THE EFFECT OF LOW CARBON CONSTRUCTION PRACTICES ON SITE MANAGERS' PRODUCTIVITY

by

REZA ESMAEILIFAR

Thesis submitted in fulfillment of the requirements
for the degree of
Doctor of Philosophy

April 2017

ACKNOWLEDGEMENT

First of all, I am greatly indebted to my supervisor, Associate Professor Dr. Mohd Wira Mohd Shafiei , for his kindness, wisdom and keenness to introduce me to the new stream research in the field of low carbon construction. Indeed, he has kindly guided me and reviewed my work from the begging upon the completion of the thesis.

Second, I would like to thank to my lovely family for supporting me and giving me the strength, love, and encouragement to peruse my postgraduate studies. I especially appreciate my beloved parents, who have always stood beside me and have helped me both financially and spiritually inspiring me to complete this research. My sincere thanks also goes to my beloved brother and sister, Mohammad and Mahla, who have always motivated me during my studies.

Third, my gratitude also goes to the academic and administrative staff in the School of Housing Building and Planning (HBP) at Universiti Sains Malaysia, whose kind support I have received over the past few years. In particular, my appreciation is extended to all the PhD students studying at PhD room in Building E08, who have shared their knowledge and expertise with me during completion of my thesis.

Again, thanks to all of you for encouraging me to complete this thesis.

TABLE OF CONTENTS

LIST OF TABLES

Page

.

LIST OF FIGURES

Page

LIST OF ABBREVIATIONS

AVE	Average Variance Extracted
CB	Covariance-Base
CO_2	Carbon Dioxide
CR	Composite Reliability
DV	Dependent Variable
ELP	Electricity Low Carbon Practices
FLP	Fuel Low Carbon Practices
GBI	Green Building Index
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IV	Independent Variable
LCA	Life-Cycle Assessment
LCC	Low Carbon Construction
LEED	Leadership in Energy and Environmental Design
MLP	Material Low carbon Practices
MV	Mediating Variable
PLS	Partial Least Squares
PRO	Productivity
SC	Sustainable Construction
SEM	Structural Equation Modeling
SPSS	Statistical Package for Social Science
S-O-R	Stimulus-Response-Organism Theory
TLP	Transport Low Carbon Practices

VIF	Variance Inflation Factor
WGLP	Waste Generation Low Carbon Practices
WLP	Water Low Carbon Practices
WP	Work Pressure

KESAN AMALAN PEMBINAAN KARBON RENDAH TERHADAP PRODUKTIVITI PENGURUS TAPAK

ABSTRAK

Antara pelbagai industri yang mempunyai kesan negatif ke atas alam sekitar, industri pembinaan adalah merupakan industri yang paling mendapat perhatian. Salah satu sebab industri ini mendapat perhatian adalah emisi karbon dioksida (CO_2) iaitu dihasilkan daripada aktiviti pembinaan dan merupakan punca utama kepada masalah alam sekitar. Kajian sebelum ini menunjukkan bahawa pengurus tapak adalah merupakan individu terpenting yang bertanggungjawab melaksanakan dan mengawal aktiviti-aktiviti di tapak pembinaan. Oleh yang demikian, pengurus tapak dapat memainkan peranan yang penting bagi mengurangkan emisi CO_2 yang terhasil semasa proses pembinaan dengan mempraktikan amalan pembinaan karbon rendah. Kajian terdahulu juga telah menegaskan bahawa perubahan dalam aktiviti pembinaan boleh mengurangkan produktiviti yang dilihat sebagai titik utama dalam industri pembinaan. Pengurus tapak bertanggungjawab untuk mengendalikan perubahan tersebut, dan ini menyebabkan tahap tekanan kerja yang tinggi kepada mereka. Kajian ini merupakan satu percubaan awal untuk menyiasat isu tersebut dalam konteks Malaysia. Pengumpulan data telah dilakukan dengan menggunakan kaedah survey. Responden merupakan pengurus tapak pembinaan dengan pengalaman dalam pelaksanaan projek GBI di Malaysia. Sejumlah 170 borang soal selidik telah diedarkan kepada responden dan daripada jumlah tersebut, sebanyak 92 soal selidik yang lengkap telah diterima iaitu pada nilai 54.12 peratus. Data telah dianalisis menggunakan structural equation modeling (SEM) – partial least squares (PLS). Hasil kajian menunjukkan bahawa pengurus tapak memerlukan lebih banyak latihan

