had achieved the original aims with high potential applicability in practice. The following chapter concludes this study and illustrates recommendations for further research.

CHAPTER 8. SUMMARY, CONCLUSIONS AND RECOMMENDATION

This chapter focuses on demonstrating the key findings and conclusions derived from this research. According to the adopted methodological approach illustrated in Chapter 4, the first part of this chapter (Section 8.1) presents an overall conclusion in the key findings in link with research objectives set up in Chapter 1. The chapter is followed with contributions to the theoretical and empirical knowledge from this research to the existing literature review (Section 8.2). The last chapter ends with research limitation and several recommendations for further research (Section 8.3).

8.1. Key research findings

This research demonstrated the insufficiency of efforts made in improving management practice to effectively delivery toward sustainability, which was mainly due to the failure in addressing the sustainability issues in current project management standards, not only in the UK but also in international viewpoint. As a result, sustainability targets were very often sacrificed to cut down of cost and to enhance financial benefits. This fact is strongly against the challenge of the construction industry in transforming toward sustainability and enabling it to produce safe, healthy, efficient building using the latest manufacturing techniques.

This thesis aimed to develop a comprehensive framework that supported project managers in initiating and delivering building projects toward sustainability. To pursue the main aim, five specific objectives were set up in Chapter 1. Summary of specific tasks and key findings for the above objectives are discussed as followed:

Objective 1: To review previous work on sustainable construction, management and achievement of sustainability in construction projects

The construction industry has made a significant contribution in reducing the negative impacts of buildings on the environment and the society; however, the fact that sustainability is not well understood remains. The literature review on sustainable construction revealed that the current focus of sustainable construction was weak at the project level. Insufficient efforts had been made in improving the management practices to direct and manage sustainable projects. In practice, no effort succeeded in addressing sustainability in current project management standards internationally. The review also showed that the current project management practices were driven by short-term financial goals that satisfy mainly clients and investors.

Six outstanding barriers that are preventing the construction industry from achieving sustainability were identified as (1) financial & risk disincentives, (2) expensive alternative technologies/materials, (3) insufficiency of research, (4) legislative forces, (5) lack of stakeholder awareness and commitment to sustainability, and (6) poor project performance due to competencies of the project team. These barriers result in the failure of the project management practice in initiating and delivering sustainable projects. The review of several approaches and discussion in Chapter 3 showed that "sustainability management process" can be potentially the most practical approach as it provides clear guidance for project managers in managing sustainable construction projects. However, very little research has focused on formulating a process for sustainability management in construction, and none of them succeeded in delivering essential issues of sustainability integration such as stakeholder management, human resource management, procurement, risk management, and communication management. In other words, there is no comprehensive framework that supports project managers in initiating and delivering sustainability throughout the life-cycle of projects and helps to overcome human-related barriers (such as human resource, competencies, or stakeholder engagement and communication). There is an urgent need for the construction industry to embed core principles and proper processes of sustainability into project management standards, which can help to raise awareness and promote positive behaviour of project teams toward sustainable development. Furthermore, project managers should be responsible for integrating sustainability in their projects. A process for sustainability management in construction is crucial to help project managers fulfilling that duty. This process should not only focus on the planning and assessment of sustainability value, but also should consider stakeholder management, human resource management, procurement, and communication management. Developing such a framework was also the main focus of this research. The first step in building the framework should start at understanding key components that sustainability management in construction should have as well as how they can affect the overall success of sustainable projects – which are the focal points of objective 2 and 3.

Objective 2: To develop a conceptual model for Sustainable Project Management

In order to develop project management guidance, this study aimed to gain a better understanding of the critical success factors (CSFs) for sustainability management. Another literature review was carried out on topics related to project management, and it led to the identification of 35 potential factors contributing to the achievement of sustainability in construction projects. These factors were then categorised into five groups and formed a new conceptual (and measurement) model for Sustainable Project Management (SPM), called MaSBuP (See Figure 3.1) with five corresponding components. The five components were coded and named as: (1) GOAL - Sustainable goal definition; (2) ENHA - Project team enhancement toward sustainability; (3) PLAN - Planning for sustainability; (4) ASSE - Sustainability assessment; and (5) STAK - Stakeholder management.

