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An empirical study on the impact of lean construction techniques on sustainable construction in the Gaza Strip

دراسة تجريبية لتأثير تقنيات البناء السلس على التشييد المستدام في قطاع غزة

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إقـــــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

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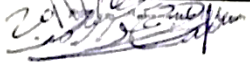
Signature:		التوقيع:
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دراسة تجريبية لتأثير تقنيات البناء السلس على التشييد المستدام في قطاع غزة

An Empirical Study on the Impact of Lean Construction Techniques on Sustainable Construction in the Gaza Strip

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Dedication

This thesis is dedicated to:

My parents, Mohammed Obaid & Fatma Yassin "As a sign of love and Gratitude"

My beloved wife Falasteen

My beloved sons and daughters Ahmed, Mohammed, Hassan and Fatma

My beloved brothers Ayman, Ahmed, Hussam, Mahmoud

My beloved sisters Amal, Mona

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Abstract

Problem: Construction industry faces abundant chronic problems; either as source of wastes and environmental pollutant through its whole life cycle from the design till demolition, or the efficiency problems like delays, overruns, etc. Countries worldwide are trying to overcome those problems in their development visions. On the other hand, researchers suggested that the construction industry should depend on a new green management process that care about the effect of construction industry on environment, society, and solve its efficiency problem as well.

Aim and Objectives: The purpose of this study is to explore the impact of implementation of the lean construction tools\techniques on sustainable construction in Gaza Strip through five main objectives: investigate the benefits of lean and sustainable construction, investigate the barriers to lean and sustainable construction, investigate the integration between lean and sustainable construction, investigate the success factors of lean and its application to sustainable construction, analyse the lean construction tools for enabling sustainability.

Methodology: in this study a quantitative survey was used. After testing and piloting the questionnaire was approved and was distributed to the whole sample (purposive sample) from the target group which consists of engineers who work in construction industry (civil, industrial, architects, electrical, and mechanical). One hundred and twenty-nine copies of the questionnaire were distributed and 100 copies of the questionnaire were received from the engineers with a response rate = 77.5 %. To obtain expressive results, the collected data have been analysed by using the quantitative data analysis techniques (which include Relative important index, Factor analysis, Pearson correlation analysis, and others) through the Statistical Package for Social Science (SPSS) IBM version 25.

Results: The research results showed that the most important benefits are: reduction of waste, environmental improvement and reduction of cost. The strongest barriers are: lack of top management leadership and commitment, lack of long-term perspective and resistance to change. The most important areas of integration are: waste reduction, cost reduction and quality improvement. The most important success factors are: business plan and vision, leadership and fiscal incentives. The most important tools are: last planner system, increased visualization and Kaizen. Factor analysis has clustered the success factors into three groups. The major factor is: top management group; the second factor is: government, company, and stakeholders' group; the third factor is: financial, employees, and regulations group. Finally, Pearson correlation analysis asserted that there is a positive relationship between lean construction tools and between each of lean sustainable benefits, barriers, area of integration and success factors.

Conclusions & Recommendations: This research contributes to lean and sustainable construction knowledge and understanding. It is of the studies that contributes meaningfully to consider lean construction tools impact on sustainable construction in Gaza strip and explores into lean and sustainable construction benefits, barriers, areas of integration and success factors as perceived by construction engineers. This study can provide a reference for lean and sustainable construction status quo in Gaza strip.

الملخص

مشكلة الدراسة: تواجه صناعة التشييد مشاكل مزمنة متعددة، إما كمصدر للنفايات والملوثات البيئية من خلال دورة حياتها الكاملة من التصميم حتى الهدم، أو مشكلة الانجاز مثل التأخير، التجاوزات، إلخ. تحاول دول العالم التغلب على تلك المشاكل في رؤاهم التنموية. من ناحية أخرى، اقترح الباحثون أن صناعة البناء يجب أن تعتمد على عملية الإدارة الخضراء الجديدة التي تهتم بتأثير صناعة التشييد على البيئة والمجتمع، وكذلك حل مشكلة الكفاءة. كان الهدف من هذه الدراسة هو استكشاف تأثير استخدام ادوات/ تقنيات التشييد المرن على التشييد المستدام في قطاع غزة من خلال خمسة أهداف رئيسية: التحقق من فوائد التشييد المرن والمستدام، والتحقيق في الحواجز التي تحول دون التشييد المرن والمستدام، والتحقيق في التكامل بين التشييد المرن والمستدام، والتحقق من عوامل النجاح في الاستخدام والتطبيق للبناء المستدام، ودراسة اسهام أدوات التشييد المرن من أجل تمكين الاستدامة.

المنهجية: تم استخدام المسح الكمي في البحث. تم اعتماد الاستبانة وتم توزيعها على العينة بأكملها (عينة مستهدفة) من المجموعة المستهدفة. تم توزيع 129 نسخة من الاستبانة وتم استلام 100 نسخة من الاستبانة من المستجيبين بمعدل رد = 77.5٪. ومن أجل استخلاص نتائج ذات معنى، تم تحليل البيانات التي تم جمعها باستخدام تقنيات تحليل البيانات الكمية (والتي تتضمن المؤشر النسبي المهم، تحليل العوامل، تحليل ارتباط بيرسون، وغيرها) من خلال الحزمة الإحصائية للعلوم الاجتماعية IBM (SPSS) الإصدار 25.

النتائج: أشارت نتائج الدراسة إلى ان أهم الفوائد هي: التقليل من النفايات، وتحسين البيئة وخفض التكلفة. أقوى العوائق هي: عدم وجود قيادة من الإدارة العليا والالتزام، وعدم وجود منظور على المدى الطويل ومقاومة التغيير. أهم مجالات التكامل هي: تقليل النفايات، وخفض التكاليف وتحسين الجودة. وأهم عوامل النجاح هي: خطة العمل، والرؤية، والقيادة، والحوافز الضريبية، وأهم الأدوات هي: نظام المخطط الأخير، وزيادة التصور، وكايزن. قام التحليل العاملي بتجميع عوامل النجاح في ثلاث مجموعات، العامل الرئيسي هو: مجموعة الإدارة العليا، والعامل الثاني هو: الحكومة والشركة ومجموعة المستفيدين؛ العامل الثالث هو: المجموعة المالية، والموظفين، واللوائح. وأخيراً، أكد تحليل ارتباط بيرسون أن هناك علاقة إيجابية بين أدوات التشييد المرن وبين كل من فوائد التشييد المرن والمستدام، والعوائق، ومجالات التكامل وعوامل النجاح.

الخلاصة والتوصيات: ستضيف هذه الدراسة إلى المجموعة الحالية من المعرفة حول التشييد المرن والمستدام في جميع أنحاء العالم. وتعد هذه الدراسة من الدراسات التي تساهم بشكل كبير في النظر في تقنيات التشييد المرن التي تؤثر على التشييد المستدام في قطاع غزة وتحقق في فوائده، والعوائق، ومجالات التكامل وعوامل النجاح كما يراها مهندسو الإنشاءات. يمكن أن توفر هذه الدراسة توثيقًا مرجعيًا عن حالة التشييد المرن والمستدام في قطاع غزة.

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List of Abbreviations

ANOVA	ANOVA Analysis of Variance
CI	Continuous Improvement
CFA	Confirmatory Factor Analysis
EFA	Exploratory Factor Analysis
FA	Factor Analysis
JIT	Just-in-Time
KMO	Kaiser-Meyer-Olkin
LC	Lean Construction
LPS	Last Planner System
PCA	Principal Component Analysis
PDCA	Plan-Do- Check-Act
SPSS	Statistical Package for the Social Sciences
SCi	Sustainability Construction index
SC	Sustainable Construction
SCM	Supply Chain Management
TPM	Total Productive Maintenance
TQM	Total Quality Management
TFV	Transformation Flow View
UK	United Kingdom

Chapter 1

Introduction

Chapter 1

Introduction

As part of the world, Gaza strip is suffering from the environmental pollution resulting from construction sites. Since construction works are considered the most waste production amongst all other kinds of works. The investigation of the impact of lean construction tools on sustainable construction is deemed crucial. Since the influence of lean construction tools in sustainable construction cannot be over stressed.

Japan introduced the term of lean and it was converted to lean construction for use inside construction. Lean construction (LC) was pioneered by Koskela along with other researchers (Ogunbiyi, Goulding, & Oladapo, 2014). LC is a continuously developing concept that makes the construction process more effective (Koranda, Chong, Kim, Chou, & Kim, 2012). The fundamental difference between lean manufacturing and lean construction lies in production line assembly (Koranda et al., 2012).

The concept of sustainability is broad. It uses resources effectively to sustain the tri-pillars of sustainability: environment, economy and society. It deals with attitudes and judgment of the people. Sustainability encourages less energy consumption, reuse and recycling, and other mechanisms in order to preserve the natural resources and make less harm to the environment. Thus, it sustains the environment for future generations.

1.1 Background and context

The common aims and objectives show that lean and sustainability have wide range of integration (Ogunbiyi et al., 2014). Both lean construction and sustainable construction objectives at waste reduction (Koranda et al., 2012). The introduction of environmental and social matters as new values can make the lean construction a good approach to sustainable construction (Bae & Kim, 2008).

The major amount of resources is consumed by construction. sustainable development needs that the environmental burdens caused by construction to be mitigated in order to remedy our environment (Huovila & Koskela, 1998). Built

environment along with construction works have a destructive effect on the natural environment, health, and economy; hence, the construction industry has the ability to enhance sustainability practices (Nahmens & Ikuma, 2011).

The majority of construction projects in the Gaza Strip are suffering from inefficiencies, large variability and low productivity and thus wasting time, money and other resources. In this study, we will show that there is an impact of some lean construction tools on sustainable construction in Gaza construction industry in order to promote sustainability and eventually satisfy customer needs. According to the global consideration of sustainability and the environment which has been increasingly emerged, it's the time for us to start thinking about using lean construction techniques more efficiently. The current situation and its future consequences necessitate the adoption of practical approaches that enhance sustainable construction and apply baseline conceptual culture in accordance with national requirements and needs.

1.2 Aim and Objectives

1.2.1 Research Aim

To study on the impact of lean construction techniques on sustainable construction in the Gaza Strip.

1.2.2 Research Objectives

The main objectives of this study are:

1. To explore the benefits of implementing lean construction techniques on sustainable construction;
2. To identify the area of integration between lean and sustainability;
3. To investigate the barriers to lean construction and sustainable construction;
4. To investigate the success factors of lean construction and sustainable construction;
5. To investigate the level of contribution of lean construction tools for enabling sustainability.

1.3 Signification

This study will enable professionals who works in the construction industry such as contractors, consultants and owners, and the government agencies, to get a strong understanding view of the status quo of lean and sustainable construction in the Gaza Strip. In addition, this research represents a platform that would allow performing further contributions related to lean and sustainable construction implementation in the Gaza Strip.

1.4 Limitations

In this research, the following areas are discussed:

- ✓ Subject: this study concentrates on lean and sustainable construction tools and techniques. It aims at increasing the knowledge about lean and sustainability in order to identify basic features (lean and sustainability benefits, the integration between them, success factors and their barriers) this will pave the way for adopting lean and sustainability in projects by stakeholders in the construction industry. Towards this aim, more than 150 studies from all over the world were included in rigorous literature review to identify basic factors.
- ✓ Methodology: A quantitative survey was used to measure the objectives of the research. The questionnaire included all the factors retrieved from previous studies in the field, and by collecting the responses and analyzing it, the objectives of the research have been realized.
- ✓ Location: the research focused on construction industry in Gaza strip in Palestine. All of the five governorates (North, Gaza, Middle, Khan Younis and Rafah) were included in the survey.
- ✓ Target group: target group was the engineers in the construction industry (civil, industrial, architect, electrical, and mechanical). One hundred out of 129 copies of the questionnaire were valid and complete. Purposive sampling was adopted. Sample size was chosen according to a statistical equation to achieve 95% confidence interval.

1.5 Research Design

The following steps were adopted in the design of this research

- ❖ Set the problem, define it, make aim and objectives. Then choose research plan, approach and technique.
- ❖ Make rigorous literature review on the field and focus on the more recent studies.
- ❖ Develop a questionnaire founded on the more recent studies.
- ❖ Arbitrate the questionnaires by academics from different universities.
- ❖ Pilot study was done by selecting 30 engineers in different positions and asked them to fill the questionnaire. Then Statistical Package for Social Science (SPSS) was used to perform the validity and reliability tests
- ❖ Having succeeded both tests, the questionnaire was agreed upon and administered to the target group.
- ❖ The questionnaire was analyzed using SPSS.
- ❖ The statistical results were tabled and graphically represented, then they were commented on by the researcher.
- ❖ In the end, conclusions and recommendations were presented to the reader.

1.6 Research Hypothesis

1. There is a significant relationship between lean construction tools and (benefits of lean construction, barriers of lean construction, areas of integration, and success factors to lean construction).
2. There are statistically significant differences attributed to the demographic data of the respondents at the level of $\alpha \leq 0.05$ between the means of their views on the subject of the impact of lean construction techniques on sustainable construction in the Gaza Strip.

1.7 Key questions:

1. What are the benefits of lean and sustainable construction.
2. What are the barriers to lean and sustainable construction.
3. What are the areas of integration between lean and sustainable construction.
4. What are the success factors of lean and sustainable construction.
5. What is the impact of lean construction techniques for enabling sustainability.

1.8 Contribution to Knowledge

This study is going to enrich the present knowledge on both lean and sustainable construction. It is one of the first studies that tackles the impact of lean construction tools on sustainable construction in Gaza strip. This research also investigates the benefits, barriers, areas of integration, success factors of both lean and sustainable construction. This study can be a first step in the long road for the adoption of lean and sustainable construction in Gaza Strip. It will increase the existing knowledge of lean and sustainability.

1.9 Thesis Contents

Chapter 1: Introduction

In which, the background of the research. The research subject will be introduced to the reader, the problem definition and purpose of the research, study aim, objectives, study delimitations, study approach, study limitations, and study contribution to knowledge and the outline of the study. At last, the contents of the thesis are summarized.

Chapter 2: Literature review

This chapter contains rigorous literature review about lean and sustainable construction benefits, barriers, areas of linkage, success factors. Moreover, the contribution of lean construction tools for enabling sustainability. In the end of the chapter, the benefits, barriers, area of integration and success factors for both lean and sustainable construction were arranged in tables according to their sources.

Chapter 3: Research methodology

Which includes a presentation of the methodology used throughout this research. This includes sampling procedure, research design, target group, and statistical tests.

Chapter 4: Results and discussions

In this chapter, the results were presented to the reader. The results of the study were further discussed, commented on and compared with recent studies.

Chapter 5: Conclusion and recommendations

In which, conclusion and recommendations were suggested by the researcher.

Chapter 2

Literature Review

Chapter 2

Literature Review

2.1 Introduction

The term lean was first introduced by the Japanese, then it was converted to a suitable form to be used in construction. Koskela was the first pioneer who introduced the transformation flow view (TFV) theory of production to construction industry. Many countries have benefited from lean construction around the world like UK, USA, Singapore and turkey (Ogunbiyi et al., 2014).

There is a huge difference between lean manufacturing and lean construction. In manufacturing, there is a production line assembly by which the products move by means of a conveyor system while the equipment stay in place; in this way, the correction of defects in a product will eliminate it from reappearing in any successive product. On the contrary, in construction the equipment move from a place to another, so the elimination of a defect in production system cannot be repeated easily in another place (Koranda et al., 2012).

The first International Conference on Sustainable Construction held in Tampa defined sustainable construction as "the efficient use of resources and ecological principles in order to maintain a healthy built environment" (Kibert, 1994).

Sustainable construction is characterized by thinking as whole considering construction and management of the built environment from a lifecycle viewpoint. It employs construction that does not harm the environment and also operation and maintenance which are environmental friendly (Du Plessis, 2002). Sustainable construction integrates environmental, social and economic concerns into construction practices and strategies (Ogunbiyi et al., 2014). Sustainable construction is similar to lean construction because both of them aim to reduce waste during construction (Koranda et al., 2012).

Many countries around the world have adopted sustainable construction, so we need to adopt it also in Palestine in order to achieve sustainable development in our country

Gaza Strip situation

Gaza Strip is a special case where sustainable construction is a must due to the deteriorated environment and the overpopulation which consumed most of the Gaza strip's resources. Gaza Strip is facing water and energy crisis, so construction needs to be efficient in using these resources.

2.2 Background

Ogunbiyi, et al. (2014) indicated that many benefits are gained from the integration of lean and sustainable construction. According to questionnaire survey they found that improved corporate image and sustainable competitive advantage are - amongst other benefits - achieved due to integration of lean construction and sustainable construction within construction industry. Koranda et al. (2012) found that although sustainability and lean concepts can both lead to a reduction in waste generated during construction, there are still significant differences between these concepts. Bae and Kim (2008) demonstrated that a great deal of sustainable construction can be realized through efficient project management which help reduce upfront costs from a qualitatative viewpoint.

Bashir, Suresh, Proverbs, and Gameson (2010) performed literature review on lean construction showing its contribution in developing sustainable construction. In which, they identified the barriers to sustainable construction and discussed it. They further categorized the barriers into six categories: managerial, attitudinal, technical, governmental, financial and educational. The sustainability studies have been focusing on technical, ecological, and geographical sustainability for many years. This approach neglected the social contradictions which resulted in making the environmental aspect essentially a technical issue (Du Plessis, 2002). Sustainable development can be very successful in construction sector. The implementation of LC principles and making social and environmental values as new goals to achieve can be one of the possible approaches in sustainable development. This can make the benefits of lean construction to the environment not accidental (Bae & Kim, 2008).Vieira and

Cachadinha (2011) conducted a case study in which, they applied LC tools in a construction site so as to study the relationship between LC and Sustainability Construction Index (SCI). Construction sector is one of the largest and most important industrial sectors. On the other hand, it is one of the most polluters (Bae & Kim, 2008).

Jamil and Fathi (2016) investigated various dimensions of sustainable construction and lean construction, where they provided a foundation to link the two techniques in order to reduce resources consumption. Many researchers have considered the benefits of lean and sustainable construction. They found that the main benefits are waste reduction, improvement of environmental quality and health & safety. There are other benefits such as: cost reduction, improved quality and better competitiveness (Ogunbiyi et al., 2014). sustainability and lean concepts define waste and value in a different way. While most large projects can easily justify additional costs, the small projects cannot. Hence, these projects first need economic justification, and simpler approaches, and finally, a clear direction in which to implement both sustainability and lean concepts. The benefits of sustainability and lean concepts cannot be achieved if only a small number of projects use both concepts (Koranda et al., 2012).

Enshassi and Mayer (2005) examined the concepts of sustainable development in construction sector, and highlighted the potential barriers to their application in Palestine. Such as, lack of sustainability knowledge, lack of trained engineers and professionals, lack of regulations that promote sustainable construction, lack of financial incentives, also sustainable construction may raise the cost of the project in the short term. Recommendations were proposed to improve the sustainability of construction sector, such as the beginning of sustainable construction from the design stage by setting out concrete environmental requirements to be abided by all parties involved in the construction activities, the designers should also consider the environmental qualities of construction materials as a starting point in order to achieve the environmental goals of the project, the manufactures should consider the life cycle of their products and the contractors should see that environmental- friendly practices as an aspect of competitiveness.

Lean construction and sustainable construction were seen as separate and independent strategies, where lean considers improving economic standards, while sustainability

considers preserving the environment (Jamil & Fathi, 2016). However, recently it was shown that the two strategies are interdependent as they both aim to waste elimination. Very few studies have been conducted in the field of integration of both strategies.

The construction industry is lagging behind manufacturing by a minimum of ten years. Due to the complexity in construction, new techniques and strategies need more time to be applicable in construction industry. Construction industry uses a fragmented approach rather than integrated approach. Lean construction techniques could be more beneficial to construction industry (Ahuja, 2013).

Ahuja (2013) studied the new concept of lean construction and how its tools affect the construction and operation of sustainable facilities. the productivity of construction industry can be improved by using lean and sustainability techniques. His research proved that lean construction tools and techniques have great contribution to sustainable construction. To achieve his aim, he developed three main objectives: 1. He investigated the application of lean concept in construction, 2. He investigated the application of sustainable construction, 3. He linked both lean and sustainability.