terutama pada empat daripada amalan pembinaan karbon rendah (bahan api, elektrik, bahan buangan dan pengangkutan) yang mewujudkan tekanan kerja terhadap mereka. Hasil kajian juga mendapati bahawa dua amalan pembinaan karbon rendah (bahan dan air) tidak mewujudkan apa-apa tekanan kerja terhadap pengurus tapak. Oleh itu, amalan ini boleh dilaksanakan secara signifikan untuk mengurangkan emisi CO_2 aktiviti pembinaan. Dari segi tekanan kerja pengurus tapak, didapati bahawa produktiviti pengurus tapak memberi kesan negatif terhadap tekanan kerja mereka. Akhirnya, keputusan kajian menunjukkan bahawa, amalan karbon rendah yang terdiri daripada bahan api, pengangkutan, elektrik dan bahan buangan mengurangkan produktiviti pengurus tapak dan perlu diuruskan dengan baik untuk mengawal amalan-amalan tersebut. Sebaliknya, amalan karbon rendah yang terdiri daripada bahan dan air adalah merupakan amalan pembinaan karbon rendah yang signifikan, yang tidak mempengaruhi produktiviti pengurus tapak melalui tekanan kerja mereka. Di samping itu, kajian ini juga menunjukkan bahawa, kontraktor dan alam sekitar boleh mendapat manfaat daripada penggunaan amalan pembinaan karbon rendah ini.

THE EFFECT OF LOW CARBON CONSTRUCTION PRACTICES ON SITE MANAGERS' PRODUCTIVITY

ABSTRACT

Among the various industries, which have a negative impact on the environment, the construction industry is the one receiving the most attention. One of the main reasons is that Carbon Dioxide (CO2) emissions from construction activities which is considered as the main cause of environmental problems. The previous studies indicate that the construction site manager, as a key person on the construction site, is responsible to apply and control the activities in construction sites. Therefore, site managers, who are the major actors in the construction phases, can play essential roles in reducing CO2 emissions in the construction process by applying low carbon construction practices. Also in previous studies, it has been maintained that changes in construction activities could decrease productivity, which is viewed as the main point in the construction industry. The site manager is accountable to handle the changes, which requires a high level of work pressure for them. The present study is an initial attempt to investigate this issue in the context of Malaysia. A survey method was conducted from the data collection. The respondents were construction site managers with GBI project experience in Malaysia. A total of 170 questionnaires were distributed to the respondents and 92 stable questionnaires were duly returned, yielding a 54.12 percent respondent rate. The main data analysis was performed using structural equation modeling (SEM) – partial least squares (PLS). As the result of the study suggests, more training for site managers is needed on four of the low carbon construction practices (fuel, electricity, waste and transportation practices) that create the work pressure on them. The other two low

carbon construction practices (material and water) do not create any work pressure on site managers and, thus; these can be implemented significantly to reduce the CO2 emissions of construction activities. In terms of site managers' work pressure, it appears that site managers' productivity is negatively affected by their work pressure. Finally, the result indicates that, low carbon fuel, transport, electricity and waste practices decrease site managers' productivity and need to be well managed to control these practices. On the other hand, low carbon material and water practices are the significant low carbon construction practices, which do not influence site managers' productivity through their work pressure. In addition, it indicates that, contractors and the environment can benefit from the adoption of these low carbon construction practices.

CHAPTER 1

INTRODUCTION

1.1 Overview

In the present chapter, the background to the research, statement of the problem and the rationale of the study have been presented. Furthermore, the aim and purpose of the research, the outline of methods applied in the study, as well as an overview of the study has been offered.

1.2 Background of the Study

Numerous worldwide environmental problems are perceived by the world. (Subbarao & Lloyd, 2011). Among these problems, global warming has been considered as the main problem, by many scientists, that life is facing on Earth (Jang & Hart, 2015; Houghton et al., 2001; Easterling et al., 2000). According to Crosbie et al. (2010), the emission of greenhouse gases (GHG) is the main cause of climate change and global warming. As maintained by Li et al. (2012), Carbon Dioxide (CO_2) has been regarded to have the highest level of emission and, accordingly, is being considered as the most significant element in the climate change.

The industrial revolution caused the level of atmospheric CO_2 concentrations to be increased into its highest level in 2010 (Wong et al., 2013). According to Stadel et al. (2011), this phenomenon has resulted in governments, industries and societies throughout the world becoming risk conscious about this issue and demanding for additional efforts in dealing with the hazards of global warming and climate change.