Objective 3: To empirically identify the relationship between sustainable project management (SPM) and sustainable project success (SPS)

This objective was set to understand the relationships between SPM and SPS in real projects with 5 hypotheses (and 15 sub-hypotheses). The modelling for SPM was the result of Objective 2 as demonstrated above.

In this study, project success in the construction industry should not be considered only as of the golden triangular (i.e., meeting time, budget and quality requirements), it should include criteria of satisfying stakeholder satisfaction and achieving sustainability. In other words, Sustainable Project Success (SPS) should be the targeted outcome for the new generation of buildings. The modelling for SPS was built on 24 identified indicators from the literature to measure the success of sustainable projects in the construction industry (See Table 2.2).

A structured questionnaire (containing questions required to evaluate the management performance of 35 factors of SPM, and to assess the results of 24 indicators of SPS in real projects) was carried out with the participation of experienced professionals in the UK, and 144 valid responses were retrieved. Partial Least Square Structural Equation Modelling (PLS-SEM) technique was used as the primary tool to analyse the data collected. The results of SEM analysis on the measurement model of these components showed that five components were valid and reliable in presenting the concept of SPM.

The hypothesis testing identified the inter-relationships among the five key components of SPM, showing that they support each other in performing activities related to sustainability management. The management of sustainability in project level, therefore, should not rely on the adoption of a “green building rating system” that only focuses on assessing sustainability outcomes. The proper approach should have a combination of all five key identified components (i.e., the goals, project team, planning, assessment, and stakeholder engagement).

In terms of the impact between SPM and SPS, the findings also pointed out that stakeholder management and sustainability assessment play an essential role in the achievement of SPS. It is interesting to note that stakeholder management has not less critical meaning than sustainability assessment in achieving the sustainable results of the building. Moreover, a sustainability management plan was found as necessary for the assessment of sustainability.

A mediation analysis revealed that the definition of sustainability goals has a critical meaning to the project. Further implementation of the processes in project delivery (including planning, assessing of sustainability, managing stakeholder) needs a clear vision of project goals and a proper team to carry them out. It is found that project managers are used to be restricted with traditional project constraints (mainly for cost budget and time) as well as limited power. Therefore, an explicit goal of sustainability can free them to use all their potential ability in managing stakeholder and in planning project toward sustainability.

Objective 4: To develop a framework for managing sustainability in building projects that follows a holistic approach to support the achievement of sustainable project success

The first objective concluded that there is an urgent need for a guide or a method that supports project managers in initiating, delivering sustainability throughout the life-cycle of projects, and overcome human-related barriers of sustainable projects. The GEPAS framework, with details demonstrated in Chapter 6, was developed to address this demand. It aimed at facilitating the sustainability management process in building projects in a way that enhances competencies, knowledge, awareness, and motivation of the project team on sustainability through integrated project team's meetings.

The development of GEPAS was based on the conceptual model of SPM (in Objective 2), and inter-relationships identified in the Objective 3 via hypothesis testing among the five key components of SPM and SPS (MaSBuP model). The model used the IDEF0 modelling language for presentation of process maps. Furthermore, the framework processes are developed to be compatible with the existing guidelines and best practices of project management in the UK, including: RIBA (2013b - Plan of Work) CIBSE (2007 - Guild L on Sustainability), BS:6079 standards (BSI, 2010a, 2012). GEPAS also matches with principles of sustainability in building construction from BS ISO 15392:2008 - Sustainability in Building Construction: General principles (BSI, 2008).

The framework has five processes: A1 - define sustainability **G**oals; A2 - **E**nhance project team; A3 - **P**lan for sustainability; A4 - **A**ssess sustainability; and A5 - **S**takeholder management (A5). The name GEPAS was combined from the five key letters of each component process. GEPAS means "appropriately" in Afrikaans, a language sourcing from southern Africa, and also from where the dawn of homo sapient began 300,000 years ago. The name of the framework suggests doing the appropriate things from the beginning.

