ENGLISH VERSION

Exploring sustainable factors during construction projects' life cycle phases

Exploración de los factores de desarrollo sostenible durante las fases del ciclo de vida de los proyectos de construcción

A. Enshassi [1]*, H. Al Ghoul*, S. AlKilani **

* Islamic University of Gaza, Gaza. PALESTINA
** University of New South Wales. AUSTRALIA

Fecha de Recepción: 15/10/2017
Fecha de Aceptación: 19/01/2018
PAG 51-68

Abstract

This paper explores the sustainable factors, which are taken into consideration by engineers during the holistic process of building Projects Life Cycle (LC) in the Gaza Strip. A total of 53 sustainable factors (economic, social, and environmental)) were identified from extensive literature review and were modified according to the pilot study.
These factors are classified into 5 project LC phases: inception phase, design phase, construction phase, operation phase, and demolition phase. A questionnaire survey is adapted in this study. A total of 119 questionnaires were distributed randomly to engineers working in construction projects in the Gaza Strip to solicit their opinions regarding taking sustainability concepts into consideration. The results revealed 10 most important sustainable factors that were taken into consideration by engineers in the LC phases of the construction projects in Gaza Strip, which are classified as follows: 4 factors are classified under the inception phase, 3 factors under the design phase, 2 factors under the construction phase, and 1 factor under operation phase. The most common factors that are taken in consideration are: provision of services, standardization, community amenities, materials choice, and site security.

Keywords: *Sustainability, consideration, construction projects, life cycle*

Resumen

Este trabajo estudia los factores de sostenibilidad considerados por los ingenieros durante el proceso holístico del ciclo de vida de los proyectos de construcción en la Franja de Gaza. Una revisión extensa de la literatura existente sobre el tema permitió identificar 53 factores de sostenibilidad (económicos, sociales y medioambientales) que fueron modificados de acuerdo a un estudio piloto.
Estos factores fueron clasificados en 5 fases del ciclo de vida de los proyectos: fase de inicio, de diseño, de construcción, de operación y de demolición. Para el estudio, se realizó una encuesta tipo cuestionario. Se distribuyó al azar un total de 119 cuestionarios entre ingenieros que trabajaban en proyectos constructivos en la Franja de Gaza para conocer sus opiniones respecto de la toma en consideración de los conceptos de sostenibilidad. Los resultados revelaron los 10 factores de sostenibilidad más importantes considerados por los ingenieros durante las fases del ciclo de vida de los proyectos constructivos en la Franja de Gaza, los que se clasificaron de la siguiente manera: 4 factores se clasificaron bajo la fase de inicio, 3 factores bajo la fase de diseño, 2 factores bajo la fase de construcción y 1 factor bajo la fase de operación. Los factores más comunes son: provisión de servicios, estandarización, servicios comunitarios, selección de los materiales y seguridad en la obra.

Palabras clave: Sostenibilidad, consideración, proyectos de construcción, ciclo de vida

1. Introduction

Sustainable construction is a relevant subject in contemporary world because it is one of the approaches for achieving sustainability in all the aspects of society development (Khalfan, 2006). Sustainable performance of an individual construction project across its life cycle is a crucial aspect in attaining the goal of sustainable development (SD). While many researchers investigated the sustainability factors of the end product, a few studies investigated the sustainability factors to be taken into account during delivering process of the project or what so called the project life cycle (LC).

Construction practitioners worldwide are beginning to appreciate sustainability and to acknowledge the advantages of sustainable building (Zainul Abidin, 2010). The impacts of construction activities on SD can be considered in three main aspects: social, economic, and environmental. These impacts are considered especially significant in developing countries. According to El-alfy (2010) developing countries have suffered for a long time from overlooking or underestimating the basic requirements that must be considered for designing sustainable developments.

Research confirms the need to manage construction activities throughout the project LC. So that from the outset of the construction process to the end of the life of the facility including the demolition or refurbishment, all processes is carried out in a sustainable manner. To do this, the construction industry needs to incorporate and consider sustainability issues/factors within every activity in the project LC. This paper investigates the current practice of adopting sustainable factors during the building projects' LC in Gaza strip. The paper starts with giving a brief overview of sustainability development and sustainable construction, whereas the most important sustainable factors were selected based on a comprehensive literature review. This list of sustainable factors was refined through a pilot study before proceeding with the actual data collection via an exploratory questionnaire survey. Consequently, the most important sustainable factors that taken into account by engineers during the project LC in Gaza Strip were identified.

[1] *Corresponding author:*

Department of Civil Engineering. Islamic University of Gaza, Gaza. Palestina.
E-mail: enshassi@iugaza.edu.ps

2. Sustainability Development and Sustainability Pillars

The concept of sustainability was first introduced in 1972, whereas the international conference with the objective of analysing special environmental concerns was held by the United Nations on the Human Environment in Stockholm (Babashamsi et al., 2016). Just after this conference, the most definitions of sustainability established with that issued by the World Commission on Environment and Development (WCED, often referred to as the Brundtland Commission) in 1987, whereas Sustainable Development (SD) was identified as " the development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (UN, 1987). The WCSD in Johannesburg' leaders and representatives of 183 countries reaffirmed sustainability, or SD as a central element of the international agenda (Weaver et al., 2008, Hisham, 2011). In this meeting, the governments agreed to a wide range of concrete commitments and targets for actions to achieve SD objectives. The sustainability agenda moved further, consolidated, and broadened the understanding of SD, particularly the important linkages between poverty, the environment, and the natural resources (WCED, 1987).

Holton (2009) and Parkin et al. (2003) reported that the awareness about SD is growing around the globe for the last few decades. Hopwood et al. (2005) stated that the widespread rise of interest in, and support for, the concept of SD is potentially an important shift in understanding the relationships of humanity with nature and between people. Many international and national initiatives showed the increasing concern to protect the environment for future generations by adopting SD principles (Parkin et al., 2003; Khalfan and Asaad, 2006). A number of key factors have been identified in the literature as critical to achieving sustainability in the development process. These factors have been grouped in a variety of ways. The UN designates three "pillars of sustainability": economic, social, and environmental (UN, 2002). Following the classification by the UN, many researchers adapted this classification, whereas modification, expanding or additions were made that depend on the field of research. For example, many researchers used the same classification but called those groups of factors as "triple bottom line" for example: (Khalfan, 2006; Parkin et al., 2003). On the hand, McConville (2006) adapted the UN classification of SD factor, but expanded the social pillar into three components: socio-cultural respect, community participation, and political cohesion. The result is a group of five factors, containing practices central to achieving sustainability in development.

Akadiri (2011) emphasized that for development to be sustainable, it must take into account social and ecological factors, as well as economic factors. Du Plessis (2007) pointed that the relationship between humans and their environment is determined by a number of factors. The first is the interpretation of quality of life held by a particular society. The second factor is the choices made in terms of the technological, political, economic, and other systems adopted by mainstream society. Parkin et al. (2003); Bennett and Crudgington (2003) presented three essential areas involved in sustainability which are environmental responsibility; social awareness; and economic profitability. Pant et al. (2011) ensured that SD goals include: Environment: reduces water use, reduce net land disturbance, and reduce net emissions; social: improve equal employment opportunities, improve contribution to community capacity building, reduce impact on heritage; and Economic: optimize long-term economic value. Ball (2002) and Bossink (2002) considered that SD is a broader concept than sustainability and includes issues on the quality of life and the integration of social, economic, and environmental spheres of activity. Social pillar improve the quality of life, provision for social self-determination and cultural diversity, protect and promote human health through a healthy and safe working environment (Hill and Bowen 2010).

As can be seen from the previous discussion, many past studies presented several themes for SD; the most famous theme is the three pillars or what so called "Triple Bottom Line" (social, environmental, and economic issues) (Khalfan, 2006; Parkin et al., 2003) Economic pillar: ensure financial affordability, employment creation, adopt full-cost accounting, and enhance competitiveness, sustainable supply chain management (Hill and Bowen 2010). The economic sustainability is to ensure financial affordability to the intended beneficiaries, to promote employment creation; to enhance competitiveness, to choose environmentally responsible suppliers and contractors, and to maintain capacity to meet the needs of future generations (Chen et al., 2010; Weaver et al., 2008; and Riley et al., 2003; Shen et al,. 2007; Adetunj, 2005 and Shelbourn et al., 2006). Environmental pillar: waste management, prudent use of the four generic construction resources (water, energy, material, and land), avoid environmental pollution and etc. Technical pillar: construct durable, functional, and quality structure. Larsson (2005); Zhang et al. (2005); Ekins et al. (2003); Bennett and Crudgington (2003); Blismas and Wakefield (2007) stated that the philosophy of environmental sustainability is to leave the earth in as good or better shape for future generations. McKenzie (2004); Shen et al. (2007); Khalfan (2002); Chmutina (2010); and Johnson et al. (2004) suggested that social SD as social sustainability is a positive condition marked by a strong sense of social cohesion, and equity of access to key services including health, education, transport, housing and recreation. Hill and Bowen (2010) said that social pillar improve the quality of life, provision for social self-determination and cultural diversity, protect and promote human health through a healthy and safe working environment.