Compared to the pre-industrial period, it has been demonstrated by scientific studies that there has been a 2°C raise in the global temperature (Matei et al., 2010). According to Jos et al. (2012), in CO_2 emissions, we will witness this cumulative emission to exceed this level in a period of two decades. This has been the fundamental reason for carrying out numerous studies (e.g., Houghton et al., 2001; Easterling et al., 2000; Frich et al., 2002) which has emphasized the phenomenon as a major concern.

Due to the potential social and environmental consequences of global warming, the international community has given greater weight to the conservation of energy and mitigation of carbon emissions (Trappey et al., 2012). Developing low carbon societies has been suggested as one of the main approaches in resolving the above mentioned challenge. This strategy has been extensively employed by many societies to reduce the emission of carbon and, accordingly, pollution, as well as provide savings (Acquaye & Duffy, 2010; Chang et al., 2010 and Peters, 2008).

Regarding the emission of CO_2 and the consumption of the world's energy, the construction sector plays the main role in the reduction of carbon emissions. This is due to the fact that this sector is responsible for 50% and 40% of the emissions and consumption, respectively (Stadel et. al. 2011; Yahaya & ZainulAbidin, 2013). Succeeding the approval of the Protocol of Kyoto, a great deal of attempts have been made since 1997 in controlling the level of GHGs emitted by the construction section as well as to control the resulted change in climate (Dunn, 2002; Climate Change Secretariat, 2002). This protocol can be suggested as the most prevailing global action to target the reduction of CO_2 emission through encouraging the countries of the world to mitigate the CO_2 emissions problem. The protocol encouraged countries to reduce the level of their CO_2 emissions by 5% during the period of 2008 to 2012;

the criteria for the reduction was the rate of emissions in the year 1990. According to the protocol's Secretariat (2002), there have been some countries which have implemented the programs to fulfill their commitment by the approved period. The reduction of energy consumption is an important strategy in reducing the level of GHGs. This strategy can be carried out in such different sections as industries, transportation, and construction in a society. Using clean energy sources as an alternative to fossil fuels has also been suggested as the other method in this regard (Dunn & Daniels, 2002).

In every Asian and Oceanian countries, the total carbon dioxide emission is increasing on a daily basis (Azad & Alam, 2011). According to Rad (2013), Malaysia's rank in CO_2 emissions declined from 69 in 2000 to 57 in 2007 with 5.4 and 7.3 metric tons of CO_2 per capita, respectively. In a study by Nasir Shafiq et al. (2015) in the context of Malaysia, it was found that, a study on the effect of CO_2 emissions in view of the conventional construction, is necessary; also, there is a necessity for any other alternative possible solutions to avoid or minimize their harmful effects on environment. According to the International Energy Agency (2009), one of the chief CO_2 producers in the region was Malaysia. This had been due to the urbanization of the country and, accordingly, the increase in energy consumption as a result of developments in the construction industry and the growth in the number of buildings. Hence, the obligation of the Malaysian government in reducing the amount of GHGs and recognizing a sustainable environment through sustainable construction for the future generation has been emphasized.

As mentioned by Shi et al. (2014) and Zhang et al. (2014), "sustainable construction" is a term that is used to define the worldwide attention given to the shift from the traditional development towards a sustainable one in the construction

industry. Despite the obvious problem regarding the emission of carbon by construction processes, it has been largely neglected and rather much more focus has been on energy consumption in the field of building operations (EPA, 2009; Wong et al., 2013). According to Sharrard et al. (2007), regarding the construction process, the main sources of GHG emissions are assumed to be electricity and diesel fuel. This use of energy is related to the needed construction equipment in project site processes which produce a great amount of CO_2 (Lee et al., 2009). It needs to be noted that emissions from construction equipment, bearing more than 50% of the impact, are considered as the key source of environmental impact among different parts of construction practices, such as energy consumption, waste generation, resource depletion etc. (Guggemos & Harvath, 2006; Ahn et al., 2009; Waris et al., 2014a; Waris et al., 2014b and Sodagar & Fieldson, 2008). Moreover, based on Heydarian and Golparvar-Fard (2011), an extra 8% of the global GHG emissions are caused by the embodied carbon released mainly during the first year of the production and transportation of materials in a project. Regarding this, construction activities, which have CO_2 emissions, can be separated into six parts as shown in Figure 1.1.

