LEAN ENABLING CAPACITY BUILDING FRAMEWORK FOR SMALL AND MEDIUM ENTERPRISES IN CONSTRUCTION INDUSTRY

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Degree of Doctor of Philosophy

Department of Building Economics

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Thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

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DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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ABSTRACT

Lean Enabling Capacity Building Framework for Small and Medium Enterprises in Construction Industry

Lean implementation has embarked on a positive trend in Small and Medium Enterprises (SMEs) in the construction industry. Lean practices ensure yielding a higher value for construction processes at a lower cost. However, countless barriers have led to a low success rate in lean implementation in construction SMEs. Therefore, all necessary capacities need to be identified and developed by construction SMEs to achieve the full benefits of lean. Although the challenges of lean implementation in construction and solutions to overcome them have been previously explored in the international arena, there is a dearth of research on lean implementation and strategies to overcome barriers in lean implementation in Sri Lankan context. While exacerbating the situation, capacity building to overcome lean implementation barriers is often overlooked in construction SMEs. Hence, this research aims to develop a lean enabling capacity building framework for construction SMEs in Sri Lanka. The critical review of literature initially developed a working definition for the term construction SMEs in Sri Lanka and established the importance of developing the ability of individual, organisational and environmental capacities to enable lean in order to optimise the value of construction SMEs. The research adopted ontological, idealist assumptions in the interpretive paradigm for the study to collect, analyse and validate data. The data collection comprised of two rounds of empirical investigations (EIR-1 and EIR-2). Adopting a case study strategy, EIR-1 included data collection from five construction SMEs selected through quota sampling. Data triangulation was achieved through 18 semi-structured interviews, three focus group interviews, observations at eleven progress review meetings and eight site visits and documentary reviews. EIR-2 included in-depth interviews with 24 experts selected through purposive sampling.

Findings of EIR-1 were extended to develop a SWOT analysis and 5-Whys analysis to identify non-value adding activities (NVAA) in construction SMEs. EIR-1 further presented the current level of implementation and understanding of lean tools and techniques within construction SMEs. EIR-2 identified 66 drivers and 62 barriers for lean implementation in construction SMEs at three capacity levels. Further, 7, 5 and 4 numbers of lean enabling capacities at individual, organisational and environmental levels of construction SMEs were identified, respectively. ‘Lean knowledge dissemination’, ‘lean learning’, ‘start lean by doing’ and ‘lean skills developments’ are noteworthy individual level lean enabling strategies. All eleven organisational strategies are interconnected and inter-dependent. ‘Maintaining a lean culture’, ‘networking’ and ‘lean training’ are the foremost organisational lean enabling capacity building strategies out of eleven strategies. All four environmental strategies including ‘establishing a professional institute for lean construction’, ‘organising lean awareness programmes’, ‘disseminating inter/intra industry lean knowledge’ and ‘introducing national policies and legislation to support lean implementation’ are notable lean enabling capacity building strategies. Lean enabling capacity building framework was developed by mapping the lean enabling capacity building strategies for construction SMEs. This research contributes to the body of knowledge as it uncovers individual, organisational and environmental level strategies for enabling lean through capacity building in Sri Lankan construction SMEs. The outcomes of this research study will be beneficial to construction SMEs, academics, researchers, and government institutions in developing countries sharing similar socio-economic, demographic or cultural traits to Sri Lanka.

Keywords: Capacity Building; Construction Industry; Lean Construction; Small and Medium Enterprises (SMEs); Sri Lanka.

DEDICATION

To all my teachers

&

To my beloved family

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LIST OF ABBREVIATIONS

3P	-	Production Preparation Process
5-Whys	-	Five-Whys Analysis
BIM	-	Building Information Modelling
BOQ	-	Bills of Quantities
CBA	-	Choosing By Advantage
CAD	-	Canadian Dollar
CCI	-	Chamber of Construction Industry Sri Lanka
CIDA	-	Construction Industry Development Authority
CIOB	-	Ceylon Institute of Builders
COYLE	-	Chamber of Young Lanka Entrepreneurs
CPD	-	Continuous Professional Development
EIR	-	Empirical Investigation Round
ERP	-	Enterprise Resource Planning
GDP	-	Gross Domestic Product
H&S	-	Health and Safety
HRM	-	Human Resource Management
IFC	-	International Finance Corporation
IGLC	-	International Group for Lean Construction
IPD	-	Integrated Project Delivery
JIT	-	Just-in-Time
KTP	-	Knowledge Transfer Partnerships
LBMS	-	Location Based Management System
LKR	-	Sri Lankan Rupees
LPS	-	Last Planner System
MR	-	Malaysian Ringgit
MENA	-	Middle East and North Africa
NCASL	-	National Construction Association of Sri Lanka
NVAA	-	Non-Value Adding Activities
OECD	-	Organisation for Economic Co-operation and Development
PAQS	-	Pacific Association of Quantity Surveyors

PDCA	-	Plan-Do-Check-Act
PEPFAR	-	President‘s Emergency Plan for AIDS Relief
QSR	-	Qualitative Solutions and Research Limited
R&D	-	Research and Development
RCA	-	Root Cause Analysis
RPS	-	Reverse Phase Scheduling
SME	-	Small and Medium Enterprises
SMED	-	Single Minute Exchange of Dies
TFV	-	Transformation-Flow-Value
TPM	-	Total Productive Maintenance
TPS	-	Toyota Production System
TQM	-	Total Quality Management
TVD	-	Target-Value Design
UNDP	-	United Nations Development Programme
UNESCO	-	United Nations Educational, Scientific and Cultural Organisation
USD	-	United States Dollar
VAA	-	Value Adding Activities
VSM	-	Value Stream Mapping

CHAPTER 1

INTRODUCTION

1.1 Background

Small and Medium Enterprises (SMEs) are key parts of economic growth in all countries, which employ the prevalent percentage of the workforce (Papadopoulos, Baltas, & Balta, 2020; Agwu, & Emeti, 2014; Guzman, Serna, Torres, & Ramirez, 2012). Yet, there is no universally accepted definition for SMEs, as it seems to vary from industry to industry and also from country to country. Ayanda and Laraba (2011) identified three (03) parameters generally applied by most countries to define SMEs as (a) capital investment on plant and machinery, (b) number of workers employed, and (c) volume of production or turnover of business.

In developed and newly developing countries, SMEs generally employ a large percentage of the workforce and are responsible for income generation opportunities. Nevertheless, Harvie (2004) and Harvie and Lee (2003) stated that the majority of SMEs are relatively small and over 95% of SMEs in the East-Asian region employ less than 100 people. This number varies across countries. In Sri Lanka, the category of SME is made up of enterprises, which have an annual turnover less than Sri Lankan Rupees (LKR) 750 Mn (nearly USD 4.3Mn) and employ less than 300 employees (Ministry of Industry and Commerce, 2015). Approximately 90% of enterprises are SMEs in Sri Lanka, contributing to nearly 52% of country's Gross Domestic Product (GDP) and generating 45% of employment (Ministry of Industry and Commerce, 2015). SMEs contribution was further reported by Attygalle et al. (2014), Kapugamage and Gajanayaka (2020) and Deyshappriya and Maduwanthi (2020) highlighting the significance of SMEs role in the Sri Lankan economy irrespective of their development status.

According to Harvie (2004), construction SMEs play a greater role in Taiwan, China, Japan, Thailand and Vietnam contributing to over 70% of employment, while in Indonesia and Malaysia, construction SMEs contribute to approximately 40% of employment. Hence, the relative importance of construction SMEs in advanced and developing countries would continue to reconsider the role of construction SMEs in the economy (Ayanda & Laraba, 2011; Wedawatta, Ingirige, Jones, & Proverbs, 2011). However, construction SMEs are under pressure to compete in the industry and to maintain their market position due to the monopoly created by the large firms (Tezel, Koskela, & Aziz, 2017; Pulaj, & Kume, 2014; Opafunso, & Adepoju, 2014). Researchers such as Windapo, Olugboyega and Odediran (2020), Kissi et al. (2019), Ulubeyli, Kazaz, and Sahin (2018), Ofori and Toor (2012), and Yan and Chew (2011) identified the constant issues and the risks faced by construction SMEs as lack of job continuity, difficulties in the operating environment, access to finance, competition from the larger number of enterprises in the industry offering the same services, low level of technology, lack of skilled workers and management expertise, lack of access to international markets and unsupportive legislations.

The continuous changes that affect the business environment, due to the globalisation process and the technology innovations force SMEs to persistently look for a new direction to preserve and advance their market position (Aremu, 2004; Ayanda, & Laraba, 2011). To remain competitive in the global context and to be able to meet unprecedented market changes, organisations must not only design and offer better products and services; but need to improve their operations and processes (Rahman, Sharif, & Esa, 2013). Bertelsen and Koskela (2004) stated that construction need to be understand as a flow of work and a creation of value, where construction SMEs should precisely looking for new ways, which creates value for their organisations. The conventional systems used in the construction industry pursue the 'task' of project completion, however, neglect minimising non-value addition and maximising value enhancement (Koskela, 2020; Koskela, Howell, Ballard, & Tommelein, 2002). Nevertheless, the concept of 'value' has been commonly related to cost, function and quality (Garrido, & Pasquire, 2011), which are major parameters to choose the success of the construction organisation. Therefore, there is a need for the construction SMEs to be strategic in planning (Ofori, & Toor, 2012), deliberately handle risk and uncertainty (Kissi et al., 2019), adapt to changing environment (Windapo et al., 2020), able to improve creativity through developing networks

(Wee, & Chua, 2013; Seymour, 2013) and aim to develop and implement new construction processes yielding higher value at lesser costs (Bertelsen, & Koskela, 2004). There is a need for construction SMEs to implement new concepts and methodologies to remain competitive in the industry, while increasing the value addition.

In the early 1990s, researchers embedded production management practices influenced by Japaneese manufacturing industry into construction project management to improve the performance (Tommelein, 2015; Gao, & Low, 2014; Howell, & Ballard, 1998; Koskela, 1992). This had gained a global competitive edge by accepting some production management principles and techniques explicated under the term ‘Lean Production System’ (Jasti, & Kodali, 2015; Shah, & Ward, 2007; Fujimoto, 1999; Womack, Jones, & Roos, 1990). Subsequently, the efforts towards implementing lean into the construction industry and project delivery process were accumulated and termed as lean construction (Tommelein, 2015; Ballard, & Howell, 2003; Howell, 1999).

Lean concept has significantly evolved and expanded beyond its roots in the automotive industry (Hines, Holweg, & Rich, 2004). Rahman et al. (2013) defined lean as a set of tools that assist in the identification and elimination of waste that improves quality, production time and cost. Similarly, lean is referred to as an integrated manufacturing system aimed at maximising capacity use through the minimisation of variability in the system (Fuentes, & Dias, 2012; Treville, & Antonakis, 2006; Wacker, 2004). The dual focus of lean on increasing business value and eliminating non-value adding activities (NVAA) made it one of the most popular business performance improvement approaches of the past (Tzortzopoulos, Kagioglou, & Koskela, 2020) and highlighted that, many organisations are implementing or willing to implement lean in the construction industry.

As a result, many organisations tend to introduce lean concept as one of the most prominent improvement approaches within the construction industry to gain value addition (Tezel et al., 2017; Tommelein, 2015; Mossman, 2015; Nesensohn, Bryde, Ochieng, Fearon, & Hackett, 2014; Sarhan, & Fox 2013; Sage, Dainty, & Brookes, 2012; Koskela et al., 2002). Further, many researchers such as Tzortzopoulos, et al. (2020), Aziz and Hafez (2013), Al-Aomar (2012), Hamzeh, Kallassy, Lahoud, and Azar (2016) and Alarcón, Diethelm, Rojo and Calderon (2005) have proven the possibility of increasing value addition through lean implementation in construction industry. Similarly, Tezel et al. (2017, 2018, 2020), Tezel, Koskela, and Aziz (2018), Ankomah, Ayarkwa, and Agyekum (2017, 2018, 2020) and Avelar, Meiriño, and Tortorella (2019) emphasised that construction SMEs can be benefited by converting their processes to lean provided the processes are adjusted accordingly to improve the performances.

Seymour (2013) declared that lean construction is a philosophy and a set of practices that largely originated from the seminal work of Koskela, Ballard and Howell. Conferring to lean construction principles of Koskela (1992) and research on lean construction by Howell and Ballard (1998, 1999), the adoption of lean has speed up in the construction industry. Koskela (2004) further added that lean provides a well-established, comprehensive basis equivalent to a theory for the transformation of any activity in the construction industry. Aziz and Hafez (2013) stated that lean aims to optimise the performance of the production system against a standard of perfection to meet the requirements of the client comparing to traditional mass and craft forms of production. Fuentes and Dias (2012) contended that the definitions of lean to be more focused on value delivery targeting on operations carried out in the organisation and particularly at the shop floor level. However, the definitions are more towards the benefits that can be gained through lean implementation. Due to benefit-oriented definitions, there is an increasingly positive trend in the construction industry to implement lean and gain the said benefits to the organisations (Rooke, 2020; Alves et al., 2016; Arroyo, Tommelein, & Ballard, 2015; Nesensohn et al., 2014).

Lean construction is the application of lean thinking to the whole construction processes to improve project delivery through achieving client needs, which emphasise ‘optimising the total value’ instead of ‘minimising the cost’ as the prime objective (Ogunbiyi, Oladapo, & Goulding, 2013). However, Koskela et al. (2002)

introduced two slightly differing interpretations of lean construction. One interpretation holds the application of lean production concepts to construction and the other interpretation views lean production as a theoretical inspiration for the formulation of a new, theory-based methodology for construction (Koskela et al., 2002). Hines, Found, Griffiths, and Harrison (2008) indicated the need of whole life consideration of construction projects for successful lean implementation.

Egan Report (1998) recommended adopting lean thinking as a means of sustaining performance improvement in construction projects in the United Kingdom. Moreover, several benefits of lean construction have encouraged industry practitioners to adopt lean to their projects. Many researchers have identified benefits of lean construction such as reducing waste, client satisfaction, improvements in productivity, reduction of cost, risk management and improvements in safety and project delivery (Tillmann, & Miron, 2020; Arrayo, & Gonzalez, 2016; Tommelein, 2015; Bernstein, & Jones, 2013; Aziz, & Hafez, 2013; Marhani, Jaapar, & Bari, 2012; Hamzeh, 2011; Alves et al., 2009; Koskela et al., 2002). However, comparing to construction production/assembly, there is a difference in practical repercussions of applying the lean approach in construction design (Jorgensen, & Emmitt, 2009). Indeed, lean construction is still not at the fully developed stage (Koskela, 2020). Many critics thus were rightfully attacking lean, yet often neglected the fact that lean has, and continues to develop (Tzortzopoulos et al., 2020; Hines et al., 2004). However, embedding lean construction in an organisation typically requires many changes and is a challenging endeavour (Nesensohn et al., 2014).

A survey conducted by the practitioners of lean implementation in manufacturing industry revealed that changes to the production environment due to lean have only a 30% success rate and 70% of lean implementations experience decay and return to the original way of doing business (Schipper, & Swets, 2010). Undoubtedly, construction SMEs too face countless barriers due to the heterogeneous nature of the sector. Hence, lean implementation is not free from barriers such as lack of support and commitment, cultural and philosophical issues, government-related issues and procurement related issues, lack of long-term philosophy, absence of a lean culture in the organisations, ineffective inventory management, lack of supplier participation, lack of quality control and lack of top management commitment in the construction SMEs (Tazel et al., 2020; Avelar et al., 2019; Ankomah et al., 2018). Therefore, these barriers need to be minimised by SMEs in the construction industry to obtain the benefits of lean implementation.

The transformation towards lean construction will lead to changes in the culture and its people (Green, Harty, Elmualim, Larsen, & Kao, 2008). Therefore, lean relies heavily on the skills of the people and how they respond to changes (Sawhney, & Chason, 2005) to overcome the lean implementation barriers. However, Koskela et al. (2002) added the need for appropriate organisational structure emphasising the need for organisational strategies, plans and coaching programs within the construction organisation to overcome the lean barriers. Many researchers including Gomas and Tzortzopoulos (2020), Mossman (2018) and Koskela et al. (2002) contended that changing procedures, techniques and corporate systems is stress-free comparing to changing mind-sets of peoples. Similarly, the importance of having lean training programs that are multi-disciplinary, learner-centered and with a focus on developing people and process skills is inevitable in the lean implementation process. These training programs need to be backed by the capacities of organisation and the external environment in which the organisation operates (Linné, & Ekhall, 2013). Therefore, lean-based construction emphasised the need of changes in individual behaviour, resources of the organisation and the external environment. This has indicated the call for defined capacities for successful lean implementation. Hence, SMEs must identify the necessary capacities and ways of building these capacities to obtain the benefits from lean implementation.

Merino and Carmenado (2012) identified capacity building as an abstract and multidimensional concept. United Nations Development Programme (UNDP, 2012) defined capacity building as the process of obtaining, strengthening, and maintaining the capabilities to set and achieve the development objectives over time by individuals, organisations, and external environment. Therefore, organisational capacities need to be built by considering both individual and environmental level capacities. However, most of the local construction companies in developing countries are unable to achieve the demand for construction work, due to lack of capacities (Kululanga, 2012: Thwala, & Mvubu, 2008; Enshassi, Al-Hallaq, & Mohamed, 2006). SMEs in both developed and developing countries today face tough and challenging times in improving performance due to the challenges faced by them from the industry. At the same time, high competition demands SMEs a higher level of capacity to maintain or increase the performance of the business steadily (Guzman et al., 2012; Lagace, & Bourgault, 2003). To sustain a fair level of competitiveness in both local and global markets, SMEs must strive to utilize tools and new concepts to reach the right markets in cost-effective ways (Singh, Garg, & Deshmukh, 2010). Further, Harvie (2004) highlighted the significance of promoting more adaptable and flexible strategies by capacity building in construction SMEs.

To achieve lean objectives, construction SMEs need to identify lean enabling capacity building strategies to be competitive in the construction industry.