While, many efforts and researches were conducted in the area of sustainability and SD, Scheuer (2007) noted that there appears to be no common understanding either on the definition of SD or on the possible measures needed to be taken in order to achieve it. Since the introduction of the concept of SD by Bruntland in 1987, many progressive world events had taken place to increase the awareness on environment and sustainability agendas (Zainul Abidin, 2008). The need for greater sustainability consideration has been accepted by many governments, businesses, organizations, and individuals (Ofori, 2001). Consequently, sustainable construction is seen as a way for the construction industry to contribute to the effort to achieve sustainable develop- ment. (Zainul Abidin, 2010). The direction of the industry is now shifting from developing with environmental concern as a small part of the process into having the development process being integrated within the wider context of environmental agenda (Das Gandhi et al., 2006).

3. Construction sustainability and project sustainability Performance factors

Zainul Abidin & Pasquire (2005) distinguished between sustainability and sustainable construction. Sustainable construction is a process whereby, over time, sustainability is achieved (Parkin et al., 2003). Hence, according to Zainul Abidin & Pasquire (2005), sustainability is an objective. .Kaatz et al. (2005) defined sustainable construction as achieving better environmental performance of buildings through technical innovation and improved efficiencies of building materials and components. Saparauskas and Turskis (2006); and Gibb and Isack (2001) stated that the sustainable construction is the way for the construction industry in achieving SD. Sustainable construction is defined as: the creation and responsible management of a healthy built environment based on resource efficient and ecological principles, and recognizes that energy conservation, pollution prevention, resource efficiency, system integration and LC costing are very important factors for sustainable construction (Soetanto et al., 2004).

Kibert (2013) defined sustainable construction as the creation and responsible management of a healthy built environment based on resource efficient and ecological principles. DETR (2000) defined it as profitability and competitiveness, customers and clients satisfaction and best value, respect and treat stakeholders fairly, enhance and protect the natural environment, and minimize impact on energy consumption and natural resources. CIB (1999) concluded that sustainable construction include: minimization of resource consumption, maximization of resources reuse, use of renewable and recyclable resources, protection of the natural environment, create a healthy and non-toxic environment, and pursue quality in creating the built environment.

Generally, sustainable construction is defined as a construction process, which is carried out by incorporating the basic objectives of sustainable development. Such construction processes would thus bring environmental responsibility, social awareness, and economic profitability to new built environment and facilities for the wider community (Khalfan, 2006). Consequently Zainul Abidin (2010) redefined the main three SD pillars that governed by sustainable construction as environmental protection, social well-being and economic prosperity. Whereas, environmental protection concerns the built environment and the extraction of natural resources. Social well-being concerns the human feelings: security, satisfaction, safety and comfort, human contributions: skills, health, knowledge, and motivation. Finally, economic sustainability is concerned with the monetary gains from the project for the benefits of the clients, construction players, public, and the government.

Ahn et al. (2010) referred that the built environment has a major share of environmental impact of our society, along with transportation and industrial processes. It accounts for approximately 40% of total energy use. When economies prosper, more infrastructure and facilities are needed to sustain economic development. As a result, more pressure is put on natural resources, which could have a severe impact on the environment and on all living organisms (Majdalani et al., 2006). The main challenge for the industry is to play an integral part in reducing the impacts of its activities on the environment and local communities. In order to have a sound and more sustainable construction industry, its three major players must take the leadership role in such transformation (Holton, 2009; and Bennett and Crudgington, 2003). During construction, operation, and deconstruction, homes consume large amounts of energy, raw materials, and water (Loftness, 2004). Homes are responsible for 20 percent of the energy consumed and carbon dioxide emitted in the United States (Scheuer, 2007; Shelbourn et al., 2006). Kaatz et al. (2005) ensured that the adverse environmental effects from construction activities have been extensively addressed including energy consumption, dust and gas emission, noise pollution, waste generation, water discharge, misuse of water resources, land misuse and pollution, and consumption of non-renewable natural resources.

Chen et al. (2010); Jaillon (2008); and Yu and Kim (2011) presented several benefits of applying sustainable construction, including: shortened construction time, lower overall construction cost, improved quality, enhanced durability, better architectural appearance, enhanced occupational health and safety ,material conservation, less construction site waste, less environmental emissions, and reduction of energy and water consumption. Akadiri an Olomolaiye (2012) considered that construction of buildings is a huge factor of human impact on the environment. Landman (1999) recognized a number of environmental, social, and economic benefits to be reaped from building more sustainably, those include:Air and water quality protection; Soil protection and flood prevention; Solid waste reduction; Energy and water conservation; Climate stabilization; Ozone layer protection; Natural resource conservation; and Open space, habitat, and species/biodiversity protection.

Appreciation of the significant impacts of construction activities on sustainable development, beside the significant benefits of adopting sustainable approaches by the construction industry, has led to the development of various management approaches and methods to guide construction participants in achieving better project sustainability performance. In this essence, performance measurement and benchmarking processes are considered as ways that the construction industry can move towards attaining sustainable procurement and development (Shen et al., 2010). Key Performance Indicators (KPIs) are commonly defined for this purpose (Alkilani et al., 2012; Ofori, 2001). Developed economies are taking both reactive and proactive steps towards the sustainable construction procurement by establishing regulations and controls, introducing economic incentives, and initiating non-regulatory activities For example, the UK's National Procurement Strategy (NPS), and the Australian Procurement and Construction Council introduced Australian and New Zealand Government Framework for Sustainable Procurement (Alkilani et al., 2012). Further many initiatives and methods were established to incorporate sustainability into construction design and process. For example the US's LEED scheme, the UK's Building Research Establishment Environmental Assessment Method (BREEAM), and the Australian 'GreenStar' assessment tools have been introduced to assess the environmental impact of building designs and benchmark the sustainability of designs against recognized industry standards, measures and performance criteria (Ding, 2008).

In addition, sustainable performance of an individual construction project across its life cycle is considered as a crucial aspect in attaining the goal of sustainable development. According to the Royal Institute of British Architects (RIBA) reported that the Life cycle (LC) process of a construction project includes conception and feasibility studies, engineering and design, procurement, construction, start-up and implementation, and operation or utilization (RIBA, 2003). Scheuer et al. (2003); and Younan (2011) said that the complexities of interaction between the built and the natural environment that Life cycle assessment (LCA) represents a comprehensive approach to examining the environmental impacts of an entire building. ISO14040 (2006) and Bragança et al. (2010) stated that the LCA as a systematic method that quantifies the potential environmental impacts of a product or a service throughout its whole life cycle, from raw material acquisition phase, manufacture phase, use and maintenance phase till the end of the life. The potential environmental categories cover the resource depletion, human health, and ecological health (Du, 2012). The LCA process can be used to determine the potential environmental impacts from any product, process, or service (Pant et al., 2011). Curran (2012); Wang et al. (2011) and Gibb and Isack (2001) said that the LCA is a well-known analytical tool for assessing the environmental impacts of a product from the acquisition of raw materials to the final disposal of products.

Generally, the LC phases of a construction project are broken down into planning and design (inception, feasibility outline, scheme and detailed), construction, facilities management (operation, maintenance and reuse), and decommissioning at the end of its life (Zhang et al., 2005; Du Plessis, 2007; Khasreen et al., 2009; Pant et al., 2011). Previous studies suggested the LC of construction projects, including conceptual phase, through project definition, execution, operation, and finally demolition. Another considered the LC of a construction project is divided into predesign, design, preparing to build, construction, occupation, refurbishment, and demolition. According to Shen et al. (2007), five major processes are applied to compose a project life cycle, namely, inception, design, construction, operation and demolition. Shen et al. (2007) developed a framework of SP checklist to help understanding the major factors affecting a project SP across its life cycle. The data used for analysis are mainly from a comprehensive literature review. Chen et al. (2010) developed a holistic SP criteria set to assist design team members in the selection of appropriate construction methods in concrete buildings during early project stages. Wang et al. (2010) developed and demonstrated a LCA approach in a case study the strategic design of a Flagship Store in Shanghai. Yu and Kim (2011) provided a review of the environmental assessment schemes for buildings based on the Indoor Air Quality (IAQ) issues, which could have an important impact on the health and wellbeing of occupants.

