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Factors Affecting Sustainable Performance of Construction Projects during Project Life Cycle Phases

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Abstract

Sustainable development (SD) is one of the main challenges faced by the construction industry, which has acquired global attention. Sustainable performance (SP) of a construction project during its life cycle (LC) is considered crucial to achieve the SD. The aim of this paper is to investigate the factors affecting sustainable performance of construction projects throughout project life cycle phases in the Gaza Strip. A total of 53 sustainable factors (economic, social, and environmental sustainable factors) were identified through extensive literature review and confirmed by experts' interviews and a pilot study. These factors are classified in relation to the project life cycle phases; inception phase, design phase, construction phase, operation phase, and demolition phase. A structured questionnaire survey is employed in this study for primary data collection. A total of 119 questionnaires were distributed randomly to engineers working in construction projects in the Gaza Strip to solicit their views regarding the factors affecting sustainable performance of construction projects throughout project life cycle phases. The results revealed that five factors among the top ten factors that impacting the sustainable performance of construction projects are classified under the construction phase, which confirmed that the construction process has the most effect on the projects SP. Three factors are classified under the inception phase, which assured that the inception of a potential project has a considerable effect projects. In addition, one factor was classified under operation phase and one factor was classified under demolition phase. The most common factors affecting the SP of construction project through the overall sustainability elements: reusable/recyclable element, provision of services, energy consumption, water cost, and water pollution assessment. Further studies are recommended to explore how to integrated sustainability concepts into the whole construction process in order to achieve sustainable construction project.

Keywords: *Sustainability; Performance; Construction projects; Life cycle*

1.0 Introduction

Khalfan and Asaad [1] reported that SD referred to the fulfillment of human needs through simultaneous socio-economic and technological progress and conservation of the earth's natural systems. Sustainable world progress is dependent upon continuous economic, social, cultural, and technological processes [2]. The World Commission on the Environment and Development (WCED) [3] stated that SP meets the needs of the present without compromising the ability of the future generations. The main components for sustainability are social, economic, and environmental components [4], whereas its established policies are oriented to balance economic and social systems, and ecological conditions [5].The construction activities have various effects on the environment [6]. The basic effects include energy consumption, dust and gas emission, noise pollution and waste generation. In addition water discharge, misuse of water resources, land misuse and pollution, and consumption of non-renewable natural resources [7, 8].

Sustainable performance (SP) of a construction project during its life cycle (LC) is a main objective to achieve the SD. The environmental impacts of buildings on the LC process had been considered as a key problem facing the construction sector [9,10,11].The assessment of the environmental impact has led to recognize the significant effects of construction activities on SD that led to develop different management approaches [12,6]. The factors affecting SP of construction project can be examined in three main categories: economic sustainability factors (ESF), social sustainability factors (SSF), and environmental sustainability factors (EnSF) [7]. The purpose of this paper is to investigate the factors which affecting sustainable performance of construction projects throughout project life cycle phasesin the Gaza Strip**.** The paper is organized as follows. It starts with reviews of social SD, environmental SD, economic SD, life cycle assessment and environmental impacts of construction activities. The methodology of this research is then presented followed by reporting the results. The paper then closes with discussion and conclusion.

2.0 Sustainable development in the construction industry

In the World Summit on SD (WSSD) in Johannesburg, leaders and representatives of 183 countries reaffirmed sustainability, or SD as a central element of the international agenda [2, 13]. The governments agreed to a wide range of concrete commitments and targets for actions to achieve SD objectives. The sustainability agenda moved further and consolidated and broadened the understanding of SD, particularly the important linkages between poverty, the environment and the natural resources [3]. Hopwood et al. Hopwood et al [14] stated that the widespread rise of interest in, and support for, the concept of SD is potentially an important shift in understanding the relationships between humanity, nature and people. Parkin et al. [15] and Holton [16] reported that awareness and significance of SD has been growing around the world for the last few decades. Many international and national initiatives showed the increasing concern to protect the environment for future generations by adopting SD principles [10, 15, 16].