1.2 Research Problem

Participation of construction SMEs is vital for the success of Sri Lankan construction industry (Kapugamage, & Gajanayaka, 2020; Balachandra, 2014). Moreover, their noteworthy contribution in employment generation in recent years has created research interest in challenges and prospects of construction SMEs in Sri Lanka (Kandewatta, Kurukulasooriya, & Keembiyahetti, 2021; Erandi, & Sachitra, 2021). It is accepted that there is a lack of value addition leading to challenges for construction SMEs. Nevertheless, the facts and data available are extremely insufficient and difficult to assess the current situation of construction SMEs in Sri Lanka. SMEs have not been a priority sector in the Sri Lankan research agenda (Silva, 2013) and particularly construction SMEs. Considering the investment levels of the construction industry, and the development needs in the country, attention to the matters of construction SMEs is long overdue.

An increasing need arise to develop and implement new construction processes among construction SMEs for yielding higher value at a lower cost (Tezel et al., 2020; Avelar et al., 2019). In this context, lean is one such increasingly positive trend in the construction industry that seeks the required improvement targets. Moreover, construction SMEs need to identify necessary capacities to obtain the full benefits of lean implementation and it needs to be viewed in a wider context.

Although the challenges of lean implementation in construction and solutions to overcome them have been previously explored (Shang, & Pheng, 2014; Jadhav, Mantha, & Rane, 2014; Ogunbiyi et al., 2013; Aziz, & Hafez, 2013; Bertelsen, & Koskela, 2004), there is a dearth of research on lean implementation and how to overcome the barriers for lean implementation in construction SMEs specially in the Sri Lankan context.

According to Jadhav et al. (2014), lean implementation issues may vary from country to country and even may depend on the work culture of the organisation and geographic location within the country. Although the construction industry appears to be one of the pioneering industries to be absorbing lean concepts and techniques (Shang, & Pheng, 2014), lean does not receive the attention it deserves in the construction industry. Rework, uncertainty, labour skills, site conditions and location are some examples of factors that need further analysis for leaner construction processes (Al-Sudairi, 2007).

Most of the large-scale organisations have been adopting the lean concept and thus, there is a plethora of research in lean construction for large organisations. Although attempts have been made to develop lean frameworks, which include capacity building in China (Gao, & Low, 2014), Middle East (Al-Aomar, 2012), United States of America (USA) (Paez et al., 2005), United Kingdom (UK) (Sarhan, & Fox, 2013) and India (Ahuja, Sawhney, & Arif, 2018) in the construction industry, the focus on construction SMEs capacity building in such frameworks is relatively insufficient. Therefore, any improvement efforts to SMEs will impact greatly the performance of the industry. Nevertheless, there is a significantly lower rate of adoption of lean principles in construction SMEs than in large enterprises (Ankomah et al., 2020; Tezel et al., 2017).

Plethora of research and successful application of lean can be found in the global construction context, yet research on the lean application in construction industry of Sri Lanka is limited to few initiatives in the past (Pandithawatta, Zainudeen, & Perera, 2019; Ekanayake, & Senaratne, 2012; Thilakarathna, & Senaratne, 2012; Senaratne, Ekanayake, & Siriwardena, 2010; Senaratne, & Wijesiri, 2008). These studies have largely focused on lean in general, or they have focused on larger enterprises by neglecting SMEs. Thus, there is a gap in the literature on lean implementation that is pertinent to SMEs. The fact that the lean concept has worked well for large construction enterprises could not be interpreted as it will work well in construction SMEs too, due to the salient features of construction SMEs.

Unlike the manufacturing industry, research investigating lean implementation in construction SMEs has remained scarce (Antosz & Stadnicka, 2017; Zhou, 2016; Achanga, Shehab, Roy, & Nelder, 2006). Although Tezel et al. (2018) differentiate the current status and future direction for lean construction from a SMEs perspective, the unavailability of an implementable framework for construction SMEs have hindered the lean implementation among the construction SMEs.

All aforementioned key studies have investigated limited aspects of lean construction and capacity building concepts individually in construction SMEs without conclusive or substantiated results. Although lean and capacity building related literature are discussed on their own, there is a lack of study that explicitly links the capacity building to enable lean to foster construction SMEs. Therefore, the main research question (MRQ) is formulated as,

MRQ : *How to build lean enabling capacities by construction SMEs*?

Under the main research question, there are several sub-questions to be addressed as follows.

RQ1 : *How lean has implemented through capacity building in global construction industry?*

RQ2a : *What are the NVAA of construction SMEs and their root causes?*

RQ2b : What is the level of understanding and implementation of lean tools and techniques by construction SMEs in Sri Lankan construction industry?

RQ3a : What are the drivers for lean implementation in construction SMEs?

RQ3b : What are the barriers for lean implementation in construction SMEs?

RQ4 : What are the capacities required for enabling lean in construction SMEs?

RQ5 : What are the strategies for enabling lean in construction SMEs?

A well-designed empirical investigation on the above will guide the construction SMEs to identify lean enabling capacity building strategies leading to minimise challenges and optimise the performance of lean implementation.

1.3 Aim and Objectives

1.3.1 Aim

The aim of this research is to develop a lean enabling capacity building framework for construction SMEs in Sri Lanka.

1.3.2 Objectives

The aim will be achieved through the following measurable objectives:

1. Review literature on,
   a. Construction SMEs, their importance and issues faced by them,
   b. Lean philosophy and its application to construction SMEs,
   c. Capacity building in the context of construction SMEs, and
   d. Capacity building for lean construction.
2. Analyse the present situation of lean implementation in Sri Lankan construction SMEs.
3. Investigate the drivers and barriers for lean implementation in construction SMEs.
4. Determine lean enabling capacities for construction SMEs.
5. Propose strategies to build capacities necessary for enabling lean in construction SMEs.

1.4 Initial Framework of the Research Intention

In order to provide guidance to the researcher on the way forward, an initial framework was developed to present the research intention as shown in Figure 1.1.

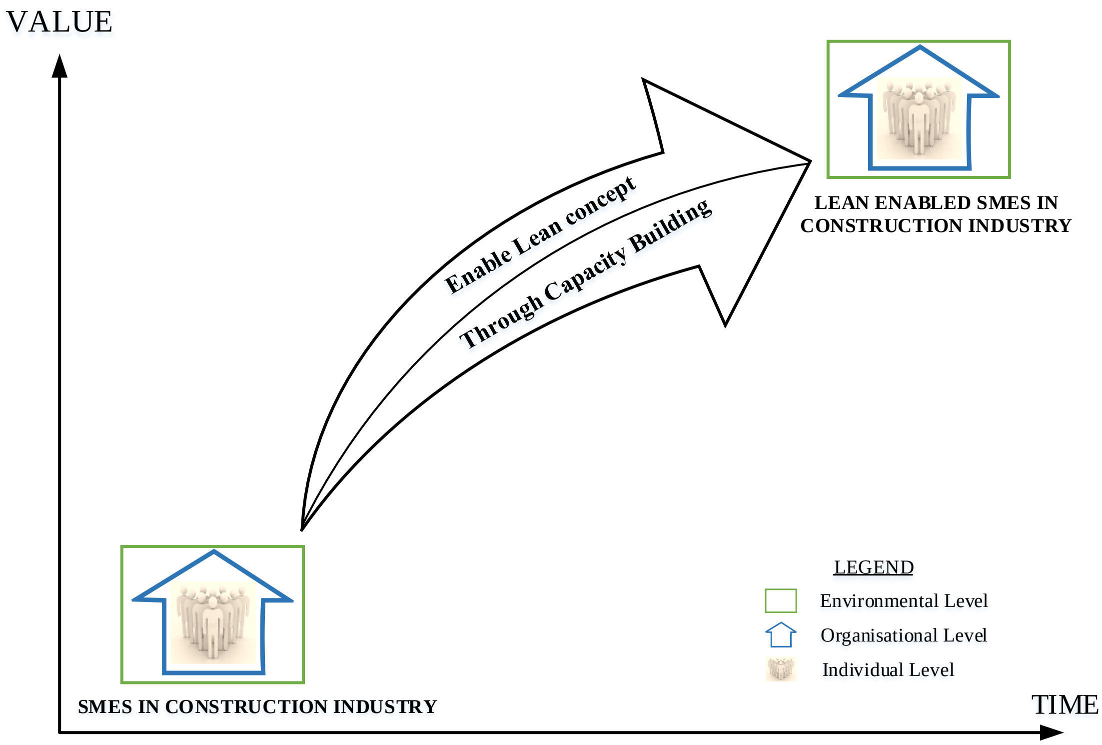


Figure 1.1: Initial framework of the research intention

The above figure depicts the lean journey on a graph, where time is presented on X axis and value is represented on Y axis. The chapter emphasised the emerging key issues of construction SMEs in a lean environment and the need for lean enabling capacity building strategies. Thus, the main essence of lean is the gradual increase of value over the time horizon. Therefore, lean implementation needs to be backed by the capacity building concept to become lean-enabled construction SMEs.

1.5 Research Methodology

The selection of an appropriate research methodology is imperative in achieving the objectives of the research. Therefore, an overall research approach is established as presented in Figure 1.2.

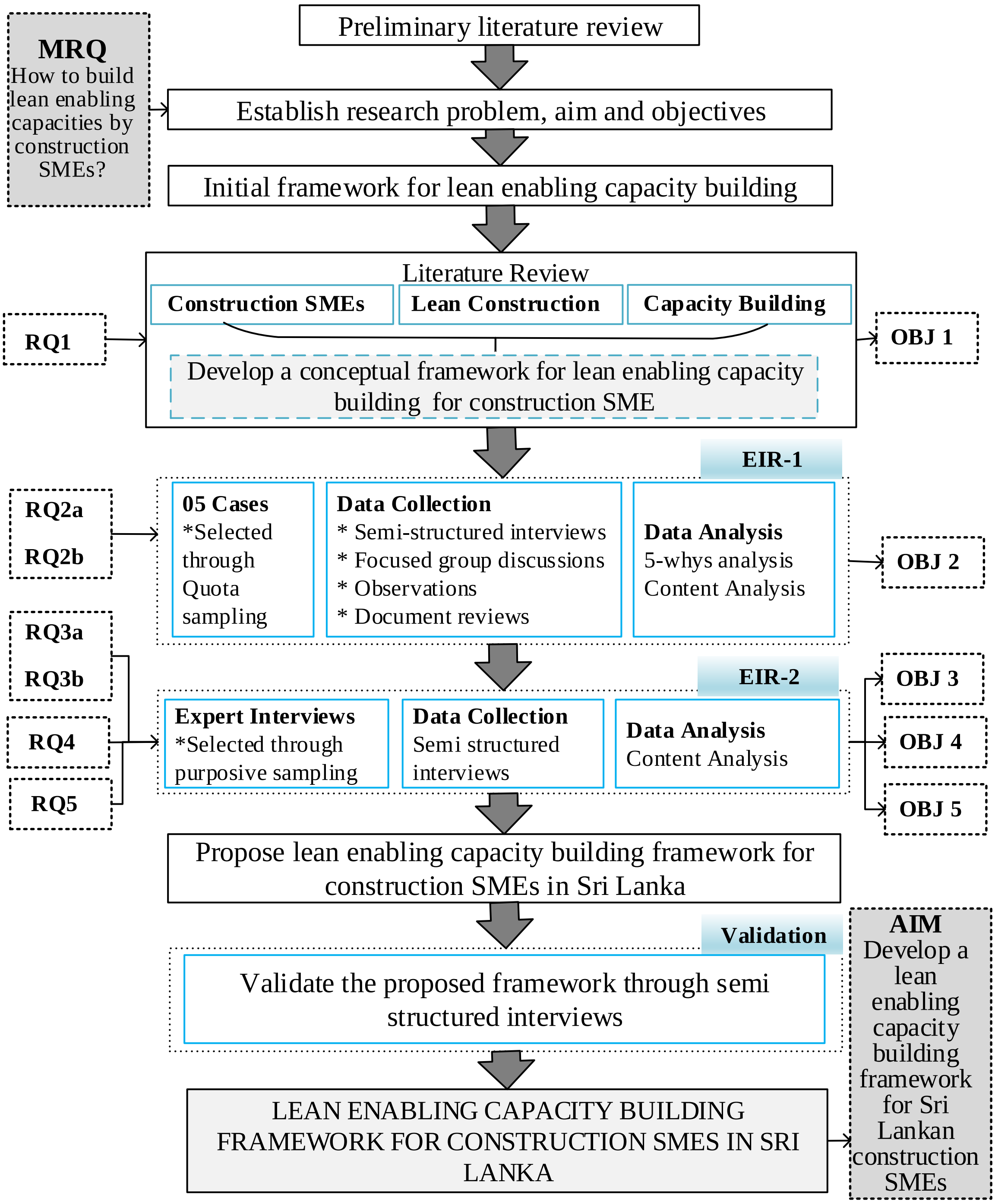


Figure 1.2: Research process

This research recognised interpretivism as the suitable research philosophy for the study for the collection and analysis of data to achieve the aim and objectives. The methodology began with a preliminary literature review to identify the research gap.

This was followed by a comprehensive literature review to develop a theoretical understanding on construction SMEs, lean construction and capacity building concept.

Subsequently, Empirical Investigation Round (EIR)-1 was carried out using 5 case studies to investigate the SWOT of construction SMEs, NVAA and their root causes and level of lean implementation by the construction SMEs in Sri Lanka. Data collection techniques used within the cases were semi-structured interviews, observations, focus group interviews and documentary review to facilitate effective data triangulation. Therefore, eighteen in-depth interviews were conducted with the top management of the selected cases. The interview process included direct and indirect questioning to identify the lean implementation by the construction SMEs in Sri Lanka. Focused group interviews were carried out with shop floor level workers in three cases. Observations were mainly made by participating in progress review meetings of the selected projects and visiting sites while recording observations based on a pre-developed guideline. Data were further collected by referring to contract documents and some selected progress review meeting minutes. Cross-case analysis was carried-out using code-based content analysis during the data analysis process. SWOT analysis and 5-Whys analysis were further facilitated the content analysis process of EIR-1.

A comprehensive literature review and EIR-1 findings were then used to refine the interview guideline of EIR-2. Semi-structured interviews with experts were used to gather data to determine barriers and drivers for lean implementation for construction SMEs, lean enabling capacities and capacity building strategies to enable lean among construction SMEs in Sri Lanka. Code-based content analysis was conducted using Nvivo11 software to organize, analyse and find insights in the collected data. The analysed data were then used to develop the lean enabling capacity building framework for the research study. The developed framework was validated from experts through semi-structured interviews. Moreover, interactive data visualisation tool PowerBI and Microsoft Visio were used to present the findings of EIR-2 of the study.

1.6 Scope and Limitations

The focus of the research was limited to small and medium contractors in the Sri Lankan construction industry due to the research objectives and the inherent characteristics of construction SMEs. Further, the majority of construction SMEs are contractors and hence the case study selection for EIR-1 was limited to the Contractors registration under Grades C2 to C6 as per the Construction Industry Development Authority (CIDA), Sri Lanka guidelines. Moreover, consultants, plant hirers and material suppliers at SME category were excluded from the study. Moreover, specialized construction contractors and micro-level contractors were not considered for the research study. Data collection of EIR-2 was limited to 24 experts in the construction industry who were selected by analysing the experience in the construction SMEs and awareness of lean construction. The limitations of this research are detailed in Chapter 7.

1.7 Chapter Breakdown

The thesis consists of seven chapters. A brief overview of the chapter content is described below.

Chapter 1: Introduction - The background of the research problem is presented in this chapter and explains the aim, objectives of the research. It further presents the methodology adopted for the study and discusses the limitations of the research. This chapter finally presents the structure of the report and summary of the research.

Chapter 2: Construction SMEs and lean construction - Review the theoretical status of construction SMEs from literature. The chapter reviews lean construction literature to identify lean principles, existing lean models, drivers and barriers for lean implementation.

Chapter 3: Capacity building - Review the theoretical status of capacity building concept through comprehensive literature survey. Lean enabling capacities and lean enabling capacity building are discussed in detail in this chapter for construction

SMEs. The chapter establishes the research problem and present the conceptual framework of the research.

Chapter 4: Research methodology – Development of research methodology of the study is the focus of this chapter. It discusses the significance of the research and presents the research design, research philosophy and research approaches of the study. The chapter finally discusses the process of data collection and data analysis of EIR-1 and EIR-2 of the research.

Chapter 5: Situational analysis of construction SMEs in Sri Lanka - Present the status quo of construction SMEs in Sri Lankan through findings of the EIR-1 from case studies. SWOT analysis and 5-Whys analysis for NVAA of construction SMEs are presented in this chapter. Level of lean implementation in Sri Lankan construction SMEs presented.

Chapter 6: Development of lean enabling capacity building framework – This chapter presents the EIR-2 findings of the research. Presents the drivers and barriers for lean implementation, lean enabling capacities and capacity building strategies for construction SMEs. Finally, the developed lean enabling capacity building framework for construction SMEs is presented.

Chapter 7: Conclusions and recommendations - Concludes by discussing the outcomes of the research, and the degree to which the aim and objectives were met. It further explains the contribution to knowledge. The chapter finally presents the practical implications, research limitations and further research directions.

1.8 Chapter Summary

Chapter 1 of the thesis presented an overview of the research aimed at developing a lean enabling capacity building framework for Sri Lankan construction SMEs. Therefore, in achieving the aim of becoming lean, this chapter further explained the research objectives and the methodological approach to achieve the research aim and objectives. Finally, the chapter discussed the limitations of the research and a brief overview of the rest of chapters was presented.

CHAPTER 2

CONSTRUCTION SMEs AND LEAN CONSTRUCTION

2.1 Introduction

The emphasis on SMEs requires a comprehensive analysis of their inherent characteristics in contrast to large organisations. Similarly, SMEs play a vital role in construction industry. Therefore, this chapter presents a literature review on enabling lean in construction SMEs.

Section I of the chapter initiates by introducing the SME sector in general and then moving to the discussion on construction SMEs. Definition for construction SMEs is provided along with the problems faced by construction SMEs both globally and locally. This first section further presents the characteristics of construction SMEs, followed by a discussion on overcoming problems faced by construction SMEs.

Section II of the chapter focuses on lean construction. This section presents the history and definitions of lean philosophy along with the chronological development of lean construction. Lean thinking comprises a set of ideas including maximise value, minimise NVAA and continuous improvement. Therefore, a detailed review on value adding and NVAA will be discussed in this section. Thereafter, a detailed literature review on lean production and lean construction is carried out to identify the possibility of implementing lean among construction SMEs. This is followed by lean principles, lean tools and techniques in literature, to necessitate the importance of lean implementation for construction SMEs. Subsequently, benefits that can be gained from lean implementation discusses in the chapter. Finally, the chapter summarises the literature findings for lean implementation barriers and drivers for construction SMEs.

