

CHALMERS



Project Managers' Role in Sustainable Building Process

*Master of Science Thesis in the Master's Programme Design and Construction
Project Management*

MAHVIN DELNAVAZ

Department of Civil and Environmental Engineering
Division of Construction Management
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden 2012
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ABSTRACT

Providing all residences of a community with a better quality of life by developing of environmental, social and economic aspects has been focused in sustainable development for decades. In order to achieve the sustainable development, the construction industry is an important sector that should adopt the sustainability concept. Sustainable construction faces some challenges in adopting new processes and working methods due to the new technologies that require some changes in the process and considering risk. Learning about new tasks, actors and roles is necessary to overcome the challenges. The role of project managers requires particular attention among the other stakeholders because project managers are in a special position at project level.

Therefore, the purpose of this study is to investigate how project managers can integrate the sustainability concept into the building process in order to deliver a successful sustainable building project considering their responsibilities in the building process.

In order to achieve this purpose, a literature review has been conducted to find out the differences between focuses as well as processes in sustainable and conventional construction, the challenges in the sustainable building process along with the roles and responsibilities of project managers in the building process.

The outcomes present the focuses and process as well as main challenges in sustainable building design and construction. These challenges are presented in a time line of a building process. Simultaneously, the potential project managers' roles in overcoming barriers and using drivers in the sustainable building process are discussed regarding their responsibilities.

As a conclusion, project managers can play a vital role in integrating sustainability to a building project during design and construction process to deliver a successful sustainable building. Their role is significant for sustainable building process due to the challenges that they should deal with. They can facilitate the changes required for sustainable building due to its specific requirement. Among their roles, providing possibilities for a better communication and coordination between stakeholders is the most important one as a response to the complexity of sustainable building projects.

Key words: sustainable development, sustainable construction, sustainable buildings, green buildings, sustainable building process, project managers, project managers' role

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Preface

This master thesis was conducted as a final task for two years of master studies at the Design and Construction Project Management at Chalmers University of Technology. The thesis has been done at the Division of Construction Management during the spring semester of 2012.

The sustainable building as a relatively new approach in construction industry has been focused specially during last decade. Understanding its challenges and project managers' role in overcoming them is important for the sustainable building development in the future.

I would like to appreciate my examiner and supervisor, Martine Buser, for all her supports during the progress of this report. She supported me to conduct this research as a literature and helped me to understand what I should really derive from my study.

I also appreciate Thanh Cong Vo for the helpful comments that he provided as the discussant.

Göteborg May 2012

Mahvin Delnavaz

1 Introduction

The green movement has spread largely across society, including to construction industry to build environmentally responsible buildings. Such kinds of buildings mainly called sustainable buildings or green buildings.

Sustainable buildings are using the valuable resources such as energy, water, materials and land more efficiently than conventional buildings. Moreover, the following benefits encourage the adoption of sustainable building concepts in the industry (Häkkinen & Belloni, 2011):

- The operational costs of sustainable buildings are more beneficial than the operational costs of conventional buildings.
- Improved performance of green buildings can enhance the productivity of their users.
- The national economy could benefit from reduced emission and use of natural resources by sustainable buildings.

What is more, buildings are the highest consumers of resources in the world. For example 40% of the European Union's (EU) total energy consumption is related to the building sector. Additionally, in the US, buildings are responsible for 70% of the electricity consumption and 40% of the world's raw materials' depletion (Holowka, 2007). Due to the high amount of energy consumption as well as the expansion of the building sector, regulators increasingly concentrate on setting rules regarding sustainability aspects. For instance, it has been emphasized on sustainable energy utilization in EU directives for energy performance of buildings (The European Parliament, directive 2010/31/EU).

Consequently, actors involved in the construction industry have started to re-evaluate how buildings are being constructed nowadays and have increased concentration on such effective and efficient solutions as sustainable construction. However, sustainable construction requires developing as the whole construction industry needs "a deliberate and managed process to improve the capacity and effectiveness of the construction industry to meet the national economic demand for building and civil engineering products, and to support sustained national economic and social development objectives" (Ofori, 2000). This development of the industry can be reached by improving on products that are buildings as well as processes of buildings' design and construction.

1.1 Problem background

For developing sustainable building, it's important to take the process of buildings into account. The most emphasis in green and sustainable buildings, according to Kubba (2010), is on the buildings that are in compatible with the environment in which they has been built as well as on the buildings that are energy efficient and use natural or domestic materials. The criteria of rating systems for sustainable buildings also show that sustainable construction focuses more on the buildings and how the sustainability requirements are achieved by improving the building systems and details. These codes consider the buildings' specifications more than their design and construction process especially management practices (Wu & Low, 2010).

Moreover, the difficulties of sustainable building process are not because of a lack of existing information, technologies and assessment methods. In fact, sustainable building process, as Häkkinen et.al (2011) state, faces the challenges of adopting new processes and working method for applying new technologies. New technologies require some changes in processes and considering the risks and unpredictable costs. Häkkinen et.al (2011) suggests learning about decision making phases, new tasks, actors, roles and ways of required networking to overcome the major challenges. Whereas, the buildings' specifications are currently in focus, it's essential to consider the process as well as involving stakeholders' roles all over the process for successfully delivering a sustainable building.

Every stakeholder involved in a building process can play a role in developing of the construction industry. Among the others, the key role of project managers is emphasized in supporting the long-term vision in construction industry. Project managers are in an exclusive position at project level to change the industry basically. As well, in order to ensure the continued development of the industry, the project managers can be drivers of change alongside their traditional role (Hills, Fox, Hon, Fong, & Skitmore, 2008).

Learning about Project managers' role in the sustainable building process is significant because sustainable building has more focuses than conventional building in order to achieve its benefits. Project managers can specifically encourage sustainable building by integrating sustainability concept to their practices. Some of the primary objectives of green buildings, according to Kubba (2010), are reducing energy consumption, protection of ecosystem, improved health of occupants and increased productivity. Considering the responsibilities of project managers, their role is noticeable in completely attaining these objectives. Because, they plan, control and monitor the process of designing and constructing of buildings so they can influence on energy consumption, productivity and protection of ecosystem by efficiently accomplishing their task.

Along with the significance of project managers' role among the other stakeholders, another reason for investigating the project managers' role in sustainable building process is the increasing consideration towards an integrated management system in sustainable building. The strategy of sustainable building will create healthier and more energy efficient building thus it is important to have their lifecycle impacts in mind when buildings are designed and operated (Kubba, 2010). Wu et al. (2010) as well emphasized a holistic solution in the whole project lifecycle, from planning till operating in order to build a green building. In fact, it is not sufficient to build a green building with new materials and technologies that are environmental friendly. So an integrated approach is vital in green building process. Applying an integrated design approach involves having architects, engineers, land planners, building owners and operators along with members of construction industry to collaborate in designing the project (Kubba, 2010). This requires an effective role of project managers during the whole process of green building in order to facilitate collaboration among various professionals.

1.2 Purpose

Due to the aforementioned importance of the project managers' role in sustainable building and the need for more attention to its process, the purpose of this study is to

investigate the project managers' role in the sustainable building process. In order to understand these roles, the challenges in sustainable building should be investigated to find out how the project managers can influence on linking sustainability to the building process by highlighting their responsibilities which make them be able to influence.

The following questions have directed this research in order to accomplish the purpose:

- What are the differences between the focuses and process in conventional construction and green construction?
- What are the challenges in sustainable building process?
- What are project managers' roles in overcoming barriers and using drivers in the sustainable building process?

To answer these research questions, firstly, the sustainability concept and its relation to construction industry are introduced. Secondly, the main focuses and process in conventional and sustainable building are presented according to the literature. Then, the challenges for green building are highlighted during the process of green building projects. Simultaneously, project managers' roles in dealing with these challenges are discussed, considering their role in conventional building. A summary of the challenges and related project managers' role is presented at the end of each phase. To conclude, the importance of project managers' role for successful delivery of sustainable building is emphasized in addition to the main learning points of this study. Finally, the possibilities for future research are suggested.

1.3 Scope

The challenges in sustainable building have often been addressed independent from the time line of a building lifecycle in literature. In this study, the process of designing, bidding and constructing a new sustainable building is considered as a time line in order to investigate the potential barriers and drivers in each phase for delivering a successful sustainable building. It considers project managers who lead, manage and co-ordinate the project teams for their daily tasks. They may manage the whole process or a part of the process, for example sustainable design phase or sustainable construction phase. Moreover, they face these challenges based on the conditions and locations of projects due to the uniqueness of construction projects.

1.4 Delimitation

There are other challenges in sustainable construction regarding cost related issues, building specifications, regulations, rating systems, technology and etc. that are worth studying but what are focused in this study are challenges in sustainable building process that can be met by project managers as well as their roles and responsibilities in successful delivery of a green project.

Many factors also influence the successful delivery of a project in addition to project management actions that are mainly taken by project managers. These factors, according to Chan et al. (2004), include human-related factors, project-related factors, project procedures and external environment. There are also many variable in each group that affect not only on each other in a group but also on the other variables of

the other groups. So the role of project managers in successfully delivery of a sustainable project depends on many other factors like size and type of the project, economic conditions, technology advanced and etc. (Chan, Scott, & Chan, 2004). What is more, the factors related to the organization such as top management support and project organization structure influence the success of a project manager in dealing with the challenges and consequently the success of the project (Hyväri, 2006).

Whereas these factors do exist and effect on project managers' actions, the focus of this study is on the areas that project managers are able to influence on integrating the sustainability concept to the project. However the other factors may hinder them to play their role effectively.