Based on the literature review, 66 sustainable factors (economic, social, and environmental) were identified. These factors are classified into 5 project LC phases: inception phase, design phase, construction phase, operation phase, and demolition phase. This list was incorporated into a questionnaire survey and used to explore the most significant sustainability factors taken by Gaza Strip construction firms.

4. Methodology

This study is exploratory in nature. According to Creswell (2002) exploratory research is usually used to increase understanding, expand knowledge and explore a phenomenon that has little research done on it. This study employs quantitative data collection and analysis methods. The study's main question is "what are the most significant sustainability factors that taken into account by engineers during building project LC?" According to Yin (2002), in such a research with main question of "what" an exploratory survey, archival or historical data collection methods are is preferred. However, there is lack of data about the research issue in Gaza Strip's construction industry. Further, there is dearth of archival or historical data that can be used to make the propositions for this study. Therefore, a survey strategy was selected. Nevertheless, it is recognized that the survey research design does have its major disadvantages of the low response rate and the low reliability and validity of survey data (Leedy 2001; Churchill Jr 1979). Therefore, this study employed various techniques such as sampling methods, pilot study and validity and reliability tests before proceeding to the actual data collection. In particular, this study employs Creswell's (2002) five interrelated steps in the process of quantitative data collection. It involves the steps of (i) determining the participants to study, (ii) obtaining permissions needed from several individuals and organizations, (iii) considering what types of information to collect from several sources available to the quantitative research, (iv) locating and selecting instruments to use that will net useful data for the study, and finally, (v) administering the data collection process to collect data.

4.1 Population and sample of the study

The population of the study consists of four engineering categories (mechanical engineers, electrical engineers, civil engineers, and architects). According to the Engineers Association in Gaza Governorates in July (2012), the number of its members was 9211 engineers. The number of engineers who are involved in construction sector was 7241 (Engineers Syndicate statistics, 2013), which is considered the population of this study. In this study a table presented by Kotrlik and Higgins (2001) is used to determine the sample size. Table 1 illustrates sample sizes for several populations assuming alpha levels of 0.10, 0.05, or 0.01. The margins of error used in the table were 0.03. Therefore, assuming alpha is 0.05, t= 1.96 and the margin error is 0.03, the sample size will be (119) engineers.

Table 1. *Minimum sample size for population. Source: Kotrlik y Higgins, 2001*

Population Size	Margin error 0.03		
	Alpha=0,10 T=1,65	Alpha=0,05 T=1,96	Alpha=0,01 T=2,58
1.000	77	110	173
1.500	79	112	183
2.000	83	119	189
4.000	83	119	198
6.000	83	119	209
8.000	83	119	209
10.000	83	119	209

4.2 Questionnaire design

The questionnaire was designed based on extensive review of previous related studies (Shen et al., 2010; Wang et al., 2010; Yu and Kim, 2011; Majdalani, 2005; Jaillon and Poon, 2008; Chen et al., 2010; Nelms et al., 2007; Johnson et al., 2004; Soetanto et al., 2004; Tam et al., 2007; Blismas and Wakefield, 2007; Enshassi, 1999; AbdHamid and Kamar, 2011; Song et al., 2005; Kim et al., 2009; Shen et al., 2007; Gibb and Isack, 2001) and interviews with experts (i.e. project managers, site engineers, lecturer engineers, office engineers, and environmentalists), who have a large experience (average experience 20 years) in the construction industry.

The modified questionnaire comprises two sections to achieve the aim of this research, as follows: Section one: general information. This section informs about the type of institution involved, position of the respondent in his institution, educational degree, and experience. In addition, the number, type, and cost of the implemented construction projects by the institution. Section 2: sustainable factors that taken into consideration through the project LC. The LC of the project classified into five phases following Shen et al.'s (2007) classification: concept phase; design phase; construction phase; operation phase; and demolition phase. Every phase consists of three main groups factors of SD. They are the environmental factors, the social factors, and the economic factors. A framework of project sustainability factors is proposed in a matrix format as shown in Table 2 (Shen et al., 2007).

Sixty-six factors were collected from the literature, (31) were selected without modification; (5) factors were added to suite the construction industry in Gaza Strip, while (13) factors were modified and (4) factors were merged. The final selected factors are 53 factors.

Table 2. *The Framework of project's SP factors. Source: Shen et al., 2007*

Project Phases	*Project SP factors*		
	ESF	*SSF*	*EnSF*
I (Inception)	*ESFI*	*SSFI*	*EnSF-I*
II (Design)	*ESFII*	*SSFII*	*EnSF-II*
III (Construction)	*ESFIII*	*SSFIII*	*EnSF-III*
IV (Operation)	*ESFIV*	*SSFIV*	*EnSF-IV*
V (Demolition)	*ESFV*	*SSFV*	*EnSF-V*
Where: ESF: Economical Sustainable Factors SSF: Social Sustainable Factors EnSF: Environmental Sustainable Factors			

4.3 The Pilot study

The pilot study was conducted by distributing the questionnaire to the experts (i.e., project managers, office engineers, site engineers, lecturers, and environmentalist). Those experts have extensive experience in the same field of the research. 35 questionnaires were distributed as follows: ten questionnaires for the Ministry of Works, eight questionnaires for the Ministry of Housing, thirteen site engineers' works at private construction companies, and about five for UNRWA. Recommendations from the experts were taken into consideration before distributing the final questionnaire.

4.4 Validity of the questionnaires

4.4.1 Criterion validity

The internal validity of the questionnaire is the first statistical test that used to test the validity of the questionnaire. It is measured by a scouting sample, which consisted of (35) questionnaires through measuring the spearman correlation coefficients between each factor in-group and the whole group, the mean and the standard deviation of factors. The significance values are less than 0.05 or 0.01. The correlation coefficients of all the fields are significant at α = 0.01 (ρ-value < 0.01) or α = 0.05 (0.01 < ρ-value < 0.05). It can be said that the fields are valid to measure what it was set for to achieve the main aim of the study. It was found that the ρ-values (Sig.) are less than 0.01. Therefore, the spearman correlation coefficients of all factors is significant at α=0.01. It can be said that the selected factors are consistent and valid to measure what it was set to.

4.4.2 Structure validity

Structure validity (Internal consistency) is the second statistical test that used to test the validity of the questionnaire's structure. It tests the validity of each group and the validity of the whole questionnaire. It measures the correlation coefficient between one group and all factors of the questionnaire. The internal consistency of the five project LC phases, for the sustainability factors that taken into account are tested by finding the correlation matrix for those phases with the total score of the scale, as illustrated in Table 3. It is shown that the five phases are associated with the total score for factors' impact on SP. The factors are linked substantial and statistically at the significant level (0.01).

Table 3. *Correlation coefficients matrix for the five phases for sustainable factors that taken into account*

	Phase	Concept	Design	Construction	Operation	Demolition	Total
Total	Correlation	0.56	0.66	0.81	0.70	0.59	1
	ρ-value (Sig.)	0.00	0.00	0.00	0.00	0.00	
	Number	35	35	35	35	35	35

4.4.3 Reliability of the questionnaire

Split half method

Correlation coefficient between the total degrees of individual factors, and total scores of even factors was calculated using Spearman- Brown correlation (Table 4). It was found that ρ-values (Sig.) is ranged in the mid for factors' impact on SP between (0.45 - 0.89).

Cronbach's alpha

This method is used to measure the reliability of the questionnaire between each field and the meaning of the whole fields of the questionnaire. The normal range of Cronbach's coefficient alpha value is between 0.00 and +1.00. The higher values reflect a higher degree of internal consistency. Table 6 shows that the Cronpach's alpha values for the five phases are greater than 0.00 and lower than +1.00. When Alpha is closed to 1, the internal consistency of items (variables) will be assumed great.