Lean and sustainability benefits have been discussed by many researchers. Benefits such as improved environment and waste reduction were considered the most important (Ogunbiyi et al., 2014). Waste elimination can be considered the clearest area of connection between lean and sustainability. However, lean looks at waste reduction as a way to reduce cost and save time, while sustainable construction looks at waste as a pollutant to the environment that should be eliminated. Similarly, reduced time of the whole project will result in less pollutants to the environments such as, gas emissions. The debate about the link between lean and sustainability is still about the cost reduction when integrating both strategies. Some say that sustainable construction would increase the cost of a project, while others say that sustainable construction would do just the opposite to the whole cost of a project (Ogunbiyi et al., 2014).

Energy efficiency and reducing life cycle cost will undoubtedly enhance the environment. The six basic principles of sustainable construction are: 1. Minimum resource consumption, 2. Maximum resources reuse, 3. Using recycled resources, 4. Preserving the environment, 5. Creating healthy environment, 6. Quality sustainable construction (Koranda et al., 2012). The built environment needs to be healthy, clean

and sustainable in order to preserve the environment for future generations. The bad effects of the built environment can reduce the chance of future generations to survive.

2.3 Sustainable construction definition

Du Plessis (2002) defined sustainable construction as a complete course targeting to return and sustain harmony between the natural and built environments and create settlements that support human dignity and encourage economic equity. The general sustainability is defined as: securing the requirements of existing generation without compromizing the needs of upcoming generations.The last difinition explains all stakeholder's efforts and endeavors to make harmony between the environment and human made buildings.

2.4 Sustainable development

The development of the present without compromizing the future is the main aim of sustainable development. Another aim is to improve the quality of human life without harming the environment. Consequently, environmental, social and economic services can be delivered to all humans without compromizing the ability of the environment to deliver those services (Huovila & Koskela, 1998). As a result, economic and social development will progress.

2.5 Lean construction

Lean construction was adopted from Japan which had used its principles in its manufacturing. Toyota motor company in the 1950's had developed the principles of LC.

2.5.1 Definitions and concept of lean construction

Several definitions of LC were developed in recent studies. There are many definitions of LC:-

Koskela (1992) : The advancement of the new production philosophy in terms of productivity, quality, and solid indicators in practice in order to improve the swift dissemination of the new principles".

Howell and Ballard (1999) : Lean construction is to better realizing customer requirements while using a reduced amount of of everything".

Lapinski, A., Horman, M. and Riley, D (2006): Lean construction is the application of lean manufacturing principles, or lean thinking, to construction industry.

Yahya and Mohamad (2011) : Lean construction delivers customers' needs, manages and improves the construction activities by removing waste in construction flow in order to make things right first time,

2.5.2 The concept of lean construction

LC improves value adding steps and removes non value adding steps like waste. If waste was eliminated from the production line, this will result into decrease in cycle time until reaching certain limits. By means of fine-tuning of machinery and continuous improvement, lean construction can improve value-adding activities. LC will gain popularity after this improvement is realized, and many organizations will compete to involve this new technology.

2.5.3 The principles of lean construction

Lim (2008) and Bashir et al. (2011) discovered there were five principles of lean construction, which are specify value from the customer's view, identify the value stream, make the value creating flow, customer pull at the right time, and persue perfection for continuous improvement. Meanwhile, Cain (2004) outlined four priciples of lean construction. 1st principle is elimination of inefficiency and waste, 2nd end users benefit from low cost, 3rd dealing with certain suppliers, 4th a single point of contact. On the other hand, Salem et al. (2005) suggested five priciples of lean that are applicable to construction industry: waste elimination, continuous improvement, workplace standardization, culture/people and customer focus.

Lean construction principles in construction according to Marhani, Jaapar, and Bari (2012):- 1. Satisfied end users 2. End users benefit from lowering cost 3. Waste reduction 4. Integration with suppliers 5. Clarify responsibility and accountability 6. Establishing improvements by measuring, according to Salem, Solomon, Genaidy, and Luegring (2005) 1. Customer focus 2. Culture/people 3. Workplaces standardization 4. Waste elimination 5. Continuous improvement/built-in quality.

2.5.4 Lean construction tools/techniques

First run studies, last planner, increased visualization, the 5s process and fail safe for quality are some of lean construction tools/techniques. Last planner is a tool that deals with variability in construction. The Last Planner is a person or group responsible for operation planning. The increased visualization tool is about posting various signs around the construction site containing useful information; When workers visualize signs and posters containing vital elements such as: performance targets, workflow and required actions, they will remember them. Daily huddle meetings can help realize employees involvement by means of two-way communication. Employee satisfaction, self-esteem, job meaningfulness and sense of growth will increase with awareness of the project and problem solving involvement along with some training provided by other lean tools. First run studies can be used to redesign vital assignments as a part of continuous improvement effort; and include review work methods and productivity studies by smoothing the different functions involved. These studies usually use graphics, photos and video files to illustrate the work instruction. The 5s tool means five levels of housekeeping which help minimize waste. These five levels are: Sort which means separate needed tools from unneeded ones. Straighten is to arrange tools and materials for easy access. Shine is to clean up. Standardize is to maintain the first 3s. Sustain is conforming to the rules. Fail safe for quality is to generate ideas that alert for potential defects. This tool differs from the concept of quality control which inspects a sample , then dicisions are made after defects already had happened (Salem et al., 2005).

2.6 The benefits of implementing lean construction techniques on sustainable construction

Lean production can be adopted in construction to achieve the same benefits achieved in automotive industry. Koskela (1992) reviewed the constituent elements of lean and its concept. Construction was defined as philosophy of production and the problems faced the practitioners were identified (Koskela, 1992). Lean production has three layers identified by Koskela as follows: -

- Effective production method and waste free
- A general management philosophy
- Tools that improve quality

Koskela (2000) stated that construction should be considered as a process flow rather than conversion activities. The elimination of non-value adding activities such as transporting, waiting and material examination are the benefits of process flow definition. Scherrer et al. (2009) argued that applying lean and obtaining the standards of organizational commitment, information tranparency and employee independence needed to ensure its success is a hard task. The first attempt for an organization to get lean will not always be successful.

LC improves sustainability in construction, that is a method of achieving sustainable construction. Lean construction aims at the elimination of all forms of waste from construction activities in order to be efficient. Recent studies emphasized lean as a tool for resources optimization, safety improvement, working conditions, productivity, and the economical, social, and the environmental outcome (Nahmens, Ikuma, & Khot, 2012). Lean terminology have defined several forms of waste, such as: material, poor safety and processes which are considered as possible wastes that deter the flow of value. The most efficient and cost effective approach is material waste removal which have the potential to encourage sustainable construction. Similarly, LC principles have the potential for creating a sustainable revolution by emphasizing on efficient, waste-free and safe flow, minimized cost, energy and resources consumption, and deliver value for end users (Nahmens & Ikuma, 2009).

Climate change is one of the main problems that face sustainability as recognized in the literature which is considered as one of the main threats to the environment (Change, 2007). Many researchers have emphasized the great contribution of LC on the road to sustainability of the environment. E.g., Huovila and Koskela (1998) considered environmental enhancement, minimization of resources consumption and contamination as the main contribution of LC to sustainable development. Nevertheless, lean construction contribution reaches the economic and social aspects of sustainable developments as well as the environmental aspect. LC might have different outcomes on social, environmental, and economical pillars of sustainable development

2.6.1 The economic, social, environmental benefits of lean construction utilization to sustainability

The environmental, social and economic benefits have been emphasized by many reseaches. Nahmens and Ikuma (2012) case study of modular home building is a good example of assessing the application of LC to improve sustainability. LC tools/techniques served as a platform for improvement in the delivery of sustainable modular houses. The application of the lean approach for the purpose of sustainability in the above-mentioned example is shown in Figure 2.1.

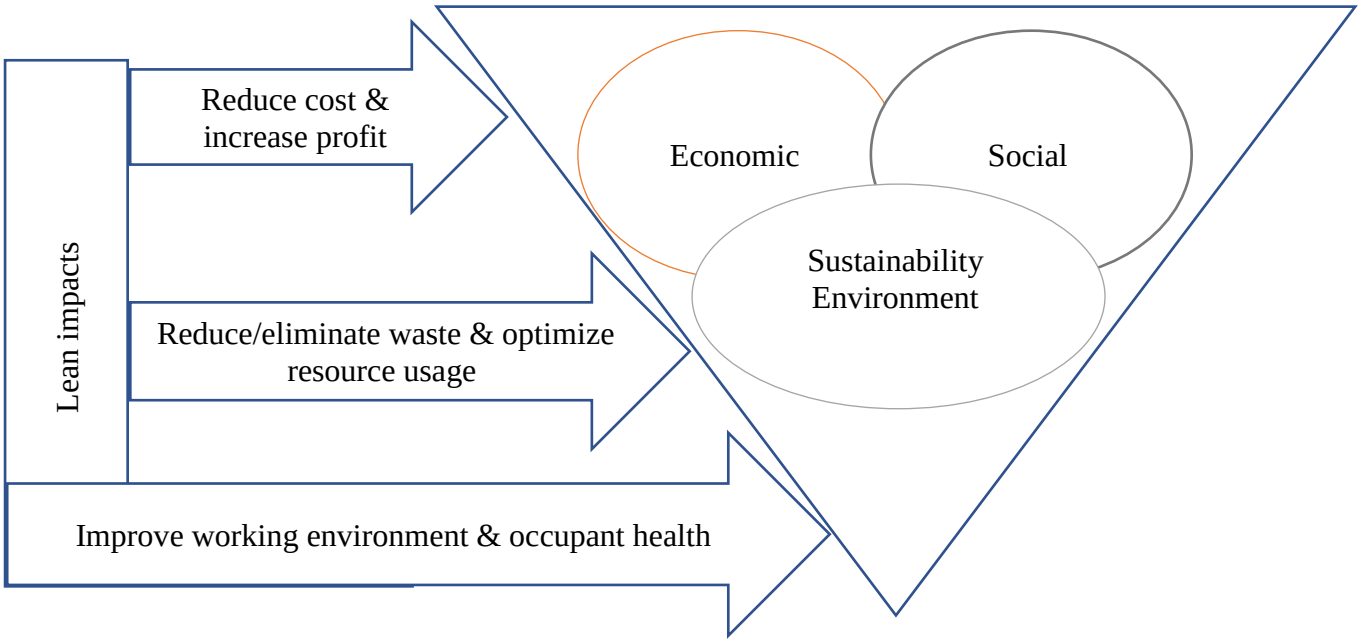

Figure (2. 1): Conceptual model: effect of lean on sustainability

(Nahmens and Ikuma, 2009)

Ogunbiyi et al. (2014) concluded that lean construction affects the Tri-Pillars of sustainable construction, namely, social, economic, and environmental. In his research, he addressed the benefits of implementing lean construction techniques on sustainability. Especially, the improvement of health and safety by using LC techniques, environmental improvement and waste reduction. The benefits of the application of lean tools and techniques are numerous. Economic and social benefits can also be derived from lean application. Although sustainability and lean lead to waste reduction, they are different in their motives. While sustainability aims at environment improvement, lean aims at value generation (Koranda et al., 2012).

According to Bae and Kim (2008) the main benefits of using Lean construction procedures for the purpose of sustainability are categorized as follows:

• Economic viewpoint: possible upfront cost reduction, resource savings,

operating cost reduction, and high-performance ability;

• Social viewpoint: workshop safety, occupant health, community welfare,

loyalty among stakeholders, and external image enhancement;

• Environmental viewpoint: reduced resource exhaustion, pollution inhibition

by eliminating waste, and resource conservation.

Koranda et al. (2012) concluded that the requirements for lean and sustainability initiatives on a project are different, depending on the project size, locations, settings, environment, etc., they also concluded the importance of the project size and the knowledge level of the personnel. The authors suggested that a more detailed study needs to be performed in order to quantify the relationships between sustainability and lean concepts in construction. Unfortunately, the benefits of lean tools on sustainability can't be achieved in the short run, but rather it can be realized in the long run. Thus, construction stakeholders need to be patient in their application of lean tools. Both developed and developing countries should joint their efforts in this regard because we live on the same planet (Du Plessis, 2002).

Despite the fact that LC aims at time and cost reduction and able to achieve direct economic benefits to construction organization, sustainability seeks other benefits, such as decreasing harm to the environment. Since they are different in motivations, lean tools effect on sustainability needs to be assessed. From sustainability perspective, some lean techniques like "look ahead and weekly planning" can help coordinate between different trades in construction site resulting in reduced energy consumption and air emissions (Song & Liang, 2011).

2.6.2 Enhancement of sustainability by lean construction

Nahmens and Ikuma (2009) specified that LC principles contribute to sustainable construction implementation. Sustainable construction (SC) integrates social, environmental and economic concerns with construction industry. SC applys the

principles of sustainability to construction industry starting from the mining of raw materials to design and construction of various structures and infrastructure, until their final deconstruction and management of the resultant waste (Tan, Shen, & Yao, 2011).

The main priciples of LC are increasing the effectiveness of conversion activities and the removal of non-value adding flow activities (Schaltegger & Synnestvedt, 2002). The implementation of LC principles within construction industry will benefit the sustainable construction. Found (2009) proved that LC methodology of waste removal has a significant potential for economic and environmental sustainability. Lean thinking and its application have focused on social and economic characteristics of sustainability. It needs more focus on the environment though. Table (2.1) summarizes the benefits of implementing lean construction techniques on sustainable construction.

Table (2.1): Summary of the benefits of implementing lean construction techniques on sustainable construction

No	Benefit	References
1	Reduction of waste	Salgin, Arroyo, and Ballard (2016); Scherrer (2009);
2	Better organization image	Ogunbiyi et al. (2014)
3	Reduction of cost	Ogunbiyi et al. (2014); (Scherrer et al., 2009); (Bae & Kim, 2008)
4	Environmental improvement	Ogunbiyi et al. (2014); (Scherrer et al., 2009); (Bae & Kim, 2008)
5	Reduction in material usage	Ogunbiyi et al. (2014); (Scherrer et al., 2009); (Bae & Kim, 2008)
6	Health and safety improvement	Ogunbiyi et al. (2014); (Scherrer et al., 2009); (Bae & Kim, 2008)
7	Productivity improvement	Ogunbiyi et al. (2014); (Scherrer et al., 2009); (Bae & Kim, 2008)
8	Less water consumption	Ogunbiyi et al. (2014); (Scherrer et al., 2009); (Bae & Kim, 2008)
9	Less energy consumption	Ogunbiyi et al. (2014); (Scherrer et al., 2009)
10	Better employee commitment	Ogunbiyi et al. (2014); (Scherrer et al., 2009)

2.7 Identifying the area of integration between lean and sustainability

Lean and sustainability can be integrated in many areas such as: cost reduction, energy minimization, quality improvement, performance maximization, health and safety

improvement, continuous improvement, value maximization, environmental management and waste reduction. Both lean and sustainability aim at waste reduction but with different approaches.

2.7.1 Lean and sustainability

Construction is considered one of the major and largest industrial sectors, yet it is one of the largest polluters. Construction sector can give great benefits to sustainable development by implementing lean construction tools and techniques by introducing the environmental and social values as new goals to achieve, rather than considering the benefits of LC to the environment as byproducts (Bae & Kim, 2007, 2008).

Bae and Kim (2007); (Bae & Kim, 2008) described how lean construction techniques can benefit sustainable construction as follows:-

Kaizen "Continuous improvement", in Japanese; Kaizen can improve all facets of sustainability; it has a major role in improving construction sector towards sustainable development.

JIT (just in time) tool which can harm and benefit the environment in the same time; it reduces the amount of material waste; minimizes extra stock; the increased transportation of materials can cause extra gas emissions.

VSM (value stream mapping) Visual tool, which illustrates the processes (products and information); allows to recognize the steps that generate waste to eliminate it; VSM is not only used for economic purpose, but also for social and environmental ones, this tool can help in sustainable development by adding the environmental information to the map.

Martínez, González, and Da Fonseca (2011) discovered the relations between lean and sustainability concepts by applying the principles of Morphologic analysis and Cross-impact Matrix. They disposed many construction activities in different scenarios by developing conceptual integration methodology. This methodology can be applied within the life cycle of a construction project.

Scherrer et al. (2009) concluded that Implementing LC and its levels of organizational commitment is not straightforward. LC have significant benefits like process flow improvement, improved corporate image and waste reduction. By integrating lean and

sustainability cost and waste can be reduced along with environmental improvement. Lean and sustainability have many areas of integration. integrating lean and sustainability can benefit both of the two initiatives (Larson & Greenwood, 2004).

Salgin et al. (2016) explored how to reduce construction waste and contribute to sustainability by using lean design methods. They conducted three case studies in three hospital projects in USA and used lean tools/techniques during design. They found that waste reduction can be achieved by using lean design methods. This can benefit sustainability of the environment and reduce harm caused by the built environment to the environment.

Larson and Greenwood (2004) found that substantial resource productivity improvements can be achieved by lean manufacturing which contribute directly to environmental performance gains. Moreover, eco-sustainability share common themes with lean manufacturing.. In other words, lean and sustainability can enhance the strength of both and reduce their weaknesses. The synergy between lean and sustainability has the potential for success.

Lean and sustainability have many areas of integration as identified from their objectives. Both lean and sustainability share waste reduction as a common priority (Koranda et al., 2012). They also share value maximization, environmental management and health&safety etc. (Hall & Purchase, 2006). Also, environmental sustainability will inevitably benefit from lean. Sustainability has value maximization from resource usage as an essential component (Found, 2009). Thus, lean has a connection with sustainability which is reducing non-value adding activities (Womack and Jones, 1996).

There is a need to point out the areas of integration between lean and sustainability as they can be of great benefits to construction industry in Gaza Strip which suffers from frequent delays and reworks which result into harming the environment.

In the following Figure (2.2), Larson and Greenwood (2004), compared the strengths and weaknesses of lean and eco-sustainability.

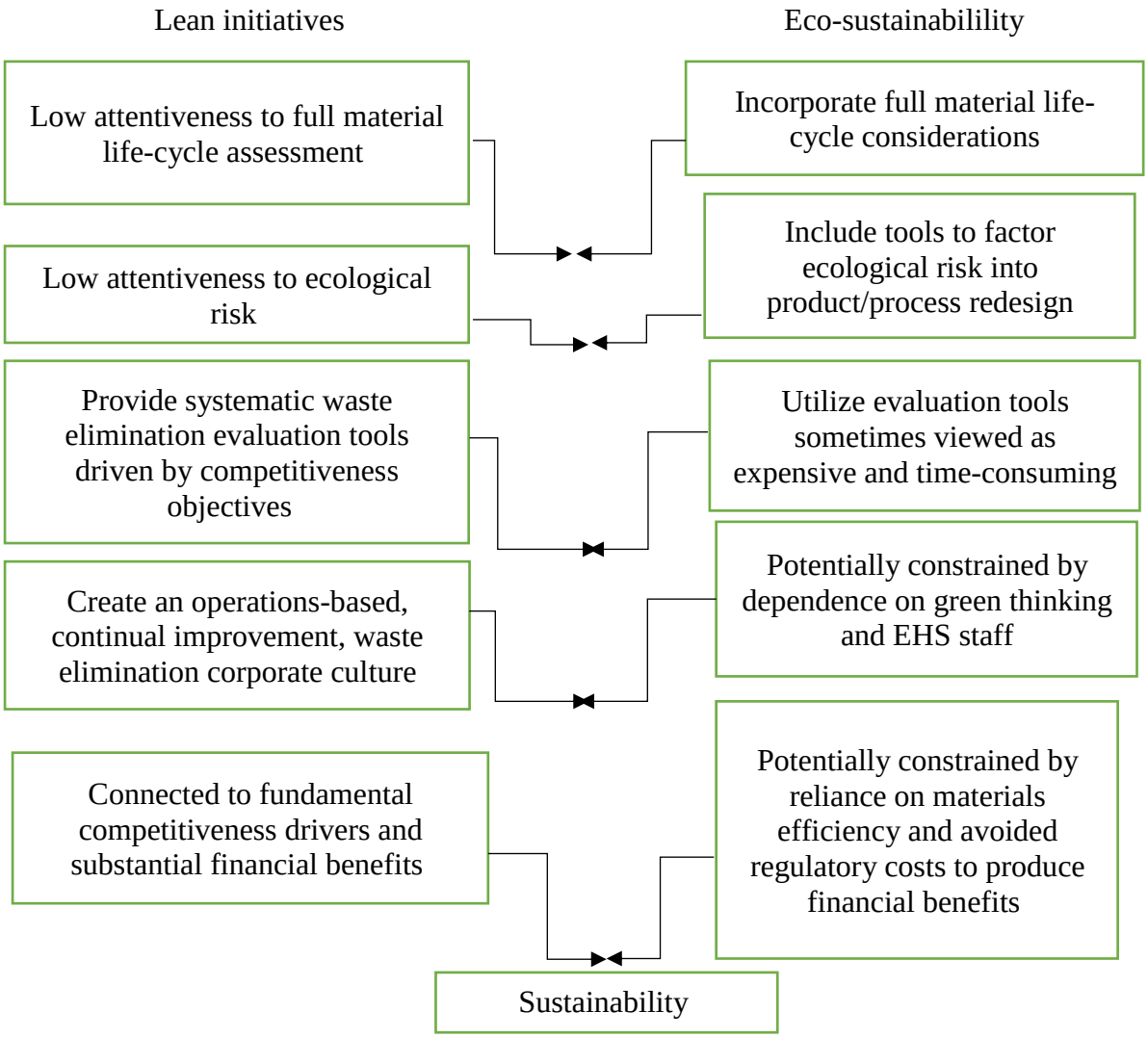

Figure (2. 2): Lean and eco-sustainability initiatives

(Larson and Greenwood, 2004)

LC is the first step to sustainability and any problem can be tackled by its tools. Waste elimination as lean objectives fits sustainability perfectly. Both concept and practice of sustainability and lean are shared by eachother; if we extended lean to much broader objective, we would obtain sustainability (Langenwalter, 2006). Both lean and sustainability share the same viewpoint except that sustainability emphasize on continuous sustainable solutions while lean have goal-oriented thinking. Even more, sustainability is seeking long-term outcomes by means of whole-system thinking. Top-down driven lean and sustainability decisions need to be taken by top management (Friedman, 2008). Eliminating waste and health and safety in construction are

common goals shared by lean construction and sustainability (Bae and Kim 2008; Nahmens and Ikuma, 2009).