2 Methodology

In order to carry out this research a literature review was conducted. The literature that has been reviewed consists of Journal articles, book chapters and websites related to the purpose of this research. The main fields that were reviewed are listed below:

- Sustainability concept, sustainable development as well as its relation to construction industry to investigate the definitions for some common terms in sustainable construction, for example sustainable building and green building
- Focuses and process in sustainable and conventional building in order to find the differences in sustainable and conventional building
- Rating systems in order to find out how much the process of sustainable building and its management are considered in their evaluation process
- Sustainable building challenges to investigate what barriers and drivers are significant in the sustainable building process and what challenges exist in designing and constructing a green building during design and construction process
- Project managers' roles and responsibilities in the building process that can be highlighted for the related challenges
- Some case studies regarding the challenges for sustainable building to find some examples of each challenges in order to make them more understandable

Findings of literature review regarding the challenges are presented according to the process of sustainable building. Simultaneously, the importance of these challenges in green building process is specified as well as the project managers' roles in dealing with these challenges are discussed.

Conclusion is a wrap-up of the main outcomes of this study and implications for further research.

3 Findings and discussion

The following subchapters represent the main findings from literature review and related discussions. First, sustainability concept, sustainable development and construction industry as well as focuses and process in conventional and sustainable building are presented to introduce the context of this research. Furthermore, the challenges in sustainable building process and its importance are presented and the project managers' roles are discussed for each challenge according to the process of sustainable building.

3.1 Sustainability concept

The most known definition of sustainable development is “development that meets the needs of the present without compromising that ability of future generations to meet their own needs.” This is from the Brundtland Report (1987). In addition, several definitions for sustainability concept and sustainable development are presented by other authorities as cited in Huovila et al. (1998). These definitions can be considered as a complementary in order to get a better understanding of the sustainability objectives:

- *“Improving the quality of human life while living within the carrying capacity of supporting ecosystems” (Caring for the Earth, IUCN/UNEP, 1991)*
- *“development that delivers basic environmental, social and economic services to all residences of a community without threatening the viability of natural, built and social systems upon which the delivery of those systems depends” (International Council for local Environmental Initiatives, 1996)*
- *“Determined to promote economic and social progress for their peoples, taking into account the principle of sustainable development and within the context of the accomplishment of the international market and of reinforced cohesion and environmental protection, and to implement policies ensuring that advances in economic integration are accompanied by parallel progress in other fields” (Amsterdam Treaty, 1997)*
- *“It is about ensuring a better quality of life for everyone, now and for generations to come” (Consultation paper3 on a UK strategy for sustainable construction, 1998)*

These different definitions were presented in the years following Brundtland Commission's report to create a standard definition of sustainable development. In 1999, the Board on Sustainable Development of the U.S. presented a table in its report, “Our common journey: a transition toward sustainability” which shows what is to be sustained and what is to be developed by reviewing different definitions. Figure 1 shows this table. It is informative and helpful to grasp what are important aspects of sustainable development in different definitions.

As can be seen from the figure 1, three main categories are identified as nature, life support systems and communities as well as sub-categories for each one. It was found by the Board that the most emphasis in surveyed literature was on life support systems such as ecosystem services, resources and environment (Kates, Parris, & Leiserowitz, 2005). There were also clear ideas about what should be developed: people, economy and society. The emphasis in the early literature was focused on economic development but human development has been focused more recently with emphasis

on increased life expectancy, education, equity, and opportunity. Sustainable development definitions also suggest linking what is to be sustained and what is to be developed but there are differences in extremes of “sustain only” and “develop mostly”. The time period of concern has also differed from what was described in standard definition as “now and in the future” (Kates, Parris, & Leiserowitz, 2005).

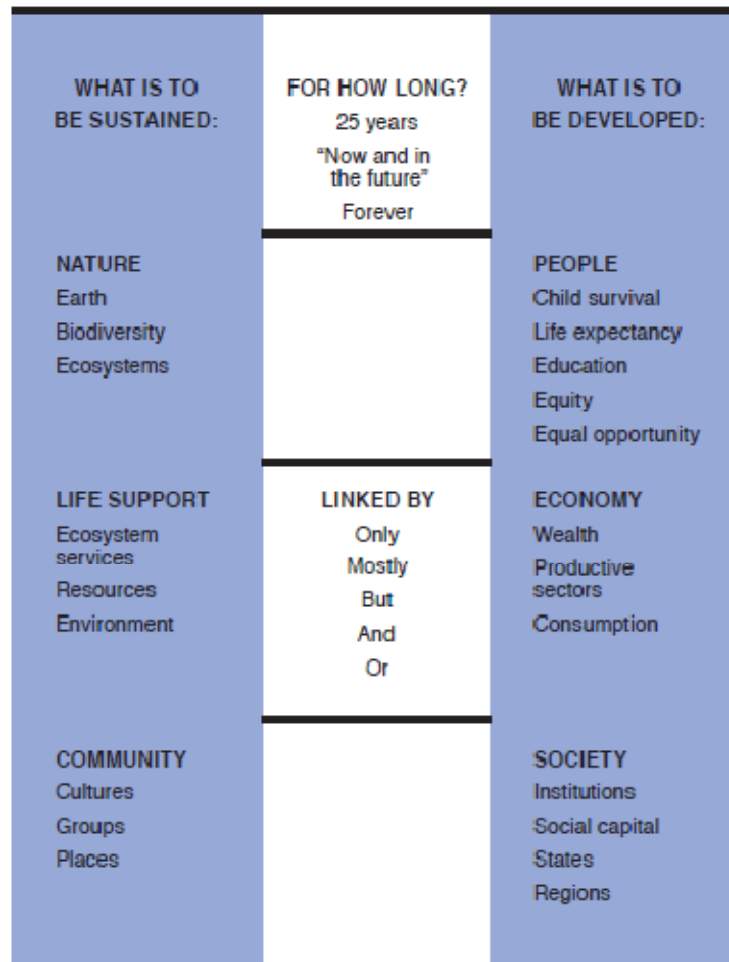


Figure 1: different aspects of sustainable development definitions (U.S. National Research Council, Policy Division, Board on Sustainable Development, 1999)

According to Kates et al. (2005), a further expansion of the standard definition of sustainable development was marked by the 2002 World Summit on Sustainable Development that has highlighted three pillars of sustainable development: economic, social and environmental. In “Johannesburg Declaration”, it has been emphasized on “a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development -economic development, social development and environmental protection- at local, national, regional and global levels”.

3.2 Sustainable development and construction industry

In order to achieve the sustainable development, the construction industry is definitely an important sector that should adopt the sustainability concept, since it has important direct and indirect links with the different aspects of the sustainable development: economic, social and environmental (Bourdeau, 1999). Some reasons support this claim clearly.

One reason is the construction industry consumes high amount of resources, so improving its quality has a significant effect on the sustainability of the whole society (Huovila & Koskela, 1998). For example green buildings use 36% less energy than conventional buildings that also caused reduction in CO2 emissions (Holowka, 2007). Some literatures suggest another reason which considers built environment, the end product of the construction industry. Built environment is the context for the majority of human activity that can largely influence the sustainability of the whole society (Mills & Glass, 2009) by increasing health and productivity of inhabitants. According to Holowka (2007), people who live in green buildings have 40-60 per cent fewer incidents of cold, flu and asthma. Finally, the built environment contains one of the main supports of economic development which are infrastructures and buildings (Bourdeau, 1999).

The trends towards sustainable development have its own consequences on the construction industry. As Bourdeau (1999) states, the challenge of sustainable development is responded by the building sector as sustainable construction. According to the road map (figure 2) that is suggested by Huovila et al. (1998), sustainable construction is the response of the building sector to the sustainable development that has its own process and outcome. The process is named “sustainable building process” and the outcome is named “sustainable buildings”.

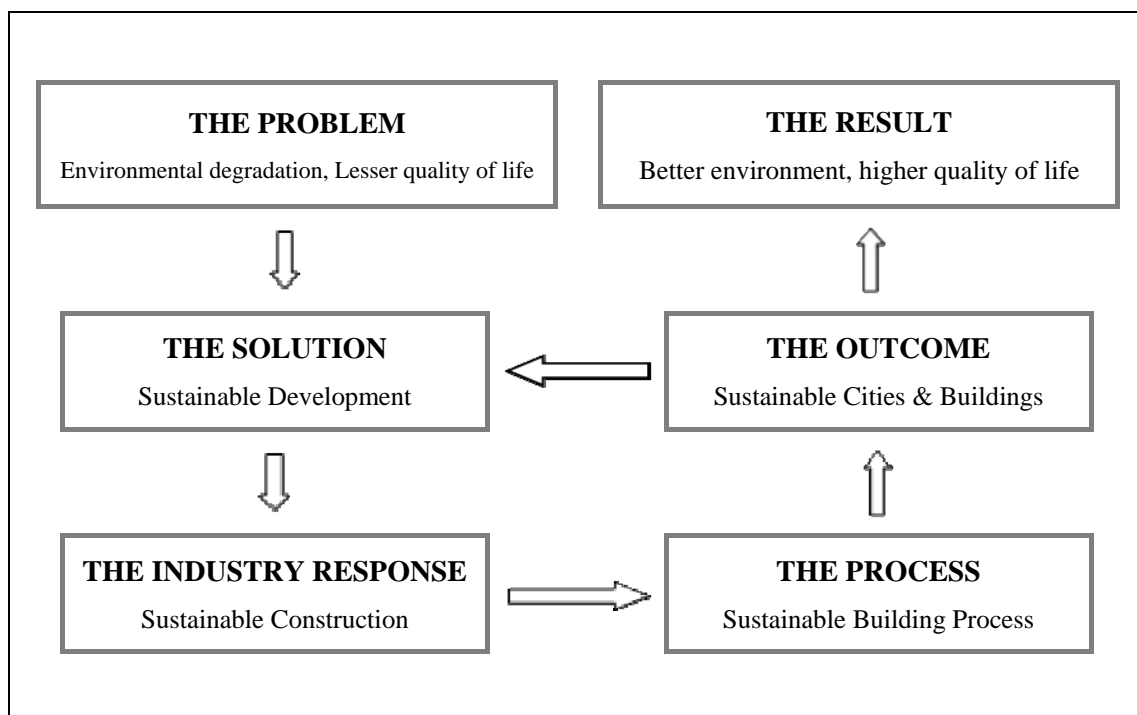


Figure 2: Road map for sustainable construction (Huovila & Koskela, 1998)

Sustainable construction has been developing since the late 1980s. Sustainable construction should continuously improve because there is increasing evidence about

the depletion of the environment and environmental loadings (Matar, Georgy, & Ibrahim, 2008). Consequently, for improving sustainable construction, the construction industry has been enormously changed during the last decade (Kubba, 2010). In fact, the aim of the sustainable construction is integrating the general sustainability concepts with conventional construction practices (Matar, Georgy, & Ibrahim, 2008).