Scheuer [17] 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. WCED [3] proposed the most widely used definition of SD as it meets the needs of the present without compromising the ability of the future generations to meet their own needs [3]. Akadiri [18] emphasized that for the development to be sustainable, it must take account of social and ecological factors, as well as economic factors. Du Plessis [42] 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. [15] and Bennett and Crudgington [19] presented three essential areas involved in sustainability which are environmental responsibility; social awareness; and economic profitability. Pant et al [20] reported 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 [21] and Bossink [22] considered that SD is a broader concept than sustainability and includes issues of the quality of life and the integration of social, economic and environmental aspects 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 [23]. Other researchers 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 [7, 16, 24, 25, 26]. Hill and Bowen [23] 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… etc.

Economic pillar: ensures financial affordability, employment creation, adopts full-cost accounting, and enhances competitiveness, sustainable supply chain management [23]. 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 [2, 7, 27, 28, 29]. Environmental pillar comprises; waste management, prudent use of the four generic construction resources (water, energy, material and land), avoid environmental pollution… etc. Technical pillar includes, construct durable, functional, quality structure and etc. Some researchers stated that the philosophy of environmental sustainability is to leave the earth in as good or better shape for future generations [19, 30, 31, 3 2, 33].

Previous studies presented several themes for SD; the most famous themes are the Triple Bottom Line (social, environmental and economic issues) and the five capital themes which are: natural capital, human capital, social capital, manufactured capital and financial capital. Other studies referred that SD is all about ensuring a better quality of life for everyone [1, 13, 27]. It was established that sustainability is the integration of the environmental, social and economic systems to improve the quality of life within earth's carrying, regenerating and assimilating capacity [13, 29, 34].

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 [35]. The LCA represents a comprehensive approach to examining the complexities of interaction between the built and the natural environment, through the impact of the environment on an entire building [36, 37]. ISO 14040 [38] and Bragança et al. [39] 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, which include 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 [39]. The LCA process can be used to determine the potential environmental impacts from any product, process, or service [20]. Curran [40], Wang et al. [4], and Gib and Isack [41] reported 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.

The life cycle (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 [20, 31, 42, 43]. 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 predesigned, design, preparing to build, construction, occupation, refurbishment, and demolition. According to Shen et al [7], five major processes are applied to compose a project life cycle, namely, inception, design, construction, operation and demolition. Kibert [44] defined sustainable construction as 'the creation and responsible management of a healthy built environment based on resource efficient and ecological principles'. DETR [45] defined it as achieving 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 [46] 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.

Ahn et al. [12] 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 grow 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 [47].The main challenge for the industry is to reduce the impacts of its activities on the environment and local communities. In order to have a sound and more sustainable construction industry, contract parties must take the leadership role in such transformation [16, 19]. During construction, operation, and deconstruction, homes consume large amounts of energy, raw materials, and water [48]. Homes are responsible for 20 percent of the energy consumed and carbon dioxide emitted in the United States [17, 49]. Kaatz et al. [6] confirmed 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.

Several researchers have presented some 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 [27, 50, 51]. Akadiri an Olomolaiye [52] considered that the construction of buildings is a key negative factor of human impact on the environment. Landman [53] recognized a number of environmental, social, and economic benefits to be obtained from building more sustainably:

- 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.

Zeng et al. [54] recognized that energy conservation, pollution prevention, resource efficiency, system integration and LC costing are very important factors for sustainable construction. Factors which can affect sustainable construction include: at initial phase: a construction project consumes various environmental resources including soil, minerals, water, plants and animals in all their biological and genetic diversity. During the construction phase, typical environmental impacts resulted from constructing a project include air pollution, the emission of sulfur dioxide, and the degradation of water quality, noise pollution, and the generation of solid waste. During its operation, a construction project consumes a vast amount of energy and environmental resources [7, 48, 55]. At the end of a construction project's life cycle, the demolition activities generate a large volume of various construction wastes [17].

Shen et al. [7] developed a framework of SP checklist to help understanding the major factors affecting a project SP across its life cycle. The factors selected to build the framework were mainly from a comprehensive literature review. Chen et al [27] 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 [55] established a LCA approach in a case study from the strategic design of a Flagship Store in Shanghai. Yu and Kim [51] 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.