This framework embedded several vital principles, which are critical to achieve sustainability, including: (1) the definition of *sustainability objectives* in the beginning stage of the project; (2) the *strong collaboration* and *early involvement of stakeholders* under the form of a multidisciplinary integrated-project-team (IPT) that could provide constructive contributions to the project from design stage; (3) the use of a *sustainability management plan* as separate plan to direct the further actions of management; (4) the *multi-phase assessment* of sustainability; and (5) the *stakeholder management* approach that links them with objectives and provides sufficient information as way to better engage them to the project. A unique speciation of GEPAS is the adoption of integrated project delivery principles and methods. It brings together all internal stakeholders in its processes, including project manager, sustainability champions, client team, designers, suppliers, contractors, end-users, building maintainers and operators to achieve their active involvement in different activities and to benefit the project with their knowledge and constructive contributions. ***Objective 5: To evaluate the applicability and effectiveness of the framework***

GEPAS framework was evaluated using interviews with 12 experienced professionals in the UK construction industry. The detail aim, adopted methodology, process, results, and discussions of the evaluation were demonstrated in Chapter 7. GEPAS was assessed and recognised to achieve the original aims with potential applicability. It was found to offer a good logical structure processes of which can easily be followed by users. The framework focused on not only the delivery process, but also the initiation of the project – where most project management methodologies fail to address sustainability. Furthermore, a holistic approach that paid attention to the life cycle of the project was believed to change the thinking of professionals.

8.2. Key research contributions to knowledge

The key findings illustrated in this research make both theoretical and empirical contributions to the literature. It added new discoveries to the existing knowledge of sustainability with a focus on construction building projects.

First, this research contributed to the knowledge with ***a new conceptual model for "sustainable project success"***. Project success in this study was seen as not only the traditional project success viewpoint (i.e. the meeting of golden triangular of budget-cost-time) but also the satisfaction of stakeholders and sustainability criteria under the triple-bottom-line. While previous research and practice is dominating with traditional criteria, the consideration of Sustainable Project Success (SPS) is highly recommended in setting goals for further projects and indicators for SPS in the study could work as a useful suggestion for setting sustainable goals. It is argued that if the project is driven by the existing criteria of project success, only the achievement of economic and social sustainability can be promoted, whereas, the achievement of environmental sustainability, which does not have a clear impact on the conventional success of projects, might easily be traded-off with "cost saving" (Phung et al., 2019a). As a result, the true and targeted sustainability would never come to our buildings.

Second, this research contributed to existing knowledge by ***developing a conceptual model for Sustainable Project Management (SPM)***. All existing models of SPM in the literature were found with processes of sustainability goals definition (GOAL), sustainability planning (PLAN), and assessment (ASSE). However, this model is the first that highlights the critical value of professional competencies (ENHA) and stakeholder management (STAK) to support the sustainability in construction projects. The study added them as two key components of SPM concept, and formed the most comprehensive model of SPM with the five key components as demonstrated earlier. The additional constructs provided a broader and more complete view of sustainable management approach in solving existing and outstanding social barriers to sustainability in the construction industry. These barriers were found as the lack of awareness from stakeholders, short-sight view on the benefit of sustainability, poor project performance, lack of knowledge on sustainability, or the lack of collaborative working in current projects.

Thirdly, this research has been the first to ***identify the relationship between key components of SPM and their impacts to achieve SPS***. The testing results of hypotheses between SPM and SPS revealed a number of key suggestions for the management approach that could support the achievement of sustainability and project success in practice.

Previous research considered that initiation process is more important than the project delivery process to achieve sustainability. This study further *clarified two critical enablers in the initiation process of a sustainable project: official sustainable goals and project team competencies*. These two enablers also had a substantial relationship that further practitioner should carefully consider both of them in their project preparation stages. In detail, sustainable goals were proven in this study as a fundamental ground for sustainability to be developed and embedded in the project, but it was necessary to have a proper team with sufficient knowledge and skills working in a high collaborative environment to deliver that goal. The highly skilled, experienced and multidisciplinary project team would help to prevent/reduce risk, wastes and errors - which leads to effectively results of return on investment for clients and users, including the sustainability value/benefits.