Different terms exist in this context like high performance, green and sustainable construction. These terms are often used interchangeably but according to Kibert (2005), sustainable construction most comprehensively addresses the ecological, social and economic issues of a building in the context of its community. The Conseil International du Batiment (CIB) in 1994 defined the goal of sustainable building (Kibert, 2005, s. 9):

“The goal of sustainable construction is to create and operate a healthy built environment based on resource efficiency and ecological design.”

As Kibert state CIB also presented seven core principles for sustainable construction that should notify decision making during design and construction phases. These principles are reducing resource consumption, reusing resources, using recyclable resources, protecting nature, eliminating toxics, applying life cycle costing, and focusing on quality.

Sustainable construction and green building have various definitions similar to sustainable development during their improvement throughout the years. The term “green building” is established in this context and is relatively new in construction industry (Kubba, 2010) therefore a precise definition of this term is helpful to have a perception of what is supposed to build and what should be focused during its building process.

The US Environmental Protection Agency (2010) defines the green building as:

“The practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building’s life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building”

As well, the International Organization for Standardization (2008) presents sustainable development of building and construction as:

“The required performance and functionality with minimum adverse environmental impact, while encouraging improvements in economic and social (and cultural) aspects at local, regional and global levels”

Robichaud et al. (2011) present a definition as a conclusion of some previous definitions that is more articulated. They define green building (that is also referred as sustainable construction) as:

“A philosophy and associated project and construction management practices that seek to:

- *Minimize or eliminate impacts on the environment, natural resources, and non-renewable energy sources to promote the sustainability of the built environment;*

- *Enhance the health, wellbeing and productivity of occupants and whole communities;*
- *Cultivate economic development and financial returns for developers and whole communities;*
- *Apply life cycle approaches to community planning and development.”*

Furthermore, what are important to be found out from the various definitions of the sustainable construction are the main features of them. An international study by Bourdeau (1999) had done to define a clear vision of sustainable construction. They collected definitions from the experts of various countries based on the Kibert's definition in 1994. They categorized the key elements of these sustainable construction definitions as below:

- To reduce the use of energy resources and depletion of mineral resources
- To conserve natural areas and bio diversity
- To maintain the quality of built environment and management of healthy indoor environment.

Bourdeau (1999) also distinguished the following topics in a more detailed level from different definitions:

- Meeting user needs in the future, flexibility, adaptability
- Long service life
- Use of local resources
- Building process
- Efficient land use
- Water saving
- Use of by-products
- Distribution of relevant information to their decision making
- Unimportant services
- Urban development and mobility
- Human resources
- Local economy

These features display the important detailed aspects of sustainable construction that should be considered during the whole process of design and construction.

Thus, Sustainable construction supports the triple bottom line of sustainable development (economic, social and environmental) by setting the following goals that are derived from DETR (2000) (Presley & Meade, 2010):

- Achieving more profitability and more competitiveness
- Reaching Greater satisfaction of customers and users as well as well-being and value to them
- Considering its stakeholder more objectively and respecting them
- Improving the protection of the natural environment
- Minimization of the energy consumption and other national resources

What is assumed by key elements and the road map is green building and sustainable construction terms point to the process of constructing rather than just a final building that is built in compliance with the standards from different rating systems. This statement is also recognized by Presley et al. (2010). Sustainable construction

according to Presley et al. (2010) refers to the buildings and spaces as well as the processes or activities used to construct them.

3.2.1 Sustainable building versus conventional building focuses

The sustainable building should result in better environment and higher quality of life so its process has to focus on some more factors along with the traditional construction competitive factors.

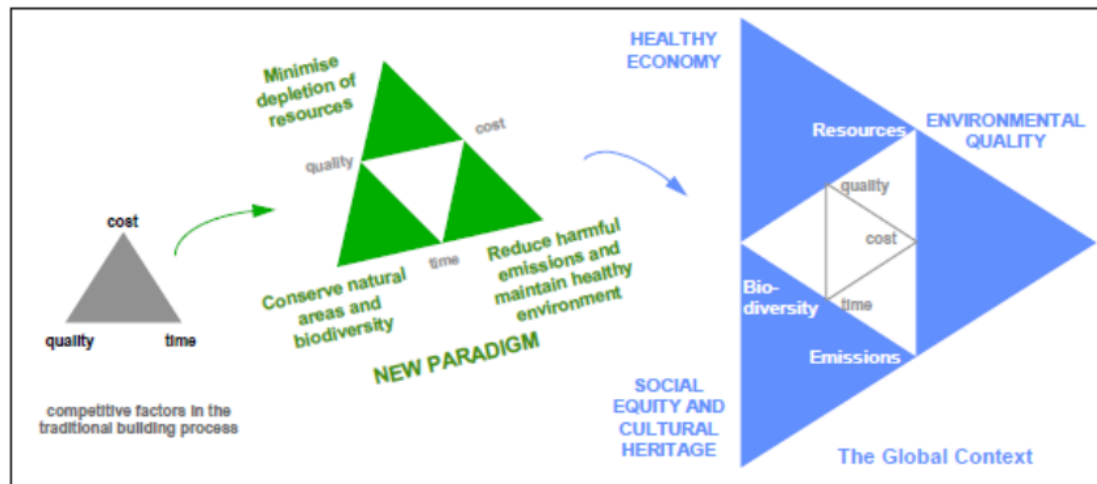


Figure 3: Challenges of sustainable construction in global context (Huovila & Koskela, 1998)

Cost, performance and quality objectives are focused in traditional construction. Sustainable construction enhances this traditional focus by adding more criteria: minimization of resource depletion, minimization of environmental degradation, and creating a healthy built environment (Huovila & Koskela, 1998). A new model has suggested by Vanegas et al. (1996) as cited in Huovila et al. (1998). Figure 3 shows this new model. The model considers the sustainable objectives for decision making at all phases of a project lifecycle.

Furthermore, sustainable designers and contractors should consider the whole life cycle of a building rather than the initial capital investment. They should also consider the built environment as a part of natural environment as well as the flow and exchange of material and energy between them. The living components of built environment (flora, fauna and people) should also be considered in addition to the non-living components because these two groups of components operate together as a whole system (Vanegas, DuBose, & Pearce, 1996).

In addition, the project managers' challenges are expected from this new model. These challenges can be due to the new objectives that should be focused in sustainable construction. Moreover, it can be because of the interaction between the new and old criteria. These challenges will be introduced in section 3.4 and will be discussed regarding the project managers' role in dealing with each one.

3.2.2 Sustainable building versus conventional building process

Mills et al. (2009) suggest a sustainable building process based on the conventional building process that is presented in Outline Plan of Work 2007 by Royal Institute of British Architects (RIBA).

Work stages of a building process according to the RIBA (2007) are preparation, design, pre-construction, construction and use. These stages are divided into some detailed stages that are shown in table 1. The sequences of these work stages may overlap or vary to suit the procurement method (RIBA, 2007).

Key work stages in conventional building	Detailed work stages	Phases in sustainable building
Preparation	Appraisal	Sustainable building design
	Design Brief	
Design	Concept	
	Design Development	
	Technical Design	
Pre-construction	Production Information	
	Tender Documentation	
	Tender Action	
Construction	Mobilisation	Sustainable construction
	Construction to practical completion	
Use	Post practical completion	Sustainable building (deliverable)

Table 1: key and detailed work stages in a building process (RIBA, 2007) versus the phases in sustainable building (Mills & Glass, 2009)

Based on these work stages, Mills et al. (2009) present sustainable building process containing two main parts: Sustainable building design and sustainable construction. Sustainable building design happens prior to sustainable construction and these two stages lead to a deliverable that is called sustainable building and facilitate sustainable development.

As can be seen in Figure 4, typical phases of a construction process are presented in one of these stages in sustainable building process. Thus, sustainable building design

consists of the practices for preparation design and preconstruction phase including tender action. Furthermore, sustainable construction contains activities for mobilization and construction to practical completion. Sustainable building as a deliverable includes post practical completion and post occupancy evaluation.