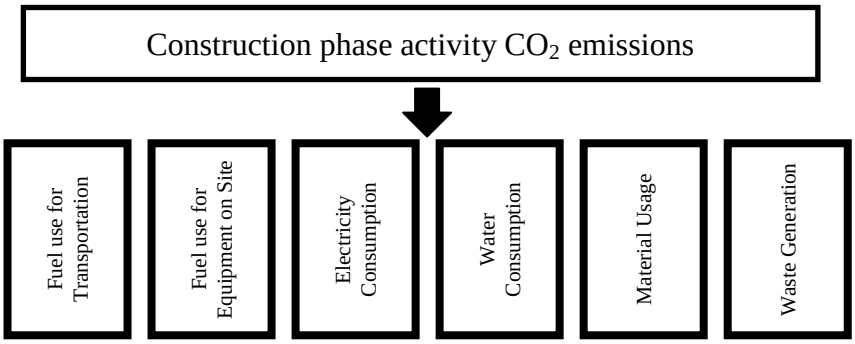

Figure 1. 1 Construction phase activity CO_2 emissions

Source: Sodagar and Fieldson (2008)

Due to this problem, standardized low carbon practices on construction sites are needed in order to control and manage the emission of CO_2 caused by equipment and wastage in the construction section. In fact, what is required is an accurate and reliable standardization of low carbon practices.

As a result, low carbon construction (LCC) aims to make the construction process more environmentally friendly. LCC is often expected to differ from conventional construction in a number of ways, such as using environmentally friendlier materials, reducing energy consumption and using sustainable methods in the construction phase (Presley & Meade, 2010; Mokhlesian, 2014). LCC covers a broad scope, making the exact distinction between low carbon and non-low carbon (conventional) construction difficult and, at times, impossible; as, the level of greenness varies depending on the extent to which the green criteria are met in individual projects. From the perspective of this thesis, LCC is a relative concept, suggesting the term more sustainable construction during site operation as compared to conventional use.

The unique nature of the construction industry makes the role played by the site manager, as a person who is responsible on the construction site to apply and control the new technologies, technics and activities (as sustainability and low carbon practices), particularly essential to the construction practice (Styhre, 2006). The site manager's ability and capacity will be the main influence on the failure or the success of the task and project (Styhre & Josephson, 2006).

As it has been highlighted through out the literature, site managers, as the key person, are subject to extreme the pressure from their work (e.g. Djerbarni 1996; Styhre & Josephson 2006). They are responsible and accountable for the day-to-day management of a vast range of activities on the construction site, including the

technical, managerial and legal aspects of the task and work (Styhre, 2008; Price, 2010). If LCC practices were to be implemented on construction sites, they are supposed to be controlled and applied by the site managers.

However, there are problems regarding this method. These problems are mainly discussed under their effectiveness as regulations, generally, business people tend to avoid rather than abide by them. In a study by Abdul Kadir et al. (2005) in the context of Malaysia, it mentioned that, productivity declined if changes in the construction activities occurred. The site managers are responsible to handle the changes, which otherwise actuate to project delay. In addition, construction management is a main and key influence on the productivity of the construction's employees (Haugbølle et al., 2011); and as is clear, productivity is essential in the construction industry concerning the economic perspective (Miller et al., 2011; Nuntasunti & Bernold, 2003). In addition, as maintained by Lee et al. (2009), such criteria is generally refused to be accepted by the industry when the work site environment or the particular features of the machinery are not taken into account in passing these criteria. This refusal and rejection can be because of the loss of productivity.

In summary, proposing changes in the process of building construction seems to need urgent action. Considering the direct influence of building and construction on the environment as well as the turning of the climate change as a commonly discussed issue presently, the construction industry is required to provide help to the professionals in other sectors in encountering the environmental problems . The sustainable construction principles should be distinguished and recognized by LCC for reducing the environmental damage of construction activities and processes. However, for this aim to be achieved, site managers need to be taken into account in

construction projects. This is because any changes may, unavoidably, bring along challenges, which per se may cause more work pressure. This may entail a decrease in project productivity, which is an important issue in the construction industry.

1.3 Statement of the Problem

The increasing attention to sustainability though low carbon practices is pushing the construction sector towards rapid changes (IPCC, 2007). Also, moves to sustainability are creating a diversity of innovations as well as new organizational preparations, arrangements and tools in several arenas and at various scales (Seyfang & Smith, 2007). For several years, the unsustainable construction activities in Malaysia have had detrimental impacts on both people and the environment (Ping et al., 2009; Nagapan et al., 2012; Abidin, 2012). Since industrialization has changed the construction activities in Malaysia, the role of industry of building has remarkably improved in order to fulfill people's needs and aspirations (Alaghbari et al., 2007). Therefore, new methods have been introduced in the construction industry in order to achieve the determined goals (Ministry of Housing & Local Government, 1997).