2.7.2 From lean to sustainability

Lean is the first step a company can take to grasp sustainability. When teams and individuals throughout an organization ask themselves this question "how does this add value to the customer?" and, "how this can be done better?", lean will work well. Lean also works when resources, time and encouragement are made available for those individuals and teams in order to identify opportunities, investigate them, and implement improvements. Lean will succeed when the top management walks the talk. Top management is also important for sustainability which is focusing on three bottom lines — profitability, people, and the planet, as well as on the economic customer (the one who is buying our product or service). In a longer term, sustainability focuses on life (Langenwalter, 2006).

The eduction is crucial as the starting point for sustainability as well as lean. Education combines all efforts at all levels toward a common goal. The creativity of people at all levels is both a cause and a result of education. Sustainability – unlike lean – digs deeper to help our children in the future. Employees will feel good when they work for a company that cares about the health of people and the planet. Sustainability stands for the right things (Langenwalter, 2006).

Lean can have negative, positive, or neutral environmental impacts of different magnitudes. When a contractor only focuses on economical measures of lean, this will actually result in a negative impact on sustainability. A "green value" is a new term that result from combining both lean and sustainability objectives. To achieve both green and lean values, improved management practices are needed. This improvements can only be realized by using lean concepts which incur little or no additional cost. This way, sustainability can be achieved at low-cost by using "free green" approach. Innovative contracting methods should be applied to make construction works less harmful to the environment. This will help promoting effective waste elimination which is the value of both lean and sustainability. Therefore, the contractor should be involved earlier in design to provide better sustainable design and construction solutions (Song & Liang, 2011).

2.7.3 Area of link between lean construction and sustainability

2.7.3.1 Management of the environment

Practices that promotes sustainability of the environment are an extension of lean philosophy and techniques. Many attempts to minimize waste generation and the harms of construction works on the environment have been emphasized since the construction activities have great potential to damage the environment (Tan et al., 2011). Damages done by construction activities to the environment can be minimized, by using new technologies in construction which can save the environment (Huovila & Koskela, 1998). Klotz, Horman, and Bodenschatz (2007) confirmed that sustainable construction can minimize energy use, and reduce waste and resources consumption, and contribute to healthy environment. This is vital since construction activities are the main consumers of resources. In Europe, more than 40% of energy consumption goes to buildings and more than 40% of waste is generated by construction sector (Huovila & Koskela, 1998).

Environmental concerns are becoming prominent in construction industry. There was a great debate over the linkage between economic and environmental performance in the literature. One of the views sees that the improvement of environmental performance leads to additional costs for the firm which reduce the profits. On the other hand, a second view sees improving environmental performance would save some costs and increase sales. The debate is still going and not concluded so far (Schaltegger & Synnestvedt, 2002).

According to Griffith and Watson (2003), The effective management of the environment has its focus on planning and organizing the site works taking into account their effects on the environment. They also stated that the waste generated by construction works varies by type and quantity into three categories which are (1) reusable like concrete, bricks, asphalt and aggregates; (2) recyclable like wood, glass, plastic, oils and metals; and (3) unusable-unrecyclable like paint and asbestos. Griffith and Watson (2003) Made a framework for management of projects environmentally which takes into consideration the effects of a construction project on the environment.

2.7.3.2 Minimization of waste

Waste is the biggest problem in construction projects. Lean construction techniques have been adopted by many contracting firms in order to reduce all kinds of waste generated by construction activities. Thus, they can enhance their competitiveness in the construction market (Polat & Ballard, 2004). There have been many attempts for reducing waste and reducing the harmful effects of construction works on the environment (Tan et al., 2011).

2.7.3.3 Improving of health and safety

Safety is very important in production process. It relies on the materials, persons and actions and should not be ignored (Nahmens and Ikuma, 2009). To achieve productivity, increased value, reduced costs and improved worker health, poor safty must be avoided in production processes. Worker compensation costs, lost time, and lost productivity can result from lack of safety (Pharmacopoeia, 2007). High accident rates result from lack of safety problems in construction. Industrialized housing industry suffer from high rates of accidents compared to on-site construction (Nahmens and Ikuma, 2009).

According to Rozenfeld, Sacks, and Rosenfeld (2009), the task of safety management in manufacturing plants is much easier than managing it in construction sites due to several factors such as frequent workers movement, working in the open weather, high proportions of unskilled and temporary workers. Rozenfeld et al. (2009) developed (Construction Job Safety Analysis) which is a structured method for risk analysis in construction activities to deal with the difficulties facing construction sites. As the workers move in the site while the physical environment around them is changing constantly, they always face dangerous activities performed by other workers. Construction Job Safety Analysis method is used in construction sites to enhance safety management.

2.7.3.4 Value maximization

Lean construction continually redefines perfection and maximizes value. LC relates value to parts, products and materials which are tangible and can be understood and specified (Koskela, 2004). The collective efforts of design and construction teams produce value that is vital to productivity; and provide an inclusive agenda in which

to work. The discussion and agreement of value is inevitable in the road to achieve better productivity and end-user satisfaction because the end-goal of all construction projects is value (Emmitt, Sander, & Christoffersen, 2005). The scorecard for the organization is value maximization which is not a theory in contrast with stakeholder theory and not a vision. The success in realizing a vision or implementing a strategy is told by the scorecard which will help the participants of an organization be confident about their work (Jensen, 2001). Table (2.2) summarizes the areas of integration between LC and SC.

Table (2.2): Summary of the area of integration between lean construction and sustainable construction

No	Area of integration	References
1	Cost reduction	Dayna and Damien (2005); (Diane, Hannah, Wendy, & Monique, 2010)
2	Energy minimization	Ogunbiyi et al. (2014)
3	Resource management	Ogunbiyi et al. (2014); (Scherrer et al., 2009); (Bae & Kim, 2008)
4	Elimination of unnecessary processes	Ogunbiyi et al. (2014); (Scherrer et al., 2009); (Bae & Kim, 2008)
5	Health and safety improvement	Taubitz (2010)
6	Value maximization	Ogunbiyi et al. (2014); (Scherrer et al., 2009); (Bae & Kim, 2008)
7	Environmental management	(Dayna & Damien, 2005; Diane et al., 2010); Niall and Nick (2015)
8	Waste reduction	Ogunbiyi et al. (2014); (Scherrer et al., 2009); (Bae & Kim, 2008); Diane et al. (2010)
9	Continuous improvement	Ogunbiyi et al. (2014); (Scherrer et al., 2009)
10	Quality improvement	Niall and Nick (2015);Dayna and Damien (2005)

2.8 Investigation of the barriers to lean construction and sustainable construction

As we discussed above the benefits of integration of lean and sustainable construction and the integration between them. Now, we should investigate the barriers in the road to the application of both approaches in construction industry.

2.8.1 Procurement and contracting procedures

The fact that construction industry is fagmented by nature delays the progress inside the industry (Myers, 2005). Fragmented structure of contracting and awarding in Gaza Strip is considered as a barrier to lean and sustainability application inside construction sector. The contracting and awarding procedures are divided by nature which make it hard to apply new technologies and intiatives (Johansen, Glimmerveen, & Vrijhoef, 2002). This problem in construction industry has been identified by many studies (Bashir et al., 2010; Mossman, 2009).

2.8.2 Lack of trust

Supply Chain Management (SCM) has been emphasized by companies which are involved in large construction projects. Tommelein, Akel, and Boyers (2003) defined it as the collaborative work of individuals and a group of companies in a chain of related processes to meet client needs and rewarding all members of the chain. Logistics management and just in time tools form the basic concept of SCM. The majority of material managers view supply chain integration as an important competitive strategy. Yet, a minority of managers believe that SCM comes last in a long list of priorities. They think that their companies cannot build long-term relationships (Fawcett & Magnan, 2001). The research performed by Diane et al. (2010), reviewed the literature about green, lean, and global supply chain, with focus on the concurrent application of these strategic intiatives. It focused on environmentally sustainable supply chains, lean supply chain, and global supply chain. This integrative literature review examined the relationship between these supply chain strategies, including their convergence and divergence.

2.8.3 Lack of agreed methodology for implementation

The lack of standard approaches to implement lean can be considered as one of the most significant barriers; this made a lot of obstacles in the way for companies intending to apply lean (Bernson, 2004). He outlined the obstacles of lean as absence of customization locally, top down implementation model, selecting the appropriate level of detail, and centrally controlled implementation model.

2.8.4 Lack of long-term perspective

The implementation of lean is a long way of continuous improvement. Training and adoption of continuous improvement culture is required along with long term thinking (Mossman, 2009). The integration of lean and sustainability has been postponed by many organizations because it will take long implementation period for the concepts of lean and sustainability. Similarly, businesses need to develop a more long-term focus in order to integrate sustainability into strategic planning. This focus will help them predict advantages and disadvantages (Hitchcock & Willard, 2009). Many parties may not be able to see the benefits of sustainability since most of the benefits brought by sustainability are generally realized in the long term. For example, the government may be in charge for a few years and therefore it will not be there when sustainability benefits are realized. That is why politicians and government might be not interested in investing in sustainable solutions, but rather invest in their short-term solutions. As public clients are used to choose the lowest price, in addition to the lack of funding could also be discouraging factors to the adoption of long term perspective. Most contractors also do not have a long-term perspective. A large proportion of the industry is represented by small contractors who are constrained by very limited resources; therefore, they cannot have long-term perspective while they are looking for short-term profits (Sourani & Sohail, 2011).

2.8.5 Lack of organizational learning

Maintaining the status quo is human nature. Employees always tend to work as they used to in their organizations, and they are always very reluctant to change. In order to increase workers mindfulness, familiarity and willingness of the adoption of environmental management systems, organizations need training and communication (Zutshi and Sohal, 2004). Education is crucial for the application of lean in an organization. Monitoring and evaluation of the current systematic change is needed for training to be successful. organizational learning is needed for effective implementation of continuous improvement program (Wiklund & Wiklund, 2002).

2.8.6 Absence of knowledge and lack of proficiency

The successful implementation of lean is hindered by the use of unsuitable tools and methods (Bashir et al., 2010; Johansen et al., 2002). In order to clearly understand the

lean construction concepts, one should have a full understanding of lean manufacturing concepts. The absence of knowledge and lack of proficiency are the most significant barriers which reflect the poor training and education in relavent techniques. The ideas and knowledge of personnel are the base for advances in the implementation of lean.

2.5.7 Low level of awareness and understanding

The majority of employees face problems in understanding lean concept. The difficulties in understanding lean, the low level of awareness and the absence of an approved definition of lean are the main reasons of these problems (Jensen, 2001; Mossman, 2009). People working in public client organizations, funding organizations, contractors and users have low level of awareness and understanding about sustainability issues. Some of them may not stimulate sufficient levels of demand to advance the agenda to best compliance with regulations (Sourani & Sohail, 2011).

2.8.8 High training costs during employment

Training costs during lean employment can affect the overall profitability of an organization willing to adopt lean. In order to reduce these incidences, the implementation of lean manufacturing should be carefully planned prior to any assignation. This may be carried out by analyzing the anticipated impact at the conceptual implementation phase (Achanga, 2007).

2.8.9 Resistance to change

Management of change cannot be overemphasized in an organization's culture because it is determinant in effective business performance. Moffett, McAdam, and Parkinson (2002) observed that both effective performance and the change management are determined by cultural human elements. Consequently, employees values, customs and attitudes must be altered so as to change an organization's culture. These changes must tackle any characteristic conflict between individual and group interests and the way of organizing power, authority and control within the organization.

Sustainability needs new ways of thinking, methods, practices and attitude. Hence, it necessitates change. But as usually happens when applying a new initiative; there is a resistance to change. This problem may exist at all levels; from client organizations,

all the way through to the supply side and funding organizations (Sourani & Sohail, 2011).

corporate culture needs to be changed by employees involvement to move towards sustainability (Pamela, 2000). Employee involvement is crucial for the adoption of environmentally responsible practices to be successful. This will help in cultural change because organizations are viewed as complex systems of individuals and coalitions, each having its own beliefs and culture. Employees in an organization need to change all beliefs and values assigned to the environment. This will need a good understanding of the obligation for change and to response appropriately. If the employees understand the futurisic business goals, they will commit to their organizations (Walker et al., 2007). Promoting an innovative environment needs organizational culture as a main element. The process of the way things are done is called the organizational culture. The core factor is corporate culture which should also fit the organization structure, leadership style, knowledge strategy systems and the management of employees (Forcadell and Guadillas, 2002). Tidd et al. (2001) found that the question of managing cultural change and overcoming resistance to innovation needs to be addressed since many process innovations represent major changes in the way of doing things.

2.8.10 Lack of effective communication networks and poor teamworking skills

Employees should be involved in the implementation process because involving the general workforce is often neglected by senior management. If knowledge remained in the minds of senior managers, then there will be no change within the organization (Achanga, 2007). Partnering and integrated teamworking course is vital to create effective communication among the parties (Thomas & Thomas, 2008). The growing flexibility to corporate culture change and enhancing knowledge distribution and cooperation within the work group for performance improvement will need effective communication networks, such as through work teams (Bernard, Cary, & Penny, 2003).

2.8.11 Lack of top management leadership and commitment

Lack of top management, leadership and commitment is found by recent studies as one significant barrier to lean construction (Abdullah, Uli, & Tarí, 2009). Also, recent

studies have found that numerous management related barriers, such as: lack of futuristic planning, logistics difficulties, lack of participative management, poor understanding of customer needs and poor planning (Alinaitwe, 2009; Oladiran, 2008). Management support is critical to the application of lean and sustainability. In attaining fruitful application of both concepts, the management of every organization has a central role to play. The head of every company or organization palys a crucial role to set a model for his/her employees to follow in the application of any new concept. Table (2.3) summarizes the barriers to LC and SC.

Table (2.3): Summary of the barriers to lean construction and sustainable construction

No	Barrier	References
1	Procurement and contracting procedures	Myers (2005); Johansen et al. (2002); (Bashir et al., 2010; Mossman, 2009)
2	Lack of trust	Fawcett and Magnan (2001); Diane et al. (2010)
3	Long implementation period	Mossman (2009);Hitchcock and Willard (2009); Sourani and Sohail (2011)
4	Gaps in standards and approaches	Bernson (2004)
5	Lack of proper training	Zutshi and Sohal (2004); Wiklund and Wiklund (2002)
6	Lack of adequate skills and knowledge	(Bashir et al., 2010; Johansen et al., 2002)
7	Human attitudinal issues	(Jensen, 2001; Mossman, 2009);Jamil and Fathi (2016);Sourani and Sohail (2011)
8	Training cost	Achanga (2007)
9	Resistance to change	Moffett et al. (2002);Sourani and Sohail (2011); D. et al. (2000);Walker et al. (2007);Forcadell and Guadillas(2002); Tidd et al. (2001)
10	Poor communications and poor teamworking skills	Achanga(2007);Thomas and Thomas (2008);Bernard et al. (2003)
11	Lack of top management commitment and support	Abdullah et al. (2009); (Alinaitwe, 2009; Oladiran, 2008)

2.9 Investigation of the success factors for lean construction and sustainable construction

Crute, Ward, Brown, and Graves (2003) carried out a case study in the aerospace industry and outlined five factors that are important for lean implementation. The five factors are: timing for performance improvements, company culture, product focus, senior management commitment and change strategy targeted and holistic.

The application of lean philosophy needs developing a culture that produces the participation of everyone in the organization. They need to be trained in the Lean philosophy concepts, as well as the planning, design, implementation and evaluation of the changes. Teams along with top management have to motivate lean in order to make it work best (Radnor & Walley, 2008).

Antony and Banuelas (2002) outlined 7 success factors which were cited in Näslund (2008): 1) organizational structure; 2) effective communication; 3) change management; 4) top management support; 5) monitoring and evaluation of performance; 6) project management; 7) business plan and vision.

Lakshman (2006) pointed out that the top management of an organization need some behaviours to sustain lean principles. Designing and conducting systematic investigation in quality, communicating through both empowering control and examination of teamwork and participation systems are described within the model developed by Lakshman (2006). These behaviours were further summarized as engaging employees, monitoring and evaluation and recognizing success.

Sustainable construction needs commitment of all stakeholders , fiscal incentives and regulations (Serpell, Kort, & Vera, 2013). Awareness, knowledge and interest of stakeholders on sustainable construction are very essential (Abidin, 2010). The role of the government is deemed crucial success factor to promote SC (Shi, Zuo, Huang, Huang, & Pullen, 2013). Regulations are the key success factors to enforce the implementation of SC. Company's awareness is also one of the main success factors that have encouraged the implementation of SC practices (Serpell et al., 2013). Table (2.4) summarizes the success factors of LC and SC.

Table (2.4): Summary of the success factors of lean construction and sustainable construction

No	Success factor	References
1	Change strategy	Crute et al. (2003)
2	Senior management commitment	Crute et al. (2003)
3	Product focus	Crute et al. (2003)
4	Company culture	Crute et al. (2003)
5	Business plan and vision	Antony and Banuelas (2002); Näslund (2008)
6	Top management support	Antony and Banuelas (2002); Näslund (2008)
7	Effective communications	Antony and Banuelas (2002); Näslund (2008)
8	Education and training	Antony and Banuelas (2002); Näslund (2008)
9	Monitoring and evaluation of performance	Antony and Banuelas (2002); Näslund (2008)
10	Leadership and responsibility	Lakshman (2006)
11	Employees engagement	Lakshman (2006)
12	Involvement & commitment of all stakeholders	Serpell et al. (2013)
13	Fiscal incentives	Serpell et al. (2013)
14	Regulations	Serpell et al. (2013)
15	Awareness, knowledge and interest of stakeholder	Abidin (2010)
16	The role of the government	Shi et al. (2013)
17	Company's awareness	Serpell et al. (2013)
18	Guide and benchmarking systems	Lam, Chan, Poon, Chau, and Chun (2010)

2.10 Investigation of the level of contribution of lean construction tools for enabling sustainability

Many researchers discussed the contribution of lean construction tools and techniques for enabling sustainability. Some tools were found to be fruitful through case studies in various literature around the world.

Salem, Solomon, Genaidy, and Minkarah (2006) examined specific lean construction tools in their study. The impact of each tool was evaluated in terms of its impact on the project performance. A new "lean assessment tool" is proposed to quantify the results of lean implementation based on the findings of the study. Six lean construction tools were evaluated using the assessment tool: fail safe for quality, five S's, first-run studies, daily huddle meetings, last planner, increased visualization.

Ansah, Sorooshian, Mustafa, and Duvvuru (2016) identified suitable lean construction tools based on their applicability and ability to control delays in Malaysian construction projects. They identified 40 lean construction tools at first through rigorous literature review. Those tools were further screened to obtain 30 tools that are suitable for application in Malaysian construction industry.

In this research, the most 13 tools that are agreed upon by researchers are summarized in Table (2.5) for further investigation of their contribution to sustainability.