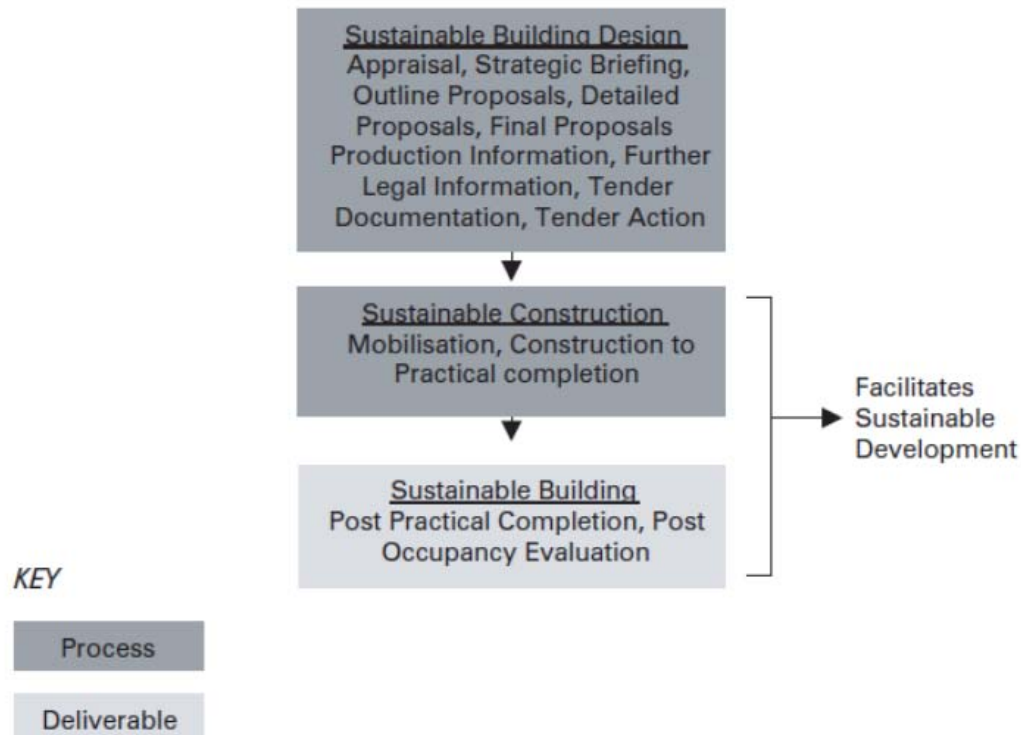


Figure 4: Major phases in sustainable building process in comparison to the typical phases of a construction process (Mills & Glass, 2009)

Moreover, Mills et al. (2009) present general consensus on sustainable building design which considers sustainable building design as the planning of a building that:

- Are built in a sustainable way
- Enable inhabitants to live a sustainable lifestyle
- Address the Brundtland's definition and triple bottom-line concept (economic, social and environmental)

3.3 Green building and project management

According to Wu et al. (2010), technical-related issues are paid much attention in the sustainable construction. These technical-related issues refer to the components of the systems that can help to achieve green goals including energy efficiency and using environmentally friendly materials. Project management is considered as a set of tools such as site management, waste management, and material management, etc. Wu et al. (2010) claim that the project management process as the nontechnical-related issues, is presently not being focused enough.

In order to reflect more common practices and focuses in green building, it could be helpful to review the aspects and focuses of the rating systems because it is common to provide conformity of buildings with the rating systems. For evaluating how green

the building is, Rating systems offer helpful information regarding good practices and measures to achieve green goals (Wu & Low, 2010). According to Wu et al. (2010) the three most applied rating systems are “LEED”, “BCA Green Mark” and “Green Globes” which are chosen for investigation of project management assessment criteria.

The lack of considering the importance of project management process in a green project has been identified by Wu et al. (2010) in two out of the three most applied rating systems however it is believed that green building should be considered as a process rather than a product because of its long duration. . In “LEED” and “BCA Green Mark”, it is project management practices such as waste management, environmental management program, material management and site management that are focused in project management section of these two rating systems. The examples of the practices in these rating systems are storage and collection of recyclables, recycled contents, regional materials, and public transport accessibility.

On the other hand, according to Wu et al. (2010), the Green Globes has more focused on the project management processes such as coordination, building commissioning, documentation, etc. So in such a strategy, they claim project managers should take an effective role in balancing between the process and practices.

Furthermore, Wu et al. (2010) suggest an effective project management package in order to achieve the desires of green building. Obviously, this effective project management package seeks an effective role of project managers. This package includes:

- Project management process in the project life cycle to accomplish sustainable construction
- Delivery of relevant goals to different project parties without missing the sustainability concept at key points in the process
- Construction management practice during the construction phase to reach the green goals
- Feedback and documentation of the project life cycle for continuous improvement

3.4 Challenges in sustainable building process and project managers’ role

According to Griffith (2002), developing and implementing new innovative ways to procure, design, construct, use and maintain development are recognized as a challenge for construction industry especially for sustainable construction. These innovative ways should meet an even more demanding range of expectations from clients, industry and society that focused on time, cost, quality, safety and environmental impact. Griffith states that the interaction between the traditionally separate processes and management functions is the much needed change that can enhance the performance of the construction process. Thus, sustainable construction as a driver for these changes should be responsive to some key challenges:

- Improving the effectiveness and efficiency of the construction process by greater interaction between key phases.

- Producing good quality products in a working environment that is healthy and safe and minimizing the improper effect to the project surroundings and inhabitants.
- Making holistic and long-term improvements to the built environment in order to meet the changing demand of clients, industry and the public.

These key challenges display the difficulties of sustainable building process which are not because of a lack of existing information, technologies and assessment methods. In fact, sustainable building process, as Häkkinen et.al (2011) state, faces the challenges of adopting new processes and working method for applying new technologies. New technologies require some changes in processes and considering the risks and unpredictable costs. Häkkinen et.al (2011) suggests learning about decision making phases, new tasks, actors, roles and ways of required networking to overcome the major challenges.

One of the actors that can have an effective role in developing sustainable building process is project managers. Project managers generally have responsibilities for achieving the major objectives of construction management. Construction management objectives consist of the best possible use of existing funds, the control of the scope of the work, effective project scheduling, preventing delays, changes and disputes, improving project design and construction quality and optimal flexibility in contracting and procurement (Arditi & Ongkasuwan, 2009).

As project managers may control different phases of a project, introducing the challenges in each phase of a green project could be more beneficial in order to finding their roles and responsibilities. Although some of these challenges may also be important to consider in the conventional construction, they turn to a challenge in the sustainable construction because of the long-term objectives of the sustainable construction that makes the benefits of sustainable buildings intangible. Furthermore, sustainable building practices and process need changes in common practices in construction industry. Because of the conservative nature of construction industry, these changes face some new challenges and even previous issues that turn to challenges in this situation.

The aforementioned stages in sustainable building process are considered at this point as a timeline for introducing the barriers and drivers in sustainable building process in order to understand the challenges that project managers face to deliver a successful green project. Simultaneously, related responsibility of project managers' are highlighted to discuss their important role in overcoming the barriers and using the drivers.

3.4.1 Sustainable building design challenges and project managers' role

Sustainable building design generally contains feasibility and design phase as well as tendering phase. The challenges for these phases and possible related project managers' role are separately discussed in the following subchapters and finally a summary of results is presented.

3.4.1.1 Feasibility and Design Phase challenges and project managers' role:

Robichaud et al. (2011) state the most significant steps toward delivering a sustainable building are performed during the feasibility and design phases. This phase is considered important because in this planning phase, materials and construction methods are identified and the manner in which inhabitants will live is determined (Mills & Glass, 2009).

The main challenges in this phase are including setting clear goals, client understanding, end user understanding, evaluation methods and tools, timing, communication and coordination, steering mechanisms as well as economics. These main challenges and the related project managers' role during this phase are discussed in the following.

Setting clear goals:

Lack of adequate knowledge for developing a project brief with clear target is a hindrance to the sustainable building (Häkkinen & Belloni, 2011). Setting clear goals is important for sustainable construction because in addition to market conditions and physical needs that are normally considered in a traditional construction, environmental goal, the amount of capital investments toward green initiatives and desired level of a rating system are considered in the sustainable construction (Robichaud & Anantatmula, 2011). The client should make decisions and set project goals before selecting a site and beginning design. It is recommended to make a professional team including manager, architect and contractor to assist the client in defining goals and priorities. In order to cost-saving it is also possible to hire a manager who is expert in all areas of green development (Robichaud & Anantatmula, 2011).

In spite of making a professional team, some decisions during this phase might be made without setting and considering sustainability goals at first. For example, in the process of selecting green structural materials and systems it is common to select the system according to the performance criteria with little discussion about sustainability. Griffin et al. (2010) have presented their findings from the interviews with four groups of building design and construction professionals regarding structural selection process. They found that the choice between different structures (steel, concrete, wood and masonry) is dictated initially by building codes or lower costs. In this way, the initial selection of material is done according to the type and scale of the building. After choosing the structural material, the improvement of the green aspects on the selected material is decided by stakeholders. This sequence may lead to choosing inadequate structural material and system regarding sustainability requirements because the green aspects have not been considered as a priority. According to their interviewees, improving the green aspects was commonly done by increasing the material efficiency or reducing the carbon print of the selected material. Thus, forcing compliance with sustainability objectives after selecting the structural materials and systems may lead to the cost inefficiency.

Since changing orders for design and construction modifications is cost inefficient, it is recommended by Robichaud et al. (2011) to define the priorities for sustainable construction at the earliest project phase. Thus, early consideration of sustainability is vital for delivering a green building. For this purpose, it is important to begin with the end in mind (Robichaud & Anantatmula, 2011). This means that the owner and

project manager have to establish clear sustainability goals before design and construction phase. Robichaud et al. (2011) emphasize setting sustainable priorities during the project feasibility in order to establish a framework for all future decision making. So, the chance for significant changes or wrong decision making that lead to cost inefficiency can be reduced.

Client understanding:

Clients are considered as developers in construction industry so their understanding of goals and objectives to choose the best alternative is always important. Their understanding is even more significant in sustainable building because the goals are long-term and the benefits seem to be intangible. Thus, clients fail to become convinced about the benefits of green buildings and they do not feel the necessity of the green buildings adoption (Hwang & Tan, 2010).