2.2 Construction Industry

Construction industry is one of the competitive industries in most of the countries with a dispersed industrial structure and few barriers to entry (Shrestha et al., 2020; Arroyo et al., 2015: Morton, & Ross, 2008). Therefore, firms are freely entering into the industry, while creating competition amongst them. Due to high competition, the construction industry in many parts of the world suffers from problems such as workmanship defects, delays and cost overrun (Harrington, Voehl, & Wiggin, 2012; Woschke, Haase, & Lautenschläger, 2016). Due to the unique nature of construction, organisations are struggling to retain in the industry (Organisation for Economic Co-operation and Development [OECD], 2008). Many researchers attempted to highlight these specific characteristics of construction industry comparing to manufacturing industry. Correspondingly, project-based production, one of a kind production, site based production, separation of design from production, complex supply chain and long life cycle, to name a few.

Although an extensive body of literature exists in the area of challenges face by large-scale construction organisations, the issues encountered by SMEs are largely unreported (Ankomah et al., 2020; Tazel et al., 2020; Hardie, & Newell, 2011). According to Saka and Chan (2020) and Harvie (2004), significance of a rapidly expanding SME sector is a common characteristic of most of the economies. Hence, the importance of SMEs cannot be downgraded as they play a great role in the construction industry and ultimately in the economy.

2.3 Small and Medium Enterprises (SMEs)

SMEs are highly important for the economy (Kapugamage, & Gajanayaka, 2020; Woschke et al., 2016). Many researchers have highlighted that SMEs are one of the backbones of economic growth in all countries, which employ the prevalent percentage of the workforce (Tezel et al., 2020; Perera, & Perera, 2020; Agwu, & Emeti, 2014; Guzman et al., 2012). Therefore, current literature on SMEs frequently emphasises the contribution of SMEs to economic growth and the need of continuous attention to growth in the long run (Ankomah et al., 2020; Deyshappriya, & Maduwanthi, 2020). Hence, it is important to have a better understanding on what constitute SMEs and their characteristics. The next section reviews the definitions of SMEs.

2.3.1 Definition of SMEs

The study by Berisha and Pula (2015) stated that there is a discrepancy in the literature regarding the terms used for the category of organisations that do not fall under the category of large enterprises. However, SME definition is far from being meaningful, solved and acknowledged issue. Therefore, absence of a universal definition of what constitutes an SME is one of the main issues in developing a cross-country analysis of SMEs (Ardic, Mylenko, & Saltane, 2011). There is no universally accepted definition for SME, as it seems to vary from country to country and from industry to industry. Most of the SME definitions are based on quantitative and qualitative parameters. Ayanda and Laraba (2011) identified three (03) parameters generally applied by most countries to quantitatively define SMEs as:

(i) capital investment on plant and machinery,
(ii) number of workers employed, and
(iii) volume of production or turnover of business.

However, among many studies intended at developing a suitable definition, Bolton Committee Report (1971) claimed that a small firm could not be adequately defined in terms of employment or assets, turnover, output or any other arbitrary single quantity, nor would the same definition be appropriate throughout the economy. This was further confirmed by Stokes and Wilson (2010). Hence, Bolton (1971) used the following parameters to qualitatively and economically define SMEs as who,

- has a relatively small share of its market,
- managed by its owners or part-owners in a personalized way, and
- does not form part of a larger enterprise and the owner-managers are free from outside control in taking their principal decisions.

Moreover, Scott and Bruce (1987, p.43) have adopted the definition put forward by the American Committee for Economic Development, which states a firm is small if; ‘Management is independent. Usually, the managers are also owners, capital is supplied, and ownership is held by an individual or small group and area of operation are mainly local, workers and owners are in one home community, but markets need not be local’. Hence, the definition clearly stated the nature of the management of SMEs, area of operations and market of SMEs. Nevertheless, the economic definition is of no use for statistical purposes, since business statistics are not classified in terms of measures like small market share, owner-managers and independence (Bannock, 2005). Although qualitative criteria-characteristics of SMEs easily differentiate SMEs from large organisations, quantitative criteria are primarily used for dimensional classification of SMEs (Berisha, & Pula, 2015). Hence, most of the countries and industries prefer to use the quantitative parameters individually or in combination to define SMEs (Bennett, 2014). Table 2.1 shows a summary of the main definitions of SMEs of several countries.

Table 2.1: Summary of main definitions of SMEs in several countries

<table>
<tr><th rowspan="3">Country</th><th colspan="2" rowspan="2">Sector</th><th colspan="2">Definition of Small</th><th colspan="2">Definition of Medium</th><th rowspan="3">Reference</th></tr>
<tr><th colspan="2">Measure</th><th colspan="2">Measure</th></tr>
<tr><th>Manufact. Sector</th><th>Service Sector</th><th>Annual Turnover (Mn)</th><th>No of Employees</th><th>Annual Turnover (Mn)</th><th>No of Employees</th></tr>
<tr><td rowspan="2">Sri Lanka</td><td>X</td><td></td><td>LKR 16-250</td><td>11 < 50</td><td>LKR 251-750</td><td>51-300</td><td>[1]</td></tr>
<tr><td></td><td>X</td><td>LKR 16-250</td><td>11 < 50</td><td>LKR 251-750</td><td>51-200</td><td>[1]</td></tr>
<tr><td rowspan="2">Canada</td><td>X</td><td></td><td>< CAD 5</td><td>< 100</td><td>CAD 5-20</td><td>100-500</td><td>[2], [3]</td></tr>
<tr><td></td><td>X</td><td>< CAD 5</td><td>< 50</td><td>CAD 5-20</td><td>50-100</td><td>[2], [3]</td></tr>
<tr><td>China</td><td colspan="2">X</td><td></td><td>50 – 100</td><td></td><td>101 -500</td><td>[4], [8]</td></tr>
<tr><td>Indonesia</td><td colspan="2">X</td><td></td><td></td><td></td><td>< 100</td><td>[5]</td></tr>
<tr><td>Korea</td><td>X</td><td></td><td></td><td></td><td></td><td>< 300</td><td>[5]</td></tr>
<tr><td>Malaysia</td><td colspan="2">X</td><td></td><td></td><td>< RM 25</td><td>< 150</td><td>[5]</td></tr>
<tr><td>Philippines</td><td colspan="2">X</td><td></td><td>10 < 100</td><td></td><td>100-199</td><td>[5]</td></tr>
<tr><td>Singapore</td><td></td><td>X</td><td></td><td></td><td></td><td>< 200</td><td>[5], [7]</td></tr>
<tr><td>Taiwan</td><td></td><td>X</td><td></td><td></td><td></td><td>< 200</td><td>[5]</td></tr>
<tr><td>Thailand</td><td>X</td><td></td><td></td><td>< 50</td><td></td><td>50-200</td><td>[5]</td></tr>
<tr><td>Vietnam</td><td colspan="2">X</td><td></td><td>< 30</td><td></td><td>30-200</td><td>[5]</td></tr>
<tr><td>EU</td><td></td><td></td><td>< Euro 10</td><td>< 50</td><td>< Euro 50</td><td>< 250</td><td>[6]</td></tr>
<tr><td>USA</td><td></td><td></td><td></td><td></td><td></td><td>< 500</td><td>[9]</td></tr>
<tr><td>Nigeria</td><td colspan="2">X</td><td></td><td></td><td>< Naira 500</td><td>< 200</td><td>[10]</td></tr>
<tr><td colspan="8">[1] Ministry of Industry and Commerce, Sri Lanka (2015), [2] The Industry of Canada (2017), [3] Statistics Canada (2018), [4] Ministry of Industrial and Information Technology, China (2011), [5] Harvie (2004), [6] EU Commission (2018), [7] OECD (2005), [8] Ward (2018), [9] United States Census Bureau (2018), [10] Saka and Chan (2020)</td></tr>
</table>

According to the table, there is no such dissimilarity between the SME definitions in manufacturing and service sectors. Yet, the majority of researchers explicitly discoursed that the number of workers employ in SMEs are less than 100. Therefore, SMEs as non-subsidiary independent firms, employs less than a specified number of employees. However, this number of employees varies across industries, regions, and countries. The most frequent upper limit defining a SME is 250 employees, as in the European Union (EU). Nevertheless, few other countries set the upper limit at 50 employees, while USA considers upper limit of SMEs as 500 employees (OECD, 2005). Unlike in many other definitions, the upper limit of number of people employed is not a must to be satisfied in countries like Malaysia, Singapore and Taiwan. Therefore, an organisation, which satisfies the turnover and balance sheet total requirements, can still qualify as a SME even if it does not satisfy the employment requirement. However, this categorisation has been derived mainly for accounting and reporting purposes.

Review of available SME definitions confirmed that, developing a universal definition for SMEs is challenging due to the inherent nature of SMEs, industry sectors, economies and countries. This has led to potential complications such as deciding the boundaries of the sample for researchers studying SMEs (Tezel et al., 2020; Ankomah et al., 2017; Lundkvist, Meiling, & Vennström, 2010). Researchers have taken efforts to resolve this problem by adjusting the definition according to the research topic (Ardic et al., 2011; Storey, 1994). Nevertheless, it is difficult to accommodate all the criteria to define SMEs from practical perspective, due to the sensitivity of data such as total of balance sheet and turnover. Hence, use of the two dimensions (number of employees and annual turnover) is worldwide acceptable and popularised for SME sample selection.

2.3.2 SMEs in Sri Lanka

In Sri Lanka, the category of SMEs includes the enterprises, which have an annual turnover less than LKR 750 Mn and employ less than 300 employees (Ministry of Industry and Commerce, 2015) (Refer Table 2.1). Most of the research in Sri Lankan SMEs (Deyshappriya, & Maduwanthi, 2020; Perera, & Perera, 2020; Ravindra, 2019: Rathnaweera, 2019; Menike, 2015) too refereeing the same definition as given by Ministry of Industry and Commerce (2015). In Sri Lanka, SMEs contributed 52% of GDP and responsible for 45% of its employment (Ministry of Industry and Commerce, 2015). This was further reported in Attygalle et al. (2014), Kapugamage and Gajanayaka (2020), and Deyshappriya and Maduwanthi (2020), highlighting the significance of SMEs role in Sri Lankan economy irrespective of their development status. Hence, it is vital to revisit in-depth the SME sector in Sri Lanka. However, the studies conducted by Ravindra (2019); Balachandra (2014) and Athukorala (2017) revealed that the available development programs for Sri Lankan SMEs do not positively contribute to developing a favourable transaction environment for SMEs.

Recent SME development programs, such as the National Policy Framework for SME Development (2014), Grama Shakthi Programme (2016) and Enterprise Sri Lanka (2016) and institutes for supporting SMEs such as Sri Lanka Chamber of Small and Medium Industries are indicative of the Sri Lankan government being mindful of the necessity to improve the SME sector. Moreover, Attygalle et al. (2014) highlighted the availability of special loan schemes from public and private sector banks for SMEs in Sri Lanka and noted that the awareness of those among SMEs is less. However, the researchers (Deyshappriya, & Maduwanthi, 2020; Ravindra, 2019; Athukorala, 2017) contended that banks do not facilitate SMEs to access reliable information, to select suitable governance mechanism and to safeguard transactions from opportunism. Moreover, Priyanath and Premaratne (2014) pointed that, development programmes for SMEs have encouraged relational governance to some extent for certain SMEs and neglected in facilitating formal governance.

Similar to other developed countries, there is a substantial employment generation from SME sector in Sri Lanka (Deyshappriya, & Maduwanthi, 2020; Ravindra, 2019; Yapa, 2017). Therefore, the researchers highlighted the importance of SME sector in the country and the need of researching the problems faced by them to achieve a competitive advantage. The SME Development Bureau in Sri Lanka indicated that, 80% of the SMEs are failed within the first five years of commencement and operation in the Western Province in Sri Lanka (Kumarasinghe, 2017). Therefore, Zhengang, Weerasiri and Dissanayake (2012) contended that SMEs comprise of both service sector and manufacturing sector enterprises and Sriyani (2020), Ravindra, (2019) and Attygalle et al. (2014) have carried out researchers to address the problem faced by SMEs in both sectors. The next section reviews the construction SMEs.

2.4 Construction SMEs

The construction industry significantly contributes to the national economy and SMEs dominate the construction industry of many countries. Therefore, the construction SMEs are critical in the structure of the industry (Ofori, & Toor, 2015). Hence, SMEs are imperative to the effective operation of the construction industry and the collective effect of SMEs' failure could lead to substantial effect on the construction industry as a whole (Saka, & Chan, 2020; Bennett, 2014). Table 2.2 provides statistics of construction SMEs' contribution to the employment of some countries.

Table 2.2: Construction SME's contribution for employment

Country/Region	Contribution (%)	Reference
Taiwan, China, Japan, Thailand and Vietnam	over 70% of employment	Harvie (2004)
Indonesia, Malaysia	around 40%	Harvie (2004)
Middle East and North Africa (MENA) region	10 to 40 % of all employment	Saleem (2010)
Arab region	90% of all firms	Emine (2012)
Ghana	90% of all contractors	Kissi, et al. (2019), Ankomah et al. (2017)
Nigeria	57% increase in the number of construction SMEs	Opafunso and Adepoju (2014)

According to Harvie (2004), construction SMEs play a vital role in Taiwan, China, Japan, Thailand and Vietnam, where they contribute over 70% of employment, than they do in Indonesia and Malaysia, where they contribute only around 40%. According to Saleem (2010), construction SMEs typically account for 10 to 40% of all employment in the Middle East and North Africa (MENA) region.

The study of Emine (2012) found that, construction SMEs are of high importance to developing countries especially in Arab region because they account for more than 90% of all firms. Moreover, research findings of Opafunso and Adepoju (2014) revealed that there was a 57% increase in the number of construction SMEs in Nigeria between the years 2009-2013. However, Saka and Chan (2020) noted that still the construction SMEs sector in Nigeria is rising. Hence, the importance of the construction SMEs to the economy should not be underestimated. The major advantage of construction SMEs is its employment potential at low capital cost (Ankomah et al., 2017; Tezel et al., 2017; Agwu, & Emeti, 2014; OECD, 2012). Further, localised demand, flexibility, and low capital requirement for entry and good labour relations were identified as significant characteristics of construction SMEs by Hilderbrandt (1971), which are still applicable to the modern construction industry (Hardie, & Newell, 2011; Wedawatta et al., 2011).

Construction SMEs significantly contribute to the development of construction industry. Besides, the vital role in facilitating the improvements of the construction industry and improving industry structure is marking the importance of construction SMEs (Ankomah et al., 2017; Windapo et al., 2020; Chew, Yan, & Cheah, 2008). However, both within-firm decision making and external environment decided the development process of construction SMEs. According to Chew et al. (2008), construction SMEs in China have taken initiatives to establish a decent relationship with the clients and the government. Similarly, Ankomah et al. (2017) indicated the requirement of resource-based practice through several business initiatives with stakeholders. Therefore, the interactions between the available internal capabilities and position of external market decide the competitive advantage of construction SMEs (Chew et al., 2008). Hence, the relative importance of construction SMEs in advanced and developing countries would continue to reconsideration the role of construction SMEs in the economy (Saka, & Chan, 2020; Ayanda, & Laraba, 2011; Wedawatta et al., 2011). However, construction SMEs are working under pressure due to the competition in the industry and to maintain their market position in the monopolistic market created by the large firms (Ankomah et al., 2017; Woschke et al., 2016; Pulaj, & Kume, 2014; Opafunso, & Adepoju, 2014).

2.4.1 Construction SMEs in Sri Lanka

Government of Sri Lanka has evidently acknowledged the significance of SME development (Sriyani, 2020; Ravindra, 2019; Yapa, 2017). Therefore, a number of programmes initiated on application of modern technology to develop the production processes and making SMEs more competitive (Wickramarachchi, Sandanayake, & Ekanayake, 2018; Zhengang et al., 2012). As noted by Athukorala (2017), outdated and inefficient technologies used by SMEs, leads to increase production waste. Thus, the Sri Lankan construction industry facing a huge threat due to the increase of waste (Senaratne, & Ekanayake, 2012; Senaratne et al., 2010; Senaratne, & Wijesiri, 2008) and the construction SME sector is no exception (Wickramarachchi et al., 2018).

Notwithstanding to Balachandra (2014) argument that the majority of registered contractors fall into the category of SMEs in the Sri Lankan construction industry, there is no published definition for the construction SMEs in Sri Lanka. Wickramatilake (2018) and Attygalle et al. (2014) highly contended the unavailability of an appropriate definition stating as a hindering factor in SME promotion initiatives due to the difference in the criteria used to define SMEs by different entities. Moreover, Attygalle et al. (2014) added that other countries with strong SME sector have set out clear definitions for SMEs, which has facilitated in SME promotion efforts more effectively.

Most of the global definitions have considered annual turnover and number of employees in defining the construction SMEs. However, there is lack of national statistics that reflected number of employees in construction SMEs owing to difficulties in identifying the number of employees in construction organisation. The construction projects heavily use casual and seasonal labour and thus, national level statistics are not available on number of employees in construction SMEs. Hence, the researcher developed a working definition for construction SMEs based on the: (a) annual turnover in Sri Lankan context (Refer Table 2.1), and (b) Construction Industry Development Authority (CIDA) registration criteria for construction contractors in Sri Lanka. CIDA is set up by the Government of Sri Lanka to develop and promote the domestic construction industry and hence, each organisation needs to be registered in order to practice in Sri Lanka. Table 2.3 presents the financial limits used for the grading of contractors as per CIDA registration in Sri Lanka.