Besides, the practice of sustainability in building project explored that practitioners relied significantly on a measure of sustainability in their projects, typically a green building rating system or energy performance system. This research agreed that sustainability assessment has an important value, but only using it in the traditional management approach is not enough. The findings in this thesis showed the achievement of SPS need a whole system to support it. It showed that the right management approach should also pay attention to sustainable project goals that set orientation for further actions, a competent project team working collaboratively, a proper attention to stakeholder management, and good planning for sustainability. In other words, this research criticised all studies that focus solely on using a building rating system to achieve the building's sustainability, which might be insufficient. Indeed, it would need a whole system behind and the conceptual framework of SPM gave the answer for what components that system would have.

Furthermore, the literature experienced that social sustainability is now disappearing in sustainable building projects. This research results revealed a key solution to balance three pillars of sustainability by focusing more on stakeholder management. Previous studies clarified the effect of stakeholder management in better satisfying stakeholder, reducing conflicts among participants. This study further discovered the value of stakeholder management in supporting sustainability, especially social sustainability which heading to working condition of employee, living condition of occupants and community commitment on sustainability.

Fourthly, the research contributed to the practice with ***a framework that supports project managers in initiating and delivering their building project toward sustainable project success***, named as GEPAS. The GEPAS framework could fulfil the critical needs for an SPM approach in practice with a step-by-step guide following a holistic approach. It provides guidance for the process of sustainability planning, assessment, and stakeholder management in consideration of committed sustainability objectives. GEPAS also considered its application in different cases of procurement routes and types of construction work. Moreover, it suggests project managers a number of useful tools, techniques, and documentation for the application of GEPAS in real projects. The use of GEPAS was found to fit with large-scale project, with pro-active clients with sustainability in their agenda, and/or a supportive legislative frame for green, high-performance and low-impact buildings. The adoption, wholly or partly, of this framework in practice should be tailored in particular context, and to do so, trainings would be necessary to overcome barriers of sustainable construction.

8.3. Limitations

There is a possibility that the findings of this study were limited by response bias, which refers to issues that draw participants away from accurate or truthful answers. Especially for social desirability bias, which may have contaminated the data because the research questions focus on sustainability. Participants with high awareness on sustainability might be biased by their positive belief of sustainability, and then their answers would rather to be absolute value, potentially in both optimistic and pessimistic viewpoint.

Regarding the participant bias, the research collected the majority of evaluations from project managers or construction managers (accounting for more than 80% of samples). Their evaluation for questions in the survey might be biased by their background knowledge and viewpoint as a project manager in a particular construction stage. The contribution of other stakeholders, such as program developers, designers, assets managers, or facility managers was not sufficient to provide a broad viewpoint of the construction industry. Moreover, the use of a multi-stage evaluation of both project processes and project outcomes in the questionnaire survey resulted a remarkable number of missing data. Some respondents failed to answer all questions as they might not undertake or able to access information of other project stages. Also, the missing data might be a consequence of the fact that many individuals and organisations did not undertake all the sustainability-related activities being examined.

Regarding the regional and cultural factors, the generalisation of this research's findings is limited to the construction industry in the UK. The consideration of GEPAS framework in other countries might examine the difference between their condition and UK, particular in policies, or regulations, or government incentives on sustainability, culture, and economic factors.

Regarding the final outcome - GEPAS framework in this research was only evaluated by opinions of evaluators; it was not applied in a real project. A real case study could provide more constructive feedback for the further development of this framework. However, the framework was developed at the end of this PhD study, which is time-bound, and then, it was not able to have an evidence-based result.

8.4. Direction for further research

This study suggests a few areas for further research, including:

- The GEPAS framework was set up under the theme of BS:6079 standard and RIBA's project stages. However, this does not prevent the application of GEPAS conceptual framework from being applied in other project management standards. Therefore, further research could focus on the integration of GEPAS (concepts, principles, and processes) in other project management standards, such as PMBOK, ISO21500, and the NEC suite of contracts or CIOB.
- The structure of GEPAS makes it fit with the medium-large size of projects. Additional research could benefit from principles in this study to set up tailor-made frameworks for small size and mega projects. The size of the project impacts not only the loads of work to be managed but also the allocated cost to management.
- Further action research should be carried out to identify problems when applying the GEPAS framework in real construction projects. The results of this action research could support the further development of this framework.
- This study highlighted the role of a Sustainability Project Management Plan (SPMP) as a separated plan to the project plan/project management plan. However, a complete form of this document has not been developed in this study. Further research could

focus on developing a template for SPMP in building projects and examine how it could fit with the specific context of the building project.