As an instance, according to aforementioned case study, conducted by Griffin et al (2010), it is found that the primary advocates for green structural materials are clients along with design teams by asking the four focus groups. They discussed the importance of clients who are the most financially invested. The clients must be convinced of the value added by choosing green structural materials. Thereby, their understanding of the value that can be added by considering the sustainability concepts is important.

Häkkinen et al. (2011) considered client understanding as a main factor in the developing of the sustainable construction. They stated the demand and willingness of clients are the determinants for the sustainable development. Moreover, Pitt et al. (2009) introduce the client awareness and demand as drivers for sustainability. According to a survey made in the US by the Reed Research Group, only 32% of clients have expressed interest in following green construction (Matar, Georgy, & Ibrahim, 2008). Thus, the interest and willingness of clients is a challenge for sustainable building at the beginning. This interest can increase as a result of their understanding of different aspects of sustainable building.

Different kinds of clients can influence on sustainable building development in different ways. One main group of clients is investors that own and develop private buildings. The other main group is governmental and local authority organizations that own and develop public buildings (Häkkinen & Belloni, 2011).

Investors may have a few desires to invest on sustainable buildings (Bon & Hutchinson, 2000) due to the traditional view of construction as a commercial venture with little concern to its environmental potential (Madelin & Gilham, 1999). In this regard, the project managers can influence the clients because they are the leaders of the design groups who work within the brief of clients (Pitt, Tucker, Riley, & Longden, 2009). In this situation, the project managers can inform them by providing useful information about the benefits of a sustainable building such as the reduced operating costs, promoted corporate image and increased well-being of occupants (Pitt, Tucker, Riley, & Longden, 2009). As well, these information might be included the competitive benefits in the market or incentives including tax reduction for green buildings.

Moreover, the development of sustainable buildings might be affected by the governmental organizations which own and develop public buildings. Their

understanding is also important to adopt sustainability concept and project managers as their representatives have a role to inform them about the benefits of sustainable buildings similar to their role for informing private clients.

On the other hand, governmental organizations have absolutely effect on developing sustainable buildings especially when regulations force adopting sustainability objectives (such as happened in EU directives). In this case, governmental organizations should make private design and construction companies to adopt the sustainable building methodologies by setting sustainability targets (Bon & Hutchinson, 2000). The project managers, who work within construction companies, should ensure that project objectives are reached by a clear statement of goals and limitations, careful monitoring during design in order to be sure that meets the project requirement as well as independent review during the design and prior to tender (Jaworski & Samanta, 2006).

End user understanding:

It is before mentioned to the importance of client understanding due to increasing the demand among professional clients (who are private investors as well as governmental organizations that respectively own and develop private and public buildings). On the other hand, increasing the demand among end users (who are home buyers as well as tenants) is also significant (Häkkinen & Belloni, 2011). However, it seems to relate to the marketing stage, it can be considered as a challenge in the beginning due to its effects on the willingness of professional clients for sustainable buildings. If professional clients recognize the increasing or existing end users' demand for sustainable buildings, they definitely decide to response to this demand.

For example, a case study presented by Häkkinen et al. (2011) that was a plan for an ecological area in the city of Joensuu in order to engage partners' interest. The impacts of providing information for different stakeholders were assessed and discussed. They concluded professional clients are interested in sustainable building projects if they can recognize sufficient interests and demands of end users. So, end users should access reliable information about the benefits of sustainable buildings at early marketing stage.

Häkkinen et al. (2011) also conducted personal interviews with a selected group of 20 experts based on their experiences in the sustainable construction and their positions in the building process. The group consisted of designers, product manufacturers, developers, contractors, owners and authorities. They identified the lack of demand from end users as a barrier from the interviews. The interviewees suggested influencing the general opinion by improving the availability and quality of information available to end users. The interviewees also believed that the demand for sustainable buildings would increase if end users could get more information regarding the influence of their own choice and behaviour on the environmental impacts and life-cycle costs.

In a general view, this information should be incorporated in the educational and training programs at all levels, but developers who have adopted sustainable building strategy should also give systematic sustainability information about the residential buildings to end users in order to raise the demand (Häkkinen & Belloni, 2011). Providing this information can be considered as a way of communication with end users. Since project managers as the representatives of developers should establish

basic communication procedures in this phase (Arditi & Ongkasuwan, 2009), they can play a role in providing this useful, objective and reliable information for end users.

Evaluation methods and tools:

The sustainable construction has different requirements from the conventional construction due to the objectives and strategies in green construction (Kubba, 2010, s. 93). Increasing energy efficiency and reducing environmental impacts are two examples of sustainable building requirements. Additionally, the key characteristics of a sustainable building are its requirements (Häkkinen & Belloni, 2011). A strong commitment to the environment and health issues should exist in design process which could lead to a successful green building (Kubba, 2010, s. 93) and determine sustainable building requirement. Methods for Management of sustainable building requirement should be developed and used by professional building clients and public actors (Häkkinen & Belloni, 2011). Furthermore, they should be able to state requirements that are performance based and measurable as well as are monitored and maintained during the whole process. Häkkinen et.al (2011) emphasize that the objectives and requirements should be expressed clearly and quantitatively. Furthermore, some methods should be articulated for comparisons, quality control and monitoring.

These requirements can be developed in the form of quantitative rules by regulators. Häkkinen et al. (2011) concluded from one of the case studies that the availability of building-specific assessment and evaluation methods should be improved to be able to implement these regulations.

For this purpose, As Kubba (2010) stated the progress of the green building process should be managed by measurable targets related to a specific requirement. These targets should be measured by special tools which challenge the design and construction team. For example, computer-aided programs such as computer energy simulation are employed to measure and assess energy saving early and throughout the design process. This enables design team to produce alternative concepts that focus on minimizing energy consumption.

On the other hand, using these evaluation tools needs special knowledge. Project managers as the project leaders should have enough knowledge about the related programs and its usage as well as in which step they should be used.

Timing:

Sustainable construction projects, which have more special concerns (such as minimising depletion of resources, reducing harmful emissions) than traditional ones, should consider the possibilities of right design options in early stages (Häkkinen & Belloni, 2011). According to Arditi et al. (2009), one of the duties of project managers in predesign phase is to interview and select architects, engineers, estimators, land surveyor and other consultants. But what are important for delivering a successful sustainable project are scheduling, right timing and the attendance of all needed actors (Häkkinen & Belloni, 2011).

In the case studies done by Williams et al. (2007), in spite of consulting planning authorities through advertising planning applications, there were occasions where stakeholders who should have been involved were not. They stated that it seems if

they participated early, they could have an influence on adopting more sustainability objectives. Furthermore, they found that in some cases the important stakeholders participated too late to introduce sustainability elements. For example, landscape architects argued that if they had been involved early in design stage, they could have had an influence (Williams & Dair, 2007)

Additionally, end users should be actively involved in demand specification. Their involvement is realized as one of the drivers of process innovation (Häkkinen & Belloni, 2011). In Bamburg clinic project in Newcastle, designers and users participated in the facilitation workshops at an early stage. Direct communication and consequently collaboration was very useful to recognize the users' requirements for instance the security requirements (RIBA, 2011). Häkkinen et al. (2011) also emphasized the importance of the management of the end users' participation in demand specification and the role of project managers.

The aforementioned interviewees who are interviewed by Häkkinen et al. (2011) pointed out the most important changes that are required in the sustainable building process. These changes are the forms of communication and early involvement of all parties. If the right design options are not considered early in the project feasibility phase a large part of sustainable building potential will be lost.

A solution to providing opportunities for stakeholders to participate early in the project feasibility is incorporating a charrette at the beginning of a project including all key external stakeholders. This solution can improve the communication and exchanging the initial ideas among the stakeholder group. Charrette is defined as “a collaborative planning process that harnesses the talents and energies of all interested parties to create and support a buildable Smart Growth Plan” by National Charrette Institute (Robichaud & Anantatmula, 2011). The conclusion of a charrette is a report that can be used as a guide in design process (Kibert, 2005, s. 101).

The charrette should be conducted by a facilitator who is familiar with the green building process (Kibert, 2005, s. 103). However it is not mentioned directly that this facilitator is a project manager, it can be found out from the general responsibilities of a project manager. “Establishing basic communication procedures” is recognized as a responsibility for project managers during the predesign phase by Arditi et al. (2009). Thus, the project managers with experience in green building process can play the facilitator's role in conducting a charrette to make the project benefits from the early participation of all stakeholders.

Communication and coordination:

Robichaud et al. (2011) recognize communication and coordination across a multidisciplinary team as the most important challenge to delivering a successful green project due to the more complexity of green projects than conventional ones.

The Stonebridge Hillside Hub is an example of a project driven by economic, social and environmental sustainability. The building brings together user groups of the different building areas in order to encourage strong community spirit. Consequently, some technical challenges arose due to the making a mixed-use building work. Therefore, the design team works hard together in an integrated process to meet these challenges. Moreover, effective realization of a high quality build was established by a good working relationship with contractor. It is also emphasized that the design

team worked closely with the contractor to develop designs that were buildable, cost efficient and elegant (RIBA, 2011).

An integrated design process is usually used in green building design and construction as a response to the additional considerations as well as the separated and various contributors. As the buildings include several interconnected systems that mutually impact each other, the integrated design process is necessary to be used in order to make the adjustments in these related systems in time (Kubba, 2010, s. 94). This design process considers a multi-disciplinary team of building professionals. This team should work together from the pre-design phase through post-occupancy to produce a high performance building that is cost effective and environmentally friendly (Kubba, 2010, s. 94).