Table 2.3: Contractor grading according to CIDA registration

Speciality	Grade	Financial Limit (SLR Mn)
Building Construction Highway Construction Bridge Construction Water Supply and Sewerage Irrigation and Drainage Canals Dredging and Reclamation Storm Water disposal and Land Drainage Maritime Construction Heavy Construction (Areas to be Specified)	CS2	$X > 3000$
	CS1	$3000 \geq X > 1500$
	C1	$1500 \geq X > 600$
	C2	$600 \geq X > 300$
	C3	$300 \geq X > 150$
	C4	$150 \geq X > 50$
	C5	$50 \geq X > 25$
	C6	$25 \geq X > 10$
	C7	$10 \geq X > 05$
	C8	$05 \geq X > 02$
	C9	$02 \geq X$

Source: CIDA, 2020

Construction SMEs in Sri Lanka

As per the above table and the SME definitions in Section 2.3.1, for this study, “the contractors whose annual turnover is in between Sri Lankan Rupees 16 to 750 Mn are considered as construction SMEs in Sri Lanka”. Accordingly, the contractors who are registered under the CIDA grade C2 to C6 will be considered for the case study.

In most cases, micro-enterprises are also read with SMEs for any policy-related development (Athukorala, 2017; Deyshappriya, & Maduwanthi, 2020). However, there are difficulties in accessing data required for the research from the micro-level organisations (Kapugamage, & Gajanayaka, 2020) in the construction industry in Sri Lanka and hence, omitted for this study.

2.4.2 Characteristics of construction SMEs

There is no scarcity of published studies investigating various characteristics of construction SMEs globally. Many studies have highlighted the significant benefits that SMEs offer to the national economy, including their contributions to economic development, industrial output, and tax revenue (Tezel et al., 2017; Tang, Wang, & Zhang, 2007). In the developed and newly developing countries, SMEs generally employ a large percentage of the workforce and are responsible for employment opportunities (Windapo et al., 2020; Liao, & Barnes, 2015; Kadiri, 2012).

Although government and large corporations play a dominant role in the formal economy, SMEs drive the informal sector; hence, many developed and emerging nations aggressively pursue public policies designed to encourage SMEs (Awa, Ojiabo, & Emecheta, 2015; Bennett, 2014). Large organisations desire not to retain a large employee base in many instances and to subcontract work to SMEs (Tazel et al., 2020; Fulford, & Standing, 2014). SMEs often have more flexibility in their operations (Liao, & Barnes, 2015; European Communities, 2002) and can often be more flexible and responsive to customer needs than large integrated firms (OECD, 2000), as large firms, unlike SMEs, are constrained by large investments, formal structures and procedures. Nevertheless, there are significant differences between large companies and SMEs in their ability to absorb new knowledge due to their unique characteristics (Kululanga et al., 2015; Kamal, & Flanagan, 2012). In the knowledge economy, the strength of SMEs is essentially determined by their ability to wisely take advantage of human intellectual capital and technology (Awa et al., 2015). Numerous studies have attempted to explain the differences between these two clusters (Woschke et al., 2016), however very few have achieved their targets. Wonglimpiyarat (2015) presents the funding requirements of SMEs throughout the life cycle of their growth as shown in Figure 2.1.

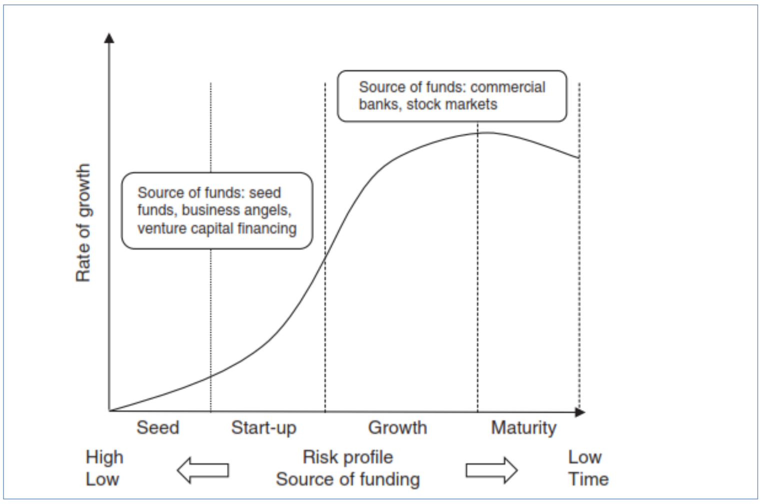


Figure 2.1: Funding requirement along the life cycle of SME growth

Source: Wonglimpiyarat (2015)

The above figure evidently indicates that SMEs can easily access to finance only at the maturity of their development. Yet, most of the SMEs are struggling to finance their business at the start (Tezel et al., 2020; Ankomah et al., 2017; Agwu, & Emiti, 2014). Hence, access to finance has become an impediment to the success stories of SMEs (Bennett, 2014; Hardie, & Newell, 2011).

One of the main characteristics of construction SMEs highlighted by Ofori (2015) is high risk. Bannock (2005) stated that the majority of SMEs are local in their operations and rooted in local communities. Consequently, Bennett (2014) and Ranadewa et al. (2017) stated that there is an uncertainty to retain in even the local market due to the challenges faced by SMEs. This distinct characteristic has allowed them to quickly adapt to changes happening in the business surroundings and gain competitive advantage, if they are willing to change.

The nature of these characteristics of construction SMEs may adversely affect their growth. Therefore, following section discusses the challenges faced by construction SMEs.

2.4.3 Challenges faced by construction SMEs

The construction industry is usually described as being one of the uncertain business sectors. SMEs faced particularly harsh business environments (Tezel et al., 2017; Ankomah et al., 2017; Awa et al., 2015). Table 2.4 presents the review of challenges faced by construction SMEs.

Table 2.4: Challenges faced by construction SMEs

Challenge	Reference
Lack of business/job continuity	
Not getting jobs	[1], [2], [3], [4], [7], [11], [14], [17], [23], [24], [25]
Less access to international markets	[1], [2], [4], [14]
Waste	
Increase of waste	[1], [2], [6], [9], [11], [13], [16], [19], [21], [23]
Quality deficiencies in the output	[3], [4], [6], [7]
Lack of value addition	
Inability to add value	[4], [8], [14], [20], [24]
Lack of innovations	[1], [2], [6], [9], [11], [13], [16], [19], [21], [23]
Competition	
From large companies	[1], [4], [6], [7], [9], [10], [13], [17], [19], [20], [25]

Challenge	Reference
From similar type (SME) companies	[1], [4], [8], [9], [11], [14], [20]
Financing the project	
Lack of Capital	[1], [3], [4], [11],
Difficulties in access to finance	[1], [2], [4], [5], [6], [7], [8], [9], [10], [11], [12], [14], [15], [16], [17], [18], [20], [21], [22], [23], [24], [25]
Lack of cost controlling techniques	[1], [4], [7]
High cost of labour	[1], [2], [7], [11], [17], [23]
High cost of material and equipment	[1], [2], [7], [12], [15]
Human resource management (HRM)	
Lack of management expertise	[3], [4], [5], [6], [7], [8], [9], [12], [17], [18], [25]
Difficulties in recruitment of staff	[1], [17], [25]
Difficulties in retention of staff	[1], [2], [6], [7], [13], [16], [19], [20], [21], [22], [25]
Shortage of labour	[7], [13], [16], [19], [22]
Lack of operational level skills	[1], [2], [4], [5], [12]
Poor Quality of existing staff	[17], [18], [20], [21], [25]
Material and equipment	
Delaying delivery by suppliers	[1], [9]
Poor quality of material and equipment	[1], [3], [4], [5], [9], [18], [20], [21]
Workmanship issues	[1], [2], [4], [6], [10], [23], [24]
New construction technology	[4], [6], [8], [9], [10], [19], [20], [22], [24]
Operational environment	
Issues relating to the organisation	[1], [3], [15], [25]
Characteristic of the project	[1], [5], [20]
Procurement related errors	
Procurement methods	[1], [9], [12]
Loopholes in the agreement	[1], [17], [23]
Design failure/ changes	[1], [3], [6], [10], [13], [16], [17], [19], [22], [23]
Estimation and documentation errors	[1], [2], [4], [14], [20], [24]
Time overrun and missed deadlines	[1], [2], [20]
Health and safety related issues	
Collisions and accidents	[1], [6], [8], [13]
Poor health and safety measures	[5], [12], [15], [21]
Legislations, regulations and policies	
Unsupportive legislations	[1], [2], [3], [8], [9], [13], [23], [24]
Change of government policies	[1], [2], [12], [14], [15], [25]
Professionalism and transparency	
Lack of professionalism & transparency	[3], [5], [15], [21], [22], [23]
Bribes and corruption in the industry	[1], [5], [9], [12], [15]
External issues	
Inherent features of the industry	[15], [21], [23], [25]
Issues in the economics environment	[6], [10], [13], [16], [19], [22]
Unfavourable weather conditions	[1], [8], [9]
[1] Ofori, & Toor (2012), [2] Kamal, & Flanagan (2014), [3] Singh et al. (2010), [4] Rymaszewska (2014), [5] Agwu, & Emeti (2014), [6] Chiarini (2012), [7] Barrett & Sexton (2003), [8] Wedawatta et al. (2011), [9] Kulemeka et al. (2015), [10] Barrett, Sexton, & Aouad (2006), [11] Davidson, & Maguire (2003), [12] Lundkvist et al. (2010), [13] Tazel et al. (2017), [14] Hardie, & Newell (2011), [15] Ofori (2012), [16] Bennett (2014), [17] Bannock (2005), [18] Saka, & Chan (2020), [19] Tezel et al. (2020), [20] Kissi et al. (2020), [21] Windapo et al. (2020), [22] Love, & Irani (2004), [23] Ankomah et al. (2017), [24] Yan, & Chew (2011), [25] Ulubeyli et al. (2018)	

A major problem with most of construction SMEs is that they function at an exceptionally low scale of production and this impedes their capacities to reduce the costs of products and engage in technological upgrades (Ankomah et al., 2018; Tezel et al., 2017; Singh et al, 2010). Therefore, capturing a certain scale of operations is very critical in SMEs growth path. Hence, the construction SMEs need to perform at their highest performance to overcome the challenges faced by them. Most of SMEs in developing countries highlighted access to finance as a key problem (Ankomah et al., 2020; Kululanga et al., 2015; Awa et al., 2015; Ofori, & Toor, 2012; Wedawatta et al., 2011; Dalberg, 2011). A research conducted by International Finance Corporation (IFC) indicated that 77% of Sri Lankan SMEs highlighted the need of medium and long-term loans for their businesses. Among them, only 53% of SMEs had access to bank loans and out of this 53%, only 29% of SMEs could successfully secure their financial requirements (Ravindra, 2019). As construction SMEs mainly finance their projects through loans, the issue is common to both developing and developed countries.

Majority of research agreed that low level of technology, lack of skilled workers and management expertise, lack of access to international markets, unsupportive legislations and ineffective incentive policies are generally common to SMEs in any country. Nevertheless, the unavailability of sufficient resources such as materials, equipment and human resources is a perpetual challenge to remain in the market position of SMEs due to greater competition created by the larger number of enterprises in the industry offering the same services. Singh et al. (2010) put forward the argument that SMEs in China and India also lack capacity in product design in the construction industry. Kamal and Flanagan (2014) and Tezel et al. (2020) detailed that SMEs are general contractors on small and medium scale projects and subcontractors for large contractors. Thus, the control over the project by construction SMEs is less compared to large firms due to the fragmentation in the construction industry. Athukorala (2017) highlighted that, the SMEs in Sri Lanka pay nearly 28 types of taxes which are time consuming and require strategic management. Thus, the researcher emphasised the need for effective strategies to reduce the costs of the organisations.

Kululanga et al. (2015) highlighted that most SMEs in Nigeria die within the first five years of operation. Moreover, Kululanga et al. (2015) revealed that few number of construction SMEs exist up to the tenth year while only about 5-10% of SMEs survive and grow to maturity in Nigeria. Nevertheless, many factors have been identified by many researchers as likely contributing factors to the premature death of construction SMEs.

Ofori and Toor (2012) confirmed Davidson and Maguire's (2003) top ten reasons for contractor failure in the construction industry that include: increase in the sizes of single jobs, obtaining work in a new geographic region, growing too fast, inadequate capitalisation, high employee turnover, poor accounting systems, poor estimating, poor cash flow and obtaining new types of work. Therefore, the premature death of SMEs impedes the construction industry. Moreover, Mossman (2018) highlighted NVAA as one of the main reasons for the failure of construction organisations. Further, lack of legislation is another challenge in the construction industry, yet rarely discussing the bribes and transparency in the industry. Thus, there is substantial stress on professionalism for the SMEs in the construction industry.

Accordingly, the above listed challenges were considered in EIR-1 in this research. It is further intended to identify the reasons behind these challenges and suitable enabling strategies to overcome these issues.

2.4.4 Addressing the problems faced by SMEs

In order to overcome the problems faced by SMEs, they need to be specifically analysed in terms of their organisation as these problems are varying from one organisation to another. However, most of the SMEs are unable to identify the challenges specific to their organisation (Saka, & Chan, 2020; Kissie et al., 2020) and they need to identify the capacities necessary to overcome these challenges (Ankomah et al., 2019), reflecting the requirement of a detailed analysis to the SMEs. However, it should be a powerful tool, which can be used to analyse and understand the existing business environment and its attractiveness (Tezel et al., 2018). Many researchers suggested of using SWOT analysis to get the prevailing condition of an organisation (Gürel, & Tat, 2017; Ommani, 2011; Leigh, 2009). SWOT analysis is used to assess the strengths, weaknesses, opportunities and threats of an organisation (Ommani, 2011). Therefore, based on SWOT analysis, construction SMEs too can understand the current condition and choose the appropriate strategy.

Some of the strategies to overcome problems faced by construction SMEs, are cost reduction (Kissi et al., 2020; Ankomah et al., 2017), quality improvement (Tezel et al., 2017; Lundkvist et al., 2010), competencies development (Yap, & Shavarebi, 2019; Chew, Yan, & Cheah, 2008), inter-firm networking (Srivastava, & Tyll, 2020) and innovation (Hardie, & Newell, 2011). Nevertheless, Singh et al. (2010) contended that economic development largely depends on the SME development. Liu (2004) stated that, SME development is interrelated to the entrepreneurship skills in China. Evidence from other regional economies (Ankomah et al., 2017; Ofori & Toor, 2012) emphasised that SMEs were able to overcome the economic crisis better than large organisations. Therefore, the avoidance of a future crisis will depend on the development status of the SME sector (Tezel et al., 2018; Ofori, 2015; Bennett, 2014). To sustain the competitiveness in local and global markets, SMEs need to employ communication and information technologies to reach the right markets in cost-effective ways (Saka, & Chan, 2020; Windapo et al., 2020; Nowotarski, & Paslawski, 2017). Moreover, SMEs need to focus on building human resources and implementing quality improvements (Wickramarachchi et al., 2018; Awa et al., 2015). As highlighted by Dave and Koskela (2009), the majority of problems faced by construction SMEs can be overcome through good networking and collaboration within the industry.

The continuous changes that affect the business environment, due to the globalisation process and the technology innovations, force SMEs to persistently look for new directions to preserve and advance their market position (Yap, & Shavarebi, 2019; Ayanda, & Laraba, 2011), while increasing their capacities. In order to remain competitive in the global context and to be able to meet unprecedented market changes, organisations need to improve their operations and processes (Tezel et al., 2020; Rahman et al., 2013). Concerning the construction industry, construction should be understood as a flow of work and a creation of value, rather seen as a transformation only (Bertelsen, & Koskela, 2004). However, the flow of work and the creation of value are largely neglected in the construction industry (Mossman, 2017). Thus, it is vital to establish process improvement methodologies that will create value and consequently, improve the construction SMEs.

The concept of value has been commonly related to parameters such as cost, function and quality (Mossman, 2015; Garrido, & Pasquire, 2011). Hence, there is a need for construction SMEs to be strategic in managing risk and uncertainty, adapt to changing environment (Ofori, & Toor, 2012), develop networks (Wee, & Chua, 2013) and aim to develop and implement new construction processes yielding higher value at lower costs (Tzortzopoulos et al., 2020; Bertelsen, & Koskela, 2004). Nevertheless, the conventional systems used in the industry pursue the 'task' of project completion, however, neglect minimization of non-value addition and maximisation of value (Dave, Kubler, Främling, & Koskela, 2016; Koskela et al., 2002). Therefore, a challenge is in front of the construction SMEs to look for new techniques, concepts and strategies for moving up the ladder, while increasing the value addition (Bhamu, & Sangwan, 2014).

As a response, many organisations are seeking to maximise value addition through embedding lean; as one of the most prominent improvement approaches within the construction industry for value addition (Sarhan et al., 2017; Nesensohn et al., 2014; Sage, Dainty, & Brookes, 2012). Further, Dave et al. (2016), Aziz and Hafez (2013) and Koskela (1992) suggested lean as one of the best approaches for improving the value in the construction industry. Therefore, SMEs can also be benefited by adopting lean (Tazel et al., 2020; Ankomah et al., 2019) with the appropriate customisation to the process and people (Rymaszewska, 2014).

It should be noted that SMEs too will be benefitted from lean implementation as long as they successfully adapt lean to suit their individual requirements (Alkhoraifa, Rashid, & McLaughlin, 2019) as inappropriate adoption will create more problems for construction SMEs (Tezel et al., 2017).

2.5 Summary of Section I - Construction SMEs

Section I of Chapter 2 provides an in-depth analysis of construction SMEs. The focus on SMEs necessitates a deeper understanding of the inherent characteristics in comparison to large organisations. Thus, this Section I initiated by introducing SME sector in general and then moving to construction SMEs. As there is no published definition for construction SMEs, the researcher developed a working definition for construction SMEs in Sri Lanka.

Accordingly, medium-sized contractors in Sri Lanka can be categorised under whose annual turnover between LKR 250 – 750 Mn and small-sized contractors having annual turnover between LKR 16 - 250 Mn. Hence, the category of construction SMEs in Sri Lanka is considered as a contracting organisation, which has a grade from C2 to C6 as per the CIDA contractor registration criteria which have been informed to the research.

The challenges faced by SMEs were notified and that will be used to analyse the construction SMEs in Sri Lanka. This section presents the challenges of construction SMEs under lack of job continuity, increase of waste, lack of value addition, competition, project finance, human resource management, material and equipment, operational environment, procurement related errors, health and safety related issues, legislations and regulations related issues, professionalism and transparency issues and external issues. Therefore, the literature findings emphasised the need of implementing process improvement methodology by construction SMEs to minimise these challenges.