3.0 Methodology

3.1 Population and sample of the study

The population of the study consists four engineering categories (mechanical engineers, electrical engineers, civil engineers, and architects). The Engineers Association in Gaza Governorates [56] stated that in July (2012) the number of its members was (9211) engineers. The number of engineers who are involved in construction sector was (7241) which is considered the population of this study (Engineers Syndicate statistics, 2013).In this study a table presented by Kotrlik and Higgins [65] will be 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 for this study will be (119) engineers.

Table 1. Minimum sample size for population

Population Size	Margin error 0.03		
	alpha=0.10 t=1.65	alpha=0.05 t=1.96	alpha=0.01 t=2.58
1000	77	110	173
1500	79	112	183
2000	83	119	189
4000	83	119	198
6000	83	119	209
8000	83	119	209
10000	83	119	209

(Source: Kotrlik and Higgins [65])

3.2 Questionnaire design

The questionnaire was designed based on extensive review of previous related studies [4, 5, 7, 27, 33, 41, 47, 50, 57, 58, 59, 60, 62]. Also by conducting 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.

To achieve the objectives of this study, a questionnaire survey that comprises two sections was employed to collect data. Section one**:** participants' general information; 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 two**:** factors affecting the SP of the construction projects. The questionnaire was constructed to investigate the factors influence the buildings' SP during the entire LC of the construction projects. The LC of the project grouped into five phases: concept phase; design phase; construction phase; operation phase; and demolition phase. Every phase consists of three main 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 [7].

Table 2. The Framework of projects SP factors

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			

(Source: Shen et al [7])

Fifty three 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.

3.3 Pilot study

The objective of the pilot study was to test the competency of the questionnaire and the effectiveness of the factors selected to assess SP of buildings in Gaza Strip. The pilot study was conducted by distributing the questionnaire to selected experts (i.e., project managers, office engineers, site engineers, lecturers, and environmentalist). Those experts have extensive experience in the same field of the research. Thirty five 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.

3.4 Validity of the questionnaires

3.4.1 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 consists (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 $\alpha = 0.01$ (p-value < 0.01) or $\alpha = 0.05$ ($0.01 <$ p-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 p-values (Sig.) are less than 0.01. Therefore, the spearman correlation coefficients of all factors is significant at $\alpha=0.01$. It can be said that the selected factors are consistent and valid to measure what it was set to.

3.4.2 Structure validity

Internal consistency (structure validity) is the second statistical test that used to test the validity of the questionnaire's structure. It will test 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 phases, for factors' impact on SP 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 of impact on SP

Phase	Inception	Design	Construction	Operation	Demolition	Total
Correlation	0.56	0.66	0.81	0.70	0.59	
P- Value (Sig.)	0.00	0.00	0.00	0.00	0.00	
Number	35	35	35	35	35	35

3.4.3 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 6). It was found that P-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 6. Spilt half method and Cronbach's alpha result

Phase	Split Half Method	Cronbach's Alpha	Number of factors
Inception	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

3.4.4 Data processing and analysis

In this study, ordinal scales were used. Ordinal scale is a ranking or a rating data that normally uses integer in ascending or descending order. Five-point 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. Based on Likert scale, the following scale is considered: (1) very low impact factors, (2) low impact factors, (3) moderate impact factors, and (4) high impact factors and (5) very high impact factors. 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 sign test is used to test the null hypothesis that the median of a distribution is equal to some value (The hypothesized value is the middle of the used Likert scale equals 2.5). It can be used in place of a one-sample t-test in parametric tests. If the P-value (Sig.) is smaller than or equal to the level of significance $\alpha = 0.05$, then the mean of a paragraph is significant. On the other hand, if the P-value (Sig.) is greater than the level of significance $\alpha = 0.05$, then the mean a paragraph is insignificantly different from a hypothesized value, which is 2.5.