Table (2.5): Summary of the lean tools that can contribute to lean construction and sustainable construction

No	Lean tools	References
1	Last Planner System	Nordin, Deros, Wahab, and Rahman (2012); Aziz and Hafez (2013)
2	Increased Visualization	Alireza and Sorooshian (2014); Nordin et al. (2012); Khan et al. (2013)
3	The 5S (House-keeping)	Alireza and Sorooshian (2014); Nordin et al. (2012); Khan et al. (2013)
4	Error-Proofing (Poka-yoke)	Khan et al. (2013); Alireza and Sorooshian (2014)
5	The 5 Whys	(Alves & Tsao, 2007); Khan et al. (2013)
6	Daily Huddle Meetings	Salem et al. (2005); Khan et al. (2013)
7	First Run Studies	Salem et al. (2005); Khan et al. (2013); Nordin et al. (2012)
8	Just in Time	Khan et al. (2013); Nordin et al. (2012);
9	Value Stream Mapping	Nordin et al. (2012)
10	Six Sigma	Nordin et al. (2012); Alireza and Sorooshian (2014)
11	Concurrent Engineering	Aziz and Hafez (2013)
12	Total Preventive Maintenance	Alireza and Sorooshian (2014)
13	Kaizen	Alireza and Sorooshian (2014)

2.11 Summary

Many studies explained the concept of lean and sustainability. In this study, the definitions and concepts of lean and sustainability as well as their principles were reviewed. Lean and sustainability have various definitions which were reviewed generally.

In addition, sustainability and lean have numerous functions which can contribute to construction throughout its phases from design, during construction until handover and operation. Also, sustainability and lean benefits were reviewed too. The barriers to adopt sustainability and lean in the construction industry were reviewed. The areas of integration between lean and sustainability were reviewed. Success factors were investigated in the previous literature in order to extract the most important factors. Finally, the contribution of LC tools for enabling sustainability was reviewed.

Sustainability and lean have combination of multi definitions. They can be defined as a managed process of using environmental resources wisely for the benefit of a project. At its core is a new method of thinking that contains all the tools to reduce waste and non-value-added removal. It supports collaboration, operation of a project, and management of a construction activity during project cycle. In general, sustainability and lean promise exponential improvements in construction quality and efficiency.

Chapter 3

Methodology

Chapter 3

Methodology

This chapter contains information about the methodology which have been adopted in this research. Research aim and objectives were accomplished by the research methodology. This chapter contains information about research plan, sample size, population, questionnaire design, validity and reliability of the questionnaire, final form of the questionnaire and statistical analysis methods.

3.1 Research aim and objectives

This research investigates the relationship between lean construction and sustainability. In order to achieve this aim, five objectives were outlined:

1.To explore the benefits of implementing lean construction techniques on sustainable construction;

2. To identify the area of integration between lean and sustainability;

3. To investigate the barriers to lean construction and sustainable construction.

4. To investigate the success factors of lean construction and sustainable construction.

5. To investigate the level of contribution of lean construction tools for enabling sustainability.

3.2 Research plan/strategy/framework

The approach that should be taken towards research ethics is determined by the research strategy chosen. Basic ethical principles should be adhered to by all dissertation research at the undergraduate and master's level, this does not mean that the approach taken in this research will be the same as other students. This dissertation adopted a research approach consistent with the selected research strategy. The adopted approach should reflect the research strategy components.

This study used quantitative survey approach to study the impact of lean construction tools and techniques on sustainable construction in Gaza Strip. A questionnaire survey was used to measure the objectives of the study.

Figure (3.1) shows the methodology flowchart

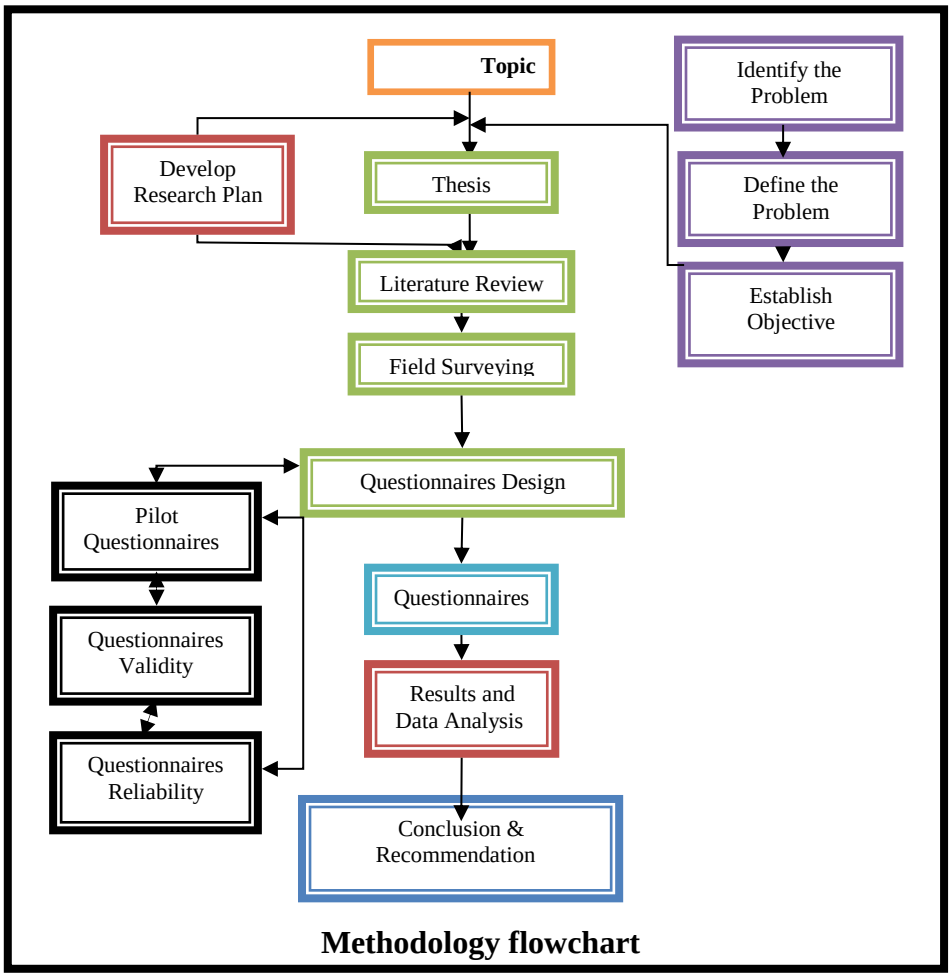

Figure (3.1): Research framework

3.3 Research location

This study was conducted in Gaza Strip. All five governorates (North, Gaza, Middle, Khan Younis and Rafah) were included in the survey.

3.4 Target population

The target group was chosen as the engineers (civil, architects, electrical, mechanical) who work in construction industry and presumed to have knowledge about the new strategies like lean and sustainable construction, in addition to academic engineers presumed to have studied and taught these new techniques in construction. The target group were focused on those who have knowledge about the subject of the research.

3.5 Research sample

Purposive sampling method was used in this research. A purposive sample is a non-probability sample that is selected based on characteristics of a population and the objective of the study. Purposive sampling is also known as judgmental, selective, or subjective sampling (Field, 2009). In this research the whole population is hard to get the exact number of which and it is impossible for the researcher to contact them all. The limited time and resources have led the researcher to adopt the purposive sample instead which brings good results as long as no generalizations will be made about the whole population.

3.6 Data collection

Easterby-Smith, Thorpe, and Lowe (2002), presented a rough formula for calculating sample size (n) in terms of (E) the maximum error required, as shown in Equation 1

$$n = \frac{2500}{E^2} \quad \text{.....Eq (3.1)}$$

This was the same equation used by Ogunbiyi et al. (2014) in a similar study conducted in the UK in which he also used purposive sampling method.

By using a standard error of, say, not more than 5 per cent the minimum sample size would be 100. One hundred and twenty-nine questionnaires were distributed in order to achieve a good degree of reliability and validity in the results. A hundred questionnaires were returned for further analysis. Response rate was calculated as 100/129 * 100 = 77.5% which is considered a good response rate given the fact that both mails, online and face to face questionnaire were used.

3.7 Questionnaire design

The questionnaire took quite a long time in development. The first copy was developed in January 2018 and then it was modified according to peer review and pilot study until it reached its final form in June 2018. The questionnaire consisted of six parts:

- 1st part, was about the demographic data of the respondents;
- 2nd part, assessed the benefits of lean and sustainable construction;
- 3rd part, assessed the barriers to lean and sustainable construction;
- 4th part, assessed the areas of integration between lean and sustainable construction;

- 5th part, assessed the success factors of lean and sustainable construction;
- 6th part, assessed the level of contribution of lean construction tools to sustainable construction.

Apart from the first section which included questions about demographic data of the respondents, the remaining five parts of the questionnaire included close-ended questions with Likert scale. Likert scale is applied as one of the most fundamental and frequently used psychometric tools in educational and social sciences research (Joshi, Kale, Chandel, & Pal, 2015). Five points Likert scale was used in order to get quantified data for further statistical analysis.

3.8 Face validity

Face validity was conducted by contacting 15 experts in lean and sustainable construction in order to get their feedback on the validity of the questionnaire. Face validity, as a measure of a quality of a test, can apparently be established statistically. In addition to having statistical validity, the questionnaire should also appear valid (Nevo, 1985). Face validity serves easing the way respondents understand the questionnaire in order to answer the questions of the questionnaire truly and completely as they did not find difficulties with the layout of the survey. This will help the researcher be sure of the results of his survey.

The fifteen experts have been contacted, only three of them suggested modifications to the questionnaire. Those modifications are summarized in the following Table (3.1).

Table (3. 1): Results of face validity

Name	Specialization	Modifications
Expert A	Ph.D. in construction management	1. The definitions of lean construction and sustainable construction in the beginning of the questionnaire were modified to be more specific and clearer. 2. Item 3 in part1 was deleted which contained information about study place because it is irrelevant. 3. Item 4 in part 1 which asked about specialization, the (other) option was deleted. 4. Item 5 in part 1 which asked about the nature of workplace. The NGO and Other options were deleted. 5. Item 6 in part 1 which asked about the location of workplace was deleted. 6. The title of part 2 was modified to be the benefits of lean and sustainable construction. 7. Item 2 in part 2 was split to 2 items 2,4 reduced waste and reduced cost respectively. 8. The whole items of part 2 were modified to begin with a verb. 9. Item 2 in part 3 was modified to be lack of trust item 1. 10. Items 6,8 in part 4 were deleted. 11. Definitions of lean construction tools were integrated into the items.
Expert B	Ph.D. in construction management	1. Correction of the Arabic translation of the word questionnaire. 2. Decreased the size of the tables to fit into one page. 3. Converted the wording of Likert scale to numbers. 4. Compressing the whole questionnaire to fit into 4 pages by means of formatting text and tables.
Expert C	M.Sc. in construction management	1. Corrected the wording of some questions of the questionnaire. 2. Added item 5(improving health and safety) to part 2(benefits). 3. Added item 2 (increased visualization) to part 6. 4. Added item 10 (six sigma) to part 6.

3.9 Pilot study

After face validity, the Arabic version of the questionnaire was distributed to 33 respondents from the target group and the responses were entered to SPSS version 22 as a pilot study. Pilot studies can serve many purposes. Pilot study aims included assessment of (a) feasibility, (b) adequacy of instrumentation, and (c) problems of data collection strategies and proposed methods. To these they added: (d) answering methodological questions, and (e) planning a larger study (Hertzog, 2008). According to Nieswiadomy and Bailey (2008) 10 respondents or 10% of the whole sample would be adequate as a pilot study sample size.

These tests were conducted as follows:

1. Statistical validity of the questionnaire/ criterion related validity
2. Reliability of the questionnaire by Half Split method and the Cronbach's coefficient Alpha method.

3.9.1 Statistical validity of the questionnaire

Validity reflects whether the question, item or score measures what is supposed to measure (Golafshani, 2003). To test the validity of the questionnaire, two statistical tests were applied. The first test is criterion-related/internal validity test (Pearson test) which measures the correlation coefficient between each item in the field and the whole field. The second test is structure validity test (Pearson test) by testing the validity of each field and the validity of the whole questionnaire. It measures the correlation coefficient between the sum or average of one field and the sum or the average of all the fields of the questionnaire that have the same scale (AbuHamra, 2015; Enshassi, Hamra, & Alkilani, 2018).

Internal validity of the questionnaire was measured by the sample of the pilot study, which consisted of 33 questionnaires. It was done by measuring the correlation coefficients (Pearson test) between each item in one field and the sum of the whole field. Tables in Appendix C from 1 to 5 show the correlation coefficient P-value for each item in each field. The test applied on the parts (2: benefits of lean and sustainable construction, 3: barriers to lean and sustainable construction, 4: areas of integration between lean and sustainable construction, 5: success factors of lean and sustainable construction, and 6: level of contribution of lean construction tools for enabling sustainability) of the questionnaire. Tables C1, C2, C3, and C4, and C5 show the P-

values are less than 0.05, so the correlation coefficients of each field are significant at $\alpha = 0.05$. Thus, it can be said that the items of each field are consistent and valid.

Structure validity test

The second test was structure validity test used to examine the validity of the structure of the questionnaire by testing the validity of each field against the validity of the whole questionnaire. It is performed by calculating the correlation coefficient between each field and the sum or average of the other fields of the questionnaire (AbuHamra, 2015; Enshassi et al., 2018). Table (3.2) shows the P values along with Pearson correlation coefficients which indicate that the fields are valid.

Table (3. 2): Structure validity of the questionnaire

Fields		Sum of all fields
Benefits of lean construction and sustainable construction	Pearson Correlation	.690**
	Sig. (2-tailed)	.000
Barriers to lean construction and sustainable construction	Pearson Correlation	.759**
	Sig. (2-tailed)	.000
Areas of integration between lean construction and sustainable construction	Pearson Correlation	.829**
	Sig. (2-tailed)	.000
Success factors of lean construction and sustainable construction	Pearson Correlation	.900**
	Sig. (2-tailed)	.000
The level of contribution of lean construction tools for enabling sustainability	Pearson Correlation	.826**
	Sig. (2-tailed)	.000

**. Correlation is significant at the 0.01 level (2-tailed).

3.9.2 Reliability test

Reliability is the ability of an instrument to obtain consistent measurement and get the same results each time when conducted under the same conditions or population (Streiner, 2003). Cronbach's alpha reliability (Cronbach, 1951) is one of the most widely used measures of reliability. Cronbach's alpha reliability describes the reliability of a sum (or average) of q measurements where the q measurements may represent q raters, occasions, alternative forms, or questionnaire/test items. When the measurements represent multiple questionnaire/test items, Cronbach's alpha is referred to as a measure of "internal consistency" reliability (Bonett & Wright, 2015). The reliability of the questionnaire was measured with Cronbach's alpha method. The Cronbach's coefficient alpha (Cα) have a normal range between 0.0 and +1.0 and

higher value reflects a higher degree of internal consistency (AbuHamra, 2015; Enshassi et al., 2018). The Cronbach's coefficient alpha (Cα) was calculated for five fields as shown in table (3.3). The values ranged from 0.845 to 0.937 and the overall reliability for all items equals 0.971. As the values is above 0.7, the results indicate high reliability of the questionnaire.

Table (3. 3): Cronbach's Coefficient Alpha for reliability (Cα)

No	Fields	Cronbach's Alpha (Cα)
1	Benefits of lean construction and sustainable construction	0.902
2	Barriers to lean construction and sustainable construction	0.845
3	Areas of integration between lean construction and sustainable construction	0.928
4	Success factors of lean construction and sustainable construction	0.954
5	The level of contribution of lean construction tools for enabling sustainability	0.937
6	All items	0.971

Half Split Method

Half split method can be done by finding Pearson correlation coefficient between the means of odd rank questions with the means of even rank questions for each field of the questionnaire. Then, the results are corrected by using Spearman Brown correlation coefficient of correction. Correction is done by the following equation: Consistency coefficient = 2r/(r +1), where r is the Pearson correlation coefficient. The normal range of corrected correlation coefficient 2r/ (r +1) is between 0.0 and + 1.0 (AbuHamra, 2015).

As shown in Table (3.4), all the corrected correlation coefficients values are between 0.82 and 0.972 and the general reliability for all items equals 0.975. Thus, it can be said that the studied fields were reliable according to the Half-Split method.

Table (3. 4): Split-Half Coefficient method

No.	Fields	Pearson-correlation	Spearman-Brown coefficient	Guttman Split-Half Coefficient
1	Benefits of lean construction and sustainable construction	0.931	0.964	0.964
2	Barriers to lean construction and sustainable construction	0.695	0.82	0.816
3	Areas of integration between lean construction and sustainable construction	0.837	0.911	0.906
4	Success factors of lean construction and sustainable construction	0.945	0.972	0.971
5	The level of contribution of lean construction tools for enabling sustainability	0.867	0.929	0.928
6	All items	0.95	0.975	0.974

3.10 Final form of the questionnaire

Finally, after conducting pilot study and validity and reliability of the questionnaire were tested, the final form of the questionnaire was approved. A cover letter was attached to ensure the security of the information. The English version of the questionnaire is included in appendix A. The Arabic version is included in appendix B.

3.11 Measurements

SPSS was used to analyze the questionnaires received. The following quantitative measures were used for the data analysis:

A. Descriptive statistics

1- The mean
2- Standard deviation
3- Relative importance index (RII)
4- Factor analysis

B. The inferential statistics (bivariate) / test of hypotheses

1. Pearson correlation coefficient
2. The sample independent t-test
3. Analysis of variance (one-way ANOVA)

3.11.1 Relative importance index (RII)

The relative importance index method (RII) was used to determine the ranks of items/ variables as perceived by the respondents in each of part 2, part 3, part 4, and part 5. The relative importance index was computed as (Field, 2009):

$$RII = \Sigma W / (A*N) \quad \text{..... Eq (3.2)}$$

Where:

W = the weighting given to each factor by the respondents (ranging from 1 to 5)

A = the highest weight (i.e. 5 in this case)

N = the total number of respondents

3.11.2 Factor analysis

Factor analysis (FA) is one of research methods used to group many items into few factors which will give better understanding of the data (Chatfield, 2018).

3.11.3 One-way ANOVA test

The analysis of variance, popularly known as the ANOVA, can be used in cases where there are more than two groups. When we have only two samples, we can use the t-test to compare the means of the samples but it might become unreliable in case of more than two samples. If we only compare two means, then the t test (independent samples) will give the same results as the ANOVA (Field, 2009).

Chapter 4
Results and discussion

Chapter 4: Results and Discussion

4.1 Introduction

This chapter contains the analysis and discussion of the results of statistical analysis of the collected valid questionnaires. Response rate was 77.51% as 100 out of 129 valid completed questionnaires have been returned. SPSS version 25 was used to analyse the questionnaires including descriptive and inferential statistical tests. Personal information of the respondents, quantitative analysis, and discussion on the results are included in the following sections.

4.2 Respondents information

The target group of the questionnaire were construction engineers of various specializations related to construction industry. One hundred and twenty-nine questionnaires of survey were distributed. This section includes the personal characteristics of 100 respondents who returned valid questionnaires for study.

This section includes the answers of six questions about the respondent person; gender, educational qualification, specialization, nature of the workplace, job title, and years of experience. Table (4.1) shows background information of respondents.

This personal information was included in the survey to further test whether it had influence on the respondents' answers. The researcher should be very keen in asking personal information because most people are very reluctant to disclose personal information. In this questionnaire the name of the respondent was optional in order to make the respondent more comfortable in answering personal questions. In order to get unbiased results, it should be assured that the responses of the questionnaires do not depend on the respondents' gender, educational level, specialization, nature of the workplace, job title, and years of experience. This was necessary to test the second hypothesis of the research which is:

There are statistically significant differences attributed to the demographic data of the respondents at the level of $\alpha \leq 0.05$ between the means of their views on the subject of the impact of lean construction techniques on sustainable construction in the Gaza Strip.

Table (4.1): Background information of respondents.

Background information	Percent (%)
Gender	
Male	72.0
Female	28.0
Educational qualification	
Bachelor	68.0
Master	23.0
Ph.D.	9.0
Specialization	
Architect	26.7
Civil	70.0
Electrical	-
Mechanical	-
Industrial	3.3
Nature of the workplace	
Consultant	58.7
Contractor	23.9
Owner	17.4
Job Title	
Designer	24.2
Supervisor	17.9
Site engineer	31.6
Project manager	11.6
Academic	14.7
Years of experience	
Less than 5 years	42.2
From 5 to less than 10 years	28.9
10 years and more	28.9

4.2.1 Gender

The percentage of the respondents according to the gender of the person who filled the questionnaire shown in Table 4.1. It shows that 72.0% of the respondents are male, 28% of them are female. This percentage is very close to the actual distribution of males and females in Palestinian construction firms. The differences attributed to gender will be tested as part of the second hypothesis of the research by the end of this chapter.