In such a multi-disciplinary team, the role of project managers is even more vital. Thus, for forming an integrated project team, the first step is the selection of an experienced project manager during the project feasibility stage (Robichaud & Anantatmula, 2011). They can stimulate collaboration and communication among actors (Jaworski & Samanta, 2006) that could lead to a development for sustainable building. Furthermore, project managers have the responsibility of conducting planning and strategy meetings in order to ensure that project goals are understood by all team members (Robichaud & Anantatmula, 2011).

Project managers could be as well role models in integrated project teams. They could avoid dishonest behaviours that undermine trust and confidence of all. As an integrated project team contains a large number of specialists, project managers play a special role in coordination between them and provide the opportunity of fair solutions to the problems that arise (Hills, Fox, Hon, Fong, & Skitmore, 2008).

Steering mechanisms:

Different kinds of mechanisms are being used for steering in the construction industry including mandatory regulations, incentives and voluntary actions such as certification from rating systems. The lack of proper instrument may be a hindrance for the sustainable construction. On the other hand, the sustainable construction can be promoted with the help of the right regulations.

Regulations can be prescriptive or performance-based. Prescriptive regulations are related to particular technologies or prescribed means whereas performance-based regulations are based on achievement of specified results. According to Häkkinen et al. (2011), the performance-based regulations are better because they better support innovation. But the problem is defining performance for the sustainable construction is difficult.

The regulations may also have positive or negative effects on a process. For sustainable building process in primary phase, the regulations which enforce the minimum required performance are definitely effective to achieve the results. Because of the fragmented nature of the construction projects and numerous involved actors, regulations may consider as the only possible way for projects to proceed (Häkkinen & Belloni, 2011).

The role of the regulations can be positive for achieving additional and new requirements such as sustainable objectives because achieving these objectives needs some changes and new considerations in conventional ways that are already

established and regulations can force these considerations. Williams et al. (2007) acknowledged this statement by the result of their case studies. They undertook five case studies of residential and mixed-use schemes between 2001 and 2004 in England. Their interviewees were stakeholders involved in land use planning and regulation, development and construction as well as end use. They found that the lack of the achievement of sustainability objectives in the case studies was commonly because it was not considered by the stakeholders involved. It was solely considered where particular objectives were required in regulations. For example, “meeting housing needs” that was established in the local policies, appeared on the stakeholders’ agenda, as well (Williams & Dair, 2007). This example shows the importance of regulations in promoting sustainable construction by enforcing particular objectives.

On the other hand, Häkkinen et al. state that the rigid regulations could act as a hindrance for sustainable solutions. Williams et al. (2007) found this negative role of the regulations through their case studies. In many instances, sustainability objectives could not be implemented because they were not allowed or restricted by the regulators. Furthermore, in some cases policies and regulations were lagging behind the sustainable building practices and in others, sustainable solutions were not appropriate due to the local circumstances. For example, in a mixed-use development (residential, leisure, retail, offices) scheme known as BedZED in Sutton, incorporating a ‘home-zone’ type street layout (with reduced space for cars and more space for pedestrians) was not permitted by regulators because they believed the layout was only suitable for housing development and this scheme also contained a commercial part (Williams & Dair, 2007).

In this situation, providing opportunity for regulatory agencies to participate in a charette make the zoning approval process more smoothly. Regulatory agencies and local government planners are acquainted with the objectives of the project from early stages when they take part in a charette in early stages. Moreover, they are encouraged to get feedback in the charette process. Consequently, the project will be less likely to be resisted by the regulatory agencies because zoning considerations are considered in advance (Robichaud & Anantamula, 2011). The project managers’ role in conducting charette is previously discussed in “Timing” part and as it mentioned there they should provide the opportunity of early participation for all stakeholders including regulatory agencies.

The other kind of instruments is economic incentives such as tax reduction which can influence the clients’ willingness of considering sustainability objectives. As both innovations and regulations are needed for a more sustainable future in the construction industry, incentives can stimulate innovations and create demands for alternatives before the clients distinguish the alternative’s benefits with their experience (Häkkinen & Belloni, 2011). As an instance, a proposed legislation in Michigan will create financial incentives that will be based on achieving LEED certification. It is a tax abatement based on the level of LEED certification that a project achieves. According to this proposed legislation, a private client, who is planning to build a new building, could apply to the local municipality for property tax abatement for up to 12 years (Byl, 2008).

Häkkinen et al.’s interviewees supported the use of economic incentives such as public benefit charges. But they emphasized on its effective implementation that was considered complicated. Several interviewees also addressed the role of the building

authorities and municipal supervisors in providing information and organizational support.

The clients' awareness of these incentives is notable in the early phases to consider sustainability concept for their building. However project managers do not have direct influences in setting incentives, they can influence on the willingness of clients by providing information regarding incentives as it has been mentioned before. Addressing regulatory approvals to the clients is considered as one of the project managers' task at the pre-design and design stage by Jaworski et al. (2006). Providing in-time and efficient information by project managers can raise the clients' knowledge about the related incentives and consequently their willingness.

Additionally, Project managers could have an adjustable role regarding their experience. Jaworski et al. (2006) emphasize the importance of project managers' experience for this adjustable role between regulation and innovation. However project managers do not have a direct effect on steering mechanisms but if they have experience about the application of regulations and consider them in early phases, they can control the projects in the regulations' framework meanwhile they keep the projects open for innovative ideas. So the awareness and experience of project managers has a great effect on successful result.

One of the other instruments is participating in voluntary actions such as green certifications from different rating systems like LEED. The opinions of Häkkinen et al.'s interviewees were different regarding the influence of voluntary actions in promoting sustainable construction. They believed voluntary approach has not cause significant changes so normative regulations are needed. With regard to the example of the proposed incentives in Michigan based on the level of LEED certification, it is concluded that in the case of regulation support the voluntary actions can be helpful in promoting sustainable construction.

In total, the knowledge of the project manager about the steering mechanisms and their effects on each phase of project could lead to the greater interaction and consideration of them during the sustainable building process. An efficient sustainable building process could result from improved project managers' role in interaction between steering mechanism and project.

Economics:

Another barrier to sustainable building in this phase is the concern of clients to the higher investment costs and higher risk of unforeseen costs in its process. This higher risk of unforeseen costs are related to unfamiliar techniques, the lack of previous experience, additional testing and inspection in construction, a lack of manufacturer and supplier support and a lack of performance information (Häkkinen & Belloni, 2011).

Still, the cost effects of sustainable buildings are not clearly recognized. Häkkinen et.al (2011) state that the constructing of a building that is energy efficient does not increase the investment cost significantly. On the other hand, Robichaud et al. (2011) state that initial cost of sustainable building can be higher than conventional building. However, they believe higher cost can be recovered in longer-term because of cost saving in operation and maintenance. Nevertheless, an investor who has no long-term

relation to the operating of buildings might be uninterested in maintenance or operation cost saving.

In spite of the cost recovery opportunity during a building lifecycle, according to the following case studies, this assumption is dominant that sustainable options cost too much. The interviewees in Griffin et al. (2010)'s case study announced the increase in cost or perceived cost as the most frequent challenge in using green structural materials. Although, some structural materials used in conventional buildings can cost more, the assumption of many stakeholders about higher cost of green alternatives is yet a large issue. Another instance is Williams et al. (2007)'s case study. Stakeholders involved in development and construction were sure that anything other than 'business as usual' would be more expensive. Moreover, the interviewees pointed out that the cost of providing schemes for sustainable buildings and developments is considerably higher than for conventional schemes.

Providing cost estimation for clients helps them to have a more realistic assumption of sustainable building cost. This early estimation of cost can be done during the charette. The Charette accelerates the process of decision making and makes stakeholders to establish the fundamental decisions early in the project. The economics of each decision should be considered and it is the responsibility of project managers to provide a conceptual cost estimate for review by the owner (Kibert, 2005, s. 103).

Pitt et al. (2009) state sustainability options are used if they are profitable. In order to a better understanding of economics effects, the distinction between profitability and cost is important. According to Robichaud et al. (2011), cost refers to the efficiency with which the building is produced, whereas profitability of a facility refers to how well the benefit of the building was studied before starting the construction of the project. Thus, profitability can be related to the demand for sustainable buildings. Interviewees in Williams et al. (2007)'s case study believed that there is not an extensive demand for sustainable buildings. The profitability will definitely rise if the demand for sustainable building increases. As it mentioned before, increasing demands for sustainable building is related to arising end users understanding of the green buildings' benefits.

But for decreasing cost, Robichaud et al. (2011) suggest developing strategies for containing costs during the initial phases of the project by project managers. One of these strategies is cost saving in the areas of lower priorities. Project managers have role in assisting with pricing and developing cost saving strategies in the areas of lower priorities (Robichaud & Anantatmula, 2011).

The other strategy is to establish effective communication by forming an integrated team. Robichaud et al. (2011) argue the benefits of effective communication to contain costs. It will be possible to maximize sustainable practices at the most efficient costs if professionals and experts in design and construction can be involved early in project design. Although, making this integrated team needs more upfront investment, this extra cost is recovered by decreasing cost related to rework and later required coordination for fixing problems (Robichaud & Anantatmula, 2011). The project managers' role regarding to forming this group and coordinating its member are before discussed in communication and coordination part.

Even if the client is unable or unwilling to form this integrated team early in the project due to its upfront cost, hiring a generalist project manager with a good

knowledge of green building can benefit the project (Robichaud & Anantatmula, 2011).

By developing these strategies, project managers are able to formulate an initial budget and schedule which can be completed more efficiently and in a better level of quality due to the presence of an integrated team (Robichaud & Anantatmula, 2011).