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APPENDIX

QUESTIONNAIRE SURVEY FOR KEY SUCCESS FACTORS IN MANAGING CONSTRUCTION PROJECTS

Letter to the Participant

Dear Sir/Madam,

We wish to invite you to participate in a survey, which is aimed at (1) Identifying the key factors in enhancing project management of construction buildings and (2) detecting the challenges faced by project management team in integrating any degree of sustainability into construction project management.

The questionnaire should take no longer than 20 minutes to complete. Your time in filling the questions below is highly appreciated. We also hope that the questions would bring you a chance to review your past projects. Moreover, if you are interested in this research, we will be happy to share our findings with you.

Please answer the questions below honestly with your personal experience. There is no right or wrong answer because the questionnaire is designed to investigate the practice in our current project management approach. All the responses will be treated in strict confidence and only used for academic purposes. Results will not be published in any form that allows the identification of individuals or organizations.

Thank you in anticipation of your kind support!

If any queries arise, please feel free to contact the research team:

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SESSION A: BACKGROUND INFORMATION

1. Your main area of expertise?

○ Project manager	○Construction manager	○ Facility manager
○ Project sponsor	○ Lead consultant	○ Project architect
○ Project director	○ Quantity surveyor	○ Technical engineer
○ Program manager	○ Quality control	○ Others................

2. Years of experience in project management and execution

○ Less than 2 years	○ 10-15 years
○ 2-5 years	○ 16-20 years
○ 6-10 years	○ Above 20 year

3. Please indicate project management standards and guidelines that you are aware of (You may choose more than one answer)

☐ BS 6079-1:2010 – Principles and guidelines for the management of projects
☐ CIOB – Code of practice for project management for construction and development
☐ ISO 21500:2012 – Guidance on project management
☐ PRINCE2
☐ IPMA 4.0 – Individual competence baseline
☐ APM – Body of knowledge
☐ AIPM – Professional competency standards for project management (Australia)
☐ PMI – Project management body of knowledge (PMBoK guide - US)
☐ Other……………………………….

4. Do you have any experience in managing and directing green-building, high-performance building or low-carbon-building projects?

- ***Green buildings*** *are ones that reduce the use of resources, create healthier living environment for people and minimize negative impacts on local, regional and global ecosystems. Green buildings are often known with such certificates as BREEAM, LEEDS, green star, green globes, or living building challenge...*

- ***High-performance buildings*** *are ones that integrate and optimize energy efficiency, building durability, life-cycle performance, and occupant productivity. High-performance buildings normally relate to display energy certificate (DECs) or energy performance certificate (EPCs)...*

- ***Low carbon buildings*** *are ones that emit significantly fewer greenhouse gases than regular buildings; they also include zero-carbon/net-carbon buildings.*

○ Yes	→ Move to session B1 (Move to Question 5)
○ I'm not sure	→ Move to session B2 (Move to Question 9)
○ No	→ Move to session B2 (Move to Question 9)

SESSION B1: YOUR MOST RECENT SUSTAINABILITY PROJECT'S CHARACTERISTIC

Please choose one of the **most-recent green building, high-performance building or low carbon building projects** that you have worked on. Construction stage should have been finished and now the building is in operation stage. Then, please answer all questions below according to your chosen project, hereinafter referred to as "***the project***".

5. Which of the following describes the project best? (Please tick all that apply)

☐ Commercial building
☐ Residential building
☐ Industrial building
☐ Medical building
☐ Educational building
☐ Government building
☐ Civil work
☐ Others..

6. Please choose the type of the project

○ New building
○ Refurbishment
○ Renovation
○ Retrofit
○
Others…………………………………

7. Please indicate the city or country or region area that the building is located

....

8. Please indicate any sustainability-related certificates or special features that the project achieved or will achieve; and provide the ranking of those certificates? *(For example: BREEAM Good, LEEDS silver, or Energy Performance Certificate (EPC) rank B…)*

....
....
....