4.2.2 Respondents educational level

The percentage of the respondents according to the educational qualification of the persons who filled the questionnaire shown in Table 4.1. It shows that 68.0% of them have educational level bachelor, 23.0% of the respondents have educational level

master, and 9.0% of the respondents have educational level Ph.D. These percentages are very close to the qualification's distribution in Palestinian construction firms. Also, the differences attributed to qualification will be tested by the second hypothesis of the research by the end of this chapter.

4.2.3 Specialization

The percentage of the respondents according to the specialization of the persons who filled the questionnaire shown in Table 4.1. It shows that 26.7% of them are architect, 70.0% are civil, and 3.3% of the respondents are industrial. These percentages are very close to the specialization's distribution in Palestinian construction firms. Also, the differences attributed to specialization will be tested by the second hypothesis of the research by the end of this chapter.

4.2.4 Nature of the workplace

The percentage of the respondents according to the nature of the workplace of the persons who filled the questionnaire shown in Table 4.1. It shows that 58.7% of them are consultant, 23.9% are contractor, and 17.4% of the respondents are owner. These percentages are very close to the nature of the workplace distribution in Palestinian construction sector. Also, the differences attributed to the nature of the workplace will be tested by the second hypothesis of the research by the end of this chapter.

4.2.5 Job title

The percentage of the respondents according to the job title of the person who filled the questionnaire shown in Table 4.1. It shows that 24.2% of the respondents are designers, 17.9% are supervisors, 31.6% are site engineers, 11.6% are project managers, 14.7% are academic. These percentages are very close to the job title distribution in Palestinian construction sector. Also, the differences attributed to the job title will be tested by the second hypothesis of the research by the end of this chapter.

4.2.6 Years of experience

The percentage of the respondents depend on the years of experience of the persons who filled the questionnaire shown in Table 4.1. It shows that 42.2% of the respondents have experience less than 5 years, 28.9% of the respondents have experience from 5 years to less than 10 years, 28.9% of the respondents have experience more than 10 years. These percentages are very close to the years of experience distribution in Palestinian construction sector. Also, the differences attributed to the job title will be tested by the second hypothesis of the research by the end of this chapter.

4.3 Benefits of lean construction and sustainable construction

This section contains ten items of benefits. These items were analysed and shown in Table (4.2). In this table: means, standard deviation, t-value, p-value, relative importance index (RII), and ranks were computed.

Results illustrated that the total average for all items in the first field "Benefits of lean and sustainable construction" equal 3.83, T-test 13.02 and the P-value equal 0.000 which is less than 0.05. This means that the respondents have agreed on the high importance of the benefits of lean construction and sustainable construction, and the results are confident. The SD was also used to quantify the amount of variation or dispersion of respondent opinions regarding "benefits of lean and sustainable construction items". As shown in Table (4.2), the average SD were 0.64, which indicates that the respondent's results are consistent and are not spread out over a wider range of values. This means that results are confident. According to Table (4.2)

- P-value = 0.000 < 0.05, and T statistics (13.02) > T critical (1.98), so, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.83) and hypothesized mean (3) on the field of benefits of lean and sustainable construction
- Average mean = 3.83 > 3 (Neutral RII), which means that the importance of benefits of lean construction and sustainable construction is high.
- SD = 0.64, which means that the respondents results are consistent and are not spread out over a wider range of values. So, the results are confident.

Table (4.2): Benefits of lean and sustainable construction

No.	Item	Mean	Std. Dev.	RII (%)	T value	P value Sig.	Rank
A1	Better organization image	3.83	0.96	76.60	8.61	0.000*	6
A2	Reduction of waste	4.16	0.91	83.20	12.79	0.000*	1
A3	Environmental improvement	4.08	0.94	81.60	11.50	0.000*	2
A4	Reduction of cost	4.06	0.95	81.21	11.16	0.000*	3
A5	Health and safety improvement	3.89	1.02	77.78	8.68	0.000*	5
A6	Reduction in material usage	3.55	1.09	71.00	5.07	0.000*	9
A7	Less water consumption	3.57	1.11	71.31	5.08	0.000*	8
A8	Productivity improvement	4.00	0.98	80.00	10.16	0.000*	4
A9	Better employee commitment	3.52	1.04	70.40	5.00	0.000*	10
A10	Less energy consumption	3.66	1.05	73.20	6.31	0.000*	7
All items		3.83	0.64	76.60	13.02	0.000*	

The findings indicated that "Reduction of waste" benefit item (A2) (RII =83.20%; P-value = 0.000; T-value = 12.79; SD = 0.91) has the highest rank in this field.

Figure 4.1 shows the RII of items (A1 to A10). Since P-value here equal 0.000 which less than 0.05, and T statistics = 12.79 > T critical (1.98). So, there is a statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (4.16) and hypothesized mean (3). SD equal 0.91, is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that the results are confident.

Waste reduction also took a high rank in a study in the UK by Ogunbiyi et al. (2014). In which it was ranked 3 with a mean of 3.24. This is a very reasonable rank as waste reduction is one of the primary benefits of lean and sustainable construction. Gaza strip suffers too much from waste management and chronic environmental problems compared to the UK, so it is not surprising that waste reduction took higher rank in this study.

The results also revealed that "Environmental improvement" benefits item (A3) (RII = 81.60%; P-value = 0.000; T-value = 11.50; SD = 0.94) is ranked in the second

position in this field. Since P-value here equal 0.000 which less than 0.05, and T statistics = 11.50 > T critical (1.98). So, there is a statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (4.08) and hypothesized mean (3). SD equal 0.94, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that results are confident.

Environmental improvement was ranked 10 amongst 14 benefits by Ogunbiyi et al. (2014) with a mean 3.16. Here it took a high rank which is more reasonable as environmental improvement is considered very important benefit of lean and sustainable construction. Specially, in Gaza Strip, the environment is very deteriorated due to the Israeli blockade and the chronic shortage of power and fuel which explains the importance of this benefit to Gaza Strip construction industry.

"Better employee commitment" benefits item (A9) (RII = 70.40%; P-value = 0.000; T-value = 5.00; SD = 1.04) was ranked in the last position in this field. Since P-value here equal 0.000 which less than 0.05, and T statistics = 5.00 > T critical (1.98). So, there is a statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.52) and hypotheses mean (3). SD equal 1.04, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that results are confident

Employee commitment also took the least rank (14) by Ogunbiyi et al. (2014) with mean 3.05. Angelis, J., Conti, R., Cooper, C., & Gill, C. (2011) found that lean practices have both negative and positive effects on employee commitment. As most of the respondents are engineers who work in construction firms, they presume that commitment exists already and cannot be considered as a benefit of lean and sustainable construction implementation. Any new technology adoption will be face first by doubt and fear from the employees. This can be explained as the higher level of productivity demanded by the new technology may make them lose their positions if they were found incompetent.

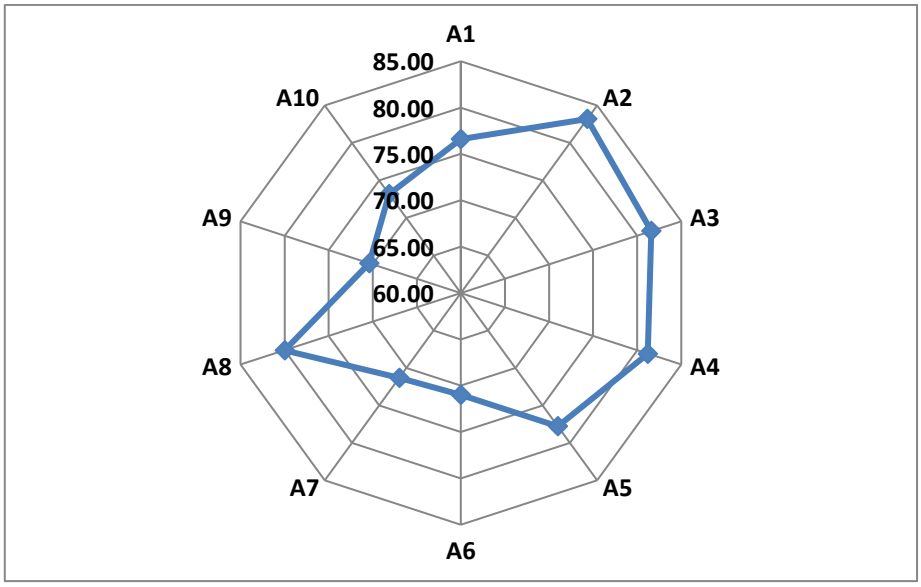

Figure (4.1): RII of items (A1 to A10)

4.4 Barriers of lean construction and sustainable construction

This section contains twelve items of barriers. Table (4.3) shows the outcomes of the statistical analysis of the responses.

Results illustrated that the total average for all items in the second field "Barriers of lean and sustainable construction" equal 3.47, T-test 7.42 and the P-value equal 0.000 which is less than 0.05. This means that members of the study sample believe that there are strong barriers facing lean and sustainable construction, and the results are confident. The SD was also used to quantify the amount of variation or dispersion of respondent opinions regarding "Barriers of lean and sustainable construction items". As shown in Table (4.3), the average SD were 0.63, which indicate that the respondent's results are consistent and are not spread out over a wider range of values. This means that results are confident. According to Table (4.3):

- P-value = 0.000 < 0.05, and T statistics (7.42) > T critical (1.98), so, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.47) and hypothesized mean (3) on the field of barriers of lean and sustainable construction.
- Average mean = 3.47 > 3 (Neutral RII), which means that the importance of the barriers of lean construction and sustainable construction is strong.

- SD = 0.63, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, the results are confident.

The findings indicated that "Lack of top management leadership and commitment" barriers item (B10) (RII =73.80%; P-value = 0.000; T-value = 6.69; SD = 1.03) has the highest rank in this field.

Since P-value here equal 0.000 which is less than 0.05, and T statistics = 6.69 > T critical (1.98). So, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.69) and hypothesized mean (3). SD equal 1.03, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that the results are confident.

Table (4.3): Barriers of lean and sustainable construction

	Item	Mean	Std. Dev.	RII (%)	T value	P value Sig.	Rank
B1	Lack of trust.	3.31	1.10	66.20	2.82	0.006*	12
B2	Procurement and contracting procedures	3.54	0.89	70.80	6.05	0.000*	4
B3	Lack of agreed methodology for implementation	3.52	1.09	70.40	4.78	0.000*	5
B4	Lack of long-term perspective	3.63	1.03	72.60	6.11	0.000*	2
B5	Lack of organizational learning	3.31	1.01	66.20	3.06	0.003*	11
B6	Low level of awareness and understanding	3.43	1.04	68.60	4.15	0.000*	7
B7	Absence of knowledge and lack of proficiency	3.49	1.02	69.80	4.80	0.000*	6
B8	Resistance to change	3.56	1.05	71.20	5.35	0.000*	3
B9	High training costs during employment	3.35	0.99	67.00	3.54	0.001*	10
B10	Lack of top management leadership and commitment	3.69	1.03	73.80	6.69	0.000*	1
B11	Poor team working skills	3.37	0.94	67.40	3.94	0.000*	9
B12	Lack of effective communication networks	3.43	1.11	68.60	3.87	0.000*	8
All items		3.47	0.63	69.40	7.42	0.000*	

The successful implementation of any new strategy needs support of top management. Sufficient time and resources need to be provided by top management to develop active strategy, and handle changes resulting from the implementation process (Bashir et al., 2010). Even though the studies conducted by Abdullah et al. (2009), and Alinaitwe (2009) have recognized lack of top management leadership and commitment as a focal barrier to the implementation of LC, Mossman (2009) thinks that middle management is the problem not the top management. Unlike Ogunbiyi et al. (2014) who found that lack of top management support at the sixth rank amongst eleven barriers.

The results also revealed that "Lack of long-term perspective" barrier item (B4) (RII = 72.60%; P-value = 0.000; T-value = 6.11; SD = 1.03) is ranked in the second position in this field. Since P-value here equal 0.000 which is less than 0.05, and T statistics = 6.11 > T critical (1.98). So, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.63) and hypothesized mean (3). SD equal 1.03, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that the results are confident.

According to Sourani and Sohail (2011), 33% of the interviewees identified lack of long-term perspective as one of the significant barriers. Since most of sustainability benefits are gained in the long term, many stakeholders may not see these benefits and therefore might be reluctant to investing in sustainability.

"Lack of trust" barrier item (B1) (RII = 66.20%; P-value = 0.006; T-value = 2.82; SD = 1.10) was ranked in the last position in this field. Since P-value here equal 0.000 which less than 0.05, and T statistics = 2.82 > T critical (1.98). So, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.31) and hypothesized mean (3). SD equal 1.10, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that the results are confident

Lack of trust is ranked the ninth amongst eleven barriers in Ogunbiyi et al. (2014) study. Figure 4.2 shows the RII of items (B1 to B12).

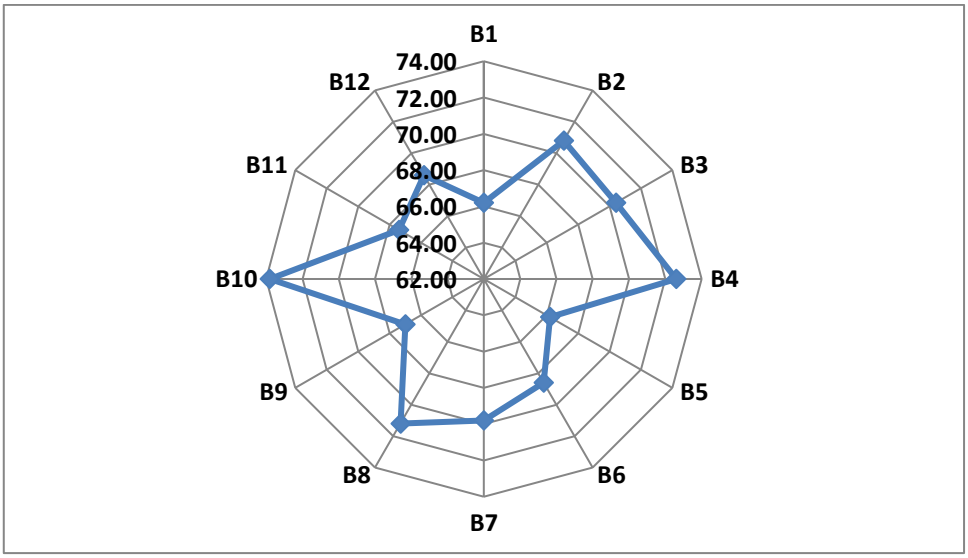

Figure (4.2): RII of items (B1 to B12)

4.5 Area of integration between lean construction and sustainable construction

This section contains ten items of area of integration. Table (4.4) shows the results of the analysis of the respondents' views.

Results illustrated that the total average for all items in the third field "area of integration" equal 3.88, T-test 13.21 and the P-value equal 0.000 which is less than 0.05. This means that members of the study sample believe that the area of integration between lean and sustainable construction is wide, and the results are confident. The SD was also used to quantify the amount of variation or dispersion of respondent opinions with regard to "area of integration between lean and sustainable construction". As shown in table (4.4), the average SD were 0.66, which indicate that the respondent's results are consistent and are not spread out over a wider range of values. This means that results are confident. According to table (4.4):

- P-value = 0.000 < 0.05, and T statistics (13.21) > T critical (1.98), so there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.88) and hypothesized mean (3) on the field of area of integration between lean and sustainable construction.

- Average mean = 3.88 > 3 (Neutral RII), which means that the area of integration is wide.
- SD = 0.66, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, the results are confident.

Table (4.4): Area of integration between lean and sustainable construction

No.	Item	Mean	Std. Dev.	RII (%)	T value	P value Sig.	Rank
C1	Resource management	3.86	1.04	77.20	8.23	0.000*	7
C2	Waste reduction	4.06	0.93	81.20	11.40	0.000*	2
C3	Energy use reduction	3.96	0.86	79.20	11.15	0.000*	4
C4	Elimination of non-value processes	3.56	0.92	71.20	6.06	0.000*	10
C5	Environment improvement	3.87	0.96	77.40	9.06	0.000*	6
C6	Performance maximization	3.75	1.01	75.00	7.44	0.000*	8
C7	Environmental management	3.70	1.04	74.00	6.73	0.000*	9
C8	Cost reduction	3.97	0.95	79.40	10.24	0.000*	3
C9	Health and safety improvement	3.94	1.00	78.80	9.37	0.000*	5
C10	Quality improvement	4.12	0.91	82.40	12.27	0.000*	1
All items		3.88	0.66	77.60	13.21	0.000*	

The findings indicated that "quality improvement" area of integration item (C10) (RII =82.40%; P-value = 0.000; T-value = 12.27; SD = 0.91) has the highest rank in this field.

Since P-value here equal 0.000 which is less than 0.05, and T statistics = 4.12 > T critical (1.98). So, there is a statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (4.12) and hypothesized mean (3). SD equal 0.91, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that results are confident.

Quality improvement is one of the principal pillars of lean construction. If it gets such a high rank by the respondents, then they think that lean and sustainable construction are not separable. Unlike the study performed by Ogunbiyi et al. (2014), quality improvement ranked sixth amongst eleven areas of linkage between lean and sustainable construction.

The results also revealed that "waste reduction" area of integration (C2) (RII = 81.20%; P-value = 0.000; T-value = 11.40; SD = 0.93) is ranked in the second position in this field. Since P-value here equal 0.000 which is less than 0.05, and T statistics = 11.40 > T critical (1.98). So, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (4.06) and the hypothesized mean (3). SD equal 0.93, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that the results are confident.

Waste reduction is the greatest area of integration between lean and sustainable construction. Since lean construction is a system that is focused on the elimination of wastes thereby facilitating process streamlining and waste reduction. In the recent days, the need for environmental consciousness is very much realized. The environmental waste is regarded as the ninth waste. Waste reduction also ranked first by Ogunbiyi et al. (2014) amongst eleven areas of linkages between lean and sustainable construction.

"Elimination of non-value processes" area of integration item (C4) (RII = 71.20%; P-value = 0.000; T-value = 6.06; SD = 0.92) was ranked in the last position in this field. Since P-value here equal 0.000 which less than 0.05, and T statistics = 6.06 > T critical (1.98). So, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.56) and hypothesized mean (3). SD equal 0.92, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that the results are confident

Elimination of non-value processes also ranked low (8^{th}) amongst eleven areas of linkage between lean and sustainability by Ogunbiyi et al. (2014). Non-value elimination from processes is more attributed to lean construction and the direct effect of it on sustainability is rather seen by experts.

Figure (4.3) shows the RII of items (C1 to C10).

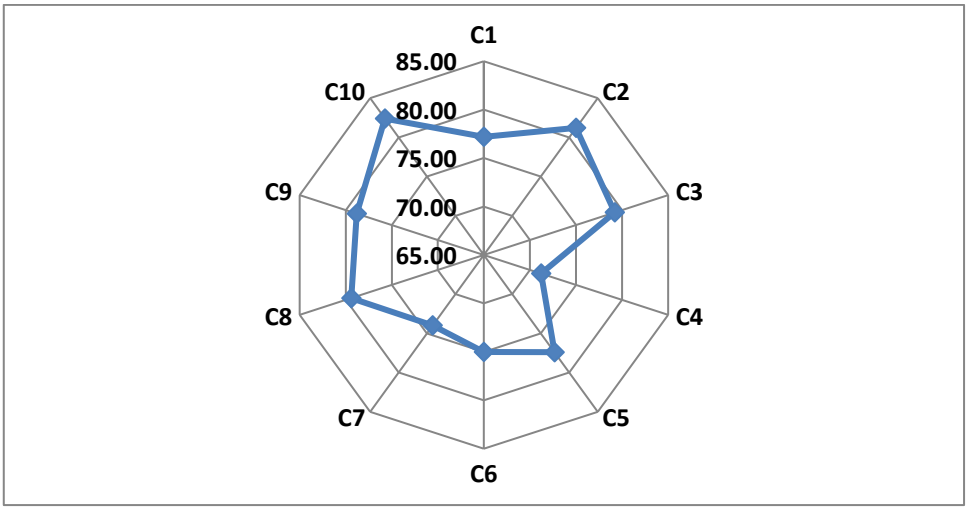

Figure (4.3): RII of items (C1 to C10)

4.6 Success factors of lean and sustainable construction

This section contains eighteen items of success factors. Table (4.5) shows the results of the analysis of the respondents' views.