3.4.1.2 Bidding phase challenges and project managers' role:

Häkkinen et al. (2011) recognize a huge challenge for tendering phase because of the sustainable building essence that is about achieving the required performance while its environmental impact should be minimal and simultaneously, should encourage economic, social and cultural improvement at a local, regional and global level. The main challenge in this phase is evaluation of tendering documents considering solely the price.

Price-focused procurement:

Objective procurement is a challenge for sustainable building because it's difficult to specify sustainable building requirement as a measurable parameter. The measurable requirements are problematic to define in sustainable building so this issue is distinguished as one of the most important obstacles for successful sustainable building. Häkkinen et al. (2011) distinguished this problem from a web survey. 69 % of contractors stated that design documents do not show adequate performance and capacity requirements. They believed that the result is the competition on the basis of price.

Focusing on price in procurement practices and the low-risk culture are recognized as the main barriers in sustainable building (Häkkinen & Belloni, 2011). Regarding the choice of green structural materials, interview findings showed the concern of contractors about the uncertainty for increasing the cost of green materials in the time of purchasing the materials during the construction phase (Griffin, Knowles, Theodoropoulos, & Allen, 2010). This uncertainty should be considered properly in cost estimates and bids. Otherwise, this potential increase in cost may prevent stakeholders from choosing the green structural materials.

Such problems can be reduced by attendance of contractors' representatives in design phase. Contractors' representative should be included in design team due to their significant role in providing estimating services. This participation could result the estimation of costs in early phases and selection of proper solutions of sustainable building that fit with the client's budget (Häkkinen & Belloni, 2011). Furthermore, this more accurate estimation of cost is beneficial for bidding phase as it provides more realistic budget that can help contractors to qualify their practices.

The role of project manager in overcoming this barrier is emphasized by Ang et al. (2005). Project managers as clients' representatives should organize evaluation process in tendering phase. So project managers could have a vital role in performance-based tendering and procurement.

3.4.1.3. Summary

Table 2 shows the challenges in sustainable building design process, why these challenges are specified for sustainable construction and the project managers' roles discussed for each challenge.

Challenges in sustainable building design	Specificity of the sustainable building	Project managers' Role
Setting clear goals	Additional considerations like environmental goals and the amount of capital investments toward green initiatives	<ul style="list-style-type: none"> ▪ Setting sustainable priorities and goals early in feasibility study
Client understanding	long term goals and intangible benefits for clients	<ul style="list-style-type: none"> ▪ Providing information regarding sustainable building benefits and value added
End user understanding	Necessity of raising end users' demand that leads to raising clients' willingness to change their priorities	<ul style="list-style-type: none"> ▪ Establishing basic communication procedures by providing useful, objective and reliable information for end users.
Evaluation methods and tools	Different requirements due to the additional objectives that should be monitored and maintained	<ul style="list-style-type: none"> ▪ Being acquainted with measurable targets and their evaluation tools
Timing	Importance of considering the right design options in project feasibility to fulfil sustainable building potential	<ul style="list-style-type: none"> ▪ Conducting charette to establish basic communication among key stakeholders
Communication and coordination	Complexity of the green projects that require more interdisciplinary works	<ul style="list-style-type: none"> ▪ Stimulating collaboration and communication among actors ▪ Conducting planning and strategy meetings ▪ Being a role model among the project team members
Steering mechanisms	<p>Importance of innovation and proper regulation for Developing the sustainable construction</p> <p>Difficulty of defining performance in the sustainable construction</p>	<ul style="list-style-type: none"> ▪ Adjustable role between innovation and regulation ▪ Providing in-time and efficient information regarding different regulations ▪ Providing opportunities for regulatory bodies to participate in the charette
Economics	Higher investment cost and higher risk of unforeseen cost	<ul style="list-style-type: none"> ▪ providing a conceptual cost estimate for review by the owner in the charette process ▪ developing strategies for formulating an initial budget and schedule in the presence of an integrated group
Price-focused procurement	<p>More considerations of environmental impacts</p> <p>Difficulty of defining measurable requirement</p>	<ul style="list-style-type: none"> ▪ organizing evaluation process for performance-based tendering and procurement

Table 2: Summary of the challenges for sustainable building design process, the specificity of sustainable construction and the project managers' roles discussed for each challenge.

3.4.2 Sustainable construction challenges and project managers' role

Sustainable construction phase contains activities for mobilization and construction to practical completion. The following subchapters consist of the main construction phase challenges and discussion on related project managers' role as well as a summary of what has been found as a result.

3.4.2.1 Construction phase challenges and project managers' role

The construction phase is a long-term period that can influence the local and national environments depending on the nature of projects (Wu & Low, 2010). According to Wu et al. (2010), planning and scheduling is the aim of the green construction to achieve the green project requirements. As green building projects should apply sustainable construction practices in addition to conventional construction procedures (Hwang & Tan, 2010), these new practices could be a challenge in construction phase especially for project managers.

The main challenges in sustainable construction phase are including environmental impact, cost saving, health and safety, physical resources as well as training and education. These main challenges and the related project managers' role during this phase are discussed in the following.

Environmental impact:

All construction activities have various impacts on the environment such as extraction and use of materials, emitting pollutant gases and liquids, consuming energy and producing solid waste on demolition and construction sites (Del Río Merino, Gracia, & Azevedo, 2010). Griffith (2002) stated the environmental impact of construction activities is one of the key challenges in sustainable construction. Reducing the inadequate effects of construction process on surroundings should be an agenda for sustainable building. These environmental impacts continue affecting during the construction phase from day to day. So, dealing with these impacts could be a challenge for successful sustainable constructing process. According to Griffith (2002), adopting environmentally responsible practices and procedures alongside environmentally classified products and minimizing external pollution and environmental damage can facilitate sustainable construction. In fact, planning for dealing with environmental issues should be done in green design phase but implementing of these plans could be considered as a challenge in green construction phase.

- **Waste creation:** According to Pitt et al. (2009), reduction of waste during construction could be possible by increasing the cost associated with disposal and related taxes. This forces major contractors to adopt waste management policies and practices in site (Pitt, Tucker, Riley, & Longden, 2009). However, there are always some challenges regarding construction and demolition waste reduction at construction sites. The McLean County pilot project was a four-unit townhome of approximately 6,000 square feet that finished in 2008. The project goal was to not exceed typical waste hauling fees by implementing waste management system. But they could save for less dumpster than originally estimated. Total waste reduction of the project was 27% that was contained wood and cupboard recycling. Three large boxes were

placed on site, one for wood waste only, the second one for cardboard only and the last one for non- recyclable waste. The challenge was the occurrence of illegal dumping and contamination that should be removed from the recycle boxes. Creating a culture of recycling also was a challenge that took time. Some strategies were adapted to overcome these challenges that can be considered as the keys to success. Waste handling requirements were discussed with workers and subcontractors before the beginning of the project and re-emphasize their importance at weekly meetings as work progressed. The recycle containers clearly designated and posted the lists of what is and is not recyclable on them as well as the recycling containers are monitored to prevent contamination (ISTC, 2012).

Del Rio Merino et al. (2010) also highlight the implementation of waste management strategies and involvement of all actors in construction process and allocating responsibilities between construction managers, main contractors and subcontractors to minimize the production of waste. Thus project managers have role in waste reduction during construction phase. Project managers as involved actors in construction phase should be aware of the possible cost savings of successfully reducing construction waste along with the environmental impacts and the long-term national and global consequences (Del Río Merino, Gracia, & Azevedo, 2010).

- Energy use: energy utilization and optimizing the consumption should be concerned during construction (Pitt, Tucker, Riley, & Longden, 2009) to minimize the environmental impact of construction. According to NCC AB (2008), during a conventional building life time, energy consumption for production was 15% and the remaining was used in its maintenance. These ratios change if a low- energy building is constructed (NCC AB, 2008). So energy consumption during construction becomes a major part if the construction activities are not environmentally friendly. For this reason, minimizing of energy use should be considered as a part of green construction. For instance, NCC AB (2008) defines its green construction includes workplaces that are more energy efficient with energy efficient building huts, Timer-controlled lighting, and eco-labelled electricity.

One of the duties of project managers, according to Arditi et al. (2009), is to organize access to temporary facilities and services. So they should ensure about energy efficiency of the temporary facilities by using proper technology.

- Water use: An essential part for applying the principles of sustainable development is the rational use of natural resources (Del Río Merino, Gracia, & Azevedo, 2010) including water as an important one, Because the construction industry is responsible for 1/6th of freshwater withdrawal (Reddy, 2009).

Some challenges have been identified by Waylen et al. (2011) for reducing water usage on construction sites. One of these challenges is the price of water. Water is a relatively cheap resource so it doesn't consider important on temporary construction sites. The other challenge is related to the technology that should be robust and be able to stand up to the demands of construction sites. The next challenge is behaviour change that takes time. Technology also influences on behaviour change and may accelerate it. Understanding of where water is used in construction sites and therefore where water is wasted is also a major challenge (Waylen, Thornback, & Garrett, 2011).

Project managers as actors who control construction sites have a great effect on water usage behaviour. They can provide information for workers in order to change their habits and use the technologies that are helpful to reduce water usage during construction activities. In a broader view, Project managers should ensure about rational water usage as a major resource by implementing Environmental Management System (EMS) as an efficient way to improve use of resources.

- Reuse and recycle: reusing and recycling construction material during construction phase is one of the important aspects of sustainable construction (Pitt, Tucker, Riley, & Longden, 2009) that can reduce waste material volumes to be disposed of and discharged into the environment (Tam, 2011).