Then, please skip questions 9-12 (Session B2) and move to question 12 (Session C)

SESSION B2: YOUR MOST RECENT SUSTAINABILITY PROJECT

Please choose one of the **most-recent building projects** that you have worked on. Construction stage should have been finished and now the building is in operation stage. Then, please answer all questions below according to your chosen project, hereinafter referred to as "***the project***".

9. Which of the following describes the project best? (Please tick all that apply)

☐ Commercial building
☐ Residential building
☐ Industrial building
☐ Medical building
☐ Educational building
☐ Government building
☐ Civil work
☐ Others...

10. Please choose the type of the project

○ New building
○ Refurbishment
○ Renovation
○ Retrofit
○Others………………………

11. Please indicate the city or country or region area that the building is located

....

12. Please indicate any building features or project activities that relates to sustainability? (If applicable – optional)

Sustainability is defined as the achievement of current and future generations' need, including the conservation of natural resources and environment, the wellbeing and higher living quality for the community, and the assurance for financial and economic feasibility during the whole life cycle of buildings.

....
....
....

SECTION C: EVALUATION OF THE PROJECT

Note: In reviewing the result of the project, how would you rate each of the project outcomes below on a scale of 1-5 (Your answer should be based on your own experiences, so there is no right or wrong answer)? *Number 1 represents "strongly disagree" and number 5 means "strongly agree". Please don't mind to select "N/A" if any project outcome is not applicable to your opinion or your experience.*

13. Project performance

No	Factors	1	2	3	4	5	NA
Ppss1	Project has met all scope successfully						
Ppss2	The project was delivered within budget						
Ppss3	The project was delivered within given time						
Ppss4	The project was completed to specified quality						

14. Stakeholder satisfaction

No	Factors	1	2	3	4	5	NA
Ppss5	Clients and investors were satisfied with the project outcomes						
Ppss6	Occupants/end-users were satisfied with the building						
Ppss7	Project team were satisfied with the success of project						
Ppss8	Local community and external stakeholders happily accepted the building						

15. Economic performance

No	Factors	1	2	3	4	5	NA
EcS1	The building could bring adequate profitability in short term to investors/clients						
EcS2	The building could bring adequate economic benefits in long term to all stakeholders						

EcS3	Building functionality could be ensured during life-cycle of the building						
EcS4	Building was designed to prepare for future challenges of users/clients (such as climate change, flooding…)						
EcS5	Project team got improvement in their skills and experiences						

16. Environmental performance and impacts

No	Factors	1	2	3	4	5	NA
EnS1	The building could minimize energy consumption during its life cycle						
EnS2	Waste was reduced, reused and recycled effectively in construction site						
EnS3	Environmental-friendly material options were used in the building as much as possible						
EnS4	Minimum carbon footprint was achieved during project life cycle						
EnS5	Bio-diversity of surrounding areas were conserved						
EnS6	Pollution to surrounding areas were kept to minimum						

17. Social concerns and impacts

No	Factors	1	2	3	4	5	NA
SoS1	Construction site ensured health and safety of all project team members and workers						
SoS2	The building had created healthy, safe and a high quality living for occupants/users						
SoS3	Project created a good working condition (fair salary, working hours, no child labour...) for everyone employed						
SoS4	Project increased public awareness and commitments to sustainability						
SoS5	Project had a positive impact to local employment						

SECTION D: KEY FACTORS FOR ENHANCING PROJECT MANAGEMENT OF CONSTRUCTION BUILDINGS

Note: In reviewing the management of the project, how would you rate each of the factors below on a scale of 1-5 (Your answer should be based on your own experiences, so there is no right or wrong answer)? *Number 1 represents "very low" and number 5 means "very high". Please don't mind to select "N/A" if any factor is not applicable to your opinion or your experience.*

Sustainability is defined as the achievement of current and future generations' need, including the conservation of natural resources and environment, the wellbeing and higher living quality for the community, and the assurance for financial and economic feasibility during the whole life cycle of buildings.