The tough exploitation of new ideas – incorporating new designs, technologies and best processes and practices (Seyfang & Smith, 2007); an idea, practice or a purpose that is perceived as new by a person or other unit of assumption and adoption (Sor, 2004), in other words, green and sustainable innovation, involves a "change in routine" (Ulfah & Dhewanto, 2015) and the "carrying out of new combinations" (Stevenson & Jarillo, 2007).

However, as it would be expected, any innovation is associated with an increase in job pressure (Akadiri et al., 2012). In this view, the necessity to minimize

the undesirable impacts of construction activities and applying the new ideas are raising the pressure on the construction industry to accept proactive environmentally sustainable -like Low Carbon practices- strategies, practices and actions in the construction process (Labuschagne & Brent, 2005).

If a change in the project practices and activities is needed, the site manager will generally be the one who has to arrange to handle the change order, or directs the order to be well drawn (Gunderson et al., 2015; Styhre & Josephson, 2006). On-site work needs to be coordinated by site managers to ensure that tasks which are applied to minimize the undesirable impacts of the construction activities are prioritized properly while the work is performed productively (Labuschagne and Brent, 2005; Akadiri et al., 2012 and Garcia-Lopez & Fischer, 2014). Malaysian site managers are not exceptional, who shoulder the responsibility for scheduling the projects and construction success (Alias & Hewi, 2004).

Although a great number of studies have been conducted on design concepts for sustainability in the construction industry (e.g. Tsai & Chang, 2012; Sieffert et al., 2014), there are very few studies on the managers' quality practices in sustainable projects of building and on the importance of the site managers' role in achieving sustainable construction success (Tabassi, et al., 2016).

This controversial situation obviously requires a high level of work load for the site managers (Mäki & Kerosuo, 2015; Dossick & Neff, 2009 and Leung et al., 2011). Also, there is a paucity of research on work load and pressure on construction site managers in specific and site managers in general. The reason is that they are known to play a paramount role in the construction activities and encounter serious and stressful tasks. They are also supposed to lead sustainable activities in construction sites (Leung et al., 2011). Akadiri et al. (2012) show that the ability to

spot environmental opportunities enables site manager to run environmentally friendly projects. Yahaya and ZainulAbidin (2013) believe that site managers are efficiently able to observe and monitor all tasks in the projects. Site managers are, then, recognized as the only figures who are able to run low carbon activities, which are assumed to be green and sustainable in the construction projects. In addition, Loosemore and Waters (2004) found that significant levels of work pressure among site managers damaged productivity. However, as discussed by Jimoh (2012), due to the complexities in the technical aspects of the construction activities as well as the potential management problems, this is not an easy task. This issue cannot be neglected because productivity improvement is always at the heart of construction project management (Gong & Caldas, 2009). On the other hand, the success of the construction activities within the limit of time and cost depends on the approaches and methods involved in the construction projects (Al-Moumani, 2000). Indeed, this is very important for the real construction activity and projects' productivity so as to motivate construction contractors and companies for employing green and sustainable approaches.

According to Ibbs (2011), any unplanned change in construction projects could possibly result in productivity loss. This shifting from sustainable methods to unsustainable one will lead to productivity damage. To be more specific, in Malaysian weak project activities and productivity in construction industry seem to be a common scenario because this industry necessitates several parties, time-consuming processes and numerous stages (Lim YenWui et al., 2009; Chia et al., 2012). Then, it is obvious that there is a lack of a real study on productivity and the costs of Malaysian construction projects (Alaghbari et al., 2007).

In general, based on the literature review, three gaps can be highlighted. Past studies have looked at the influence of work pressure on construction productivity as a whole. However, the site manager, as the key person who plays the major role in making critical decisions, has been hardly considered. This study pays special attention to the influence of work pressure on the construction site managers. In spite of a rich literature on exploring LCC practices, the probable pressure that such practices may leave on the site manager has been overlooked. Thus, the current study has looked at how low carbon practices may bear pressure on the site manager. The last but not least, is the mediatory role that the pressure on the site managers may play between the low carbon practices and productivity. The current study, has mainly focused on the influence of the site manager on productivity as a person who goes under pressure due to applying the LCC practices.

In addition it had to be mentioned that this thesis focuses on electricity as the major producer of CO_2 in construction and water system. Both of these two factors will be analyzed in the phase of operation in construction site.