3.5 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. 38.3% (41) were contractors' respondents and 3% (2.8) were from others institutions. The findings also, show 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. The (53) identified factors are classified into (5) phases:

inception phase, design phase, construction phase, operation phase, and demolition phase. The factors of each phase are classified into three sub-groups factors, factors under the economic sustainable factors- ESF, factors under social sustainable factors- SSF, and factors under environmental sustainable factors- EnSF. Table 7 presents the classification of these factors.

Table 7. Classification of factors affecting project SP during the LC five 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			

3.5.1 Factors affecting project SP during inception phase

Thirteen factors were considered 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).

Economic sustainability factors (ESF- I)

The results presented in Table 8revealed that the “Finance plan” is the highest ranked factor by the respondents, with weighted mean equals (58.85%) and P-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 =2.94). The weighted means for the four factors of the economic sustainable of the inception phase were ranged from (58.85%) for “finance plan” to (56.67%) for “project and business scale”. This indicated that these factors have moderate impact on SP of building in Gaza Strip. This agreed with the socioeconomic background of the sustainable construction in Gaza Strip. There is a lack of sustainable culture and the lack of knowledge of the SP in Gaza Strip. The respondents’ perceptions showed that economic sustainability factors do not play a significant role to attain the SP of the project inception phase. This result is not consistent with Adetunji et al [29], Ekins et al. [34] and Hisham [13] outcome.

Social sustainability factors (SSF- I)

The results revealed that "Workers' health and safety assessment" is ranked the highest by the respondents with weighted mean equals (61.14%) and P-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 =3.05). "Community amenities" factor was ranked second with weighted mean equals (60.94%) and P-value = 0.00, which is smaller than the level of significance α = 0.05. The sign of the test is positive; the mean of this factor is significantly greater than the hypothesized value (mean =3.04). Jaillon [50] reported that enhanced occupational health and safety is one of the benefits of applying sustainable construction, which gives a good impact on local economy

Table 8. Weighted means and ranks of factor impacting SP at inception phase

Factors affecting project SP during 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	2.83	0.00	56.67	10	3
Effects on local economy	Projects served both the local economy and took advantage of the infrastructure in the local economy to generate economic benefits	2.83	0.00	56.67	11	4
Capital budget	The capital budget defined to planning and controlling project total cost	2.91	0.00	58.24	6	2
Finance plan	The finance plan defined and planned for projects finance schedule, for example, when, how, and how much to finance	2.94	0.00	58.85	5	1
SSF- I : Social sustainability factors						
Employment	Projects implementation able to provide local employment opportunities.	2.87	0.00	57.45	9	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.	2.88	0.00	57.67	8	3
Community amenities	Projects providing community amenities for the harmonization of new settlements and local communities.	3.04	0.00	60.94	3	2
Workers' health Safety assessment	The assessment of safety conducted to identify any future safety risks to the public and project users.	3.05	0.00	61.14	2	1
EnSF-I: Environmental sustainability factors						
Ecology preservation	Projects avoiding as much as possible the irretrievable impacts on the surroundings from implementing project.	2.82	0.00	56.44	12	4
Air Pollution assessment	Examining the potential air pollution from the proposed project and its impact on the local climate	3.06	0.00	61.36	1	1
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.	2.89	0.00	57.82	7	3
Noise assessment	Examining the potential noise pollution du ring both project construction and operation phases.	2.99	0.00	59.81	4	2
Waste generation	Examining the waste generation at both project construction and	2.77	0.00	53.45	13	5

Table 8. Weighted means and ranks of factor impacting SP at inception phase

Factors affecting project SP during inception phase		Mean	P-Value	Weighted mean	Total Rank	Group Rank
assessment	operation phases.					

Environmental sustainability factors (EnSF-I)

"Air Pollution assessment" is ranked as the most impact factor under this group. It has relatively a high impact on SP at the inception phase with weighted mean equals (61.36%), and P-value=0.00, which is smaller than the level of significance α=0.05. The sign of the test is positive. The mean of this factor is significantly greater than the hypothesized value (mean=3.73). Noise assessment and water pollution assessment have a moderate weighted mean and were ranked in the 2nd and the 3rd position under this group. This result is in line with Weaver et al. [2] findings which indicated that the environmental sustainability factors at the inception phase are very important to SP assessment.