The findings revealed that SMEs can be benefitted through lean implementation. Nevertheless, before examining how SMEs can be benefited from implementing lean, it is important to understand the concept of lean, as there still seems to have some misinterpretations on definitions for lean, waste and value. Therefore, the next section reviews the lean concept and presents its implementation in the construction industry.

SECTION II - LEAN CONSTRUCTION

2.6 Lean Thinking

The goals of lean thinking redefine performance against three dimensions of perfection: a uniquely customised product (i.e., value addition), delivered instantly, with nothing in stores (i.e., waste elimination) (Howell, & Ballard, 1998; Womack & Jones, 1996). Hence, lean thinking offers a coherent synthesis of the most effective techniques that can be used to minimise waste and achieve sustained improvements. As per Andersen, Belay and Seim (2012), one main tenet of lean thinking is that everything can be further improved. Similarly, a focus within lean thinking is to create capacity by removing waste with the application of improvements and subsequently, the overall supply chain effectiveness (Hines et al., 2004; Rich & Francis, 1998). Lean offers a new way to organise production (Mossman, 2017; Howell, & Ballard, 1999). However, most importantly, Hines et al. (2008) stated that, there is a variety of complimentary approaches that have been used in conjunction with lean.

Based on the ideologies of waste reduction and value maximisation, different meanings to lean have been provided (Koskela, 2020, 1992; Alves, Milberg, & Walsh, 2012). Rahman et al. (2013) defined lean as a set of tools, where Laureani and Antony (2012) defined lean as a process improvement methodology. Hence, dual focus of lean on increasing business value and eliminating the waste made it one of the most popular business performance improvement approaches (Peters, 2010; Jadhav et al., 2014). Moreover, lean is highly interpretive and there is no shared definition or understanding of what is meant by lean, lean production, and lean construction (Jørgensen, & Emmitt 2008). According to Hines et al. (2008), there are three types of activities in an organisation namely, (a) non-value adding activities (NVAA), (b) value adding activities, and (c) necessary non-value adding activities. Moreover, NVAA is defined in terms of value and hence, knowing value in the first instance is imperative (Mossman, 2009). Thus, the next section reviews the concept of value in the construction industry.

2.6.1 Value adding activities

In lean thinking, client's value identification is a key stage of its philosophy. Womack (2013) specified that, value adding activities as any activity that create more value with less waste (*muda*), variation (*mura*), and overburden (*muri*). Hines et al. (2008) specified value adding activities that add value to a product or service in the eyes of the end customer. These activities are part of the product or service that the customer is willing to pay for. Thus, the organisation needs to decide which to be considered as the value for their organisation.

Nevertheless, it is worth remarking that there are definitional problems emerging due to a tendency in the literature to use the term '*value*' to refer to different phenomena. From the Economist point of view, Erdogmus, Favaro and Strigel (2004) identified value as the return on investment. Indeed, the consideration for value here is given by considering the net present value, opportunity cost and the risk factors. Similarly, Bowman and Ambrosini (2000) stated that, clients' perceptions of the value of a good is established based on the needs and beliefs about the good, expectations and unique experiences. However, McGeorge and Palmer (1997) highlighted that value is created by organisational members. Indeed, the Economists believe achieving value for money through quality products at a lesser cost. Nevertheless, factors of production need to be analysed with value definition in economy whereas Dean and Kretschmer (2007) specified that factors of production includes land, labour, capital, entrepreneurship and knowledge.

Mossman (2009) identified value in construction industry as a capacity demarcated by the client and delivered at the correct time and at the right cost. Arroyo and Gonzalez (2016) and Koskela (2020) stated the subjectivity of value requirements by clients, thus what is value for one can be a NVAA for another. Hence, the construction organisations need to be mindful in deciding the value adding activities and NVAA in their organisations. According to the discussion by Bolviken, Rooke and Koskela (2014), value is a 'wanted output'. Thus, the organisations require getting into the customers lenses in defining the value. A smooth process flow can increase value to the customer by minimizing NVAA (Tillmann, & Miron, 2020; Arroyo, & Gonzalez, 2016; Mossman, 2009).

Nevertheless, value identification cannot be discussed without identifying the NVAA in the organisation as pointed out by Koskela (2004) by stating that NVAA and value are not independent. Moreover, Koskela (2004) contended the one-dimensional view and states that value and NVAA exist in different, even if intersecting dimensions. A product with a perfect value may be produced in a most wasteful process. In contrast, a product with a clearly deficient value may be produced in a most waste-free process. Therefore, the type of activities of one organisation will be different based on the external factors. Further, there are some activities, which fall in to neither value generation nor NVAA generation. Thus, necessary NVAA is defined by Hines et al. (2008) as any activity that does not contribute value to a product/ service in the eyes of the end-customer, yet required to deliver the product/ service to the end-customer.

Consequently, it is evident that a comprehensive analysis of the organisation is paramount to identify the values, value adding activities and necessary value adding activities prior to lean implementation in construction SMEs. Nevertheless, the value of construction SMEs will be subjective as well as sentimental, and largely affected by the external environment. Thus, the customer’s value is captivating less attention by the construction SMEs due to the challenges faced by them in construction industry, thus, leading to NVAA. The next section discusses the NVAA of production and particularly in construction.

2.6.2 Non-value adding activities

Non-value adding activities (NVAA) are generally known as wastes in the lean domain (Emuze, & Saurin, 2016; Alwi et al., 2002). Waste is anything that does not directly contribute to add value to a product, under the perspective of customers’ needs and requirements (Tzortzopoulos et al., 2020; Alves et al., 2012; Oppenheim, 2004; Howell, 1999). Hines et al. (2008) highlighted that NVAA has to be the target for immediate removal.

Womack and Jones (1996) stated that NVAA includes all inefficiencies in a system as well as causes of those inefficiencies. Thus, by eliminating waste, activities can become 'lean'; which provides more with fewer resources (Womack, & Jones, 2003). However, elimination of NVAA is neither a difficult task nor a very easy task (Ankomah et al., 2017).

Removal of NVAA is a fundamental concept of lean and one of the most efficient ways of enhancing capacities and improving profitability of a company. Nevertheless, setting out to minimise waste from a project/organisation in isolation from the value purpose is potentially wasteful (Mossman, 2009). In the manufacturing industry, the fundamental nature of waste is well understood and usually visible. Nevertheless, waste within the construction industry is not visible as other industries (Tezel et al., 2017; Wu, & Wang, 2016; Koskela et al., 2014). Project managers have been often inclined to conceptualize "waste" as physical construction waste (Wong et al., 2012). Therefore, in the general construction literature, waste is observed as material waste and time waste. Hence, before implementing lean concept to the construction industry, it is essential to build an understanding of waste within the construction industry and Hicks (2007) contended the need of classifying the types of waste in SMEs.

There are seven (07) types of wastes identified by Ohno (1988) under lean as overproduction, overstocking, excessive motion, waiting time, delay and transportation, extra-processing, defect and rework. Nevertheless, Liker and Meyer (2006) added a new type of waste as unused employee creativity by losing time, ideas, skills, improvements, and learning opportunities by not engaging or listening to employees. Similarly, Alves et al. (2012) referred to non-utilization of human potential as the eighth waste by considering Green's (1999) critique on negligence of human stress as a waste. In a recent research, Singh (2018) defined another category of waste as '*missed opportunity*', which can be applicable to a variety of production and operational scenarios. However, although it is predominantly applicable to lean construction, it can be reflected under negligence of human potential and thus, missed opportunity is not considered as a separate category. Table 2.5 presents the categorisation of eight types of wastes.

Table 2.5: Categorisation of waste

Type	Description	Includes	References	
			General	Construction
Transportation	Effort to transport building components/ tools into or out of job trailers or storage between processes	• Moving work-in-process from place to place • Delivering equipment • Incomplete orders • Moving to and from storage	[1], [2], [3], [4], [5], [6]	[8], [9], [10], [11], [12], [13], [14], [15], [16]
Inventory	Maintaining excess inventory of components, equipment or tools	• Excess raw material • Work in progress (WIP) or finished goods causing longer lead times • Damaged goods & Delays • Transportation/ storage costs • Large site stores of materials • Too much material compromising workspace	[1], [2], [3], [4], [5], [6]	[8], [9], [10], [11], [12], [13], [14], [15], [16]
Motion	Waste associated with unnecessary worker movement around the site	• Unnecessary movement of people, materials and equipment that does not add value • Walking between different work places • Walking between workplace and welfare facilities • Manual paperwork processing	[1], [2], [3], [4], [5], [6]	[7], [8], [9], [10], [11], [12], [13], [14], [15], [16]
Waiting	Time spent waiting for other work crews to finish their process so that the next process may begin.	• Waiting time between processes or for capacity to take the next step • Documents awaiting updating or processing • Equipment downtime • Capacity bottlenecks • Time spent waiting for parts or instructions	[1], [2], [3], [4], [5], [6]	[7], [8], [9], [10], [11], [12], [13], [14], [15], [16]
Over-production	Producing too much or too soon, resulting in poor flow of information and/or inventory	• Producing items earlier than needed or beyond specification or more than needed • Orders placed for same materials with different suppliers • Overstaffing, unnecessary storage	[1], [2], [4], [5], [6]	[7], [8], [9], [11], [12], [13], [14], [15], [16]
Over-processing	Waste associated with rework or re-handling caused by defects in construction activities	• Taking unnecessary steps • Multiple plant movements • Inefficient processing due to poor work planning • Providing high quality products than necessary • Produced to standards beyond specifications • Work done to 'fill the gaps'	[1], [2], [4], [5], [6]	[8], [9], [10], [11], [12], [13], [14], [15], [16]

Type	Description	Includes	References	
			General	Construction
Defects	Deficiencies in the finished product that require additional work to correct	• Production of defective work or corrections • Not meeting specifications first time • Inspections to reduce/remove defects • Production of replacements – rework. • Estimation errors, design failures/ Changes • Documentation errors in the procurement • Time overrun and missed deadlines	[1], [2], [3], [4], [5], [6]	[7], [8], [9], [10], [11], [12], [13], [14], [15], [16]
Under-utilised human skills	Losing improvements/ learning opportunities by not engaging with or listening to project participants to eliminate the waste	• Losing time and ideas, skills improvements and learning opportunities • Learning from one site not being used well on another • People working one or two levels down from their true capability	[2], [6]	[7], [8], [10], [11], [12], [15], [16]
[1] Ohno (1988), [2] Antosz & Stadnicka (2017), [3] Womack, & Jones (1997), [4] Hicks (2007), [5] Liker and Morgan (2006), [6] Oehmen & Rebentisch (2010), [7] Alarcon, Diethelm, and Rojo (2002), [8] Terry and Smith (2011), [9] Koskela (2004), [10] Dave et al. (2016), [11] Bolviken et al. (2014), [12] Viana, Formoso, & Kalsaas (2012), [13] Polat, & Ballard (2004), [14] Arroyo and Gonzalez (2016), [15] Vilasini et al. (2011), [16] Mossman (2009)				

The wastes listed in above table are always costly to an organisation. As suggested by Howell and Ballard (1998), waste is a cost that could have been avoided within the activities, such as rework. According to the empirical findings of Antosz and Stadnicka (2017), main NVAA which the SMEs want to minimise using the lean are machine failures, unnecessary movements and waiting for material. Recent findings of Bajjou and Chafi (2020) revealed that the noteworthy NVAA categories for the construction industry are waiting, long approval process, unused employee creativity, rework and delays.

Waste in construction and manufacturing arises from the same activity centered thinking. As discussed by Terry and Smith (2011), a link exists between waste on a project and project cost, yet the link between value and waste is not clear. The reason is evident; as the value is differ according to the organisation as well as the industry.

In contrary, Mossman (2018), and Emuze and Saurin (2016) argued that waste may exist in relation to value in lean domain. Yet, the Economists view value without consideration the NVAA. However, Howell (1999) contended that need of keeping continuous pressure for production activities as reducing the cost and duration of each activity is the strategy to improvement.

Serpell et al. (1995) stated that the waste occur due to controllable root causes as well as uncontrollable root causes. Thus, the wastes that arise due to internal causes are preventable and hence save the total cost of the project. Findings of Senaratna and Ekanayake (2012) revealed that the main waste minimizing methods for Sri Lankan construction industry were involvement of experienced workers, appropriate management control, effective communication and adequate planning of works. According to Denzer et al. (2015) and Alwi, Hampson and Mohamed (2002), waiting time, especially for instructions, lack of design and documentation contribute to NVAA during the construction process, while representing a lack of human resources skills.

Alarcon et al. (2011) highlighted that, traditional control systems focus on conversion activities and ignore flow activities, thus, most of the NVAA become invisible. Consequently, majority of SMEs take no notice of these NVAA. Therefore, the construction SMEs needs to focus on strategies to minimise NVAA to overcome the challenges faced in the industry. Thus, many new concepts have been introduced and lean concept has well received the attention to reduce NVAA. Therefore, next section reviews the evolution of lean concept.

2.7 Evolution of Lean

The origins of lean thinking can be found on the shop-floors of Japanese manufacturers and in particular, innovations at Toyota Motor (Hines et al., 2004). Monden (1983) and Ohno (1988) introduced the Toyota Production System (TPS) as a combination of methods with consistent goals; cost reduction, quality assurance, and respect for humanity to ensure sustainable growth (Salem, Solomon, Genaidy, & Minkarah, 2006). Even though, the philosophy of lean was originated by Toyota, the term ‘lean’ was first demarcated in the book, ‘The machine that changed the world’, which presents the results of a research performed at the Massachusetts Institute of Technology (Gyampah, 2005; Hopp, & Spearman, 2008). However, Laureani and Antony (2012) argued that, the first adaptation of lean were recorded in the Michigan Plants of Ford in 1913 and were then advanced to mastery in Japan. Much of the early work at Toyota was applied under the leadership of Taiichi Ohno to car engine manufacturing during the 1950s, later to vehicle assembly (1960s), and the wider supply chain (1970s) (Chen, & Taylor, 2009).

Nevertheless, early thinking in process improvement is rooted to scientific management theories. Taylor's Principles in 1909 were developed aiming ‘one best way to fix a problem’ which is the change of ‘rule of thumb’ method (Taylor, 1919). Moreover, lean rooting the revolutionary thoughts of management and production like, time and motion studies by Frank and Gilbreth in 1920 (Price, 1989), Deming principles (Deming, 1986), Henry Gantt theory (Gantt, & Rathe, 1961) for process improvement, Henri Fayol’s (1949) Classical organisation theories and Motivational theories. While scientific management theories aimed at improving the productivity, they had a substantial impact on industry which improved the monotony of work. Therefore, a considerable attention received for lean philosophy from the manufacturing industry.

According to Howell (1999), lean is about building reliability. Hence, most manufacturing companies have adopted some type of lean initiative, and the lean movement has gone beyond the shop floor to white-collar offices and is even spreading to service industries (Liker, & Morgan, 2006). Lean as a concept has undergone a significant evolution and expansion beyond its origins in the auto industry, and its narrow definition around shop-floor improvement (Koskela et al., 2014). Many critics thus were rightfully attacking lean at their respective time, yet often neglected the fact that lean has, and continues to develop (Nesensohn et al., 2014; Shang, & Pheng, 2014; Hines et al., 2008). Figure 2.2 presents the overview of chronological development of lean concept towards lean construction compiled by the author.

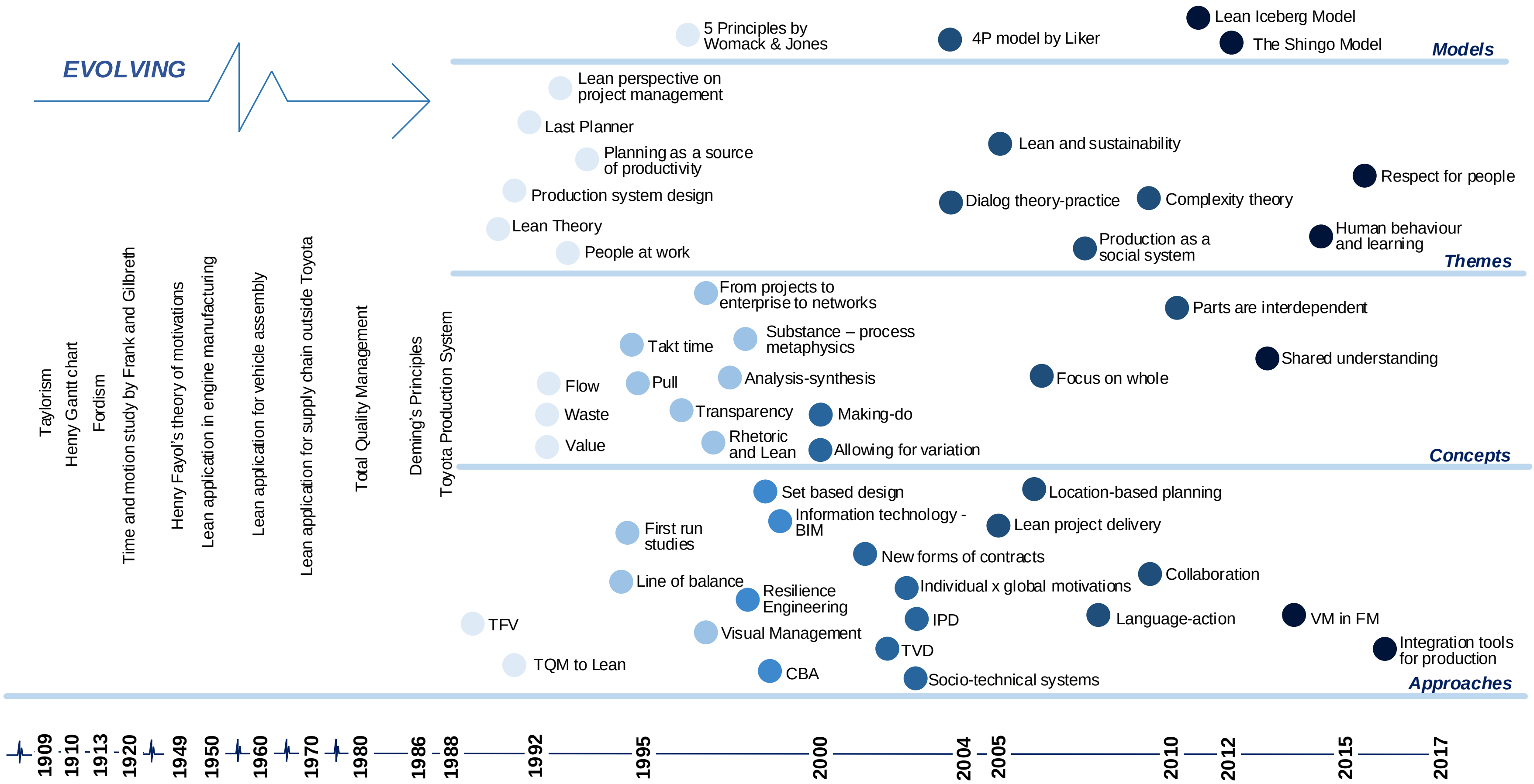


Figure 2.2: Overview of chronological development of lean construction

Compiled by Author based on Taylor (1919); Gantt and Rathe (1961); Price (1989), Liker and Morgan (2006); Hines et al. (2008); Koskela et al. (2014); Nesensohn et al. (2014); Shang and Pheng (2014) and Tzortzopoulos et al. (2020)

The above figure shows the timeline marking in the critical phases in the lean construction evolution. It presents some of the lean models, themes and concepts as developed over time along with some examples of approaches in practice, which provide an overview of developments over time. Therefore, the above figure is a demonstration of how somebody can develop the knowledge base. However, the inception of the concept has evolved from early approaches to production improvement and still concept is developing with the time.