Table 4. *Spilt half method and Cronbach's alpha result*

Phase	***Split Half Method***	***Cronbach's Alpha***	***Number of factors***
Concept	*0.89*	*0.50*	*14*
Design	*0.45*	*0.49*	*10*
Construction	*0.52*	*0.55*	*16*
Operation	*0.61*	*0.73*	*9*
Demolition	*0.78*	*0.76*	*11*

4.5 Data processing and analysis

In this research, ordinal scales were used. Ordinal scale is a ranking or a rating data that normally uses integer in ascending or descending order. Likert scale was used. It is individual attempt to quantify constructs, which are not directly measurable. It uses multiple-item scales and summated ratings to quantify the constructs of interest (Gliem and Gliem; 2003). Based on Likert scale, the following scale is considered: (1) not taken into consideration, (2) seldom/rare, (3) sometimes, (4) often, and (5) always taken into consideration. The hypothesized value is the middle of the used Likert scale equals 2.5. Data was analyzed by utilizing Statistical Package for Social Science (SPSS 20). The mean and its sign were used *to determine the significance level of the factors. If the ρ-value (Sig.) is smaller than or equal to the level of significance* **α** *= 0.05, then the mean of a factor is significant. On the other hand, if the ρ-value (Sig.) is greater than the level of significance* **α** *= 0.05, then the mean a factor is insignificant.*

5. Results and discussion

The results indicated that 28.1% (30) of total respondents were from governmental institution and 30.8% (33) of the respondents were from non-governmental agencies. Moreover 38.3% (41) were contractors' respondents and 3% (2.8) were from others institutions. These findings showed that, 13.1% (14) were project manager, 37.4% (40) of respondents were office engineers, 47.7% (51) of respondents were field engineer, and 1.9% (2) of respondents has other positions. The average experience of the respondents is 16 years. A total of 53 sustainable factors (economic, social, and environmental sustainable factors) were identified from extensive literature review and were modified according to the pilot study. These factors are classified into (5) phases (life cycle of a project): (I) inception phase, (II) design phase, (II) construction phase, (IV) operation phase, and (V) demolition phase. The factors of each phase are classified into three sub-groups factors, which were 1 factor under the economic sustainable factors (ESF), 2 factors under social sustainable factors (SSF), and 3 factors under environmental sustainable factors (EnSF). Table 5 presents the classification of these factors.

Table 5. *Classification of sustainable factors under the five LC phases*

Phases of the project LC	Group of factors	Group Symbol	No. of factors
Inception phase	Economic sustainable factors- ESF	ESF-I	4
	Social sustainable factors- SSF	SSF-I	4
	Environmental sustainable factors- EnSF	EnSF-I	5
	Total: 13		
Design phase	Economic sustainable factors- ESF	ESF-II	3
	Social sustainable factors- SSF	SSF-II	2
	Environmental sustainable factors- EnSF	EnSF-II	4
	Total: 9		
Construction phase	Economic sustainable factors- ESF	ESF-III	5
	Social sustainable factors- SSF	SSF-III	4
	Environmental sustainable factors- EnSF	EnSF-III	6
	Total: 15		
Operation phase	Economic sustainable factors- ESF	ESF-IV	2
	Social sustainable factors- SSF	SSF-IV	2
	Environmental sustainable factors- EnSF	EnSF-IV	3
	Total: 7		
Demolition phase	Economic sustainable factors- ESF	ESF-V	3
	Social sustainable factors- SSF	SSF-V	3
	Environmental sustainable factors- EnSF	EnSF-V	3
	Total: 9		
Total factors	53		
Where: ESF: Economical Sustainable Factors, SSF: Social Sustainable Factors, EnSF: Environmental Sustainable Factors			

5.1 Factors that are taking into consideration during project inception phase

Thirteen factors were surveyed under the inception phase, these factors are classified into 3 sub-groups as following: 4 factors under the economic sustainable factors (ESF-I), 4 factors under the social sustainable factors (SSF-I), and 5 factors are classified under the environmental sustainable factors (EnSF-I) (Table 6).

Economic sustainability factors (ESF-I)

*The results revealed that the highest weighted means was (72.57%) for "Capital budget''. This factor was ranked at the first position under this phase with ρ-value = 0.00 which is smaller than the threshold level of significance at **α** = 0.05. The sign of the test is positive, so the mean of this factor is significantly greater than the hypothesized value (mean=3.62). This reflected the high consideration taken by engineers regarding the application of economic sustainability factors which is valuable for sustainability assessment cross the project LC Pilbara Iron 2004, in Western Australia ensured that SD goals include economic, optimize long-term economic value that define a capital budget for the project at the first stage. Khalfan et al. (2002) explained that the consideration of the economic factors as investment in people and equipment for a competitive economy, job opportunities, vibrant local economy, services are accessible which reduces use of car, creation of new markets and opportunities for sales growth, cost reduction through efficiency improvements and reduced energy and raw material inputs, creation of additional added value, etc.*

Social sustainability factors (SSF-I)

*"Infrastructure capacity of building" with weighted mean equals (73.27%) is the most significant factor taken into consideration by engineers at the inception phase, with ρ-value= 0.00 which is smaller than the level of significance **α**= 0.05. The sign of the test is positive; mean of this factor is significantly greater than the hypothesized value (mean= 3.66). Three factors of social sustainability factors weighted means were ranged in high position (employment, workers' health safety assessment and community amenities). Only one factor "Employment" with weighted mean (68.93%) is in a moderate range. In general, the respondents' perceptions show that this factor play the most significant role in influencing the effects of the project at the inception phase on social SP. These finding agreed with Khalfan (2002) who defined the social SP as the good quality of life for humans, and this will achieve by providing a local employment opportunities for the local community. Shen et al. (2007) said that the social sustainability aimed to improve the quality of human life, to implement skills training in order to get more good employment opportunities.*

Environmental sustainability factors (EnSF-I)

*"Noise assessment", with weighted mean (63.65%) is ranked in the first position under this phase, and ρ-value=0.00 which is smaller than the level of significance **α** =0.05. The sign of the test is positive; mean of this factor is significantly greater than the hypothesized value (mean=3.18). This result indicated a good consideration given to the environmental factors at the inception phase. Shen et al. (2007) ensured that the adverse environmental which effects from construction activities have been extensively addressed including noise pollution. Further corroborating, the outcomes of Scheuer (2007) recognized that the impact caused by construction activities on the environment occurs throughout a project's life cycle and the assessment of noise must be an important activity to reduce noise pollution at construction phase.*

Table 6. *Weighted means and ranks factors' degree of consideration for inception phase*

Sustainable factors that were taken into consideration at project inception phase.		Mean	P-Value	Weighted mean	Total Rank	Group Rank
ESF – I: Economic sustainability factors						
Scale and business scope	Projects scale and the business scope during project operation are essential attributes to the project profitability	3.23	0.00	64.76	9	4
Effects on local economy	Projects served both the local economy and took advantage of the infrastructure in the local economy to generate economic benefits	3.58	0.00	71.73	4	2
Capital budget	The capital budget defined to planning and controlling project total cost	3.62	0.00	72.57	2	1
Finance plan	The finance plan defined and planned for projects finance schedule, for example, when, how, and how much to finance	3.53	0.00	70.68	6	3
SSF - I : Social sustainability factors						
Employment	Projects implementation able to provide local employment opportunities.	3.44	0.00	68.93	7	4
Infrastructure capacity-building	Projects improve local infrastructure capacity, such as drainage, sewage, power, road, and communication, transportation, dining, recreation, shopping, education, financing, and medical.	3.66	0.00	73.27	1	1
Community amenities	Projects providing community amenities for the harmonization of new settlements and local communities.	3.53	0.00	71.15	5	2
Workers' health Safety assessment	The assessment of safety conducted to identify any future safety risks to the public and project users.	3.61	0.00	72.38	3	3
EnSF-I: Environmental sustainability factors						
Ecology preservation	Projects avoiding as much as possible the irretrievable impacts on the surroundings from implementing project.	2.93	0.00	58.68	13	5
Air Pollution assessment	Examining the potential air pollution from the proposed project and its impact on the local climate	3.05	0.00	61.14	12	4
Water Pollution assessment	Examining the potential water pollution from the proposed project, including both surface and ground water, and project's consumption on water resources.	3.36	0.00	67.36	8	1
Noise assessment	Examining the potential noise pollution du ring both project construction and operation phases.	3.18	0.00	63.65	10	2
Waste generation assessment	Examining the waste generation at both project construction and operation phases.	3.16	0.00	63.27	11	3

5.2 Factors that are taking into consideration during project design phase

Nine factors which are classified under the design phase are distributed into three sub-groups as follow: (3) factors are classified under the economic sustainable factors (ESF– II), (2) factors are classified under the social sustainable factors (SSF–II) and (4) factors are classified under the environmental sustainable factors (EnSF–II).

Economic sustainability factors (ESF- II)

Table 7 illustrated that the "standardization" is ranked at the 1st position with weighted mean equals (74.62%), and ρ-value = 0.00, which is smaller than the level of significance $\alpha = 0.05$. The sign of the test is positive, so the mean of this factor is significantly greater than the hypothesized value (mean=3.73). This factor is taken into consideration and applied significantly in the design economic phase. This is due to the use of the standard modules as an essential factor in reducing the overall cost of the project, which encourages design by using modules. This result is in line with Gibb and Isack (2001) who ensured that standardization achieve the SD goals by minimizing the cost of the project from the first phases of the project. Hill and Bowen (2010) stated that economic pillar of sustainability ensure the financial affordability, employment creation, and adopted full-cost considerations at early phases of the project LC.