3.5.2 Factors affecting project SP during project design phase

Table 9. Weighted means and ranks of factors impacting SP during design phase

Factors affecting the project SP during project 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.	2.95	0.00	59.03	3	2
Standardization	The standard dimension in design specifications in layout was taken in consideration.	3.02	0.00	60.59	1	1
Materials choice	The economy, durability and availability for material selection were taken in consideration.	2.91	0.00	58.27	6	3
SSF-II: Social sustainability factors						
Safety design	The design considers emergencies such as fire, earthquake, flood, radiation, and eco-environmental accidents.	2.75	0.00	53.10	9	2
Security consideration	The design considers installation of security alarm and security screen.	2.93	0.00	58.78	4	1
EnSF-II: Environmental sustainability factors						
Designer	The designer knowledgeable of energy savings and environmental issues is good.	2.80	0.00	56.16	7	4
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.	2.90	0.00	58.10	8	3
Environmentally conscious design	Incorporation of all environmental considerations into project design for construction, operation, demolition, recycling, and	3.02	0.00	60.58	2	1

Table 9. Weighted means and ranks of factors impacting SP during design phase

Factors affecting the project SP during project design phase		Mean	P-Value	Weighted mean	Total Rank	Group Rank
	disposal have been applied.					
Modular and standardized design	The module and standard components have been used to enhance build ability and to reduce waste generation.	2.92	0.00	58.43	5	2

Economic sustainability factors (ESF- II)

The economic sustainability group consists of 3 factors. Standardization was ranked in the highest with weighted mean equals (60.59%), and P-value = 0.00, which is smaller than the level of significance α = 0.05. The mean of this factor is significantly greater than the hypothesized value (mean=3.02). It can be noticed that its weighted mean is slightly higher than the moderate range. As illustrated in Table 9, consideration of life cycle cost, and materials choice factors have a moderate weight. This reflected lack of attention by the targeted engineers of the economic sustainable factors at the design phase, which contrasts with findings from other researches, for example; Jaillon and Poon [5] and Chen et al. [27] ensured that the economic factors especially material consumption and durability were significant factors in this phase.

Social sustainability factors (SSF – II)

The social sustainability group consists of 2 factors. The results showed that "security consideration" is ranked in the highest with weighted mean equals (58.78%), and acceptable P-value= 0.00 and mean. They are located at the moderate range. Safety design factor was ranked the second with weighted mean value =53.10. Khalfan [16] stated that these factors have a significant impact on SP of the construction projects. Kim et al. [62] emphasized the importance of these factors to reach the SP goals; the findings from this study showed that, these factors did not play a significant role in project's SP at the design phase. This reflects a shortcoming in the social issues at the design phase, due to the lack of the designers' knowledge of sustainable issues.

Environmental sustainability factors (EnSF –II)

The environmental sustainability group comprises 4 factors. The weighted mean of the factors surveyed under this group was ranged from the highest weighted mean value of (60.58) % for "environmentally conscious design" to the lowest weighted mean value of (58.27%) for "designer". This indicates that engineers in the Gaza Strip have a moderate knowledge about the environmental issues at the design phase, which identified as crucial factors that impact on SP in other research, for example, Yu Kim [51]and Chen et al. [27] emphasized the environmental consideration at this phase and its positive impact on SP. Abd Hamid and Kamar [5] ensured that designer knowledge and skills affect the environmental issues at this scale.

3.5.3 Factors affecting project SP during project construction phase

The construction phase comprises 15 factors that classified under three sub-groups as following: (5) factors are grouped under the economic sustainable factors (ESF–II), (6) factors are classified under the social sustainable factors (SSF–II) and (4) factors are grouped under the environmental sustainable factors (EnSF –II).