Results illustrated that the total average for all items in the fourth field "success factors" equal 3.86, T-test 11.77 and the P-value equal 0.000 which is less than 0.05. This means that members of the study sample believe that success factors of lean and sustainable construction are strong, and the results are confident. The SD was also used to quantify the amount of variation or dispersion of respondent opinions regarding to "success factors". As shown in table (4.5), the average SD was 0.73, which indicate that the respondent's results are consistent and are not spread out over a wider range of values. This means that results are confident. According to Table (4.5):

- P-value = 0.000 < 0.05, and T statistics (11.77) > T critical (1.98), so there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.86) and hypothesized mean (3) on the field of success factors.
- Average mean = 3.86 > 3 (Neutral RII), which means that the proposed success factors are important.
- SD = 0.73, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, the results are confident.

Table (4.5): Success factors of lean and sustainable construction

No.	Item	Mean	Std. Dev.	RII (%)	T value	P value Sig.	Rank
D1	Change strategy	3.98	1.03	79.60	9.47	0.000*	6
D2	Senior management commitment	3.93	0.99	78.60	9.42	0.000*	8
D3	Product focus	3.73	0.96	74.60	7.59	0.000*	14
D4	Company culture	3.76	1.06	75.20	7.20	0.000*	12
D5	Business plan and vision	4.07	0.92	81.40	11.58	0.000*	1
D6	Top management support	3.98	0.98	79.60	9.95	0.000*	5
D7	Effective communications	3.73	1.07	74.60	6.81	0.000*	15
D8	Education and training	3.96	0.94	79.20	10.19	0.000*	7
D9	Monitoring and evaluation of performance	3.99	1.07	79.80	9.27	0.000*	4
D10	Leadership	4.02	1.03	80.40	9.86	0.000*	3
D11	Employees engagement	3.86	0.96	77.20	8.92	0.000*	10
D12	Commitment of all stakeholders	3.75	1.00	75.00	7.51	0.000*	13
D13	Fiscal incentives	4.04	0.95	80.80	10.92	0.000*	2
D14	Regulations	3.89	0.99	77.80	8.96	0.000*	9
D15	Awareness, knowledge and interest of stakeholder	3.72	1.00	74.40	7.23	0.000*	16
D16	The role of the government	3.62	1.14	72.40	5.46	0.000*	18
D17	Company's awareness	3.65	1.07	73.00	6.09	0.000*	17
D18	Guide and benchmarking systems	3.86	1.10	77.20	7.81	0.000*	11
All items		3.86	0.73	77.20	11.77	0.000*	

The findings indicated that "Business plan and vision" success factors item (D5) (RII =81.40%; P-value = 0.000; T-value = 11.58; SD = 0.92) has the highest rank in this field.

Since P-value here equal 0.000 which less than 0.05, and T statistics = 11.58 > T critical (1.98). So, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (4.07) and hypothesized mean (3). SD equal 0.92, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that the results are confident.

Business plan and vision was suggested by Antony and Banuelas (2002), and it ranked first as effective planning by Ogunbiyi et al. (2014) as the most significant success factor to implementing lean and sustainability with RII=86%. This reflects the aspect

of vision generation by the organization. There has to be a vision of a fully integrated lean sustainable organization from the outset, a realistic timescale for making changes and embedding lean and sustainability help for staff to understand how lean and sustainability initiatives may impact upon the organization, and evaluating the degree to which a process and customer view already exist within the organization.

The results also revealed that "Fiscal incentives" success factor item (D13) (RII = 80.80%; P-value = 0.000; T-value = 10.92; SD = 0.95) is ranked in the second position in this field. Since P-value here equal 0.000 which is less than 0.05, and T statistics = 10.92 > T critical (1.98). So, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (4.04) and hypothesized mean (3). SD equal 0.95, it is not far from zero, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that results are confident.

Fiscal incentives was suggested by Serpell et al. (2013), yet he did not include it in his survey in Chile construction.

"The role of the government" success factors item (D16) (RII = 72.40%; P-value = 0.000; T-value = 5.46; SD = 1.14) was ranked in the last position in this field. Since P-value here equal 0.000 which less than 0.05, and T statistics = 5.46 > T critical (1.98). So, there is a statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.62) and hypothesized mean (3). SD equal 1.14, it is not far from zero, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that the results are confident.

The role of the government ranked 2nd amongst nine success factors by Shi et al. (2013) in a study performed in China. The respondents probably do not expect much from the government in the Gaza Strip due to the political and economic circumstances. Figure (4.4) shows the RII of items (D1 to D18).

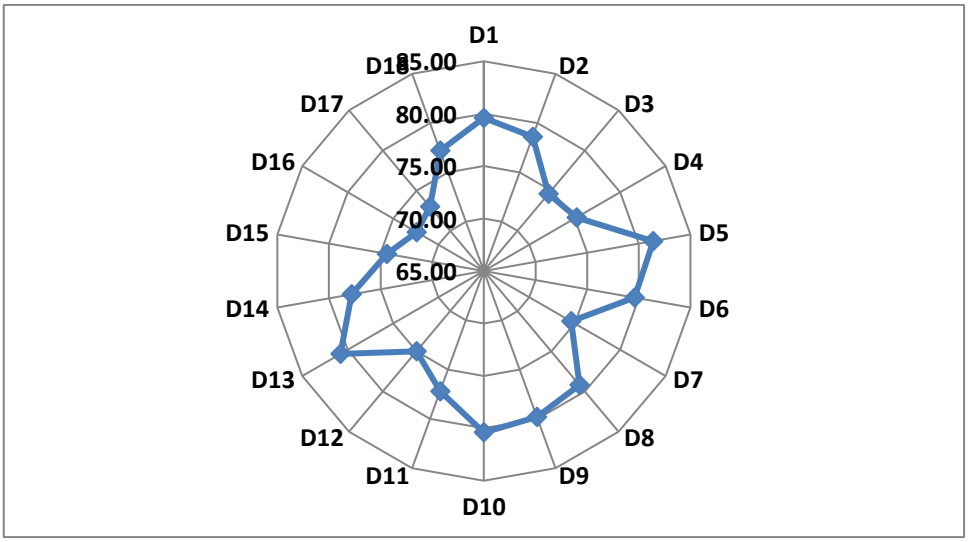

Figure (4.4): RII of items (D1 to D18)

4.7 Level of contribution of lean construction tools for enabling sustainability

This section contains thirteen items of lean construction tools for enabling sustainability. Table (4.6) shows the outcomes of the analysis of the 13 items according to the respondents' views.

Results illustrated that the total average for all items in the fifth field "level of contribution of lean construction tools for enabling sustainability" equal 3.70, T-test 10.36 and the P-value equal 0.000 which is less than 0.05. This means that members of the study sample believe that the level of contribution of lean construction tools for enabling sustainability is high, and the results are confident. The SD was also used to quantify the amount of variation or dispersion of respondent opinions with regard to "level of contribution of lean construction tools for enabling sustainability". As shown in table (4.6), the average SD were 0.68, which indicate that the respondent's results are consistent and are not spread out over a wider range of values. This means that the results are confident. According to table (4.6):

- P-value = 0.000 < 0.05, and T statistics (10.36) > T critical (1.98), so there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.70) and hypothesized mean (3) on the field of level of contribution of lean construction tools for enabling sustainability.

- Average mean = 3.70 > 3 (Neutral RII), which means that level of contribution of lean construction tools for enabling sustainability is high.
- SD = 0.68, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, the results are confident.

Table (4.6): Level of contribution of lean construction tools for sustainability

No.	Item	Mean	Std. Dev.	RII (%)	T value	P value Sig.	Rank
E1	Last Planner System	3.81	0.98	76.20	8.25	0.000*	2
E2	Increased visualization	3.82	0.95	76.40	8.66	0.000*	1
E3	The 5S (House-keeping)	3.71	0.98	74.20	7.26	0.000*	8
E4	Error-Proofing (Poka-yoke)	3.72	0.95	74.40	7.55	0.000*	6
E5	The 5 Whys	3.36	1.04	67.20	3.46	0.000*	13
E6	Daily Huddle Meetings	3.65	1.01	73.00	6.44	0.000*	11
E7	First Run Studies	3.62	1.03	72.40	6.00	0.000*	12
E8	Just in time	3.66	1.04	73.20	6.37	0.000*	10
E9	Value stream mapping	3.70	0.85	74.00	8.27	0.000*	9
E10	Six Sigma	3.72	1.01	74.40	7.16	0.000*	7
E11	Concurrent engineering	3.80	0.92	76.00	8.69	0.000*	4
E12	Total preventive maintenance	3.74	0.93	74.80	7.98	0.000*	5
E13	Kaizen	3.81	1.06	76.20	7.64	0.000*	3
All items		3.70	0.68	74.00	10.36	0.000*	

The findings indicated that "Increased visualization (making operations and quality requirements clearer using charts, displayed schedules, paintings, designated inventory and tool locations)" level of contribution item (E2) (RII =76.40%; P-value = 0.000; T-value = 8.66; SD = 0.95) has the highest rank in this field.

Since P-value here equal 0.000 which less than 0.05, and T statistics = 8.66 > T critical (1.98). So, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.82) and hypothesized mean (3). SD equal 0.95, it is not far from zero, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that the results are confident.

Increased visualization was ranked 2nd amongst sixteen lean principles and techniques for enabling sustainability in a survey done by Ogunbiyi et al. (2014).

The results also revealed that "Last Planner System (The last planner is a person or group of people with the task to control production unit. They are responsible necessitating control of workflow, verify supply stream, design, and installation in all the production units)" level of contribution item (E1) (RII = 76.20%; P-value = 0.000; T-value = 8.25; SD = 0.98) is ranked in the second position in this field. Since P-value here equal 0.000 which less than 0.05, and T statistics = 8.25 > T critical (1.98). So, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.81) and hypothesized mean (3). SD equal 0.98, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that results are confident.

At first sight, last planner system seems to have nothing to do with sustainability. However, project duration and unnecessary delays can be reduced through effective scheduling which improves work flow and minimizes conflicts, thus making less of environmental impact. For example, unnecessary float attached to repeating activities can effectively be minimized by the pull-driven approach of last planner, thus ensures a continuous work flow that is more economically and environmentally efficient (Song & Liang, 2011). Last planner ranked 10^{th} amongst sixteen lean principles and techniques for enabling sustainability in a survey done by Ogunbiyi et al. (2014).

"The 5 Whys (The five times repetition of "why" (5 whys) when confronted with a problem helps to uncover the root cause of the problem)" level of contribution item (E5) (RII = 67.20%; P-value = 0.001; T-value = 3.46; SD = 1.04) was ranked in the last position in this field. Since P-value here equal 0.001 which is less than 0.05, and T statistics = 3.46 > T critical (1.98). So, there are statistically significant differences attributed to the respondent's opinions at the level of $\alpha \leq 0.05$ between the statistical mean (3.36) and hypotheses mean (3). SD equal 1.04, it is not too high, which means that the respondents results are consistent and are not spread out over a wider range of values. So, it can be said that the results are confident

The five why's can be of a great value as a root cause analysis tool. It was used along with fishbone and pareto diagrams in a systematic approach for sustainability root cause analysis on a chemical/energy production process in a study performed by

Jayswal, Li, Zanwar, Lou, and Huang (2011). Figure (4.5) shows the RII of items (E1 to E13).

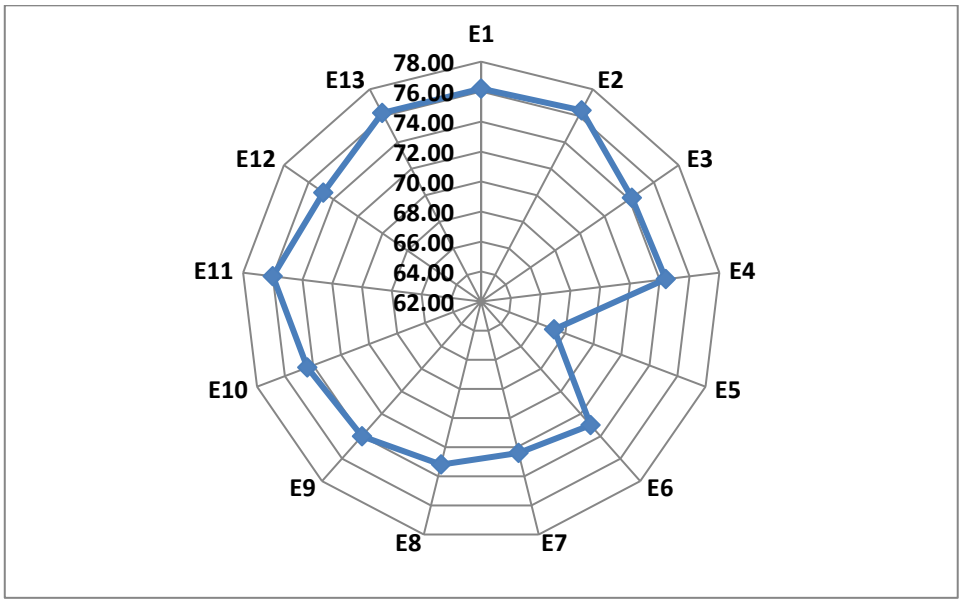

Figure (4.5): RII of items (E1 to E13)

4.8 Factor analysis results of success factors

The 18 success factors were subjected to factor analysis to find their inter-relationships and group them in smaller factors. Suitability of data was used to assess the suitability of data. Table (4.7) shows the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. KMO test is used to examine the adequacy of data to be factored. Kaiser (1974) recommended values greater than 0.5 as acceptable. In our case, KMO = 0.905, which fall into the region of being excellent; so, we are confident that factor analysis is appropriate for these data. Bartlett's test of sphericity tests the null hypothesis that the original correlation matrix is an identity matrix, which would indicate that the factor model is inappropriate. A significant test indicates that the correlation matrix is not an identity matrix; therefore, there are some relationships between the variables that may be included in the analysis. For these data, Bartlett's test is highly significant (P-value < 0.000), and therefore factor analysis is appropriate.

Table (4.7): KMO and Bartlett's Tests for Sampling Adequacy

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.905**
Bartlett's Test of Sphericity	Approx. Chi-Square	1240.342
	DF	153
	P-value	0.000

Table (4.8) contains each factor along with its eigenvalue before extraction, after extraction and after rotation. Before extraction, SPSS has identified 18 linear components within the data set. The eigenvalues associated with each factor represent the variance explained by the particular linear component and SPSS displays the eigenvalue in terms of the percentage of the variance explained (so, factor 1 explains 52.522% of total variance). It is clear that the first few factors explain relatively large amounts of variance (especially factor 1) whereas subsequent factors explain only small amounts of variance.

Table (4.8): Total Variance Explained

Statement	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	9.454	52.522	52.522	9.454	52.522	52.522	5.197	28.871	28.871
2	1.255	6.973	59.495	1.255	6.973	59.495	3.798	21.099	49.970
3	1.126	6.258	65.753	1.126	6.258	65.753	2.841	15.782	65.753
4	1.000	5.554	71.307						
5	.702	3.899	75.206						
6	.673	3.741	78.947						
7	.611	3.395	82.342						
8	.522	2.898	85.240						
9	.482	2.678	87.918						
10	.381	2.114	90.032						
11	.335	1.859	91.891						
12	.324	1.801	93.692						
13	.284	1.580	95.272						
14	.239	1.327	96.599						
15	.183	1.018	97.617						
16	.162	.898	98.515						
17	.144	.802	99.317						
18	.123	.683	100.000						

Figure (4.6) shows the Scree Plot, which leads to the main three groups of factors, because the regression line is severe up to component 3 and becomes almost straight line after that. The eigenvalues associated with these factors are again displayed with the percentage of variance explained in the column labeled "Extraction Sums of Squared Loadings" In the final part of the table (labeled "Rotation Sums of Squared Loadings"), the eigenvalues of the factors after rotation are displayed. Rotation has the effect of optimizing the factor structure and one consequence for these data is that the relative importance of the three factors is equalized. After extraction, factor 1 accounts for 28.871% of variance (compared to 21.099% and 15.782% respectively).

Then, the presence of three factors was revealed by using principal component analysis (PCA). Varimax rotation was also performed to get meaningful results.

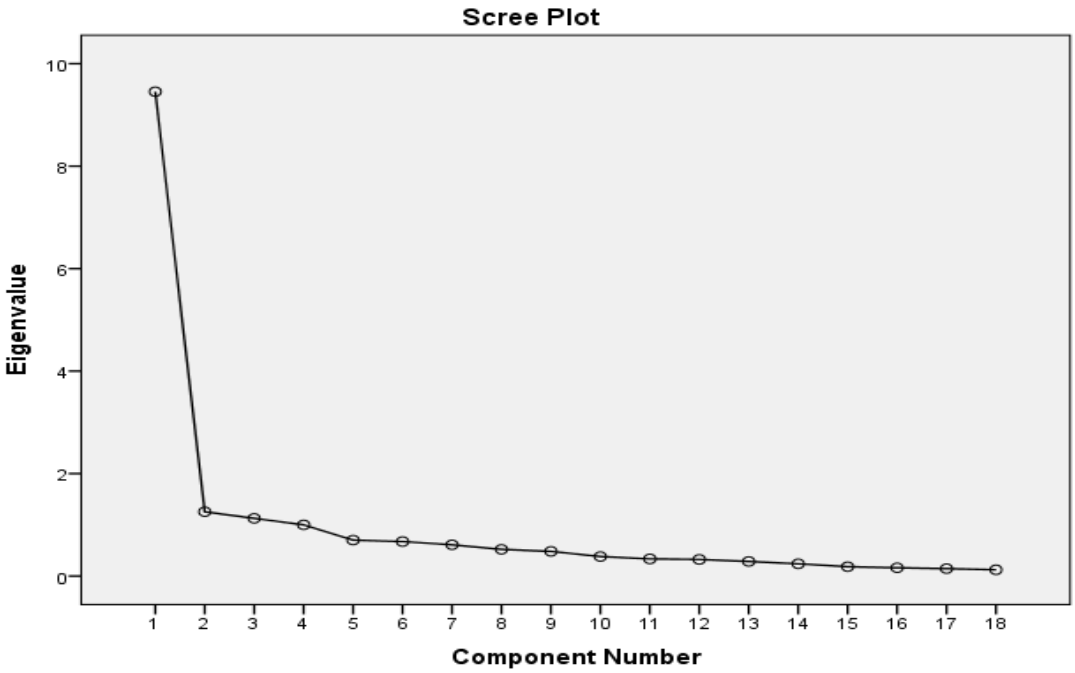

Figure (4.6): The Scree Plot

Factor interpretation

The three-factor interpreted about 65.753% of the total variance Table (4.9). Then, the number of items in each group was determined. The loading score of each factor is presented in Table (4.9). Reliability scores (Cronbach's alpha) for the factors range from 0.785 to 0.847 indicating adequate internal consistency. The results were assessed and numbered in a descending order of the amount of variance to determine the underlying features.

The first group accounted for 28.871% of the total variance and comprises 8 items relatively high factor loading (> 0.60).

The second group accounted for 21.099% of the total variance and comprises 6 items. The majority of items had a relatively high factor loading (> 0.60).

The third group accounted for 15.782% of the total variance and comprises 4 items. The majority of items had a relatively high factor loading (> 0.60).

Table (4.9) showes the three-factors solution. The number in front of each statement represents the sort of the statement in the original questionnaire.

Table (4.9): The three-factor solution

Factor	Corresponding items	Variance %	Eigenvalue	Cronbach's alpha
1	D1, D2, D5, D6, D7, D8, D9, D10	28.871	9.454	0.920
2	D3, D4, D15, D16, D17, D18	21.099	1.255	0.978
3	D11, D12, D13, D14	15.782	1.126	0.867
Group1	Change strategy, senior management commitment, business plan and vision, top management support, effective communication, Education and training, Monitoring and evaluation of performance, Leadership	Top management group		
Group 2	Product focus, company culture, Awareness, knowledge and interest of stakeholder, The role of the government, Company's awareness, Guide and benchmarking systems	Government, company, and stakeholders' group		
Group 3	Employees engagement, Commitment of all stakeholders, Fiscal incentives, Regulations	Financial, employees, and regulations group		

Thus, factor analysis helped categorize the 18 success factors into three main groups and sorted them in terms of importance as follows:

1. Top management group;
2. Government, company, and stakeholders' group;
3. Financial, employees, and regulations group.

4.9 Test of first hypothesis

There is a significant relationship between lean construction tools and (benefits of lean construction, barriers of lean construction, areas of integration, and success factors to lean construction).