Social sustainability factors (SSF- II)

"Safety design" factor was ranked by engineers at the 1st position with weighted mean equals (72.53%), and insignificance ρ-value and greater than the hypothesized value mean. It is observed from the perceptions' of engineers that this factor is important and is taken into consideration at this phase. The safety design is an essential requirement at this phase. This finding agreed with Kim et al. (2009) findings, who verified that safety design and disaster preparedness, achieves the social sustainability goals. The other factor under this group is "security consideration", which weighted with a moderate weighted mean equals (57.45%). It is clear that this factor has a low weighted mean that reflect insignificance consideration from the respondents' perceptions. This does not agree with Khalfan (2002); Chen et al. (2010); Hisham (2011); and Kamlim and Yang (2007) findings. They assured that SD is all about ensuring a better quality of life for everyone and the security alarms achieve. This must be taken in consideration from the early phases of projects construction.

Environmental sustainability factors (EnSF-II)

"Modular and standardized design" was ranked at the 1st position under this group as a critical factor in the design phase's with weighted mean equals (70.30%) and ρ-value= 0.00, which is smaller than the level of significance $\alpha = 0.05$, and greater than the hypothesized value mean. This result is in line with Wang et al. (2011) who indicated that during the pre-construction period (the design phase), various activities must be taken to reduce waste generation and pollution, such as module and standard components. Tam and Le (2007) considered that the design process affects largely the project sustainability performance. For example, the design specifications affect functional performance of building components such as air conditioners, ventilation, lighting, electrical, heating, fire and water systems and other environmental considerations. Design specifications on project components should consider the project's economic, social and environmental performance during project life cycle.

Table 7. *Weighted means and ranks for factors' degree of consideration in design phase*

Sustainable factors that were taken into consideration in design phase.		**Mean**	**P-Value**	**Weighted mean**	**Total Rank**	**Group Rank**
ESF-II: Economic sustainability factors						
Consideration of life cycle cost	The total cost considered the project life cycle, including site formation, construction, operation, maintenance cost and demolition cost.	3.47	0.00	69.51	5	4
Standardization	The standard dimension in design specifications in layout was taken in consideration.	3.73	0.00	74.62	1	1
Materials choice	The economy, durability and availability for material selection were taken in consideration.	3.65	0.00	73.14	2	2
SSF-II: Social sustainability factors						
Safety design	The design considers emergencies such as fire, earthquake, flood, radiation, and eco-environmental accidents.	3.62	0.00	72.53	3	3
Security consideration	The design considers installation of security alarm and security screen.	2.87	0.00	57.45	9	5
ENSF-II: Environmental sustainability						
Designer	The designer Knowledgeable of energy savings and environmental issues is good.	3.33	0.00	66.60	7	3
Life cycle design	Effective communications among designers, clients, environmental professionals, and relevant governmental staff to ensure all environmental requirements are incorporated into the design process was existed.	3.46	0.00	69.22	6	2
Environmentally conscious design	Incorporation of all environmental considerations into project design for construction, operation, demolition, recycling, and disposal have been applied.	3.32	0.00	66.41	8	4
Modular and standardized design	The module and standard components have been used to enhance build ability and to reduce waste generation.	3.51	0.00	70.30	4	1

5.3 Factors that are considered during project construction phase

Fifteen sustainable factors were identified for construction phase (Table 8). They are distributed into three sub-groups as following: (5) factors are classified under the economic sustainable factors (ESF-II), (6) factors are classified under the social sustainable factors (SSF-II) and (4) factors are classified under the environmental sustainable factors (EnSF-II).

Economic sustainability factors (ESF -III)

"Site security" was ranked at the 1st position as a critical factor that is taken into consideration under the construction phase with weighted mean equals (72.88%), and acceptable, ρ-value, and mean= 3.64. Site security is considered very important for economic sustainability that. This result is in line with Chen et al (2010); Riley et al. (2003), and Yu and Kim (2011).

Social sustainability factors (ESF-III)

Table 8 illustrated that "public awareness" is considered a critical factor that was taken into consideration at the construction phase with weighted mean equals (71.60%). This reflects a high degree of consideration at the social factors of the construction phase. This result agreed with AbdHamid and Kamar (2011) and Song et al. (2005) result, who confirmed that public awareness, is a good way to reach the sustainability.

Environmental sustainability factors (ESF-III)

"Legislation" is ranked at the 1st position by the respondents with weighted mean equals (69.41%). Song et al. (2005) considered that the environmental legislations must be applicable to achieve sustainability at the design phase. Shen et al. (2007) ensured that the adverse environmental effects from construction activities have been extensively addressed including noise pollution.

Table 8. *Weighted means and rank for factors' degree of consideration in construction phase*

Sustainable factors that were taken into consideration in construction phase		***Mean***	***P-Value***	***Weighted mean***	***Total Rank***	***Group Rank***
Group III -Project construction phase:						
ESF-III: Economic sustainability factors						
Labour cost	*Salaries were paid to human resources, such as general construction workers, plumbers, pipelines, carpenters, stonemasons, and bricklayers in time.*	*3.47*	*0.00*	*69.41*	*6*	*3*
Materials cost	*Using of the materials was costly.*	*3.50*	*0.00*	*70.00*	*3*	*2*
Energy consumption	*Using various types of energy such as electricity, oil, gas, and coal was costly.*	*3.38*	*0.00*	*67.60*	*8*	*4*
Water cost	*Using water resources and for dealing with surface water, and ground water was costly.*	*3.33*	*0.00*	*66.80*	*9*	*5*
Site security	*Various types of measures for protecting the site safety have been used.*	*3.64*	*0.00*	*72.88*	*1*	*1*
SSF-III: Social sustainability factors						
Direct employment	*Provisions of working opportunities from implementing the project to the local labour market, including construction workers, professionals, and engineers were applied.*	*3.43*	*0.00*	*68.65*	*7*	*3*
Working conditions	*Safety measures, facilities, and insurance for working staff were applied.*	*3.01*	*0.00*	*60.40*	*14*	*4*
Public awareness	*Provision of warning boards and signal systems, safety measures and facilities for the public were applied.*	*3.58*	*0.00*	*71.60*	*2*	*1*
Improvement of infrastructure	*Provisions of better drainage, sewage, road, message, heating, and electrical systems were applied.*	*3.47*	*0.00*	*69.47*	*4*	*2*
EnSF-III: Environmental sustainability factors						
Noise pollution	*Extreme noise and vibration induced from project operation.*	*3.10*	*0.00*	*62.16*	*15*	*6*
Workers' health and safety	*On-site health and safety by reducing the number of accidents, providing on-site supervision and providing training programs to employees was applied.*	*3.26*	*0.00*	*65.38*	*12*	*4*
Recyclable/renewable contents	*Renewable materials such as bamboo, cork, fast-growing poplar, and wheat straw cabinetry, which are reproducible, were used.*	*3.16*	*0.00*	*63.30*	*13*	*5*
Reusable/recyclable element	*Building components, rubble, earth, concrete, steel and timber were reused.*	*3.26*	*0.00*	*65.38*	*11*	*3*
Workers' health and safety	*Site hygiene and the provision of health care and safety were emphasized.*	*3.32*	*0.00*	*66.47*	*10*	*2*
Legislation	*Environmental protection law and regulations on construction activities was taken in consideration.*	*3.48*	*0.00*	*69.41*	*5*	*1*

5.4 Factors that are considered during project operation phase

Under this phase, (7) sustainable factors were identified from literature review and were distributed into (3) groups: (2) factors are classified under the economic sustainable factors (ESF-IV), (2) factors under the social sustainable factors (SSF-IV), and (3) factors are classified under the environmental sustainable factors (EnSF-IV).

Economic sustainability factors (ESF-IV)

Local economy has the highest weighted mean equals (69.31%). This result shows that this factor is to some extent taken into consideration at the operation phase (Table 9). This result agreed with Chen et al. (2010), Weaver et al. (2008); and Riley et al. (2003) results, who argued that the economic SD as it's consist of sub-themes, such as investment in people and equipment for a competitive economy, job opportunities. They emphasized that vibrant local economy as an important factor affects the economic theme at the operation phase. AbdHamid and Kamar (2011) considered the training costs as a significant factor affect the economic consideration of the project as it improves the knowledge and skills of the humans.

Social sustainability factors (ESF-IV)

"Provision of services" is ranked at the 1st position that is taken into consideration at the operation phase with weighted mean equals (75.49%). This result agreed with AbdHamid and Kamar (2011) results. Holton et al. (2008); and Bennett and Crudgington (2003) stated that the main challenge for the industry is to play an integral part in reducing the impacts of its activities on the environment and local communities.