Economic sustainability factors (ESF -III)

The results illustrated in Table 10 show that all factors under economic sustainability group, were given close rates. However, “energy consumption” factor is ranked at the first position among economic sustainability factors that affect the construction phase’s with weighted mean equals (63.00%), P-value= 0.00. Therefore, all factors, which are classified under this group, have a high weighted means. These findings showed that the economic factors have a significance impact the SP of the construction projects at the construction phase.

Social sustainability factors (ESF –III)

“Public awareness” is ranked at the first position among other factors in this group, with weighted mean equals (60.95%), and acceptable P-value, and Mean= 3.04. This result is in line with AbdHamid and Kamar [5] conclusion. “Improvement of infrastructure” factor has got the lowest weighted mean value in this group (50.34%). These findings indicate a lack of attention among the engineers regarding the social sustainability at the construction phase, which are not consistent with Song et al [61] findings, who said that the improvement of infrastructure must be taken into consideration at the design phase.

Table 10. Weighted means and ranks for factors impacting SP during construction phase

Factors affecting project SP during construction		Mean	P-Value	Weighted mean	Total Rank	Group Rank
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.	3.00	0.00	60.19	8	4
Materials cost	Using of the materials was costly.	3.05	0.00	61.13	5	3
Energy consumption	Using various types of energy such as electricity, oil, gas, and coal was costly.	3.15	0.00	63.00	2	1
Water cost	Using water resources and for dealing with surface water, and ground water was costly.	3.09	0.00	61.90	3	2
Site security	Various types of measures for protecting the site safety have been used.	3.00	0.00	60.00	1	5
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.	2.95	0.00	59.02	2	2
Working conditions	Safety measures, facilities, and insurance for working staff were applied.	2.81	0.00	56.35	4	3
Public awareness	Provision of warning boards and signal systems, safety measures and facilities for the public were applied.	3.04	0.00	60.95	9	1
Improvement of infrastructure	Provisions of better drainage, sewage, road, message, heating, and electrical systems were applied.	2.51	0.00	50.34	5	4

Table 10. Weighted means and ranks for factors impacting SP during construction phase

Factors affecting project SP during construction		Mean	P-Value	Weighted mean	Total Rank	Group Rank
EnSF-III: Environmental sustainability factors						
Noise pollution	Extreme noise and vibration induced from project operation.	3.02	0.00	60.40	10	5
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.	3.04	0.0	60.99	6	3
Recyclable/renewable contents	Renewable materials such as bamboo, cork, fast-growing poplar, and wheat straw cabinetry, which are reproducible, were used.	3.06	0.00	61.35	4	2
Reusable/recyclable element	Building components, rubble, earth, concrete, steel and timber were reused.	3.36	0.00	67.38	1	1
Workers' health and safety	Site hygiene and the provision of health care and safety were emphasized.	3.04	0.00	60.96	7	4
Legislation	Environmental protection law and regulations on construction activities was taken in consideration.	2.90	0.00	58.02	13	6

Environmental sustainability factors (ESF –III)

"Reusable/recyclable element" was ranked at the first position of environmental sustainability factors at the construction phase with weighted mean equals (67.38%). This indicated that this factor has a moderate impact the SP from the perception according to the respondents view. This is not in agreement with Ghumra et al. [64] and Song et al. [61] findings who considered it as a main environmental indicator.

3.5.4 Factors affecting project SP during project operation phase

Seven factors were considered in the operation phase. Two factors are classified under the economic sustainable factors (ESF– IV), two factors under the social sustainable factors (SSF–IV) and three factors are classified under the environmental sustainable factors (EnSF–IV) (Table 11).

Economic sustainability factors (ESF –IV)

The impact of two factors that classified under the economic group factors on the operation phase was investigated in this study. Those are, "Local economy", which was ranked at the first position with weighted mean equals (56.95%). The other factors is "Training costs" with weighted mean is around the same value. The two factors had a moderate weighted mean. This reflected a shortcoming in engineers' knowledge about the economic factors importance at the operation phase. These results disagreed with Shen et al. [7]; Adetunj [29]; and Shelbourn et al. [49] who stated that the economic sustainability is required to ensure financial affordability to the intended beneficiaries and the project benefits. Chen et al. [7]; Riley et al. [2] and Weaver et al. [28] argued the economic SD as its consist of sub-themes, such as investment in people and this achieve by training courses conducted for employees to improve the quality of human resources.