1.4 Research Questions

Based on the objectives of the study, the present research attempts to find answers to the following questions.

1. What is the effect of low carbon construction practices on work pressure?

2. What is the direct effect of manager's work pressure on their productivity?

3. Does manager's work pressure mediate the relationship between low carbon construction practices and managers' productivity?

1.5 Research Objective

The main aim of this study is to examine the effect of low carbon construction practices on site managers' productivity. This aim was achieved throw the following objectives:

1. Examining the effect of low carbon construction practices on work pressure.

2. Examining the direct effect of manager's work pressure on their productivity.

3. Examining the mediating effect of manager's work pressure on relationship between low carbon construction practices and managers' productivity.

1.6 Scope of Study

The scopes of the research are as follows:

1. The scope of study is identifying effect of low carbon practices on site managers in Malaysian constriction industry with unique geographical and environmental future.

2. This study will concentrate on work pressure and productivity on site managers in order to decrease the negative effect of low carbon practices in construction industry.

3. Data will be collected through questionnaires distributed among the site managers which have experience in GBI projects.

1.7 Significance of the Study

The theoretical and practical aspects of the present study are essentially the most significant sections of the research. Considering the significance of the theoretical perspective, further researches are facilitated by the study. It can be argued that considerable knowledge would be contributed by this research as low carbon adoption, in general, and the context of Malaysia, in particular, have hardly been explored before. Corresponding to this implication and importance, low carbon contraction practices as well as the influence of the elements on the work pressure of site managers have been identified and investigated as well.

This study can shed light on how LCC puts pressure on site managers. Furthermore, the study has identified the outcomes of LCC practice adoption, which has an effect on the site manager's productivity.

As for the practical perspective, the site managers' productivity and, accordingly, the amount of work pressure on them are expected to be improved in the following ways by adapting low carbon practices. Firstly, the adoption of LCC and the associated outcomes and importance has been explored by the study. Thus, it has raised the awareness of construction site managers and companies regarding the benefits of the issue. Therefore, due to the increasing importance of the environment and LCC, this can be argued as an essential contribution.

Secondly, the study has investigated the key practices for LCC. Contractors as well as construction site managers are highly recommended to become aware of the ways that result in less work pressure. Prominently, companies or contractors as well as site managers in the construction industry can get assistance in estimating and evaluating the potential and the intensive level of LCC activities. This is to say that the idea of the holistic emission of the construction process will be encouraged.

This will encourage the contributors in the construction industry to be involved in LCC practices and transform themselves into ‘green’ developers or contractors; and, the intensive level of this practice will be checked.

At the end, it has been found out whether managers using this practice can increase their productivity or not. The best practices with less work pressure on site managers which lead them to increase their productivities have been of the most importance in this study, and a method was found for decreasing the work pressure of each practice which had put pressure on site managers or had a negative effect on productivity.

1.8 Methodology

It comprises the research design, instruments, measurements, data collection and data analysis details. A quantitative research approach was employed in this study, which used a structured questionnaire as the main research instrument. Structured questionnaires were used as it is easy to analyze, and most statistical analysis software can easily process them. In this study, the units of analysis are site managers in constructions sites part who has experienced in GBI projects.

This study provides insights with regard to methodological contributions. In fact, this study is pioneer on conducting the quantitative data analysis using PLS-SEM approach for the purpose of study in the field of low carbon construction.

Advantage of PLS is that, it can analyze and assess the formative items in the model (complete details are addressed in Chapter 3) (Hair et al., 2013). For the purpose of the study, low carbon construction practices are included six different dimensions which were not correlated, and have their own effect on site managers

work pressure. Therefore, the recommended method is to use formative construct in order to examine all constructs in the model simultaneously (Becker et al., 2012).

In order to achieve the above mentioned objectives the entire study that is conducted can be categorized into the following components;

1) Collection of actual site data through site and companies visits as well as through accordingly designed data collection forms.

2) Transformation of data into formatted data points liable to be analyzed.

3) Data analysis and experimentation with the collected data for the purpose of determination of input parameter ranking.

4) Evaluation of the effects of low carbon construction practices that influencing the construction site managers work pressure on site activities daily and site managers productivity.

The next section addresses the definitions for the key terms used in this study.

1.9 Definition of key Terms

In this section, the key terms of the study are specifically defined and explained to offer a better understanding of the concepts and terms used in the research.