18. Managing stakeholders (Stakeholders are defined as individuals or organizations that have impact or influenced by projects' activities; key stakeholders are ones that could make major impacts to the project and could affect project success)

Code	Factors	1	2	3	4	5	NA
Stak1	Degree that long-term value creation by all stakeholders was fully considered						
Stak2	Degree to which key stakeholders' vision, strategies & objectives were determined to align them with project goals						
Stak3	Actual engagement level of internal and external stakeholders to project activities						
Stak4	Degree of effective communication between the project management team and stakeholders						
Stak5	Number of stakeholders (including users, operators, client, contractors, ...) were involved in early stages of projects (it could be under the form of an integrated design process or early meetings or intensive discussion on project design/features/requirements)						

19. Defining sustainability-related goals

Code	Factors	1	2	3	4	5	NA

Goal1	Level of promotion of stakeholders' awareness, knowledge and commitment to invest in sustainability						
Goal2	Level of a sustainability ambition created among project team members in the beginning of project						
Goal3	Degree to which a declaration of owner regarding sustainability goals was announced to all relevant stakeholders						
Goal4	Degree to which sustainability mission statement with tangible objectives were fully considered in project brief or project plan						

20. Planning for the project

Code	**Factors**	**1**	**2**	**3**	**4**	**5**	**NA**
Plan1	Adequacy of identification, assessment and planning of sustainability-related risks						
Plan2	Adequacy of identification and prioritization of sustainability issues						
Plan3	Importance of considering sustainability achievement when selecting the project delivery method (i.e. such methods as design-bid-build, design-build or construction manager at risk)						
Plan4	Degree to which waste reduction, reuse and recycle in project was considered in project plan						
Plan5	Degree to which natural environment conservation was considered in project plan						
Plan6	Extent of planning a realistic schedule						
Plan7	Level of effectiveness in allocating project resources						
Plan8	Degree to which efficient and environmental-friendly technologies and materials were used						
Plan9	Extend of proposing and prioritizing sustainability-related activities						

21. Assessing sustainability *(Project management team is defined as a group of project manager(s) and colleagues - who manage and direct the project)*

Code	Factors	1	2	3	4	5	NA
Asse1	Level/Ranking of green-building or energy-performance certificates targeted						
Asse2	Degree to which project management team considered sustainability-related standards to apply in the project						
Asse3	Degree to which project management team had sufficient understanding of regulations and legislative forces about sustainable development						
Asse4	Level of environmental, economic and social impacts assessment in design and early stages of the project						
Asse5	Level to which sustainability performance/progress was monitored and measured the project						
Asse6	Adequacy of building commissioning carried out						
Asse7	Adequacy of post-occupancy evaluation (POE) carried out						

22. Factors related to project team *(Project team is defined as a group of contractor, subcontractors, designers, and consultancies to do main tasks of the building project)*

Code	Factors	1	2	3	4	5	NA
Enha1	Suitability of responsibility and power for project team members to do their jobs						
Enha2	Number of innovative solutions from project team members proposed (and discussed)						
Enha3	Level of workers' health, safety and working conditions in construction site						
Enha4	Adequacy of project team's skills and knowledge in executing project activities						
Enha5	Adequacy of project managers' competences and experience about sustainability in construction projects						
Enha6	Adequacy of collaboration and communication among project team members						
Enha7	Adequacy of information transparency among project team members (to avoid clashes and conflicts; to share knowledge among team members)						

Enha8	Adequacy of special advisors/champions involvement in project to support for achieving sustainability targets/goals						
Enha9	Degree to which project team members were motivated towards sustainability in the beginning of the project						
Enha10	Degree to which continuous learning process was implemented among the project team						

23. We would be glad to hear your further comments, please feel free to write down all your thoughts and concerns related to questions above. (Optional)

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24. Are you willing to be contacted in the future as a follow up to your responses?

○ Yes
○ No

25. Your name and contact address/email (Optional - If you would like to be informed of the research and questionnaire outcomes)

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26. Please forward this survey to your network or let us know the name and contact details of your other colleagues that might be interested in answering these questions, so we can contact them (Optional - Please indicate in the box below)

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....

This is the end of the survey. Thank you for your kind help in completing these questions above. We highly appreciate your time!

Warm regards,

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