Environmental sustainability factors (ESF-IV)

"Waste generation" ranks at the 1st position with weighted mean equals (69.80%), and acceptable descriptive statistics under the environmental factors that are taken into consideration at the operation phase. All factors under this group are almost considered. These findings indicate a conscious statement among the engineers about the environmental issues under this phase. This agrees with Shen et al. (2007) findings, which ensured that the adverse environmental effects from construction activities have been extensively addressed including energy consumption, dust and gas emission, noise pollution, waste generation, water discharge, misuse of water resources, land misuse and pollution, and consumption of non-renewable natural resources.

Table 9. *Weighted means and ranks for factors' degree of consideration in the operation phase*

Sustainable factors that were taken into consideration in operation		***Mean***	***P-Value***	***Weighted mean***	***Total Rank***	***Group Rank***
ESF-IV: Economic sustainability factors that affect the project operation phase:						
Training costs	*Training courses conducted for employees to improve the quality of human resources.*	*3.20*	*0.00*	*64.08*	*6*	*2*
Local economy	*The project benefits economically the local economy.*	*3.46*	*0.00*	*69.31*	*4*	*1*
SSF-IV: Social sustainability factors that affect the project operation phase:						
Provision of services	*Provisions for improving living standard to local communities were considered.*	*3.77*	*0.00*	*75.49*	*1*	*1*
Provision of facilities	*Beneficial spaces and facilities were saved to involve in the development of local communities.*	*3.56*	*0.00*	*71.29*	*2*	*2*
EnSF-IV: Environmental sustainability factors that affect the project operation phase:						
chemical wastes	*Chemical wastes and organic pollutants did not release to water ways.*	*3.06*	*0.00*	*61.35*	*7*	*3*
Water pollution	*Projects releases of chemical wastes and organic pollutants to water were curing.*	*3.33*	*0.00*	*66.80*	*5*	*2*
Waste generation	*There are no negative impacts from projects operations to flora, fauna, and ecosystems.*	*3.49*	*0.00*	*69.80*	*3*	*1*

5.5 Factors that are considered during project demolition phase

Nine sustainable factors were identified in this phase and distributed into three groups: (3) factors are classified under the economic sustainable factors (ESF-V), (3) factors under the social sustainable factors (SSF-V), and (3) factors are classified under the environmental sustainable factors (EnSF-V). The degree of factors' impact on SP of the projects and the degree of consideration of each sub group analysed (Table 10).

Economic sustainability factors (ESF-V)

"Waste disposal cost" is ranked at the 1st position with weighted mean equals (67.24%). This agreed with Shen et al. (2007) findings who ensured that the adverse environmental effects from construction activities. This is including energy consumption, dust and gas emission, noise pollution, and waste generation. Hill and Bowen (2010) stated that there must be a plan for waste management at construction projects especially for demolition phase.

Social sustainability factors (ESF-V)

"Communication to public" is ranked at the 1st position by the respondents as a critical factor that is considered at the demolition phase. Its weighted mean equals (71.13%) and ρ-value= 0.00, which is smaller than the level of significance α=0.01. The sign of the test is positive and the mean of this factor is significantly greater than the hypothesized value (mean= 3.53). This agreed with AbdHamid and Kamar (2011) who confirmed that public awareness that is taken in consideration at the demolition phase.

Environmental sustainability factors (ESF-V)

With weighted mean equals (69.32%), acceptable P-value and mean, the "environment-friendly demolition method" is ranked at the 1st position among factors under this group. This result indicated the respondents did not consider highly the environmental factors at the demolition phase. This did not agree with Shen et al. (2004); Loftness (2004); and Vanegas and Pearce (2000) who recognized the impact caused by construction activities on the environment occurs throughout a project's life cycle. During its operation, a construction project consumes a vast amount of energy and environmental resources. Scheuer (2007) said that at the end of a construction project's life cycle, the demolition activities generate a large volume of various construction wastes.

Table 10. *Weighted means and rank for factors' degree of consideration in the demolition phase*

Sustainable factors that were taken into consideration in demolition phase		Mean	P-Value	Weighted mean	Total Rank	Group Rank
ESF-V: Economic sustainability factors						
Labour cost	Human resources provided for planning, managing and operating project demolition.	3.34	0.00	66.80	6	2
Energy consumed for operating demolition	Crushing, transporting and relocating operation consumes large amounts of energy.	3.25	0.00	65.19	8	3
Waste disposal costs	The waste loading and unloading, transportation, charges for disposals costly.	3.36	0.00	67.24	6	1
SSF-V: Social sustainability factors						
Communication to the public	Promotion on the public awareness of the project demolition and the possible impacts to the public were considered.	3.53	0.00	71.13	1	1
Operational safety	Provisions related to safety risks to labours and the public during project demolition from explosion, dismantling, toxic materials, and radioactive materials were considered.	3.28	0.00	65.69	7	3
Job opportunity	The projects demolition saved jobs opportunities during project demolition for site work, transportation and disposal.	3.39	0.00	67.81	4	2
EnSF-V: Environmental sustainability factors						
Environment-friendly demolition method	Adoption of technologies to alleviate the disturbance on eco-environment systems and neighbourhood, and to maximize waste reusing and recycling.	3.46	0.00	69.32	2	1
Special waste treatment	Special treatment given to toxic materials, heavy metals, radioactive chemicals released from demolition.	3.36	0.00	67.38	5	2
Waste recycling and reuse	Recycling and reclaiming of useful materials such as steel, brick, glass, timber, and some equipment.	3.24	0.00	64.90	9	3

6. Conclusion

The objective of this paper is to explore sustainable factors, which are taken into consideration during the holistic process of the project LC in Gaza Strip. The project LC consists of five phases; every phase has three main sustainable factors: economic, social, and environmental factors. 53 factors were identified through extensive literature review. The results revealed that the most important 10 sustainable factors that were taken into consideration by engineers in the LC phases of the construction projects in Gaza Strip are distributed as follows: (4) factors are classified under the inception phase, (3) factors under the design phase, (2) factors under the: construction phase, and (1) factor under operation phase. The most common factors that are taken in consideration in the LC phases of the construction projects in Gaza Strip are:

- *Provision of services: provisions for improving living standard to local communities were considered.*
- *Standardization: the standard dimension in design specifications in layout was taken into consideration.*
- *Community amenities: Projects providing community amenities for the harmonization of new settlements and local communities.*
- *Materials choice: the economy, durability and availability for material selection were taken in consideration.*
- *Site security: various types of measures for protecting the site safety have been used.*

The outcome indicated that the lowest 10 factors were: (4) factors are classified under the inception, (3) factors are *classified under the construction phases, (2) factors are classified under the operation phase and (1) factor is classified under the design phase. The factor that ranks at the least of the (53) factors is the "security consideration" under the design phase. This indicates the shortcoming of provisions of security, which were applied in Gaza Strip. That suggests a lack of awareness for the security provisions, which affect negatively the SP of the construction projects. The factors that have the lowest effect on SP of the construction projects are:*

- *Security consideration: the design considers installation of security alarm and security screen.*
- *Ecology preservation: projects avoiding as much as possible the irretrievable impacts on the surroundings from implementing project.*
- *Working condition: safety measures, facilities, and insurance for working staff were applied.*
- *Air pollution assessment: examining the potential air pollution from the proposed project and its impact on the local climate.*
- *Chemical waste: chemical wastes and organic pollutants did not release to water ways.*

7. References

AbdHamid Z. and Kamar M. (2011), *Supply chain strategy for contractor in adopting industrialized building system (IBS). Australian Journal of Basic and Applied Sciences, Vol. 5, No. 12, pp. 2552-2557.*

Adetunji I. (2005), *Sustainable construction: a web-based performance assessment tool. Unpublished Ph.D. thesis, Department of Civil and Building Engineering, Loughborough University, U.K.*

Agarwal K. (2011), *Verifying survey items for construct validity: a two phase sorting procedure for questionnaire design in information behavior research. In proceedings of the American Society for Information Science and Technology, Vol. 48, No. 1, pp.1-8.*

Ahn C.; Lee S., Peña-Mora F., AbouRizk S. (2010), *Toward environmentally sustainable construction processes: the US and Canada's perspective on energy consumption and GHG/CAP emissions. Sustainability, Vol. 2, No. 1, pp. 354-370.*

Akadiri O. (2011), *Development of a multi-criteria approach for the selection of sustainable materials for building projects. Unpublished Ph.D. thesis, School of Engineering and the Built Environment (SEBE), University of Wolver Hampton, U. K.*

Akadiri O., Olomolaiye P. (2012), *Development of sustainable assessment criteria for building materials selection. Engineering, Construction and Architectural Management, Vol. 19, No. 6, pp. 666-687.*