Social sustainability factors (ESF –IV)

"Provision of services" is ranked in the 1st position with weighted mean value equal (66.29%). The other factors have similar mean values. This indicated that the social factors are important factors at this phase. Khalfan [16] confirmed these results; he indicated that improving living standard to local communities must be considered. Parkin et al. [15] stated that facilities must be saved to serve the users of the building at the operation phase to achieve the social dimension of sustainability.

Table 11.Weighted means and ranks for factors impacting SP during operation phase

Factors impacting SP during operation phase		Mean	P-Value	Weighted mean	Total Rank	Group Rank
ESF-IV: Economic sustainability factors						
Training costs	Training courses conducted for employees to improve the quality of human resources.	2.81	0.00	56.31	7	2
Local economy	The project benefits economically the local economy.	2.84	0.00	56.95	4	1
SSF-IV: Social sustainability factors						
Provision of services	Provisions for improving living standard to local communities were considered.	3.31	0.00	66.29	1	1
Provision of facilities	Beneficial spaces and facilities were saved to involve in the development of local communities.	3.00	0.00	60.00	2	2
EnSF-IV: Environmental sustainability factors						
chemical wastes	Chemical wastes and organic pollutants did not release to water ways.	2.82	0.00	56.54	6	3
Water pollution	Projects releases of chemical wastes and organic pollutants to water were curing.	2.84	0.00	56.86	5	2
Waste generation	There are no negative impacts from projects operations to flora, fauna, and ecosystems.	2.96	0.00	59.24	3	1

Environmental sustainability factors (ESF –IV)

Three factors are classified under the environmental factors at the operation phase. "Waste generation" is ranked in the highest, which reflects the engineers' unawareness of the importance of the environmental factors impact on SP at the operation phase. This is not in line with Jaillon and Poon [50] who considered that waste generation has a significant factor, which affect the sustainability at this phase. Loftness [48]; and Shen et al. [57] recognized the impact caused by construction activities chemical wastes on the environment occurs throughout a project's life cycle but they ensured that mainly the most chemical wastes exists at the construction phase.

3.5.5 Factors affect project SP during project demolition phase

This phase consists of nine factors. Three factors are classified under the economic sustainable factors (ESF–V), three factors under the social sustainable factors (SSF–V), and three factors are classified under the environmental sustainable factors (EnSF–V) (Table 12).

Economic sustainability factors (ESF –V)

"Waste disposal cost" was ranked at the first position with weighted mean equals (59.81%). This reflects a moderate attention to the economic issues at the demolition phase. Shen et al. [7] emphasised the importance of waste disposal cost in the SP at demolition phase. Blismas and

Wakefield [33] considered these factors as important factors affecting the SP of project LC at the demolition phase.

Social sustainability factors (ESF –V)

The "Operational safety", with weighted mean (60.95%), is ranked at the first position in this group. All factors in this phase have moderate impact on SP of the engineers' perceptions. These finding are not in agreement with Chen et al.[27]; Jaillon and Poon [50] findings, who presented several benefits of applying sustainable construction, including occupational health and safety.

Table 12. Weighted means and ranks for factors impacting SP during demolition phase

Factors impacting SP during 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.	2.87	0.00	57.58	4	3
Energy consumed for operating demolition	Crushing, transporting and relocating operation consumes large amounts of energy.	2.90	0.00	58.04	8	2
Waste disposal costs	The waste loading and unloading, transportation, charges for disposals costly.	2.99	0.00	59.81	4	1
SSF-V: Social sustainability factors						
Communicatio n to the public	Promotion on the public awareness of the project demolition and the possible impacts to the public were considered.	3.02	0.00	60.40	3	2
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.	3.04	0.00	60.95	2	1
Job opportunity	The projects demolition saved jobs opportunities during project demolition for site work, transportation and disposal.	2.96	0.00	59.22	7	3
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.	2.98	0.00	59.61	6	2
Special waste treatment	Special treatment given to toxic materials, heavy metals, radioactive chemicals released from demolition.	2.88	0.00	57.67	9	3
Waste	Recycling and reclaiming of	2.99	0.00	59.81	5	1

Table 12. Weighted means and ranks for factors impacting SP during demolition phase

Factors impacting SP during demolition phase		Mean	P-Value	Weighted mean	Total Rank	Group Rank
recycling and reuse	useful materials such as steel, brick, glass, timber, and some equipment.					