With specific reference to lean construction, Koskela (2020) notes that lean construction started as local problem solving in production management, and gradually developed into a more comprehensive template, covering contractual and organisational areas.

2.8 Lean Principles

Liker and Morgan (2006) stated that the in-depth study of Toyota's approach to product-process development led to the identification of a set of management principles that can be considered as a foundation for lean product development more generally. Hence, many researchers and institutes defined various principles of lean to suit for different industries, services and products (Womack, & Jones, 1996; Lean Enterprise Principles, 2000; Lean Construction Institute, 2006; Liker, & Morgan, 2004, 2006; Koskela, 1992; Powell et al., 2014). Hence, the following sections discuss the available lean models.

2.8.1 Toyota Production System (TPS)

TPS is the foundation for what has become a global movement to think lean. However, Ohno (1988) specified that 'thorough elimination of wasteful practices' (p.87) is the basic concept of TPS. Similarly, TPS is a true systems approach that effectively integrates people, processes, and technology (Ohno, 1988; Black, 2007). Liker and Meier (2006) stated that the temple of lean production is a well-known visual model of lean that includes both the goal of the production performance and the human focused approach of involvement.

Nevertheless, different versions of the model including different principles and practices can be identified from the literature (Hook, & Stehn, 2008) with related to TPS, which is governed by Eastern thinking. Yet, Liker (2004) claimed that the core principles of the house remain the same. Figure 2.3 shows the two-pillar temple model of Toyota Production System.

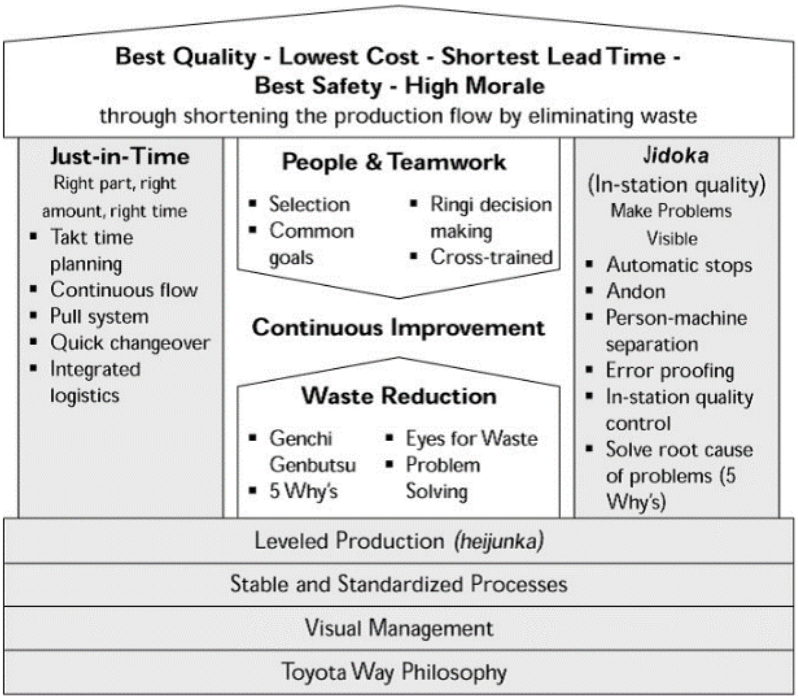


Figure 2.3: The Toyota production system

Source: Liker (2004)

TPS starts with the goals of achieving quality at lowest cost, and shortest lead time as the roof. Two outer pillars of the temple presents *just-in-time* (JIT), the most visible and highly publicised characteristic of TPS, and *jidoka,* which means never letting a defect pass into the next station and freeing people from machines automation with a human touch (Black, 2007; Liker, 2004; Ohno, 1998). The centre of the temple highlights the importance of people and waste reduction in the organisation by identifying the suitable lean techniques. Lastly, the foundation includes the need for reliable, standardised processes and also *heijunka*, which means levelling out the production schedule. However, a weaker link in the model will deteriorate the entire model.

2.8.2 Five principles by Womack and Jones

Womack and Jones (1996) stated in their book "*Lean Thinking*", the essence of Lean Production into five well known basic principles as detailed in Table 2.6.

Table 2.6: Explanation to five lean principles by Womack and Jones

	Principle	Definition	Example from Construction
1	**Precisely specify value**	• Establish what the customer really desires in terms of 'value' outcomes or deliverables	• The client will be interested in accomplishing the design specification at best 'value', which could include within budget, 'right first time' quality, delivery on or before a defined date and percentage cost saving • The common focus of parties involved in the project should be the client's value and form the basis for project objectives
2	**Identify the value stream**	• Identifying all processes required to deliver a product, service or project and then assessing how well customer value is being/will be delivered	• Defining and challenging the end-to-end processes for a construction project with the aim of achieving processes that are efficient and waste-free
3	**Make value flow without interruptions**	• Avoid disruptions and making the value flow smoothly within the production environment	• Achieving the best sequence and programme of work by ensuring balanced work, small batch production, simultaneous working, removing things that delay and disrupt in the project
4	**Let the customer pull**	• Only doing work activity in-line to the pull or demand of the customer	• Ensure that all parties align to an agreed programme where work activities are closely combined in terms of sequence and time, and activities being carried out only when needed to assist a subsequent activity. • Synchronising construction activities to the needs of the customer
5	**Pursue Perfection**	• Continually striving for perfection by practising continuous improvement	• Look for and initiate improved methods within a project, and performance improvement, lessons learnt from one project to the next

Developed by the author based on Connor and Swain (2013), Womack and Jones (2006), Koskela (2004) and Womack and Jones (1996)

Koskela (2004) stated that five principles of Womack and Jones (1996) provide an exhaustive foundation alike to a theory for the transformation of any productive activity. Aziz and Hafez (2013) stated that these principles must be followed step by step to gain the maximum benefits of the lean success. These principles broadly accepted by many production/operation managers and have been applied successfully across many disciplines (Pearce, Pons, & Neitzert, 2018; Stadnicka, & Antosz, 2017; Bhamu, & Sangwan, 2014; Muhammad et al., 2013). By considering the above principles, Liker (2004) introduced 4P model of the Toyota Way for better operationalize the lean principles.

2.8.3 '4P' model of the Toyota Way

Lean thinking based on the Toyota Way involves a deeper and pervasive cultural transformation than most organisations can begin to imagine (Liker, 2004). Hence, Liker (2004) developed 4P model of the Toyota way as present in Figure 2.4

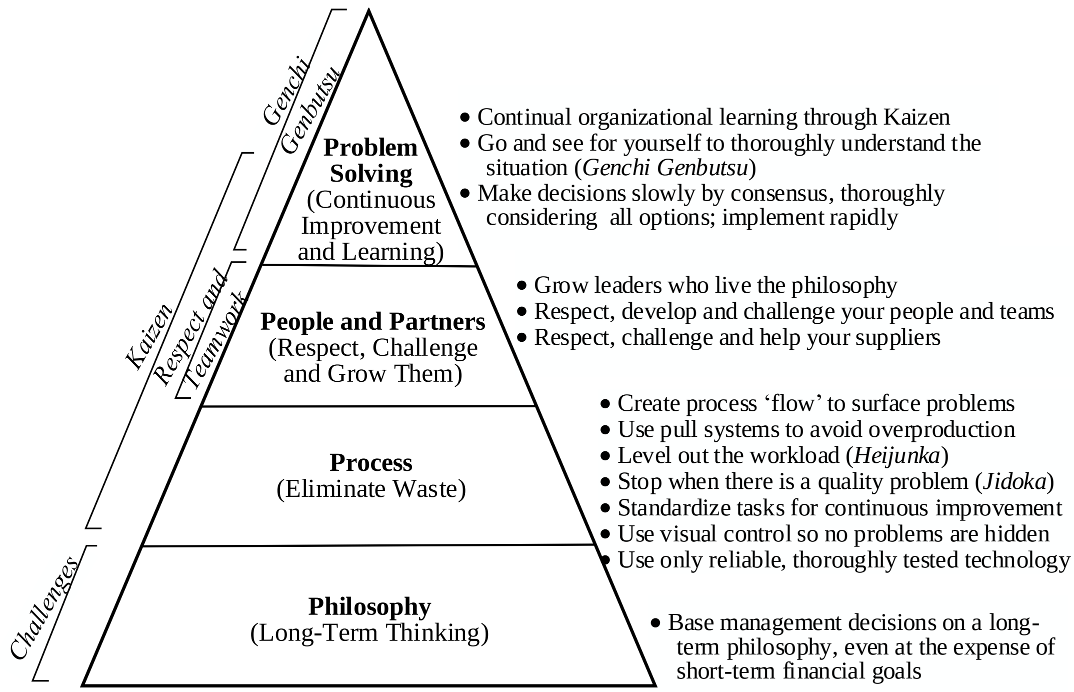


Figure 2.4: 4P model of the Toyota way

Source: Liker (2004)

Accordingly, 4P model organised in to four broad categories as problem solving, people & partners, process and philosophy. These 4Ps contains 14 principles that constitute the Toyota Way specified by Liker (2004). These key principles drive the techniques of the TPS and the management of Toyota in general (Liker, & Miere, 2006; Powell et al., 2014). Many researchers including Powell et al. (2014) indicated that, these 14 principles are much operationalised comparing to other models and principles available in the industry.

2.8.4 Lean Iceberg Model

Hines et al. (2008) indicated to view the lean process as an iceberg where major part of the iceberg is below the surface and invisible as shown in Figure 2.5.

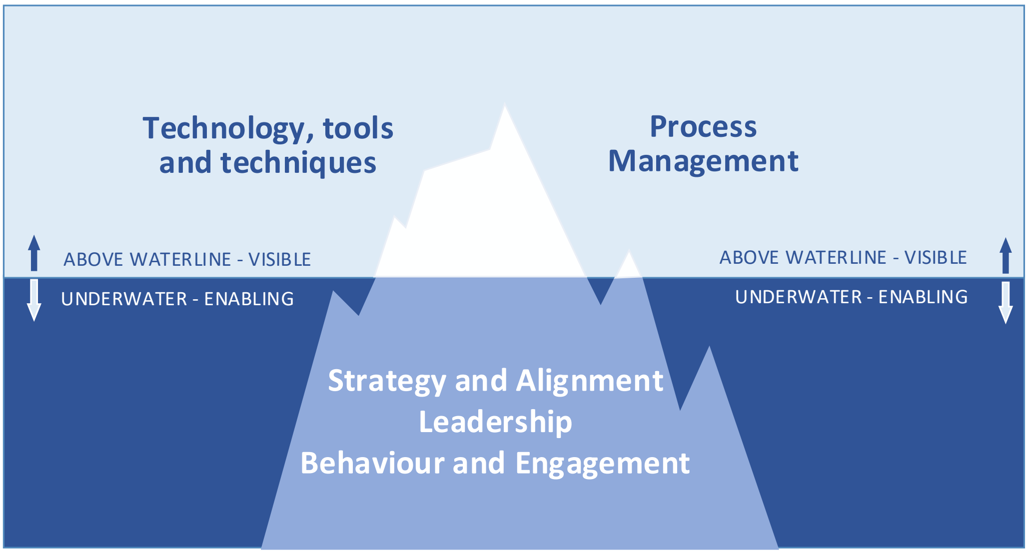


Figure 2.5: Lean Iceberg model

Source: Hines et al. (2008)

Hines et al. (2008) contended that the technology, tools and techniques that affect the lean are those visible above the waterline. However, this forms only part of the initiating mind-set required by a lean implementation team. Therefore, there needs to be an appreciation of the right mix of ‘above water’ and ‘below water’ activities for successful lean implementation. Moreover, Hines et al. (2010) noted that the effective strategy and alignment can only be achieved through powerful leadership which, in turn, will only be successfully realized in a positive organisational culture that is receptive to learning and improvement.

2.8.5 The Shingo Model

The Shingo Model is an all-inclusive transformational model which identifies that to be truly successful, the tools and techniques must be directed by guiding principles. An organisation must be able to demonstrate these guiding principles which embedded in their culture through the behaviour of all employees (Shingo-Institute, 2019). The Shingo model is presented in Figure 2.6

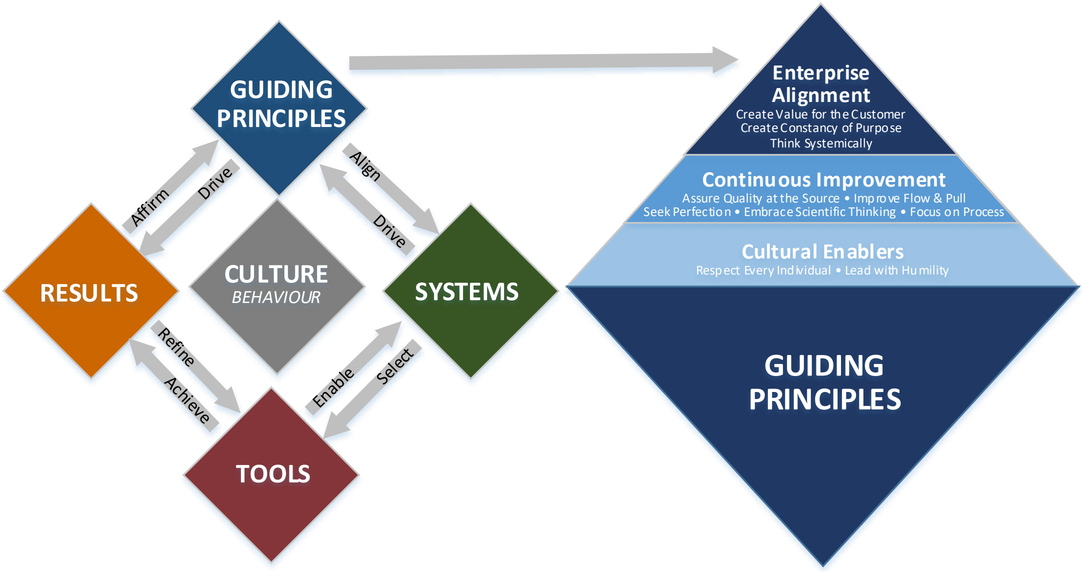


Figure 2.6: The Shingo Model
Source: Shingo-Institute, 2019

The Shingo Model is comprised of 10 guiding principles, which are reinforced with 20 supporting concepts and grouped into four dimensions as enterprise alignment, cultural enablers, results and continuous improvement (Bicheno, & Holweg, 2016). According to Shingo-Institute (2014), the model has two assessment scales as behaviour and results. Behaviour (enterprise alignment, continuous process improvement and cultural enablers) assesses the business through lenses that look at frequency, role and scope to determine the degree to which the 'Leaders', Managers' and 'Associates' behaviours are in par with the principles of operational management (Bicheno, & Holweg, 2016). Moreover, results (client satisfaction, delivery, cost/productivity, safety and quality) present the business through appropriate adaptation of Shingo model for successful lean implementation.

2.8.6 Comparison of the models

Most adopted lean principles as per the literature review were five principles specified by Womack and Jones (1996) and Toyota way 4P principles defined by Liker and Morgan (2006). This is due to the ease of application for industries and professional operations. However, the base of these principles is the TPS of Toyota.

Many researchers stated that, majority of organisations in manufacturing industry benefitted through implementation of the lean principles. However, one of the main similarities of all five set of principles is the focus of individuals in the organisation. This was highly accentuated in TPS, 4P model and Shingo model allocating one or more principles for improving individuals in the organisation to be successful in lean implementation. Nevertheless, the TPS is designed to understand how the system works to accomplish all objectives of an organisation (Black, 2007). Thus, all lean principles stressing the need of considering the organisation as a whole when developing strategies to implement lean in an organisation.

Both TPS and Womack & Jones principles stressed the need of waste reduction in the organisation by identifying the suitable lean techniques. Comparison to other Principles, Womack and Jones principles emphasised the need of defining value of the organisation, which provides a mature foundation similar to a theory for the transformation of any productive activity. In lean construction, the concept of value and value generation are presented by the Transformation, Flow, Value (TFV) theory of production. Lean construction generally connects construction practices with the TFV model of Koskela, where value is primarily delivered in the production process on site. Consequently, efforts have been taken to satisfy client requirements and little consideration given to issues in the society (Garrido, & Pasquire, 2011). Moreover, it highlights the need of continuous planning and scheduling all levels in the project.

The appropriate combination of problem solving, people, processes and long-term philosophy can convert the organisation into a lean. Moreover, these principles to be more operationalised than the Womack and Jones five lean principles, thus the Toyota Way by Liker (2004) substantiates a considerable understanding towards the application of lean principles. Although Womack and Jones' five lean principles can perhaps be interpreted as manufacturing centric; the Toyota Way principles offer a more general management philosophy where organisational purpose is understood as concepts and principles of production, and production is understood as the integration of designing and making useful things (Powell et al., 2014). Nevertheless, it is worth to note that the components of the iceberg are all interdependent. Most of the time, people will look at above water level of the iceberg and ignore the elements in the below water level. Therefore, the organisations are unable to sustain the lean implementation. However, Hines et al. (2010) clearly stated that, it is this enabling, anchoring mass which makes an iceberg a powerfully strong force. Therefore, addressing all enabling iceberg elements is imperative to deliver a sustainable, successful transformation. Accordingly, effective strategy and alignment can only be delivered through strategic leadership which, in turn, will only be successfully realised in a leaner organisational culture that is receptive to learning and improvement. Thus, there is a need to provide attention on learning of individuals in the organisational for successful lean implementation.