From Table (4.10), it is shown that

- (H1): There is a significant association at $\alpha = 0.05$, between lean construction tools and benefits of lean construction.
- (H2): There is a significant association at $\alpha = 0.05$, between lean construction tools and barriers of lean construction.
- (H3): There is a significant association at $\alpha = 0.05$, between lean construction tools and areas of integration.
- (H4): There is a significant association at $\alpha = 0.05$, between lean construction tools and success factors to lean construction.

Table (4.10): Correlation coefficient between lean construction tools and (benefits of lean construction, barriers of lean construction, areas of integration, and success factors to lean construction)

Field	Statistics	lean construction tools
Benefits of lean construction	Correlation coefficient (r)	0.461*
	(Sig.)	0.000
Barriers of lean construction	Correlation coefficient (r)	0.665*
	(Sig.)	0.000
Areas of integration	Correlation coefficient (r)	0.703*
	(Sig.)	0.000
Success factors to lean construction	Correlation coefficient (r)	0.775*
	(Sig.)	0.000

* A significant correlation at $\alpha = 0.05$.

4.10 Test of second hypothesis: Hypothesis related to respondents' profiles (respondents' analysis)

There are statistically significant differences attributed to the demographic data of the respondents at the level of $\alpha \leq 0.05$ between the means of their views on the subject of the impact of lean construction techniques on sustainable construction in the Gaza Strip.

This hypothesis was to analyze the differences among opinions of respondents toward the impact of lean construction techniques on sustainable construction in the Gaza Strip due to: gender, job title, educational level, years of experience, specialization, and nature of the workplace. One-way Analysis of variance (ANOVA) test were used to find whether there were statistically significant differences between opinions of respondents or not.

4.10.1 Analysis considering job title

ANOVA (F-test) provides a parametric statistical test of whether the means of several groups (more than two) are equal or not (by using the F-ratio). Critical value of F at degree of freedom (df) = [(K-1), (N-K)] at significance (probability) level (α) = 0.05 (Field, 2009). Thus, ANOVA was used to test the differences among opinions of respondents with respect to their job title (designer, supervisor, site engineer, project manager, and academic).

According to the results of the test as shown in Table (4.11), the P-value for the Levene's test is greater than 0.05 in each field of the five fields as well as the whole fields together. Thus, the variances of the groups are not significantly different (the groups are homogeneous). Regarding to F- test, the significance values for each field of the five fields as well as the whole fields together are not significant (P-value > 0.05). Also, the values of F-test in each field of the five fields as well as the whole fields together are less than the critical value of F (2.467). Thus, there are no statistically significant differences attributed to the respondents' job title at the level of $\alpha \leq 0.05$ between the means of their views on the subject of the impact of lean construction techniques on sustainable construction in Gaza Strip. This gives the outcomes of this research more strength as the results of the survey are independent on the jobs of the respondents. If there were any differences attributed to job title on the answers of the respondents, then Scheffe test for multiple comparisons is needed to further explain the direction of these differences and how they can be interpreted statistically. Thus, if the survey was distributed to another job title distribution, the results of the survey would not be different from this study. It can be said that the respondents gave their opinions objectively and they did not have any bias towards a certain result according to their job titles.

Table (4.11): One-way ANOVA results regarding job title of the respondents

Field	Test of Homogeneity of Variances		F-test	P-value (Sig.)	designer	supervisor	site engineer	project manager	academic
	Levene Statistic	P-value (Sig.)							
Benefits of lean and sustainable construction	1.409	0.237	0.726	0.577	3.79	3.93	3.68	3.93	3.97
Barriers of lean and sustainable construction	1.839	0.128	0.336	0.853	3.51	3.40	3.37	3.55	3.54
Areas of integration	0.167	0.955	0.274	0.894	3.76	3.87	3.86	3.95	3.97
Success factors	0.636	0.638	0.345	0.847	3.87	3.77	3.77	4.05	3.92
Level of contribution of lean construction tools for enabling sustainability	0.750	0.560	0.607	0.659	3.75	3.75	3.56	3.90	3.64
All fields	0.414	0.798	0.383	0.820	3.75	3.74	3.65	3.89	3.81

*Critical value of F at degree of freedom (df) = [(K-1), (N-K)] = [(5-1), (100-5)] = [4,95] and at significance (Probability) level 0.05 equals "2.467". *. The mean difference is significant at the 0.05 level.*

4.10.2 Analysis considering years of experience

ANOVA was used to test the differences among opinions of the respondents with respect to their years of experience (Less than 5, 5 - Less than 10, 10 years and more). According to the results of the test as shown in Table (4.12), the P-value for the Levene's test is greater than 0.05 in each field of the five fields as well as the all fields together. Thus, the variances of the groups are not significantly different (the groups are homogeneous). Regarding to F- test, the significance values for each field of the five fields as well as the whole fields together are not significant (P-value > 0.05). Also, the values of F-test in each field of the five fields as well as the whole fields together are less than the critical value of F (3.090). Thus, there are no statistically significant differences attributed to years of experience at the level of $\alpha \leq 0.05$ between

the means of their views on the subject of the impact of lean construction techniques on sustainable construction in Gaza Strip. This gives the outcomes of this research more strength as the results of the survey are independent on the years of experience of the respondents. If there were any differences attributed to years of experience on the answers of the respondents, then Scheffe test for multiple comparisons is needed to further explain the direction of these differences and how they can be interpreted statistically. Thus, if the survey was distributed to another years of experience distribution, the results of the survey would not be different from this study. It can be said that the respondents gave their opinions objectively and they did not have any bias towards a certain result according to their years of experience.

Table (4.12): One-way ANOVA results regarding years of experience

Field	Test of Homogeneity of Variances		F-test	P-value (Sig.)	Less than 5	5 - Less than 10	10 years and more
	Levene Statistic	P-value (Sig.)					
Benefits of lean and sustainable construction	0.140	0.870	0.596	0.553	3.81	3.93	3.75
Barriers of lean and sustainable construction	0.614	0.543	0.011	0.989	3.45	3.46	3.47
Areas of integration	0.216	0.806	1.058	0.351	3.95	3.71	3.86
Success factors	1.174	0.314	0.907	0.407	3.96	3.71	3.84
Level of contribution of lean construction tools for enabling sustainability	0.381	0.684	0.371	0.691	3.74	3.59	3.70
All fields	0.280	0.756	0.333	0.718	3.79	3.67	3.73

*Critical value of F at degree of freedom (df) = [(K-1), (N-K)] = [(3-1), (100-3)] = [2,97] and at significance (Probability) level 0.05 equals "3.090". *. The mean difference is significant at the 0.05 level.*

4.10.3 Analysis considering Educational level

ANOVA was used to test the differences among opinions of the respondents with respect to their educational level (Bachelor, Master, and Ph. D).

According to the results of the test as shown in Table (4.13), the P-value for the Levene's test is greater than 0.05 in each field of the five fields as well as the all fields together. Thus, the variances of the groups are not significantly different (the groups

are homogeneous). Regarding to F- test, the significance values for each field of the five fields as well as the whole fields together are not significant (P-value > 0.05). Also, the values of F-test in each field of the five fields as well as the whole fields together are less than the critical value of F (3.090). Thus, there are no statistically significant differences attributed to the respondent's educational level at the level of $\alpha \leq 0.05$ between the means of their views on the subject of the impact of lean construction techniques on sustainable construction in Gaza Strip. This gives the outcomes of this research more strength as the results of the survey are independent on the educational level of the respondents. If there were any differences attributed to educational level on the answers of the respondents, then Scheffe test for multiple comparisons is needed to further explain the direction of these differences and how they can be interpreted statistically. Thus, if the survey was distributed to another educational level distribution, the results of the survey would not be different from this study. It can be said that the respondents gave their opinions objectively and they did not have any bias towards a certain result according to their educational level.

Table (4.13): One-way ANOVA results regarding educational level of the respondents

Field	Test of Homogeneity of Variances		F-test	P-value (Sig.)	Bachelor	Master	Ph.D.
	Levene Statistic	P-value (Sig.)					
Benefits of lean and sustainable construction	0.230	0.795	0.101	0.904	3.82	3.81	3.92
Barriers of lean and sustainable construction	2.788	0.066	0.547	0.580	3.47	3.39	3.65
Areas of integration	0.060	0.942	0.291	0.748	3.89	3.80	3.98
Success factors	0.227	0.797	0.103	0.902	3.88	3.86	3.76
Level of contribution of lean construction tools for enabling sustainability	0.780	0.461	0.068	0.935	3.71	3.68	3.63
All fields	0.857	0.428	0.056	0.946	3.76	3.72	3.77

*Critical value of F at degree of freedom (df) = [(K-1), (N-K)] = [(3-1), (100-3)] = [2,97] and at significance (Probability) level 0.05 equals "3.090". *. The mean difference is significant at the 0.05 level.*

4.10.4 Analysis considering Specialization

ANOVA was used to test the differences among opinions of respondents with respect to their specialization (architect, civil, and industrial).

According to the results of the test as shown in Table (4.14), the P-value for the Levene's test is greater than 0.05 in each field of the five fields as well as the whole fields together. Thus, the variances of the groups are not significantly different (the groups are homogeneous). Regarding to F- test, the significance values for each field of the five fields as well as the all fields together are not significant (P-value > 0.05). Also, the values of F-test in each field of the five fields as well as the whole fields together are less than the critical value of F (3.090). Thus, there are no statistically significant differences attributed to the respondent's specialization at the level of $\alpha \leq 0.05$ between the means of their views on the subject of the impact of lean construction techniques on sustainable construction in Gaza Strip. This gives the outcomes of this research more strength as the results of the survey are independent on the specialization of the respondents. Thus, if the survey was distributed to another specialization distribution, the results of the survey would not be different from this study. It can be said that the respondents gave their opinions objectively and they did not have any bias towards a certain result according to their specialization.

Table (4.14): One-way ANOVA results regarding specialization of the respondents

Field	Test of Homogeneity of Variances		F-test	P-value (Sig.)	architect	civil	industrial
	Levene Statistic	P-value (Sig.)					
Benefits of lean and sustainable construction	0.994	0.374	0.639	0.530	3.83	3.79	4.23
Barriers of lean and sustainable construction	1.987	0.143	1.145	0.323	3.53	3.44	3.97
Areas of integration	0.550	0.579	1.413	0.249	4.07	3.83	4.16
Success factors	0.996	0.373	0.341	0.712	3.91	3.85	4.18
Level of contribution of lean construction tools for enabling sustainability	0.387	0.680	0.376	0.688	3.81	3.69	3.87
All fields	0.821	0.443	0.752	0.474	3.83	3.73	4.08

*Critical value of F at degree of freedom (df) = [(K-1), (N-K)] = [(3-1), (100-3)] = [2,97] and at significance (Probability) level 0.05 equals "3.090". *. The mean difference is significant at the 0.05 level.*

4.10.5 Analysis considering nature of the workplace

ANOVA was used to test the differences among opinions of respondents with respect to nature of the workplace (consultant, contractor, and owner).

According to the results of the test as shown in Table (4.15), the P-value for the Levene's test is greater than 0.05 in each field of the five fields as well as the whole fields together. Thus, the means of the groups are not significantly different (the groups are homogeneous). Regarding to F- test, the significance values for each field of the five fields as well as the whole fields together are not significant (P-value > 0.05). Also, the values of F-test in each field of the five fields as well as the whole fields together are less than the critical value of F (3.090). Thus, there are no statistically significant differences attributed to the nature of the workplace at the level of $\alpha \leq 0.05$ between the means of their views on the subject of the impact of lean construction techniques on sustainable construction in Gaza Strip. This gives the outcomes of this research more strength as the results of the survey are independent on the nature of the work place of the respondents. Thus, if the survey was distributed to another nature of work place distribution, the results of the survey would not be different from this study. It can be said that the respondents gave their opinions objectively and they did not have any bias towards a certain result according to their nature of work place.

Table (4.15): One-way ANOVA results regarding nature of the workplace

Field	Test of Homogeneity of Variances		F-test	P-value (Sig.)	consultant	contractor	owner
	Levene Statistic	P-value (Sig.)					
Benefits of lean and sustainable construction	2.000	0.141	1.216	0.301	3.89	3.63	3.86
Barriers of lean and sustainable construction	0.519	0.597	0.849	0.431	3.51	3.29	3.43
Areas of integration	0.039	0.962	0.226	0.798	3.86	3.91	3.76
Success factors	0.471	0.626	0.052	0.949	3.85	3.88	3.80
Level of contribution of lean construction tools for enabling sustainability	0.163	0.850	0.433	0.650	3.74	3.68	3.56
All fields	0.213	0.808	0.197	0.821	3.77	3.69	3.68

*Critical value of F at degree of freedom (df) = [(K-1), (N-K)] = [(3-1), (100-3)] = [2,97] and at significance (Probability) level 0.05 equals "3.090". *. The mean difference is significant at the 0.05 level.*

4.10.6 Analysis considering gender

Independent Samples T-test provides a statistical test of whether the means of two groups are equal or not. Critical value of t = 1.98, where the degree of freedom (df) = [N-2] = [100-2] = 98 (N is the sample size) at significance (probability) level (α) = 0.05 (Field, 2009). Thus, Independent Samples t-test was used to test the differences among respondents' opinions according to their gender (male and female) about the impact of lean construction techniques on sustainable construction in Gaza Strip. According to the results of the test as shown in Table (4.16), the significance value is greater than 0.05 (P-value > 0.05). Also, the absolute value of t- test is less than the critical value of t (1.98). Thus, there are no statistically significant differences according to their gender at the level of $\alpha \leq 0.05$ between the means of their views on the impact of lean construction techniques on sustainable construction in Gaza Strip. This gives the outcomes of this research more strength as the results of the survey are independent on the gender of the respondents. Thus, if the survey was distributed to another gender distribution, the results of the survey would not be different from this study. It can be said that the respondents gave their opinions objectively and they did not have any bias towards a certain result according to their gender.

Table (4.16): Independent samples t test results regarding gender

Field	t-test	P-value (Sig.)	Mean	
			Male	Female
Benefits of lean and sustainable construction	0.968	0.336	3.79	3.92
Barriers of lean and sustainable construction	0.949	0.345	3.43	3.56
Areas of integration	1.622	0.108	3.81	4.05
Success factors	1.772	0.080	3.78	4.06
Level of contribution of lean construction tools for enabling sustainability	0.901	0.370	3.66	3.80
All fields	1.526	0.130	3.69	3.89

*Critical value of t at degree of freedom (df) = (N-2) = (98) and at significance (Probability) level 0.05 equals "1.98". *. The mean difference is significant at the 0.05 level.*

Chapter 5
Conclusion

Chapter 5
Conclusion

5.1 Introduction

This chapter presents the conclusion of the research, and recommendations to certain agencies based on the analysing the questionnaire results and the literature review to help in the implementation of lean and sustainability in construction organizations. Finally, the future researches and research limitation are presented.

5.2 Conclusion of the study

Lean and sustainability are two approaches that can be implemented alongside in the construction industry. In Gaza Strip, the companies understand and focus more on the sustainability concept rather than lean philosophy. According to the review of the relation between lean and sustainability, lean and sustainability are not 100 % in similar, and not each single principle.

From all the previous, the study concludes that:

Main barriers to lean and sustainability

The research concluded that the most significant barrier is lack of top management leadership and commitment and being rejecting to adopt lean and sustainability initiatives. Lack of long-term perspective along with the resistance to change are also strong barriers to both lean and sustainability. Both lean and sustainability can be successfully implemented when their holistic principle is understood and included into strategic planning of the organization's business. Other barriers included procurement and contracting procedures, lack of agreed methodology for implementation, low level of awareness and understanding, absence of knowledge and lack of proficiency, lack of effective communication networks.

Success factors to lean and sustainability

1) a large percentage of the respondents suggested that business plan and vision, top management support, monitoring and evaluation of performance, leadership and fiscal incentives are the most significant success factors for the implementation of lean and

sustainability. Other factors include change strategy, Senior management commitment, education and training, employee's engagement and regulations.

2) Factor analysis classified the success factors into three groups:

a) Top management group;

b) Government, company, and stakeholders' group;

c) Financial, employees, and regulations group.

Integration between Lean and Sustainability

There are many areas of integration between lean and sustainability. These areas included quality improvement, waste reduction, resource management, energy use reduction, elimination of non-value processes, environment improvement, performance maximization, environmental management, cost reduction and health and safety improvement. Both lean and sustainability aim at waste reduction but with different approaches.

Lean tools for enabling sustainability

1) The most important lean tools for enabling sustainability are Last Planner System, Increased visualization, Concurrent engineering ,Total preventive maintenance and Kaizen.

2) Surprisingly, Just in Time tool did not receive high rank maybe due to the Israeli blockade and the hardships the Palestinian contractors face in their endeavours to secure the materials they need in construction.

3) Although lean tools are not initiated for environmental improvement, the application of lean concepts and tools result in improvements in environmental performance of organizations. Lean concepts and tools result in economic and social benefits for the organization as well as performance improvement.

Benefits and impacts of lean and sustainability

1) The benefits of lean and sustainability as reported by construction engineers include: reduction of waste, environmental improvement, reduction of cost, health and safety improvement, reduction in material usage, less water consumption, productivity

improvement, better organization image, better employee commitment and Less energy consumption.

2) Any organization will not adopt lean and sustainability initiatives unless they see potential benefits that can be derived from implementing them.

3) In order to maximize benefits of lean and sustainability, they should be adopted as a whole solution for the environmental problems.

The impact of lean construction techniques on sustainable construction

The study results proved a great association between lean construction techniques and both of the benefits, barriers, areas of integration and success factors to lean and sustainable construction. There is a positive correlation between them. This proves the main objective of this study.

5.3 Recommendations

Based on the results of the study, some recommendations are presented to help in achieving sustainable management process by focusing on lean and sustainability. These guidelines are directed to the government, developer/client, and consultants' companies.

5.3.1 The recommendation to the Engineering Syndicate

The Engineering Syndicate has an awareness role. The awareness will be in two axes general awareness and technique awareness through increase the society and developers' awareness to the environment, and resource limitation problems, and increase awareness of the society role towards the sustainable development of the whole country and enhance the concept of community service as volunteering. While technically, it should host international conferences to bring the latest knowledge, offer and announce for grants to study new management techniques, and hire experts to teach workforce and undergrad about new management techniques.

5.3.2 The recommendation to the government

While the government has some legislation roles through relieving the tax for the project that achieves certain percentage of sustainability in the process and after operation. While in contradict set taxes for the materials that go to landfills. In addition, it should require considering sustainability Tri pillar indicators in its projects

contracting in order to encourage people introduce sustainability in their work. As well require considering of waste management (lean) in all governmental projects to encourage people introduce those new techniques in their work.

5.3.3 The recommendation to construction firms

Construction firms should improve the process progress not just monitor it through implementing new management techniques, though studying the present process constrains that might cause future delay frequently in each progress report. In addition, they should understand the companies' role towards the society and environment development through offering training programs for the workforce about the lean technique, consider the environment as one of the clients and take it into consideration in design and alternatives analysis, and totally involvement of the end-user to the process. On the other hand, Increase the company internal and external transparency through setting a clear objective numerical goal for the upcoming years, and allows employees to know the goals. Hence all the workforce goes after achieving this goal.

5.3.4 The recommendation to developer/clients

Beside the recommendation to the government and construction firms in Gaza Strip. The research also highlighted some recommendations for developer/ clients based on the respondents' claims and categorized as: requiring, performance and identification responsibilities. In the requiring responsibility, developers should ask for waste management studies, and consider the environment as one of the requirements and values. In addition, the developer responsible for some performance problems that consequently led to problem occur. Thus, the developers are responsible for the quick response, quick approvals through the process, and transparency with the project participant, in order to reduce waste and improve process. Beside all the above, the developer/client should clearly mention the target group of the design to project participant from the start point of the design, and identify all the values and needs from the start point.

5.4 Future Research

Lean construction researches reached its maturity worldwide. However, lean design still has a lot to be done on this topic. For example, study the root source of wastes in

the design phase and the effect of lean implementation on the waste reduction in the design phase. In addition, in the recent years, most of research studies focus on studying the relation between lean and sustainability theoretically or in the construction phase. While, there is a lack of knowledge about how lean can achieve sustainability in design phase practically. Furthermore; a future research can examine the proposed framework on an empirical case study.

5.5 Research Limitation

1) The study only took thirteen tools\techniques of lean construction as they are the most approved by lean experts.

2) The outcomes of the study maybe suitable only for Gaza Strip due to the special political and economic circumstances.