Low carbon construction: The importance of low carbon construction (LCC) is the attempt to decrease the environmentally detrimental influence of the construction process and to diminish the emission of CO_2 that is produced during construction operations by construction related activities. LCC practices can improve construction activities by increasing the energy (fuel and electricity) and water efficiency, and by promoting waste generation, and reducing material usage (Byrne, 2007; Wong et al., 2013).

Site manager: This refers to a person who works on the construction sites and is under situations with excessive pressure and daily work and day-to-day production work on construction sites (Styhre & Josephson, 2006).

Site manager's productivity: Site manager productivity is defined as work accomplished, solving problems, managing resources, controlling and improving the efficiency and performance of them, on time (Hernández-López et al., 2012).

1.10 Organization of Thesis

The subsequent chapters of the study are organized as below:

Chapter 1: Chapter one starts with affording a background of the significance of LCC in contributing to sustainable development. Then, the problem statement is offered, established on the gap of the previous studies. Therefore, the gap is evoked into the study questions. Further, the objectives of the research are appointed. Lastly, the research significances are then offered.

Chapter 2: An overview of the concepts of the construction and work pressure in the past literature are presented first. This is followed by defining the concepts which will be used in the research. The model and theory in developing the practices and frameworks related to LCC and sustainable construction will be offered. Considering the hypothesis of the research, the theoretical framework will be provided. The constructs in the study as well as their hypothesized relationships will be specified and discussed in detail.

Chapter 3: The methodological design will be presented and discussed in chapter three. This will include the discussion of measuring methods, design of the questionnaire as the instrument, analysis unit, selection of the samples, collection of the data, observational study, pilot assessment and testing, as well as the method

used in the analysis of the data. The questionnaire as the instrument used will be discussed with regards to the previous literature in detail.

Chapter 4: The obtained results will be presented in chapter four. The survey carried out in the study focused on the construction site managers who had experience in GBI projects which founded the basis of analyzing the data of the research. The subjects' rate of response and their profile, and the initial analysis will be discussed in the first part of chapter four. The validity and consistency of the measuring model will be assessed in the second part of this chapter. Lastly in the final part of chapter four, the authors will focus on the evaluation and assessment of the results obtained from the structural model and the hypothesis.

Chapter 5: Consisting of two main parts, the findings and outcome of the analysis will be presented in chapter five. While the summary of the results attained in chapter four will form the first part of this chapter, the second part of chapter five will be dedicated to the discussion of the results obtained from the previous literature, the practical explanations and the discussion given by the researcher.

Chapter 6: The study will be concluded in this chapter. The chapter begins with the presentation of the general findings of the research. Next, the limitations to the research are presented. The limitations will be continued with suggesting the corresponding recommendations for future studies. As a final point, the contributions of the study, with regards to both theoretical and practical aspects, will be emphasized and described.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview

In the present chapter, the previous studies and their significant contributions in construction management as part of sustainable development will be reviewed. The chapter reviews low carbon construction (LCC) from a historic perspective as well as the established connection between carbon dioxide (CO_2) emission and construction site management.

LCC practices, site managers work pressure and productivity are the significant variables of the study. With the purpose of developing a conceptual model for this research, the present chapter will also critically review and conceptualize these variables and their links among each other will be explored. Thus, the present chapter will be the basis of the development of the conceptual model of the study. Lastly, the related hypotheses will be generated on the basis of the developed model and the links between the variables will be elaborated.

2.1 Construction Industry and the Carbon Dioxide Emissions

The anthropogenic climate change is mainly triggered by the CO_2 emissions (Friedlingstein et al., 2010). The issues of climate change and global warming have attracted much international attentions in the last few years. According to Lin and Sun (2010), the volume of the global emission of CO_2 has increased from 22.5 to

31.5 billion tons during 1990 to 2008. Wong et al. (2013), also points out to the highest level of the international emission of energy-related CO_2 that was reported in 2010. The influence of the global warming can vividly be witnessed in the melting volume of world ice and snow, the overall increase in the temperature of oceans and weather (Kean et al., 2009). This has also been the case in the context of Malaysia as, based on Yau and Hasbi (2013), there has been an increase in the temperature the country during the course of the last 40 years.

The energy consumption of building construction has attracted the majority of researches and debates around the industry-related carbon emission. This is to say that, despite being a noticeable and developing challenge, emissions from the construction process has achieved less focus and attention (Truitt, 2009). Moreover, since 50% of the greenhouse gases as well as 40% of the world's energy is emitted and consumes respectively by construction sector, a key role can be associated to construction with regards to the reduction and mitigation of carbon emissions (Yahaya & ZainulAbidin, 2013).