Comparing to other principles, the Shingo model stresses that lean conversion cannot achieve through merely implementation of lean tools which only answered the '*how*' question. The model further indicated the need of understanding the interdependent and interrelated relationships between results, tools, systems and guiding principles (i.e., collective behaviour) to answer the '*why*' question. Thus, behaviour of individuals to be appropriately controlled the lean enabling environment. Therefore, maintaining a lean culture within the organisation is signified by Koskela et al. (2020) and Hines et al. (2008).

However, Liker and Morgan (2006) stressed that all these management principles can be applied beyond manufacturing to any technical service process. Though, the said principles are successfully practicing in the manufacturing sector, researchers emphasised the requirement of lean in the direction towards construction (Koskela, 2020; Tzortzopoulos et al., 2020; Pearce et al., 2018; Mossman, 2017; Arrayo & Gonzalez, 2016; Nesensohn et al., 2014; Koskela, 1992). Therefore, the next section discusses the lean thinking and behaviour in construction industry.

2.9 Lean Thinking in Construction

The construction industry has three main peculiarities that distinguish it from manufacturing industry: one-of-a-kind projects, onsite production, and complexity, i.e., regulatory intervention and temporary multi-organisation (Koskela, 2002). In contrast to manufacturing industry, the construction industry is often seen in a class of its own, owing to the inherent characteristics of the industry (Koskela et al., 2014). These characteristics are often highlighted as the reasons when well-established and popular procedures/methods from manufacturing industry are not successfully applied in construction (Pearce, et al., 2018). Therefore, it is noted that the material, information and work flows of design and construction be analysed, first in terms of their output value, NVAA and duration.

Conferring to Koskela (1992), production can be happened as transformation (T), flow (F) and value (V) in construction industry. Later, Koskela (2000) expanded this comparison between these three approaches. As noted by Bolviken et al. (2014), Table 2.7 presents the wastes of production in construction under TFV.

Table 2.7: Wastes of production in construction under TFV

	Transformation	**Flow**	**Value**
Production Resource	Materials, machinery, energy and labour	Time	
Type of waste	Material loss	Time loss	Value loss
Wastes	1. Material waste 2. Non-optimal use of material 3. Non-optimal use of machinery, energy or labour	*In the work flow* 1. Unnecessary movement (of people) 2. Unnecessary work 3. Inefficient work 4. Waiting *In the product flow* 5. Space not being worked in 6. Materials not being processed 7. Unnecessary transportation (of material)	*Main product* 1. Lack of quality 2. Lack of intended use *By-product* 3. Harmful emissions 4. Injuries and work related sickness

Source: Bolviken et al. (2014)

Accordingly, type of wastes can be material loss, time loss and value loss. In the flow perspective, Bolviken et al. (2014) stated waiting, inefficient work, materials not being processed, unnecessary transportation, inventory, unnecessary movement and unnecessary work as the taxonomy of waste in construction. Indeed, Bolviken et al. (2014) classification of waste is in par with Ohno (1988) and Shingo (2005), the seven categories of NVAA. However, the decision of necessary activities and unnecessary activities are based on the current level of technology and knowledge. Thus, construction industry needs to clearly identify the requirement of what NVAA to be removed from the organisation. Therefore, the process improvement methods that are conducive to flow improvement to be introduced and developed to improve the activities flow (Arrayo, & Gonzalez, 2016; Pearce et al., 2018; Koskela, 1992).

Egan Report (1998) stated that lean concept holds much promise for construction. As noted by Salem et al. (2006) and Koskela et al. (2002), there is clear difference in the physical nature of the final product in manufacturing in comparison to construction industry. Moreover, there is a practical difference in implementing lean in the construction design when compared to construction assembly (Jorgensen, & Emmitt, 2009). Even though, lean construction accepts the lean philosophy as a way towards perfection, many methods form manufacturing has been rejected by the practitioners due to the inherent nature of construction industry (Vilasini, Neitzert & Rotimi, 2011; Koskela et al., 2014; Green, 1999). Correspondingly, Howell (1999) detailed the production differences between manufacturing and construction industry stating, the complexity of the design and construction of projects due to uncertainty in time and schedule. Therefore, there is a vitality to customise lean manufacturing principles to construction (Vilasini et al., 2011).

Nevertheless, construction management discusses the project where a single organisation may have several projects. Thus, many researchers contended that implementation of lean is imperative for projects (Pearce et al., 2018; Shang, & Pheng, 2014). Conversely, Koskela (2020) emphasised that main causes for NVAA in construction SMEs is due to the failures in the organisation, not the project. Therefore, the lean implementation needs to initiate with the organisation itself in the construction industry.

2.10 Lean Construction

Many researchers stated that lean construction entailed a new direction for project management (Koskela, 2020; Pearce et al., 2018; Koskela et al., 2014; Shang, & Pheng, 2014). Moving toward implementation of lean requires changing the way of thinking and construction than a change in procedure (Tzortzopoulos et al., 2020; Howell, & Ballard, 1998).

Table 2.8 presents definitions given by leading researchers for lean constructions in the seminal literature.

Table 2.8: Lean construction explanations by academics and industry leaders

Reference	Year	Working sector	Lean construction explanations
Howell and Ballard	1998	Academic	A value maximising procedure through continuous improvement to reach the perfection in construction.
Egan Report	1998	Industry	A set of practices in construction projects for sustaining performance improvement.
Abdelhamid	2004	Academic	A holistic facility design with an overarching aim of maximising stakeholders' value through synergistic, systematic, and continuous improvements in the contractual arrangements, the construction process design and methods selection, the product design, the supply chain, and the workflow reliability of construction site operations.
CRC for Construction Innovation	2007	Industry body	Adaptation of lean production methods into construction projects.
Ogunbiyi et al.	2011	Academic	The application of lean thinking to the design and construction process to meet the needs of the client and increase profitability through 'optimising the total value' instead of 'minimising the cost' as the main goal.
Lean Construction Institute	2011	Industry body	A production management-based approach to project delivery to design and build capital facilities in construction.
Seymour	2013	Academic	A philosophy and a set of practices, which largely originated in the seminal work of Koskela and Ballard and Howell.
Koskela	2014	Academic	One interpretation holds the application of lean production concepts to construction. Other interpretation views lean production as a

Reference	Year	Working sector	Lean construction explanations
			theoretical inspiration for the formulation of a new, theory-based methodology for construction.
Mossman	2018	Industry practitioner	A practical collection of theories, principles, axioms, techniques and ways of thinking that together and severally can help individuals and teams improve the processes and systems within which they work.
Koskela	2020	Academic	A theoretical innovation: the theories and philosophical commitments underpinning lean allow wider action options in comparison to mainstream operations management.

Both academics and industry practitioners took numerous efforts in defining the term lean construction. Being an academic, Koskela et al. (2014) introduced two slightly differing interpretations of lean construction, which is widely accepted definition for lean construction as it enabled formulation of new insights for construction. However, Koskela provided an improved definition in 2020. In both, Ogunbiyi et al. (2013), and Abdelhamid (2004) definitions, application of lean thinking is considered only to the design and construction phase. However, whole life consideration of lean is not stated in this definition. Moreover, these definitions provided by academics, provided a comprehensive understanding towards lean construction and highlighted that lean construction is happy to accept the continuous improvement. However, the definitions put forward by industry practitioners have tried to simplified their definitions and thus, there is a danger of losing the philosophical stance of lean.

Nevertheless, there is a slight interpretation in the definitions given by the practitioners. Definitions put forward by Egan Report (1998), CRC for Construction Innovation (2007) and Lean Construction Institute (2011), value consideration is given only for the construction projects. This emphasise how the practitioners and institutes looking at lean without considering the operational phase. Therefore, this has created lean deployment challenges among both academics and practitioners. Nevertheless, most of the definitions stated in Table 2.8 are compatible with the overall lean philosophy, which is maximise value, minimise NVAA and continuous improvement.

The first goal of lean construction is to get thorough understanding on the underlying physics of production, variations in supply chains and the effects of dependence (Howell, 1999). According to Marhani et al. (2012), even though lean is known to create a good platform for the stakeholders in the construction project, lean construction is still in the initial stage. Nevertheless, lean construction cannot categorize under '*infancy* stage' by the time of 2021 as many researchers tried to even researched the solutions to the present-day problems in lean construction (Xing et al., 2021; Evans et al., 2021; Tezel et al., 2020; Ankomah et al.,2019; Pearce et al., 2018; Nesensohn et al., 2014; Shang, & Pheng, 2014). Moreover, number of studies and successful applications of lean can be found in lean construction literature (Oke, Akinradewo, & Aigbavboa, 2021; Xing et al., 2021; Ankomah et al., 2017; Aomar, 2012; Hook, & Stehn, 2008).

2.10.1 Comparison of traditional and lean project delivery

According to Koskela (1992), the application of lean production in construction industry is first appeared in 1992. In the past years, lean received the recognition among wider group of clients, construction organisations, government institutes and industry practitioners who are interested to be benefited from lean construction (Mossman, 2018; Alves, Azambuja, & Arnous, 2016). Comparing to traditional project delivery, lean construction ensure the cooperative relationships, process focus in planning and control, and continuous improvements in the construction project (Ogunbiyi et al., 2011).

Lewis (2000) stated that lean practices will result in an overall increase in organisation's innovativeness. According to Tzortzopoulos et al. (2020) and Ballard and Howell (2003), countries such as USA, Australia, Brazil, and UK have experienced noteworthy benefits through implementation of lean construction. Similarly, developing countries such as India (Singh, 2018), Lebanon (Hamzeh et al., 2016), Malaysia (Marhani et al., 2012) too acknowledge the lean construction. Therefore, there is a need to scrutinise the project delivery system in a leaner environment.

Koskela et al. (2002) compared the lean and traditional project delivery systems. Thus, Table 2.9 presents comparison of traditional and lean project delivery done by the researcher based on the Koskela's findings.

Table 2.9: Comparison of traditional and lean project delivery systems

Area	Lean	Traditional
Focus	Focus is on the production system	Focus is on transactions and contracts
Goal	Transformation, flow, value (TFV) goal	Transformation (T) goal
Decision Making	Downstream players are involved in upstream decisions	Decisions are made sequentially by specialists and 'thrown over the wall'
Design	Product and process are designed together	Product design is completed, then process design begins
Design Considerations	All product life cycle stages are considered in design	Not all product life cycle stages are considered in design
Activities	Activities are performed at the last responsible moment	Activities are performed as soon as possible
Market	Systematic efforts are made to reduce supply chain lead times	Separate organisations link together through the market, and take what the market offers
Learning	Learning is incorporated into project, firm, and supply chain management	Learning occurs sporadically
Stakeholder Interests	Stakeholder interests are aligned	Stakeholder interests are not aligned
Inventory	Buffers are sized and located to perform their function of absorbing system variability	Participants build up large inventories to protect their own interests

Adapted from Koskela et al. (2002)

Accordingly, the conventional methods focus only on the transformation goal whereas lean project delivery considered all TFV goals. Therefore, the lean implemented organisation will be able to identify and minimise the NVAA in the construction project. In a similar note, the researchers stressed the importance of learning, involvement of employees at each level in decision making and systematic efforts in lean project delivery as favourable differences. Therefore, to enable lean in an organisation, these differences need to be considered and capacities need to be sharpened to address these differences.

2.10.2 Critique on lean construction

Lack of a universal definition for lean construction and leanness has been deliberated by Green and May (2005) as a hindering factor for successful lean implementation. Therefore, lean production and lean construction to be understood as a socio-technical paradigm and a set of lean tools (Jorgensen, & Emmitt, 2009). However, actual implementation of lean construction practices is still lagging the theoretical development (Koskela, 2020; Andersen et al., 2012). Moreover, Alves et al. (2012) and Jorgensen and Emmitt (2008) argued that a comprehensive and practicable philosophy for lean construction has not been established yet. Despite the absence of a comprehensive philosophy for lean construction, the organisations are benefited by converting to lean.

Lean has both positive views (Tzortzopoulos et al., 2020; Hines et al., 2004; Koskela et al., 2002; Howell, & Ballard, 1998) as well as contradicting views (Awa et al., 2015; Green, & May 2005; Green, 1999). However, Green (1999) stated that most of the literature take it for granted that lean production is a 'good thing' and provide a coherent and seemingly persuasive argument in favour of transporting the principles of lean production into the construction industry in dark side of lean construction. In replying to Green's (1999) above comment, Howell and Ballard (1999) stated that Green misses the key foundations of lean, which are drawn from a long history of production management thinking, which first attempts to manage the physics of production in the service of higher performance and hence, construction industry can be benefited by lean principles. However, substantial research residues to complete the transformation of lean thinking to construction (Tzortzopoulos et al., 2020; Howell, 1999) due to the fact that the lean construction evolved from the production management concepts.

The language of lean thinking is incompatible with the component of best practice in construction industry (Koskela et al., 2020; Shang, & Pheng, 2014; Green, 1999). However, moving the focus away from "*pure*" manufacturing atmosphere, many authors defined sets of principles for lean construction as discussed in the next section.

2.10.3 Lean construction principles

With the evolution, some researchers identified principles, yet some misinterpretation of lean principles leads to unstable implementation of lean. Lean principles identified by leading researchers in key literature are summarised in Table 2.10.

Table 2.10: Summary of lean construction principles

Identified lean construction principle	1	2	3	4	5	6	7	8	9	10	11	12
Reduce the share of NVAA	x		x		x	x	x		x			x
Increase output value through consideration of customer requirements	x	x			x	x	x		x			
Reduce variability	x		x								x	
Reduce cycle time	x											
Simplify by minimizing the number of steps, parts and linkages	x		x					x				
Increase output flexibility	x		x									
Increase process transparency	x										x	
Focus control on the complete process	x		x			x						
Build continuous improvement into the process	x	x			x		x		x		x	
Balance flow improvement with conversion improvement	x											x
Benchmark	x										x	
Multifunctional task groups and co-maker ship		x	x	x								
Simultaneous engineering		x									x	
Information, communication and process structure		x									x	
Process oriented, team based, flat organisation			x									
Respect & team performance incentives				x								
Risks are fairly allocate				x								
Aligned stakeholder interests						x						
Concentrate on the whole life cycle						x						
Combining project design with process design						x		x				
Downstream players are involved in upstream work						x					x	
Innovative and lean environment						x						
Eliminate buffer and pull production						x						
Participation culture and people							x		x		x	
Workplace organisation and standardization							x		x		x	
Establishing integrated team								x				
Quality assurance								x				

Identified lean construction principle	1	2	3	4	5	6	7	8	9	10	11	12
Decentralizing decision-making								x				
Collaborate, improve networks of commitments										x		
Optimise the project, not the pieces										x		
Tightly couple learning with action										x		
Increase relatedness										x		
Long term contractual agreements											x	
Supply chain integration											x	
Smooth pace of production												x

[1] Koskela (1992), [2] Melles (1997), [3] Koskela, & Leikas (1997), [4] Miles (1997), [5] Egan Report (1998), [6] Howell (1999), [7] Salem, & Zimmer (2005), [8] Pinch (2005), [9] Diekmann et al. (2005), [10] Lichtig (2005), [11] Johansen, & Walter (2007), [12] Chua, & Shen (2008)

As recommended by Howell (1999), any construction project will be benefited from lean implementation and most importantly, uncertain and complex project will be able to minimise the uncertainty and complexity through lean implementation. Nevertheless, the construction workforce needs to believe in lean philosophy together with the lean principles to accept lean construction. Koskela (1992) pioneered to introduce the first set of lean construction principles to the industry. Thereafter, various researchers in the lean construction domain developed their principles based on Koskela’s (1992) principles due to the immense popularity and being the first set of principles related to lean construction. According to the table, reduce NVAA, increase value and continuous improvement were core among the most principles stated above. Still critics of lean construction argued that emphasis of lean thinking on maximising value and eliminating waste would be another hectic process for the workforce of the organisation. Therefore, there is a threat of not accepting the lean philosophy by the workforce, if they realise lean construction would cause inconvenience in the long run. Thus, the lean construction principles have to be convenient for the workers of the organisation and easily understandable (Arrayo, & Gonzalez, 2016; Mossman, 2015).

Nevertheless, Melles (1997), Diekmann et al. (2005), Pinch (2005) and Salem and Zimmer (2005) emphasised the requirement of changing the culture within the organisation to enable lean. Indeed, Lichtig (2005) introduced tightly couple learning with action and increase relatedness considering more on human aspect in an organisation. However, to review the adaptability of lean construction phenomenon to a context, the acceptance of core principles by the construction workforce need to be investigated. Therefore, their current level of understanding on lean construction needs to be evaluated. Moreover, construction organisation required to identify the suitable tools for successful lean implementation in construction industry. Thus, the next section discusses the lean techniques that can be practiced in the construction industry.

2.10.4 Lean tools and techniques

Lean implementation in construction sites are predominantly focused on isolated implementation of lean tools, which unveil a limited success. Therefore, to achieve a high level of success, broader lean implementation is required using the five lean principles by Womack and Jones (1996) as the basis, to develop value stream map and identification of suitable tools considering the implementation at site (Picchi, & Granja, 2004).