Environmental sustainability factors (ESF –V)

Three factors were considered under this phase. "Waste recycling and reuse is ranked at the first position with weighted mean equals (59.81%). The other two factors weighted means is approximately located under the same range with moderate impact on SP at the demolition phase. This reflects a lack of engineers' knowledge of the importance of the environmental factors impact on the SP of the construction projects. These results are contrast with Bennett and Crudgigton [19] conclusions. Who explained that recycling of waste streams should be 100%, energy should be conserved and energy supplies should be entirely renewable and non-polluting. They added that the use of natural resources efficiently, minimize waste and pollution, protect natural diversity, reduce greenhouse gases' emission, reduce road traffic, good quality of rivers; population of wild birds, building new homes on brown field, reduced waste, effluent generation, and emissions to environment, reduced elimination of toxic substances, etc.

3.6 Conclusion

The purpose of this paper was to investigate the factors affecting sustainable performance of construction projects throughout the project life cycle phasesin the Gaza Strip. The project LC has five phases as it was discussed previously. A total of 53 sustainable factors that classified under three main groups; economic, social, and environmental sustainable factors were identified through extensive literature review and their applicable to the context of this study-Gaza Strip- was confirmed by interviews and a pilot study.

The result revealed that the most ten important factors influencing the construction SP in the holistic process of the project LC in Gaza Strip are: five factors that classified under the construction phase, three factors are classified under the inception phase are, one factor is classified under the operation phase and one factor is classified under the demolition phase. The results indicated that 5 factors among the top 10 factors that impacting the sustainable performance of the construction project are classified under the construction phase, which confirmed that the construction process has the most impact on the project SP. Three factors are classified under the inception phase, which assured that the inception for a potential project plays a critical role on the project's sustainability performance. In addition, one factor was classified under operation phase and one factor was classified under demolition phase. The most common factors affecting the SP of the construction project at the overall LC phases are:

- Reusable/recyclable element: building components, rubble, earth, concrete, steel and timber were reused.
- Provision of services: provisions for improving living standard to local communities were considered.
- Energy consumption: using various types of energy such as electricity, oil, gas, and coal was costly.
- Water cost: using water resources and for dealing with surface water, and ground water was costly.
- Water pollution assessment: examining the potential water pollution from the proposed project, including both surfaces.

The results indicated that the "reusable/recyclable element" as the salient factor affecting the SP of construction in Gaza Strip. It had the highest rank of all phases of the projects LC phases. This is traced to the large amount of construction debris resulted from thousands of destroyed buildings as a result of the wars in the Gaza Strip. In addition, these findings demonstrated the provision of services (i.e. provisions for improving living standard to local communities that were considered), which had the second rank. Improving the living standards is a main factor, which influences the SP of the construction projects.

The factor that was ranked the least among the 53 factors is the "Improvement of infrastructure". It is classified under the construction phase. This indicated the shortcoming of provisions of better drainage, sewage, road, message, heating, and electrical systems applied in Gaza Strip. The findings of this study show a lack of awareness for the importance of the infrastructure provisions that related to the SP of the construction projects. The factors that have the lowest effect on SP of the construction projects are:

- Improvement of infrastructure: provisions of better drainage, sewage, road, message, heating, and electrical systems were applied.
- Safety design: the design considers emergencies such as fire, earthquake, flood, radiation, and eco-environmental accidents.
- Waste generation assessment: examining the waste generation at both project construction and operation phases
- Designer: the designer knowledgeable of energy savings and environmental issues is good.
- Training courses: training courses conducted for employees to improve the quality of human resources.

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