2.1.1 Environmental issues in Malaysian construction industry

According to Zolfagharian et al. (2012), construction activities relatively impact the ecosystem, natural resources, and the public by 67.5%, 21%, and 11.5% respectively in Malaysia. These impact are predominantly directly influence the different areas and their impact seems to be irreversible (Shen et al., 2007; Son et al., 2011). Thus, the control and management of construction activities' carbon emissions has turned to a demanding problem. As mentioned by Newton and Tucker (2011), there have

recently been initiatives and action plans in developed countries which have targeted the construction sector to mitigate their carbon footprint in construction sites.

According to Lu and Zhang (2016), the natural environment as well as humans life quality is highly influenced by sustainable construction. As the result, promising results are expected to attained, especially regarding Malaysia' construction sectors, in sustainable project development as well as providing a future plan for efficient performance, provided that studies are carried out on sustainable development and industrial leadership (Tabassi et al., 2016). It can be argued that even in such developing countries as Malaysia, sustainability in construction industry is undoubtedly not practiced to an adequate level.

Briefly, it can be argued that there are both capacity and tendency in industry to tackle the issues of carbon emissions as well as climate change and transforming them into opportunity for development. The main drivers in the construction sector that have impact on the environment and particularly the emissions of CO_2 will be elaborated in more details in the following sections.

2.1.2 Carbon Emission problem in Malaysia

Carbon emission has turned out to be a critical issue in Asian countries which are experiencing rapid urbanization. Construction industry is one of the major reasons for a great amount of CO2 emission in these countries (Fujita et al., 2009). For example, Malaysia has lately witnessed a growing population and economic growth because of rapid urbanization. In light of Vision 2020, it is assumed that Malaysia will have been a fully developed country by 2020. At the end of twenty century, construction sector had the average contribution of 4.1 percent in gross domestic

product (GDP). Construction sector is known to have noticeable influence on supporting economy by backward and forward relation with other economic aspects and sectors. Therefore, it is unavoidable to ignore the significance of this sector in economic growth (Khan et al., 2014).

There has been 38% increase in the housing stock from 2001 to 2007 (Fujita et al., 2009). It has been also estimated that if nothing is done to reduce CO2 release in Malaysia, 285.73 million tons of CO_2 will have been emitted to the atmosphere by 2020, showing a 68.86% increase when it is compared to the level of CO_2 releases in year 2000 or earlier years (Safaai et al., 2011).

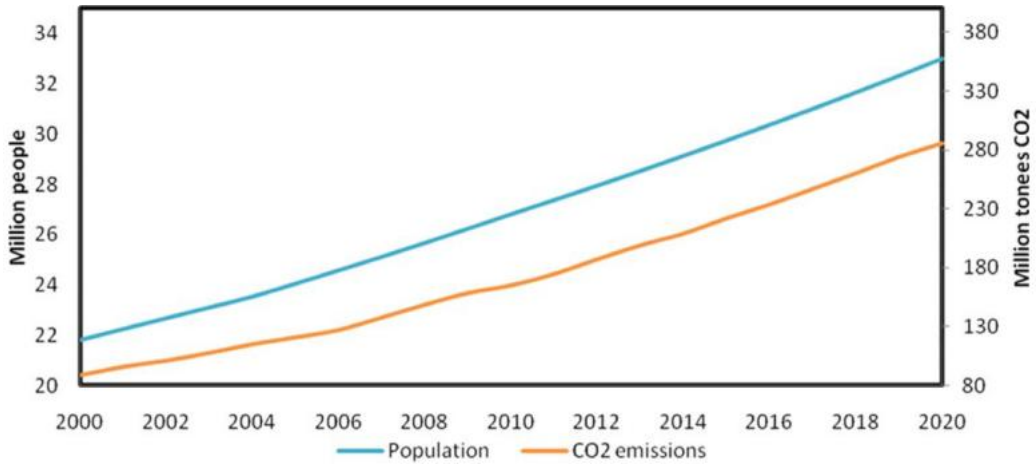

Figure 2. 1 Relationship Between Population and CO2 Emisstions in Malaysia.
Source: Safaai et al. 2011

2.2 Sustainability and Sustainable Development

Notable attention has been given to the climate change and environmental problems in the last few years. The limitations of the planet earth has been recognized by human communities. Moreover, people has also acknowledged the resultant restrictions to the economic model of growth and they have confessed that we have reached the limits. Without any doubts, we know today that if we humans are willing