3) The study did not develop a framework or offered a strategy plan as how to integrate both lean and sustainable construction

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Appendices

Appendix A: Questionnaire (English)

The Islamic University of Gaza
Civil Engineering Department
Master Program in Construction Management
Questionnaire

Subject: Questionnaire survey about: An empirical study of the impact of lean construction techniques on sustainable construction in the Gaza Strip

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- Research Aim:
  To investigate the relationship between lean construction and sustainability.
- Target Group:
- Engineers who work in the field of design, supervision, construction, and maintenance (civil, architect, and electrical engineers), as well as academic engineers.
- **Lean construction definition** Lean methods seek to develop and manage a project through relationships, shared knowledge and common goals. Traditional silos of knowledge, work and effort are broken down and reorganized for the betterment of the project rather than of individual participants. The result? Significant improvements in schedule with dramatically reduced waste, particularly on complex, uncertain and quick projects.
- **Sustainable Construction definition** aims to meet present day needs for housing, working environments and infrastructure without compromising the ability of future generations to meet their own needs in times to come. It incorporates elements of economic efficiency, environmental performance and social responsibility – and contributes to the greatest extent when architectural quality, technical innovation and transferability are included.

Best Regards

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Civil Engineer M.Sc. Candidate in construction management, IUG

Part 1: Respondent's demographic data and way of work performance

❖ Please tick (√) the appropriate option in the following questions:

	Name (optional)	…….				
1.	Gender	☐ male	☐ female			
2.	Educational qualification	☐ bachelor	☐ master	☐ Ph.D.		
3.	Specialization	☐ architect	☐ civil	☐ electrical	☐ mechanical	☐ industrial
4.	Nature of the workplace	☐ consultant	☐ contractor	☐ owner		
5.	Current field – present job	☐ designer	☐ supervisor	☐ site engineer	☐ project manager	☐ academic
6.	Years of experience	☐ less than 5 years	☐ from 5 to less than 10 years		☐ 10 years and more	

Part 2

❖ How would you rate the following benefits of lean construction and sustainable construction in terms of their importance? Please tick (√) in front of the number that reflects your point of view.

Number	Benefit	1. unimportant	2. of little importance	3. moderately important	4. important	5. very important
A1	Better organization image					
A2	Reduction of waste					
A3	Environmental improvement					
A4	Reduction of cost					

Number	Benefit	1. unimportant	2. of little importance	3. moderately important	4. important	5. very important
A5	Health and safety improvement					
A6	Reduction in material usage					
A7	Less water consumption					
A8	Productivity improvement					
A9	Better employee commitment					
A10	Less energy consumption					

Part 3

❖ How would you rate the following barriers to lean construction and sustainable construction? Please tick (√) in front of the number that reflects your point of view.

	Barrier	1. very weak	2. weak	3. average strength	4. strong	5. very strong
B1	Lack of trust					
B2	Procurement and contracting procedures					
B3	Lack of agreed methodology for implementation					
B4	Lack of long-term perspective					
B5	Lack of organizational learning					
B6	Low level of awareness and understanding					
B7	Absence of knowledge and lack of proficiency					
B8	Resistance to change					
B9	High training costs during employment					
B10	Lack of top management leadership and commitment					
B11	Poor teamworking skills					
B12	Lack of effective communication networks					

Part 4

❖ How would you rate the following areas of integration between lean construction and sustainable construction? Please tick (√) in front of the number that reflects your point of view.

Number	Area of integration	1. very weak	2. weak	3. average strength	4. strong	5. very strong
C1	Resource management					
C2	Waste reduction					
C3	Energy use reduction					
C4	Elimination of non-value processes					
C5	Environment improvement					
C6	Performance maximization					
C7	Environmental management					
C8	Cost reduction					
C9	Health and safety improvement					
C10	Quality improvement					

Part 5

❖ How would you rate the following success factors to lean construction and sustainable construction? Please tick (√) in front of the number that reflects your point of view.

No	Success factor	1. very weak	2. weak	3. average strength	4. strong	5. very strong
D1	Change strategy					
D2	Senior management commitment					
D3	Product focus					
D4	Company culture					
D5	Business plan and vision					
D6	Top management support					
D7	Effective communications					
D8	Education and training					
D9	Monitoring and evaluation of performance					
D10	Leadership					
D11	Employees engagement					
D12	Commitment of all stakeholders					

No	Success factor	1. very weak	2. weak	3. average strength	4. strong	5. very strong
D13	Fiscal incentives					
D14	Regulations					
D15	Awareness, knowledge and interest of stakeholder					
D16	The role of the government					
D17	Company's awareness					
D18	Guide and benchmarking systems					

Part 6

❖ Please indicate the level of contribution of lean construction tools for enabling sustainability in your opinion. Please tick (√) in front of the number that reflects your point of view.

No	Lean tools	1.High contribution	2.Medium contribution	3.Low contribution	4.No contribution
F1	Last Planner System (The last planner is a person or group of people with the task to control production unit. They are responsible necessitating control of workflow, verify supply stream, design, and installation in all the production units)				
F2	Increased visualization (making operations and quality requirements clearer using charts, displayed schedules, painted designated inventory and tool locations)				
F3	The 5S (House-keeping) meaning Sort, Straighten, Shine, Standardize, and Sustain. This is a process for waste removal from the workplace through the use of visual controls.				
F4	Error-Proofing (Poka-yoke) This is a mechanism design to detect and prevent errors in processes with the aim of achieving zero defects.				

F5	The 5 Whys (The five times repetition of "why" (5 whys) when confronted with a problem helps to uncover the root cause of the problem)				
F6	Daily Huddle Meetings (a brief daily start-up meeting is conducted to collect reports on the state of the work since the previous meeting)				
F7	First Run Studies (The tool uses a Plan-Do-Check-Act (PDCA) cycle to lean the process)				
F8	Just in time (a method of forwarding material or specific manpower or traits at the exact moment where it is needed, reducing on site inventories and inefficient man-hours (Waiting, and double handling)				
F9	Value stream mapping (material- and information-flow mapping)				
F10	Six Sigma (Sets of tools and techniques for improving quality through identification and removal of defects and reduction of variability in processes. Six Sigma is able to achieve process quality of 99.99966% that is free from defects)				
F11	Concurrent engineering (designing and developing products, in which the different stages run simultaneously, rather than consecutively)				
F12	Total preventive maintenance (the application of preventive maintenance strategies in an organized and standardized method)				
F13	Kaizen (Japanese business philosophy for continuous improvement. This is an approach that seeks to improve quality and efficiency through the elimination of waste from the value stream)				

Thank you very much for your valuable time and effort on this survey

Appendix B: Questionnaire (Arabic)

الجامعة الإسلامية – غزة
قسم الهندسة المدنية
ماجستير إدارة التشييد
استبيان

الموضوع: استبانة حول: دراسة تجريبية لتأثير تقنيات التشييد المرن على التشييد المستدام في قطاع غزة

- هدف الدراسة:

دراسة العلاقة بين التشييد المرن والاستدامة.

- الفئة المستهدفة:

المهندسون الذين يعملون في مجالات التصميم، الاشراف على البناء، والصيانة (مدني، معماري، ميكانيكي، كهربائي) والأكاديميين.

- **تعريف التشييد المرن**: طرق التشييد المرن تهدف الى تطوير وإدارة المشروع عن طريق العلاقات والمعرفة والاهداف المشتركة، وبفضل تقسيم المعرفة والعمل والمجهود واستخدامها من اجل تحسين المشروع ككل فضلا عن الافراد المشاركون. النتيجة؟ تحسينات ملموسة في الجدول الزمني مع تقليل التكلفة بصورة دراماتيكية خصوصا في المشاريع المعقدة وكثيرة المخاطر والمضغوطة زمنيا.
- **تعريف التشييد المستدام**: يهدف الى تحقيق متطلبات الوقت الحاضر من إسكان وبيئة عمل وبنية تحتية بدون الاخلال بقدرة الأجيال القادمة من تحقيق متطلباتهم في المستقبل، يستخدم التشييد المستدام عناصر الفعالية الاقتصادية، والأداء البيئي، والمسئولية المجتمعية، ويساهم الى حد كبير في جودة المعمار، والتقدم التقني، وقابلية الانتقال والتحول.

أطيب التحيات،

أسامة محمد عبيد، مهندس مدني/ وباحث للحصول على درجة الماجستير في إدارة المشاريع الهندسية (الهندسة المدنية)، الجامعة الإسلامية

الجزء الأول: التوزيع الديموغرافي وطبيعة العمل

❖ ضع علامة (√) امام الخيار المناسب في الأسئلة التالية:

	الاسم (اختياري)				
1.	النوع	☐ ذكر	☐ انثى		
2.	المؤهل التعليمي	☐ بكالوريوس	☐ ماجستير	☐ دكتوراه	
3.	التخصص	☐ معماري	☐ مدني	☐ كهربائي	☐ ميكانيكي	☐ صناعي
4.	طبيعة العمل	☐ استشاري	☐ مقاول	☐ مالك	
5.	الوظيفة الحالية	☐ مصمم	☐ مشرف	☐ مهندس	☐ مدير مشروع	☐ اكاديمي
6.	سنوات الخبرة	☐ اقل من خمس	☐ من خمسة الى عشر سنوات	☐ عشر سنوات فأكثر	

الجزء الثاني

❖ ما تقييمك للفوائد التالية للتشييد المرن والمستدام من حيث الأهمية؟ ضع علامة (√) امام الرقم الذي يعكس وجهة نظرك

1. غير مهم 2. قليل الأهمية 3. متوسط الأهمية 4. مهم 5. مهم جدا

الرقم	الفائدة	1	2	3	4	5
A1	تحسين صورة المؤسسة					
A2	تقليل الفاقد					
A3	تحسين البيئة					
A4	تقليل التكلفة					
A5	تحسين الصحة والسلامة المهنية					
A6	تقليل استخدام مواد البناء					
A7	تقليل استخدام الماء					
A8	تحسين الانتاجية					
A9	رفع التزام الموظفين					
A10	تقليل استخدام الطاقة					

الجزء الثالث

❖ ما تقييمك للعوائق التالية للتشييد المرن والمستدام؟ ضع علامة (√) امام الرقم الذي يعكس وجهة نظرك

1. غير مهم 2. قليل الأهمية 3. متوسط الأهمية 4. مهم 5. مهم جدا

الرقم	العائق	1	2	3	4	5
B1	غياب الثقة					
B2	إجراءات الشراء والتعاقد في مجال المقاولات					
B3	غياب منهجية متفق عليها للتطبيق					
B4	غياب الرؤيا طويلة المدى					
B5	غياب التعلم المؤسسي					
B6	القدر الضئيل من الفهم والمعرفة					
B7	غياب المعرفة المهنية					
B8	مقاومة التغيير					

الرقم	العائق	1	2	3	4	5
B9	التكلفة العالية لتدريب الموظفين					
B10	افتقاد الإدارة العليا للقيادة والالتزام					
B11	مهارات فرق العمل الضعيفة					
B12	غياب شبكات الاتصال الفعالة					

الجزء الرابع

❖ ما تقييمك للمجالات التالية للتكامل بين التشييد المرن والتشييد المستدام؟ ضع علامة (√) امام الرقم الذي يعكس وجهة نظرك.

1. غير مهم 2. قليل الأهمية 3. متوسط الأهمية 4. مهم 5. مهم جدا

الرقم	مجال التكامل	1	2	3	4	5
C1	إدارة الموارد					
C2	تقليل الفاقد					
C3	تقليل استخدام الطاقة					
C4	حذف العمليات عديمة القيمة					
C5	تحسين البيئة					
C6	تعظيم الأداء					
C7	إدارة الموارد البيئية					
C8	تقليل التكلفة					
C9	تحسين الصحة والسلامة المهنية					
C10	تحسين الجودة					

الجزء الخامس

❖ ما تقييمك لعوامل النجاح التالية للتشييد المرن والمستدام؟ ضع علامة (√) امام الرقم الذي يعكس وجهة نظرك.

1. غير مهم 2. قليل الأهمية 3. متوسط الأهمية 4. مهم 5. مهم جدا

الرقم	عوامل النجاح	1	2	3	4	5
D1	وجود استراتيجية للتغيير					
D2	التزام الإدارة العليا					
D3	التركيز على المنتج					
D4	ثقافة المؤسسة					
D5	وجود رؤيا وخطة عمل					
D6	دعم الإدارة العليا					
D7	الاتصال الفعال					
D8	التدريب والتعلم					

الرقم	عوامل النجاح	1	2	3	4	5
D9	متابعة وتقييم الأداء					
D10	القيادة					
D11	اشراك الموظفين ودمجهم					
D12	الالتزام من جميع المساهمين					
D13	الحوافز المادية					
D14	القوانين والتنظيمات					
D15	المعرفة والادراك والاهتمام من قبل المساهمين					
D16	دور الحكومة الإيجابي					
D17	معرفة وادراك المؤسسة					
D18	وجود انظمة للقياس والتوجيه					

الجزء السادس
اختر مستوى المساهمة لكل من تقنيات التشييد المرن التالية في تمكين الاستدامة من وجهة نظرك. ضع علامة (√) امام الرقم الذي يعكس وجهة نظرك. 1. غير مهم 2. قليل الأهمية 3. متوسط الأهمية 4. مهم 5. مهم جدا

الرقم	تقنيات التشييد المرن	1	2	3	4	5
E1	نظام آخر مخطط (المخطط الأخير هو شخص أو مجموعة أشخاص لديهم مهمة التحكم في وحدة الإنتاج. فهم مسؤولون عن التحكم في سير العمل والتحقق من تدفق الإمداد والتصميم والتركيب في جميع وحدات الإنتاج)					
E2	زيادة التصور (جعل العمليات ومتطلبات الجودة أكثر وضوحًا باستخدام المخططات والجداول المعروضة والمواقع المعينة للمخزون والأدوات)					
E3	(ترتيب البيت) يعني ترتيب، وتصويب، تلميع، وتوحيد، واستدامة: عملية لإزالة النفايات من مكان العمل من خلال استخدام الضوابط البصرية					
E4	تصحيح الخطأ (Poka-yoke) تصميم آلية لكشف ومنع الأخطاء في العمليات بهدف تحقيق عيوب صفرية.					
E5	5 لماذا (تكرار 5 مرات لـ "لماذا" عند مواجهة مشكلة يساعد على كشف السبب الجذري للمشكلة)					
E6	اجتماعات Huddle اليومية (يُعقد اجتماع بدء يومي قصير لجمع التقارير عن حالة العمل منذ الاجتماع السابق)					
E7	دراسات التدخل السريع (تستخدم هذه الأداة دورة خطط-افعل-افحص-تصرف (PDCA) لترشيد العملية)					
E8	في الوقت المناسب (طريقة لإعادة توجيه المواد أو القوى العاملة أو السمات المحددة في اللحظة المحددة حيث تكون هناك حاجة إليها، والحد من مخزونات الموقع وساعات العمل غير الفعالة (الانتظار، والتعامل المزدوج)					
E9	تخطيط تدفق القيمة (تخطيط تدفق المواد والمعلومات)					

E10	ستة سيغما (مجموعات من الأدوات والتقنيات لتحسين الجودة من خلال تحديد وإزالة العيوب وتقليل التباين في العمليات. ستة سيغما قادرة على تحقيق جودة عملية 99.99966٪ خالية من العيوب)					
E11	الهندسة المتزامنة (تصميم وتطوير المنتجات، التي تعمل فيها المراحل المختلفة في وقت واحد، بدلاً من أن تكون بصورة متتالية)					
E12	الصيانة الوقائية الشاملة (تطبيق استراتيجيات الصيانة الوقائية بطريقة منظمة وموحدة)					
E13	كايزن (فلسفة العمل اليابانية للتحسين المستمر. وهي عبارة عن النهج الذي يسعى إلى تحسين الجودة والكفاءة من خلال القضاء على النفايات من مجرى القيمة)					

شكرا جزيلا على وقتكم الثمين والجهد في تعبئة هذا الاستبيان

Appendix C: Correlation coefficient

Table (C1): *The correlation coefficient between each paragraph/item in the field and the whole field. Second field: barriers of lean and sustainable construction*

No.	Item	Pearson correlation coefficient	p-value
B1	Lack of trust	0.583	0.000*
B2	Procurement and contracting procedures	0.559	0.000*
B3	Lack of agreed methodology for implementation	0.636	0.000*
B4	Lack of long-term perspective	0.595	0.000*
B5	Lack of organizational learning	0.625	0.000*
B6	Low level of awareness and understanding	0.667	0.000*
B7	Absence of knowledge and lack of proficiency	0.636	0.000*
B8	Resistance to change	0.550	0.000*
B9	High training costs during employment	0.565	0.000*
B10	Lack of top management leadership and commitment	0.671	0.000*
B11	Poor teamworking skills	0.649	0.000*
B12	Lack of effective communication networks	0.661	0.004*

Table (C2): *The correlation coefficient between each paragraph/item in the field and the whole field. Third field: Areas of integration between lean and sustainable construction*

No.	Item	Pearson correlation coefficient	p-value
C1	Resource management	0.699	0.000*
C2	Waste reduction	0.689	0.000*
C3	Energy use reduction	0.576	0.000*
C4	Elimination of non-value processes	0.624	0.000*
C5	Environment improvement	0.651	0.000*
C6	Performance maximization	0.736	0.000*
C7	Environmental management	0.730	0.000*
C8	Cost reduction	0.670	0.000*
C9	Health and safety improvement	0.755	0.000*
C10	Quality improvement	0.754	0.000*

Table (C3): *The correlation coefficient between each paragraph/item in the field and the whole field. Fourth field: Success factors*

No.	Item	Pearson correlation coefficient	p-value
D1	Change strategy	0.681	0.000*
D2	Senior management commitment	0.778	0.000*
D3	Product focus	0.587	0.000*
D4	Company culture	0.759	0.000*
D5	Business plan and vision	0.757	0.000*
D6	Top management support	0.784	0.000*
D7	Effective communications	0.736	0.000*
D8	Education and training	0.796	0.000*
D9	Monitoring and evaluation of performance	0.782	0.000*
D10	Leadership	0.769	0.000*
D11	Employees engagement	0.722	0.000*
D12	Commitment of all stakeholders	0.571	0.000*
D13	Fiscal incentives	0.692	0.000*
D14	Regulations	0.689	0.000*
D15	Awareness, knowledge and interest of stakeholder	0.669	0.000*
D16	The role of the government	0.722	0.000*
D17	Company's awareness	0.773	0.000*
D18	Guide and benchmarking systems	0.723	0.000*

Table (C4): *The correlation coefficient between each paragraph/item in the field and the whole field. Fifth field: the level of contribution of lean construction tools for enabling sustainability*

No.	Item	Pearson correlation coefficient	p-value
E1	Last Planner System (The last planner is a person or group of people with the task to control production unit. They are responsible necessitating control of workflow, verify supply stream, design, and installation in all the production units)	0.563	0.000*
E2	Increased visualization (making operations and quality requirements clearer using charts, displayed schedules, painted designated inventory and tool locations)	0.681	0.000*
E3	The 5S (House-keeping) meaning Sort, Straighten, Shine, Standardize, and Sustain. This is a process for waste removal from the workplace through the use of visual controls.	0.662	0.000*

No.	Item	Pearson correlation coefficient	p-value
E4	Error-Proofing (Poka-yoke) This is a mechanism design to detect and prevent errors in processes with the aim of achieving zero defects.	0.790	0.000*
E5	The 5 Whys (The five times repetition of "why" (5 whys) when confronted with a problem helps to uncover the root cause of the problem)	0.663	0.000*
E6	Daily Huddle Meetings (a brief daily start-up meeting is conducted to collect reports on the state of the work since the previous meeting)	0.594	0.000*
E7	First Run Studies (The tool uses a Plan-Do-Check-Act (PDCA) cycle to lean the process)	0.757	0.000*
E8	Just in time (a method of forwarding material or specific manpower or traits at the exact moment where it is needed, reducing on site inventories and inefficient man-hours (Waiting, and double handling)	0.797	0.000*
E9	Value stream mapping (material- and information-flow mapping)	0.631	0.000*
E10	Six Sigma (Sets of tools and techniques for improving quality through identification and removal of defects and reduction of variability in processes. Six Sigma is able to achieve process quality of 99.99966% that is free from defects)	0.759	0.000*
E11	Concurrent engineering (designing and developing products, in which the different stages run simultaneously, rather than consecutively)	0.662	0.000*
E12	Total preventive maintenance (the application of preventive maintenance strategies in an organized and standardized method)	0.731	0.000*
E13	Kaizen (Japanese business philosophy for continuous improvement. This is an approach that seeks to improve quality and efficiency through the elimination of waste from the value stream)	0.680	0.000*