Tam (2011) conducted five case studies that were private housing project in order to investigate actual practices on reusing and recycling construction materials. He found that coordination among all actors involved in the design and construction processes are necessary and regular meetings are required to address waste issues. Consideration of 3Rs through normal practices of building work leads to waste minimization for example, reducing concrete by using prefabricated building components, reusing steel formwork as its maximum applications and recycling steel for generating income (Tam, 2011). He also distinguished through interviews that the lack of understanding in treatment for construction waste is the main problem of inefficient and ineffective practices of reuse recycle and reduction of construction waste.

Project managers can influence on these practices as the responsible actors for construction activities. Their awareness and experience is very important to promote the practice of reusing and recycling that can lead to waste reduction and consequently cost saving. For example, using recycled materials for concrete work and using timber which is from renewable resources (CIRIA, 2001 as cited in Hwang & Tan, 2010) are sustainable practices that can be executed by project managers.

- Pollutions: the pollution from construction activities could be parcels, noise, vibration and vaporous discharge. For minimizing this potential pollution, the risks should be identified and the action should be taken (Pitt, Tucker, Riley, & Longden, 2009). The main contractor and project manager should ensure that the pollution from construction activities is minimized by controlling soil erosion, waterway sedimentation and airborne dust generation (USGBC, 2009b as cited in Hwang & Tan, 2010). It can be reached by implementing EMS to facilitate sustainable construction (Griffith, 2002)

There are also other kinds of pollutions like air pollutions that should be minimized during construction. For example NCC AB (2008) considers efficient transport as a part of green construction that will reduce the air pollution as well as energy consumption. "Expedite deliveries" is one of the project managers' duties according to Arditi et al. (2009). Project managers should ensure about the optimum deliveries by right planning and scheduling that lead to the reduction of the pollutions due to the transportation.

Cost saving:

The most common known challenge associated with green buildings that can be recognized is its cost premium. As Robichaud et.al (2011) state that demand for green construction as well as increasing the high cost perception for green buildings mean that project manager should manage a green project with tighter budget and tighter profit margin. So managing the risks which lead to cost overrun is very important in sustainable construction. The role of project managers in controlling risk is important during the construction process and preventing the increase of related costs (Jaworski & Samanta, 2006). What is important is the experience of project managers in sustainable building process and their knowledge of the risks that may occur and their probabilities. So, taking the project manager's competency in to account could be vital for getting the desire economical results in the sustainable construction process.

On the other hand, using green techniques for construction activities includes additional costs that may hinder adoption of such methods so it is difficult for project managers to keep within the project budget (Hwang & Tan, 2010). In order to contain costs in sustainable construction and avoid additional cost, project managers could have significance influence by their careful choice of building methods that can save manpower and reduce overall costs, as well as reducing risk and environmental damage (Hills, Fox, Hon, Fong, & Skitmore, 2008).

Health and safety:

As Griffith (2002) state it can be said that sustainable construction have been achieved when health and safety dangers are minimized. Considering health and safety issues is one of the important responsibilities of contractors throughout the construction process (Griffith, 2002). So, project managers should consider health and safety as one of the important aspects of their responsibility. The project managers should ensure health and safety requirements during the construction phase by implementing Health and Safety Management System (H&SMS).

Physical resources:

Environmentally responsible building materials known as sustainable building products or green building products are a relatively undeveloped market due to the youth of the green building industry (Robichaud & Anantatmula, 2011). So, it is probable that green building products do not deliver the expected performance or quality in spite of increasing the cost of a project. In order to ensure the expected quality and performance in this situation, they should be chosen and controlled at construction phase accurately.

Hills et al. (2008) recognize an important role for project managers that influence the performance of the industry regarding to material supply chain. Project managers can control the supply chain by negotiations concerning delivery times, checking of factory quality and progress and the conformance with the specification upon delivery and site installation.

Training and education:

The lack of training and education in sustainable building is one of the general barriers to sustainable construction (Matar, Georgy, & Ibrahim, 2008). Robichaud et al. (2011) recommend a project management approach for green construction regarding training and education for on-site construction personnel. They suggest starting construction activities with a kick-off meeting for educating different aspects of sustainable building. In addition, monthly on-site meetings that include education and training sessions on green building are vital for all site workforces. In this approach, there is also meeting with each subcontractor for reviewing sustainability requirements before starting work (Robichaud & Anantamula, 2011) .

Hills et al. (2008) recognized a unique role for project managers in encouraging improvements for subcontractors through training and education sessions on site. As an example they state that this activity has occurred in the Hong Kong construction industry for the last ten years. Furthermore, they claim project managers have the role to create and distribute knowledge as well as to identify the hindrance for knowledge acquisition. Therefore, project manager should provide the opportunities for workforces' and contractors' training and education by ensuring planning these meetings in their agenda since the arrangement of the project team meetings and being in charge of these meeting are the project managers' responsibilities according to Arditi et al. (2009).

3.4.2.2 Summary

Table 3 shows the summary of the challenges in sustainable construction phase and why these challenges are specified for sustainable construction and the project managers' roles discussed for each challenge.

Challenges in sustainable construction	Specificity of the sustainable building	Project managers' Role
Environmental impact	Environmental considerations in sustainable construction as one of the bottom-line considerations Inadequate impact of construction activities during the construction phase	<ul style="list-style-type: none"> ▪ Implementing environmental management system ▪ Considering potential cost saving regarding reducing waste and implementing waste management system ▪ Considering energy efficiency in work places ▪ Implementing 3Rs during construction phase
Cost saving	Managing a green project with tighter budget and tighter profit margin due to the high cost perceptions of green buildings	<ul style="list-style-type: none"> ▪ Controlling risks to prevent the increase of related cost ▪ Careful choice of building methods
Health and safety	Social considerations in sustainable construction as one of the bottom-line considerations consequently the importance of health and safety for workers	<ul style="list-style-type: none"> ▪ Implementing Health and Safety Management System
Physical resources	undeveloped market for green building products due to the youth of the green building industry	<ul style="list-style-type: none"> ▪ Control the supply chain by negotiations concerning delivery times, checking of factory quality and the conformance with the specification upon delivery and site installation.
Training and education	Sustainable construction as a new approach in construction industry	<ul style="list-style-type: none"> ▪ Regular meetings for educating green building practices and objectives for all site workforces ▪ Training and education sessions for subcontractors improvement

Table 2: Summary of the challenges for sustainable building design process, the specificity of sustainable construction and the project managers' roles discussed for each challenge.

4 Conclusion

4.1 The significance of project managers role in sustainable building

This study indicates that project managers should meet some challenges in order to integrate sustainability concept to the project. These challenges exist due to the extra focuses in the sustainable building. Cost, quality and time are focused in conventional construction whereas minimization of resource depletion, minimization of environmental degradation, and creating a healthy built environment are more criteria that should be considered in the sustainable building.

These extra considerations make sustainable building projects, which follow long term goals, more complex and need to meet more requirements which are difficult to measure. The risk of unforeseen cost and higher investment cost are assumed by investors and simultaneously intangible benefits for them cause a big challenge in the beginning. Constantly, different challenges do exist during the whole building process from pre-design to bidding and construction phase. The pre-design, design and pre-construction phase that may be considered separately in conventional construction are integrated in a phase called “sustainable building design phase”. This facilitates integrated design as a response to the complexity of sustainable buildings. Sustainable building design is followed by “sustainable construction” that consists of mobilisation and construction to practical completion similar to conventional construction.

This study also shows the challenges in sustainable building design and construction phase. The challenges in sustainable building design phase are setting clear goals, client understanding, end user understanding, evaluation methods and tools, timing, communication and coordination, steering mechanisms, economics as well as price-focused procurement. The challenges in sustainable construction are environmental impact, cost saving, health and safety, physical resources as well as training and education.

As a conclusion, project managers have significant role in successfully delivering a sustainable building project because of the possibility of playing role in dealing with the challenges in sustainable building process. However project managers’ role is always significant for a project delivery, their role is even more specific for the sustainable building process due to the specificities of sustainable construction that cause the challenges.

The challenges are introduced for the whole project lifecycle. Project managers face these challenges in their projects differently due to the uniqueness of each project as well as its location. Their awareness of these challenges is important especially when they are working in a context which recently adopts an approach to the sustainable construction. This knowledge helps them to play proper role and take adequate responsibilities to help the green concept is kept in the whole building process. Most of these roles are highlighted from conventional project managers’ role that can be more effective in sustainable building process.

Providing possibilities for better communication and coordination between stakeholders both in design and construction process is one of the most important roles that they should take. Additionally, providing information for different

stakeholders especially clients, end-users, sub-contractors and workers is considered significant during the whole process. Project managers should also implement proper management systems for construction process that fulfil the sustainable construction considerations.

By awareness of these challenges, they can improve their own skills for dealing with these challenges in order to raise their competencies in this market. The awareness and experience of project managers influence in the properly playing roles that requires a separate study.

4.2 Recommendation for further research

There are many possibilities for further research in this content because it is a new approach in construction industry as well as it is necessary to consider the whole life cycle of a green building and stakeholders involved in different phases. Some of these possibilities related to this study are suggested in the following.

Firstly, it is suggested to conduct case studies regarding project managers' role in sustainable building process in order to increase its reliabilities and validities. It is also recommended that such a case study considers the experienced project managers' opinions about the role that they can have in the whole process of sustainable building to overcoming the barriers and using the drivers. Furthermore it is better to investigate the other stakeholders' expectations about project managers' role. This research can lead to a more practical view of current situation of project managers in sustainable building projects and provide opportunities to strengthen their role in the areas that require.

Secondly, it will be helpful to research on how to improve the project managers' role in the sustainable building process. This research could be done based on the skills that project managers should have to play their role as effective as possible and to help them to fulfil their responsibilities.

Finally, it is suggested to follow this research for post-construction phase, as well, to have a complete list of challenges and related facility managers' role in a project lifecycle.

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