Alkilani, S., Jupp, J.; Sawhney, A. (2012), *'Paving the Road for Sustainable Construction in Developing Countries: A Study of the Jordanian Construction Industry', AUBEA, vol. 1, Australian Journal of Construction Economics and Buildings AJCEB, Sydney, Australia.*

Babashamsi P., Md Yusoff N., Ceylan H., Md Nor N., Salarzadeh Jenatabadi H. (2016), *Sustainable Development Factors in Pavement Life-Cycle: Highway/Airport Review, Sustainability, vol. 8, no. 3, p. 248.*

Ball J. (2002), *Can ISO 14000 and eco-labelling turn the construction industry green? Building and environment, Vol. 37, No. 4, pp. 421-428.*

Bennett J., Crudgington A. (2003), *Sustainable development: recent thinking and practice in the UK. The Institution of Civil Engineers, Vol. 156, pp. 27-32.*

Beyer O. (2002), *Sustainable building and construction implementing green building in Western Australia. Unpublished M.Sc. thesis, School of Engineering and the Built Environment (SEBE), Murdoch University, Western Australia.*

Blismas N., Wakefield R. (2007), *Drivers, constraints and the future of offsite manufacture in Australia. Construction Innovation: Information, Process, Management, Vol. 9, No. 1, pp. 72-83.*

Boonstra C., Pettersen D. (2003), *Tools for environmental assessment of existing buildings. Industry and environment, Vol. 26, No. 2, pp. 80-83.*

Bragança L., Ricardo M., Heli K. (2010), *Building sustainability assessment. Sustainability, Vol. 2, No. 7, pp. 2010-2023.*

Bossink A. (2002), *A Dutch public-private strategy for innovation in sustainable construction. Construction Management and Economics, Vol. 20, No. 7, pp. 633-642.*

Chen Y., Okudan E., Riley R. (2010), *Sustainable performance criteria for construction method selection in concrete buildings. Automation in construction, Vol. 19, No. 2, pp. 235-244.*

Chmutina K. (2010), *Building energy consumption and its regulations in China. China Policy Institute, School of Contemporary Chinese Studies, International House, The University of Nottingham, U.K. Available at: https://www.sherpa.ac.uk/cpi/documents/discussion-papers/discussion-paper-67-building-energy-regulation.pdf [Accessed on 4/4/13].*

Churchill Jr G.A. (1979), *'A Paradigm for Developing Better Measures of Marketing Constructs', Journal of Marketing Research (JMR), vol. 16, no. 1, pp. 64-73.*

CIB (1999), *Agenda 21 on sustainable construction. CIB Report Publication 237. Conseil International du Batiment. Available at: http://heyblom.websites.xs4all.nl/website/newsletter/0102/A21.pdf [Accessed on 20/2/13].*

Council B. (1998), *US Green Building Council and the LEED Green Building Rating System. US Green Building Council.*

Creswell J.W. (2002), *'Educational research: Planning, conducting, and evaluating quantitative', New Jersey: Upper Saddle River.*

Curran A. (2012), *Assessing environmental impacts of biofuels using lifecycle-based approaches. Management of Environmental Quality Journal, Vol. 24, No. 1, pp. 34-52.*

Das Gandhi N., Selladurai V., Santhi P. (2006), *"Unsustainable development to sustainable development: a conceptual model", Management of Environmental Quality: An International Journal, Vol. 17 Issue: 6, pp.654-672, https://doi.org/10.1108/14777830610702502)*

Department of the Environment, Transport and Regions (DETR). (2000), *A better quality of life: a strategy for more sustainable construction, London.*

Ding G.K.C. (2008), *'Sustainable construction—the role of environmental assessment tools', Journal of Environmental Management, vol. 86, no. 3, pp. 451-64.*

Du Plessis C. (2007), *A strategic framework for sustainable construction in developing countries. Construction Management and Economics, Vol. 25, No. 1, pp. 167-76.*

Du G. (2012), *Towards sustainable construction: life cycle assessment of railway bridges. Unpublished M.Sc. thesis, Department of Civil and Architectural Engineering, Royal Institute of Technology, Sweden. Available at: http://kth.diva-portal.org/smash/get/diva2:504070/FULLTEXT03 [Accessed on 23/2/13].*

Ekins P., Simon S., Deutsch L., Folke C., De Groot R. (2003), *A framework for the practical application of the concepts of critical natural capital and strong sustainability. Ecological economics, Vol. 44, No. 2, pp. 165-185.*

El-alfy A. (2010), *'Design of sustainable buildings through Value Engineering', Journal of Building Appraisal, vol. 6, no. 1, p. 69.*

El-Haram M., Walton J., Horner M., Hardcastle C., Price A., Babington J., Atkin-Wright T. (2007), *Development of integrated sustainability assessment toolkit. In proceedings of the International Conference on Whole life Urban Sustainability and its Assessment, SUE-MoT conference, Loughborough, U.K. Available at: http://download.sue-mot.org/Conference-2007/Papers/El-Haram.pdf [Accessed on 3/4/13]*

Engineers Association of Gaza website (2013), *Available at: http://www.enggaza.ps/?action=acc [Accessed on 4/9/13].*

Enshassi A. (2000), *Environmental concerns for construction growth in Gaza Strip. Building and Environment, Vol. 35, No. 3, pp. 273-279.*

Forum for the future (2013), *The five capitals model- a frame works for the future. Available -at: http://www.forumforthefuture.org/sites/defualt/project/downloads/five-capitals-model.pdf [Accessed on 23/2/13].*

Ghumra S., Glass J., Frost W., Watkins M., Mundy J. (2011), *Validating a set of empirically weighted sustainability indicators for construction products. Association of researchers in construction management, pp. 1115-1124.*

Gibb A., Isack F. (2001), *Client drivers for construction projects: implications for standardization. Engineering Construction and Architectural Management, Vol. 8, No. 1, pp. 46-58.*

Gliem J., Gliem R. (2003), *Calculating, Interpreting, and Reporting Cronbach's Alpha Reliability Coefficient for Likert-Type. 2003 Midwest Research to Practice Conference in Adult, Continuing, and Community Education.*

Hill R., Bowen A. (2010), *Sustainable construction: principles and a framework for attainment, pp. 223-239. Available at: https://doi.org/10.1080/014461997372971)*

Hisham A., Darus M., Salleh E., Haw C., Rashid K. (2008), *Development of rating system for sustainable building in Malaysia. WSEAS Environmental problems and development, Vol. 23, No. 9, pp. 760- 778.*

Hisham E. (2011), *Sustainable development criteria set for the transportation hubs of the national association of provinces planning. Procedia Engineering, Vol. 21, pp. 1042-1055.*

Holton L. (2009), *Developing a sector sustainability strategy for the UK precast concrete industry. Unpublished M.Sc. thesis, Department of Civil and Building Engineering, Loughborough University, Australia.*

Hopwood B., Mellor M., Brien G. (2005), *Sustainable development: mapping different approaches. Sustainable Development, Vol. 1, No. 3, pp. 38-52.*

ISO 14040 (2006), *Environmental Management - Life-cycle assessment - principles and framework. Geneva: International Organization for Standardization. Availableeat:_http://www.iso.org/iso/home/standards/management-standards/iso14000.htm. [Accessed on 6/3/13].*

Jaillon L., Poon S. (2008), *Sustainable construction aspects of using prefabrication in dense urban environment: a Hong Kong case study. Construction Management and Economics, Vol. 26, No. 9, pp. 953-66.*

Johnson K., Hays C., Center H., Daley C. (2004), *Building capacity and sustainable prevention innovations: a sustainability planning model. Evaluation and Program Planning, Vol. 27, No. 2, pp. 135-49.*

Kaatz E., Root B., Bowen P. (2005), *Broadening project participation through a modified building sustainability assessment. Journal of Civil Engineering and Management, Vol. 33, No. 5, pp: 441-454.*

Khalfan M. (2006), *'Managing sustainability within construction projects'., Journal of Environmental Assessment Policy & Management, vol. 8, no. 1, pp. 41-60.*

Khalfan M. (2002), *Sustainable development and sustainable construction: a review for C-Sand project. Available at: http://www.csand.org.uk/Documents/WP2001-01-SustainLitRev.pdf [Accessed on 20/02/13].*

Khalfan M., Asaad S. (2006), *Integration of sustainability issues within construction processes. ICE-engineering sustainability, Vol. 12, No. 2, pp. 11-21.*

Khalfan M., Bouchlaghem D., Anumba C. and Carrillo P. (2002), *A framework for managing sustainability knowledge- the C-sand approach. In proceedings of E-Sm@rt conference, Salford, U.K.*

Kibert C. (2013), *Sustainable Construction, John Wiley & sons, USA.*

Khasreen M., Banfill F., Menzies F. (2009), *Life-cycle assessment and the environmental impact of buildings: a review. Sustainability, Vol. 1, No. 3, pp. 674-701.*

Kim C., Kim H., Han H., Kim C., Kim K., Park S.H. (2009), *Developing a technology roadmap for construction Randthrough interdisciplinary research efforts. Automation in Construction, Vol. 18, No. 3, pp. 330-7.*

Koroneos C., Moustakas K., Loizidou M. (2009), *Sustainable indicators for the construction sector. In proceedings of the 11th International conference of environmental science and technology publications, China, pp. 621-628.*

Kotrlik J., Higgins C. (2001), *Organizational research: determining appropriate sample size in survey research appropriate sample size in survey research. Learning, and Performance Journal, Vol. 19, No. 1, pp. 43.*

Landman M. (1999), *Breaking through the barriers to sustainable building: insights from building professionals on government initiatives to promote environmentally sound practices. Unpublished Ph.D. thesis, Department of Urban and Environmental Policy, Tufts University, U.S.A.*

Larsson N. (2005), *Regionalism and sustainable development: genesis of SB04. Building research and information, Vol. 33, No. 5, pp. 397– 404.*

Leedy P.D. (2001), *'Practical research : planning and design', in J.E. Ormrod (ed.)7th ed. edn, Upper Saddle River, N.J. : Merrill Prentice Hall, Upper Saddle River, N.J.*

Loftness V. (2004), *Improving building energy efficiency in the U.S: technologies and policies for 2010 to 2050. U.S. Congress House Committee on Science. Available at: http://www.house.gov/science/hearings/energy04/may19/loftness.pdf [Accessed on 1/9/13].*

Majdalani Z., Ajam M., Mezher T. (2006), *Sustainability in the construction industry: a Lebanese case study. Construction Innovation: Information, Process, Management, Vol. 6, No. 1, pp. 33-46.*

McConville J.R. (2006), *'Applying Life Cycle Thinking to International Water and Sanitation Development Projects: An assessment tool for project managers in sustainable development work'.*

McKenzie S. (2004), *Social sustainability: towards some definitions. The Hawke Research Institute Working Paper Series, No. 27.*

Munch J. (2009), *Sustainability assessment of buildings: a comparative analysis of BREEAM, DGNB and the Swan. Unpublished Ph.D. thesis, Technical University of Denmark, Denmark.*

Nelms E., Russell D., Lence J. (2007), *Assessing the performance of sustainable technologies: a framework and its application. Building Research and Information, Vol. 35, No. 3, pp. 237-51.*

Ofori G. (2001), *'Indicators for measuring construction industry development in developing countries', Building Research & Information, vol. 29, no. 1, pp. 40 - 50.*

Parkin S., Sommer F., Uren S. (2003), *Sustainable development: understanding the concept and practical challenge. ICE-Engineering Sustainability, Vol. 156, No. 1, pp. 19-26.*

Pant D., Singh A., Van Bogaert G., Gallego A., Diels L., Vanbroekhoven K. (2011), *An introduction to the life cycle assessment (LCA) of bio electrochemical systems (BES) for sustainable energy and product generation: relevance and key aspects. Renewable and Sustainable Energy Reviews, Vol. 15, No. 2, pp. 1305-1313.*

Riley D., Pexton K., Drilling J. (2003), *Procurement of sustainable construction services in the United States: the contractor's role in green buildings. Industry and environment, Vol. 26, No. 2, pp. 66-69.*

***Royal Institute of British Architects (RIBA) (2003)**, Available at: http://www.architecture.com [Accessed on 5/3/13].*

***Saparauskas J., Turskis Z. (2006)**, Evaluation of construction sustainability by multiple criteria methods. Technological and Economic Development of Economy, Vol. 12, No. 4, pp. 321-326.*

***Scheuer S., Keoleian G., Reppe P. (2003)**, Life cycle energy and environmental performance of a new university building: modeling challenges and design implications. Building and Environment, Vol. 35, No. 5, pp: 1049–1064.*

***Scheuer W. (2007)**, Adoption of residential green building practices: understanding the role of familiarity, Unpublished Ph.D. Thesis, University of Michigan.*

***Seiter D. (2005)**, Top five bogus reasons not to build green. Available at: http://www.builtgreen.org/homebuilders/bogus.htm [Accessed on 2/9/13].*

***Seo S. (2002)**, International review of environmental assessment tools and databases. CRC for Construction Innovation, Brisbane.*

***Shelbourn M., Anumba C., Bouchlaghem D., Khalfan M., Glass J., Carillo P. (2006)**, Managing knowledge in the context of sustainable construction. ITcon, Vol. 11, pp. 57- 71.*

***Shen L., Tam V., Tam L., Ji Y. (2010)**, Project feasibility study: the key to successful implementation of sustainable and socially responsible construction management practice, Journal of Cleaner Production, vol. 18, no. 3, pp. 254-9*

***Shen L., Hao L., Tam V., Yao H. (2007)**, A checklist for assessing SP of construction projects. Journal of Civil Engineering and Management, Vol. 13 No. 4, pp. 273-281.*

***Shen L., Wu Z., Chan W., Hao L. (2004)**, Application of system dynamics for assessment of sustainable performance of construction projects. Journal of Science, Vol. 6, No. 4, pp. 339-349.*

***Soetanto R., Dainty J., Glass J., Price F. (2004)**, Criteria for assessing the potential performance of hybrid concrete structural frames. Engineering, Construction and Architectural Management, Vol. 11, No. 6, pp. 414-24.*

***Song J., Fagerlund R., Haas T., Tatum B., Vanegas A. (2005)**, Considering pre work on industrial projects. Journal of Construction Engineering and Management, Vol. 131, No. 6, pp. 723-33.*

***UN (1987)**, Report of the World Commission on Environment and Development: Our Common Future, Published as Annex to General Assembly document A/42/427.*

***UN (2002)**, Report of the World Summit on Sustainable Development. Johannesburg, South Africa, United Nations, New York, NY. , viewed 8/01/2017, < http://www.un-documents.net/aconf199-20.pdf.*

***Vanegas J., Pearce A. (2000)**, Drivers for Change: An Organizational Perspective on Sustainable Construction. Construction Congress VI February 20-22, 2000 | Orlando, Florida, United States*

***Wang N., Chang Y., Forsberg P., Nunn C. (2004)**, Lifecycle assessment for sustainable design options of a commercial building in Shanghai. Building and Environment, Vol. 45, pp. 1415–1421.*

***Wang Q., Dulaimi F., Aguria Y. (2004)**, Risk management framework for construction projects in developing countries. Construction Management and Economics, Vol. 22, No. 3, pp. 237-252.*

***Wang Z., Calderon M., Lu Y. (2011)**,Lifecycle assessment of the economic, environmental and energy performance of biodiesel in China. Biomass and Bioenergy, Vol. 35, pp. 2893-2902.*

***Weaver A., Pope J., Saunders A., Lochner A. (2008)**, Contributing to sustainability as an environmental impact assessment practitioner. Journal of Civil Engineering and Management, Vol. 26, No. 2, pp. 91-98.*

***World Commission on Environment and Development- WCED (1987)**, The Brundtland Report,-pp.35.-Available_at: http://web.env.auckland.ac.nz/courses/geog320/resources/pdf/sustainability/Sneddon_et-al_2006.pdf [Accessed on 3/4/13].*

***Yin R.K. (2002)**, Case study research : design and methods, 3rd edn, Sage Publications, Thousand Oaks, Calif.*

***Younan A. (2011)**, Developing a green building rating system for Egypt. Unpublished Ph.D. thesis, American University, Egypt.*

***Yu C., Kim J. (2011)**, Building environmental assessment schemes for rating of IAQ in sustainable buildings. Indoor and Built Environment, Vol. 20, No. 1, pp. 5-15.*

***Zainul Abidin N. (2010)**, 'Investigating the awareness and application of sustainable construction concept by Malaysian developers', Habitat International, vol. 34, no. 4, pp. 421-6.*

***Zainul Abidin N., Pasquire C.L. (2005)**, 'Delivering sustainability through value management: Concept and performance overview', Engineering, Construction and Architectural Management, vol. 12, no. 2, pp. 168-80.*

***Zeng X., Tam M., Deng M., Tam W. (2003)**, ISO 14000 and the construction industry: survey in China. Journal of Management in Engineering, Vol. 19, No. 3, pp. 107-115.*

***Zhang Z., Yang X., Zhu Y., Wu X. (2005)**, BEPAS—a life cycle building environmental performance assessment model. Building and environment, Vol. 41, No. 4, pp. 669–675.*