Lean construction has encouraged the implementation of lean tools in the construction industry and some of the tools show a distinct difference comparing to traditional tools and techniques. According to Salem et al. (2003), these differences must be clearly identified for successful implementation of the lean tools. Nevertheless, many researchers believe that lean is more than a set of tools, yet required a change in thinking, discipline and behaviour, commitment and collaboration, and the holistic focus (Tzortzopoulos et al., 2020; Ballard, 2020; Sarhan, & Fox, 2013; Terry, & Smith, 2011; Rooke et al., 2007). Therefore, adapting to lean culture within the organisation will pave the way towards customising the available lean tools and techniques and further generating their own tools to reduce NVAA. However, Sarhan and Fox (2013) stated that many companies prefer to combine traditional techniques with lean techniques, which align with the lean principles to get the benefits of lean implementation. Therefore, the ultimate objective of lean tool usage is to minimise NVAA and maximise value through continuous improvement. Thus, the researcher developed a working definition for lean tools and techniques as:

'A method fulfilling the requirements of minimising NVAA and/or maximising value through continuous improvement'

Thus, not only the tools in the lean construction domain, lean tools in the manufacturing can be considered by a construction organisation after an appropriate customisation. Yet, Pearce and Pons (2013) indicated that, identification of tools that are appropriate to particular situation is quite challenging. However, rather than accepting one or two isolated tools, it is suggested to practice all possible techniques (Bhasin, & Burcher, 2006). Frequently, practitioners unable to come up with informed decisions on type of lean tools to be implemented in particular scenario. Thus, the individuals in the organisation need to be comprehend with which tool to be selected to a particular scenario. Table 2.11 presents a summary of lean tools that reported in lean domain.

Table 2.11: Tools and techniques that can be used in lean construction

Lean Tool/ Technique	References
Eight Wastes Identification	[2], [5], [8], [9], [12], [13], [17], [18], [20], [21]
Value Identification	[1], [7], [8], [13], [16], [17], [18], [20], [21], [22]
Continuous Improvement/Kaizen	[1], [2], [3], [4], [15], [20], [21]
Continuous Flow	[2], [3], [4], [20], [21]
Cellular Manufacturing	[1], [6], [10], [21]
U-Shape Line	[1], [6], [10], [16], [21]
Just in Time (JIT)	[2], [3], [4], [5], [10], [12], [16], [20], [21], [22]
Kanban (Pull Planning)	[1], [3], [4], [5], [10], [16], [21]
Single Piece Flow	[1], [9], [16], [21]
5S	[1], [3], [4], [5], [6], [20], [21], [22]
Visual Management	[1], [3], [4], [5], [7], [12], [13], [17], [20], [21], [22]
A3 Problem Solving	[6], [10], [11], [13], [21]
Fishbone Analysis/ Ishikawa Diagram	[6], [21]
5-Whys & 2-Hows	[6], [8], [9], [14], [21], [22]
PDCA Cycle	[4], [6], [10], [20], [21]
DMAIC	[14], [21]
LAMDA	[21]
Lean Six Sigma	[3], [4], [5], [21]
Process Mapping	[1], [10], [11], [17], [21]
Construction Process Analysis	[4], [5], [11], [14], [19]
Single Minute Exchange of Dies (SMED)	[1], [7], [11], [21]
Last Planner System	[2], [4], [5], [12]
Value Stream Mapping	[4], [5], [10], [20], [21]
Root Cause Analysis (RCA)	[10], [17], [20], [21]
Takt Time Calculation	[21]
FIFO Inventory Management	[4], [5]

Lean Tool/ Technique	References
Concurrent Engineering	[2], [4], [5], [21]
Step-change/ Kaikaku	[1], [21]
Supplier Development	[1], [10]
Supplier Base Reduction	[1], [10]
Supplier Involvement in Product Design	[10]
Customer Involvement in Product Design	[5], [6], [21]
Simplicity	[8], [20], [22]
Total Quality Management (TQM)	[13], [17], [20], [21]
Total Productive Maintenance (TPM)	[1], [3], [4], [21]
Preventive Maintenance	[3], [4], [10], [14]
Work Standardization	[3], [4], [20], [21]
3P (Production Preparation Process)	[10], [21]
JIDOKA/ Automation	[3], [4], [9], [16], [21]
Heijunka – Production Levelling	[3], [4], [9], [11], [21]
Synchronize/Line Balancing	[3], [4], [9], [18], [21]
Work Structuring	[4], [5], [12], [15], [18]
Multi-Process Handling	[3], [4]
Power NAP - Japanese	[21]
Poka Yoke	[3], [4], [10], [16], [21], [22]
Setup Time Reduction	[3], [4]
First Run Studies	[4], [5], [13], [17], [20], [21], [22]
Time and Motion Study	[3], [4]
Bottleneck Analysis	[4], [5], [10]
Gemba Walk	[3], [4], [7], [8], [20], [21]
Genchi Genbutsu	[7], [8], [21]
Andon	[7], [21]
Spaghetti Chart	[21]
Target Value Design	[1], [4], [5]
Global 8D	[21]
ChakuChaku	[6], [21]
HoshinKanri/Policy deployment	[1], [6], [7], [10], [21]
Jishuken	[21]
Team Work	[1], [5], [8], [14], [15], [20], [21]
Cross Functional Teams	[4], [10], [15], [21]
Training	[1], [2], [5], [7], [9], [11], [12], [13], [15], [17], [20]
Workforce Commitment	[1], [2], [17], [19]
Daily Schedule Adherence	[13], [16], [17], [18]
Continuous Flow	[1], [4], [5], [7], [8], [12], [17], [20], [21]
Time Based Competition	[13]
Integrated Project Delivery (IPD)	[2], [12], [17], [18]
Building Information Modelling (BIM)	[1], [2], [16]
Balance Score-card System	[19]
Reverse-phase scheduling	[1], [2], [12], [13], [17], [20]
Choosing by Advantage (CBA)	[13], [16], [17], [18]
Check Sheet	[4], [5], [14], [21]
Pareto Analysis	[4], [5], [14]
Check Points and Control Points	[3], [4], [5],
Failure Mode and Effects Analysis	[4], [5], [14], [16], [21]

Lean Tool/ Technique	References
Fail Safe for Quality	[4], [13]
Daily Meetings	[1], [4], [7], [8], [13], [18], [20], [22]
SMART Goals	[4], [10]
Quality Function Development (QFD)	[3], [4]
Statistical Process Control	[3], [4]
Nemawashi	[1], [9], [16], [21]
[1] Bhasin, & Burcher, (2006), [2] Aziz and Hafez (2013), [3] Alireza and Sorooshian (2014), [4] Ansah, Sorooshian, Mustafa, & Duvvuru (2016), [5] Rahman et al. (2013), [6] Connor, & Swain (2015), [7] Liker (2004), [8] Tommelein (2015), [9] Tsao et al. (2004), [10] Leanproduction.Com (2015), [11] Lee et al. (1999), [12] Howell, & Ballard (1998), [13] Salem et al. (2005), [14] ASQ (2015), [15] Brunet and New (2003), [16] Hutchins (2016), [17] Mossman (2017), [18] Arroyo, Tommelein, & Ballard (2015b), [19] Hudson, Smart, & Bourne (2001), [20] Koskela (1992), [21] Stadnicka, & Antosz (2013), [22] Muhammad et al. (2013)	

The extended glossary of lean tools and techniques of the above table is presented in Appendix 1.

Accordingly, many lean tools such as 5S, VSM, JIT, value analysis, last planner, visual management and continuous improvement, which are considered as the popular lean tools in the construction industry. Similarly, many researchers claimed that tools such as continuous improvement, workplace organisation, visual management, TPM, TQM, JIT and production levelling are more applicable for construction industry (Vinodh, Arvind, & Somanathan, 2010; Dombrowski et al., 2010; Koskela, 1994). In contrast to construction industry, Stump and Badurdeen (2012) stated that some lean tools such as, 5S, visual management and continuous improvement can be easily implemented in the manufacturing sector. However, implementation of them in the construction industry is challenging due to the coherent nature of the industry.

Ballard and Howell developed Last Planner in 1998 and it is one of the most widely used core idea in lean construction (Ballard, 2020; Koskela et al., 2002; Mossman, 2017). It is an unwitting demonstration of the lean evolvement process. Many researchers highlighted that last planner is popular among the construction industry although implemented in an ad-hoc manner. Moreover, the findings of Hannis-Ansah et al. (2016) confirmed 30 lean tools including LPS, Daily Huddle Meetings and Concurrent Engineering as the most operative lean-delay control tools.

Consequently, many researchers tried to prove the suitability of lean manufacturing tools to the construction industry.

The findings of Stadnicka and Antosz (2013) proven with regards to the SMEs in manufacturing industry that majority of the lean tools implemented by them take an immature death and they will not lasting more than 5 years of the operation time. Yet, Olatunji (2008) noted that lean construction acknowledge valuable capabilities such as Kaizen, VSM and 5S to enhance workflow and to minimise NVAA. Thus, the level of lean implementation can be considered with regards to the level of lean tools implemented in the organisation. Hence, the identified lean tools need to be evaluated through empirical study to explore the suitability of these methods to Sri Lankan construction SMEs.

2.11 Lean in Construction SMEs

Lean has been successfully implemented in large organisations which produce high volumes of standardised products (Powell, Strandhagen, Tommelein, Ballard, & Rossi, 2014). Hence, many construction companies benefited from lean implementation, yet few SMEs profited from implementing lean. Both SMEs and large companies are struggling with similar NVAA and the heterogeneous nature of SME sector creates more NVAA in a construction project. Therefore, Pingyu and Yu (2010) stated that effective implementation of lean in SMEs is imperative. However, the research on lean implementation from the perspective of SMEs is limited (Tezel et al., 2017; Ankomah et al., 2017). Few researchers such as Dora, Goubergen, Kumar, Molnar and Gellynck (2014); Rymaszewska (2014); Prasanna and Vinodh (2013); Laureani and Antony (2012); Chiarini (2012); Rose, Deros, Rahman and Nordin (2011); Kumar et al. (2006) and Achanga et al. (2006) highlighted the importance of implementing lean concepts in SMEs.

There is a need for the construction SMEs to be more aware of lean and be able to inspire their employees, clients and partners in order to attain greater joint performance (Tezel et al., 2020; Avelar et al., 2019; Ankomah et al., 2018). However, lean implementation in any organisation is an on-going and complex process. Similarly, project-based emphasis positively affected to the lean implementation in the construction SMEs. Nevertheless, the benefits of lean for SMEs include control of capacity development, ability to continue current operations while lean implementation take place and taking inform decisions, thanks to working in a more controlled environment (Ankomah et al., 2017; Tezel et al., 2017; Abbot, 2015).

Implementing lean in existing organisations or with people schooled in current practice is hardly automatic (Koskela et al., 2002). Lean-based project management requires changes in individual behaviour and extensive organisational development efforts to overcome the ways current practice contradicts the new (Koskela et al., 2002). Few SMEs implemented lean mechanically without reviewing the internal and external environment of the organisation (Ankomah et al., 2017) and thus, lean implementation is a ground-breaking improvement of all work habits and the processes in construction SMEs.

Table 2.12 differentiates the characteristics of SMEs which support and hinder the lean implementation with compared to large construction organisations (Rymaszewska, 2014).

Table 2.12: SMEs characteristics supporting and hindering the lean implementation

Supportive characteristics	Hindering characteristics
• Faster communication • Quick decision-making process • Unified organisational culture • Greater flexibility • Quicker response to customer needs • More authority and power to employees • Innovative environment • Support to change initiatives	• Lack of financial allocation to improvement initiatives • Fluctuations in raw materials availability and prices • Reliability upon one-person management • Inadequate education and training of entrepreneurs • Inadequate time and cash flow management • Intuitive rather than analytical decision-making • Reliance upon out-dated, labour intensive technologies and traditional management practices

Source: Rymaszewska (2014)

Many recent researchers highlighted the importance of lean for construction SMEs. However, there are significant problems with the implementation, which need prompt attention (Avelar et al., 2019; Tezel et al., 2018; Nowotarski, & Pasławski, 2018; Ankomah et al., 2017). Although researchers suggest that lean implementation minimises most of the problems of construction SMEs, misinterpretation of the lean philosophy remains precarious and lean implementation problems remain uncertain (Avelar et al., 2019; Nowotarski, & Pasławski, 2018; Ankomah et al., 2017; Tezel et al., 2017).

2.11.1 Lean tools for construction SMEs

Ankomah et al. (2017) identified 20 lean tools and techniques that can be implemented by construction SMEs. Among those tools, 19 were identified as tools that can be fully implemented with less monitory investment. The author further identified BIM as a lean tool which can be partially implemented by construction SMEs.

According to Ankomah and co-workers, SMEs can implement 5S, 5-whys, A3 report, Ishikawa diagram, Kanban cards, Heijunka and VSM with less monitory investments. Further to authors, other lean construction tools such as Concurrent Engineering, Last Planner system, CBA, LBMS and action learning are not capital-intensive, and therefore within the reach of SMEs. Considering the poverty levels in Ghana, Ankomah et al., (2017) recommended the above lean tools that require less monetary investment by construction SMEs. Even though many researchers indicated lack of financial capacity to lean tool implementation among construction SMEs, bestowing to Ankomah et al. (2017), construction SMEs too can initiate implementing them.

Antosz and Stadnicka (2017) agreed that SMEs that have implemented the lean philosophy in Poland use mostly 5S method, which require a less monetary investment to implement. Researchers such as Rose et al. (2011) and Salem et al. (2005) further added that tools such as Kanban cards, SMED, Kaizen, increased visualisation, daily huddle meetings, first-run studies, poka-yoke and Andon are the least costly, and can be implemented by SMEs. Avelar et al. (2019) and Antosz and Stadnicka (2017) stated the need of the SME organisations to improve the work through appropriate application of lean tools. Yet, the identification of specific lean tools which are specific to the levels of the organisation is vital for successful lean implementation.

As discussed in Section 2.10.4, many lean tools are available in the industry. However, even the companies which have implemented the lean philosophy use only 5S method (Antosz, & Stadnicka, 2017). Yet, the identification of most suitable techniques to appropriate individual will lead to success in the lean journey. Hence, Antosz and Stadnicka (2017) further added that, some of the tools can be initiated and implemented by the top management whereas tools like 5S, 5-Whys, PDCA, Kaizen, and check sheets can be practiced by the shop floor level workers without any technical knowledge by SMEs. Hence, there is a necessity to empirically investigate the current level of lean tool implementation by Sri Lankan construction SMEs. Following section discusses the benefits for construction SMEs from lean implementation.

2.11.2 Benefits of lean construction

Lean has various inherent direct advantages that enhance the organisations ability to successfully compete through being more effective and efficient in their operations (Hu, Mason, Williams, & Found, 2015; Koskela et al., 2002; Ballard, & Howell, 1998). Similarly, Howell (1999) stated that, lean supports to develop teamwork and willingness to learn within the construction site. Antosz and Stadnicka (2017) identified the key reasons for implementing lean as the intention to improve the company’s operation and the need to gain a competitive advantage. Yet, in addition to those obvious benefits, there are some notable indirect advantages that arise from successful lean implementation (Tzortzopoulos et al., 2020; Hu et al., 2015; AArayo et al., 2015; Umstot, Fauchier, & Alves, 2014). Table 2.13 presents some of the benefits of lean construction for SMEs in the construction industry as discussed in the literature.

Table 2.13: Benefits of lean construction

Benefits of Lean Construction	References
Alignment of all parties to deliver against an agreed set of project objectives	[3], [7], [9], [10], [11]
Better risk management	[10], [12]
Clarity of communication	[1], [4], [5], [7], [11]
Common guide for decision making, target-setting, reviewing and improving	[11], [15]
Foundation for collaborative working	[4], [11]. [15], [19], [20]
Greater customer satisfaction	[1], [3], [7], [9], [10], [11], [12], [14], [18], [20]
Greater productivity	[1], [3], [4], [5], [6], [8], [9], [10], [11], [12], [15], [16], [17], [19], [20]
Greater profitability	[5], [9], [10], [12]
Higher quality construction	[1], [3], [4], [5], [6], [8], [9], [10], [11], [12], [15], [16], [17], [19], [20]
Improve safety	[1], [3], [5], [6], [9], [10], [11], [12], [14], [16], [17], [20]
Improved sustainability	[2], [3], [5], [6], [7], [10], [17]
Improvements in design	[9], [10]
Increase reliability	[9], [10], [14], [20]
More focus by supervisory staff on managing workers	[10]
Predictability of programme delivery	[11]
Reduce construction time	[2], [3], [13], [14]
Reduce cost	[1], [3], [8], [10], [11], [12], [14], [19]
Reduce rework	[2], [13]
Reduce waste	[1], [2], [3], [5], [6], [7], [8], [9], [10], [11], [12], [13], [16], [17], [18], [19], [20]
Sustaining Performances	[4], [16], [18], [20]
Workers are happily, proudly and visibly reporting their success	[11], [17]
Workers are willing to take coaching and review their work processes	[11], [15]
Workers challenge management when standards are slipping	[11]

[1] Bernstein, & Jones (2013), [2] Antony (2011), [3] Aziz, & Hafez (2013), [4] Egan Report (1998), [5] Marhani et al. (2012), [6] Umstot et al. (2014), [7] Kumar et al. (2006), [8] Chen, & Taylor (2009), [9] Ogunbiyi et al. (2013), [10] Smart Market Report (2013), [11] Connor, & Swain (2013), [12] Karlsson, & Ahlstrom (1997), [13] Chiarini (2012), [14] Emmitt, Pasquire, & Mertia, (2012), [15] Antosz, & Stadnicka (2017), [16] Jadhav et al. (2014), [17] Ankomah et al. (2017), [18] Tesel et al. (2017), [19] AArayo et al. (2015), [20] Avelar et al. (2018)

Many researchers agreed that waste reduction and greater productivity can be perceived as benefits of implementing lean. The quality of construction ultimately leads to achieve the benefits mentioned in the table. However, increasing overall competitiveness in the industry is another benefit that firms can get through lean implementation (Smart Market Report, 2013).

Number of benefits from lean construction has encouraged the industry practitioners to adopt lean to their projects and thus, several researchers highlighted that many organisations are implementing or willing to adopt lean principles (Tazel et al., 2017; Koskela et al., 2014; Jadhav et al., 2014; Aziz, & Hafez, 2013; Umstot, et al., 2014; Hines et al., 2010). Further, main benefits of lean construction as per Howell (1999) include better control throughout the life cycle of the project from inception to completion, maximising performance for the client at the project level, and availability of defined set of objectives for the construction process. Moreover, Ogunbiyi et al. (2013) and Avelar et al. (2020) noted improvements in design, quality, safety and reliability as benefits which fortified the practitioners to be more competitive in the market.

According to Egan Report (1998), the Neenan Company in Colorado used lean construction over two years to reduce the time to produce a schematic design by 80% and project times and costs by 30%. Similarly, Pacific Contracting of San Fransisco has used lean construction to increase the productivity and turnover by 20% in 18 months (Egan Report, 1998). Nevertheless, almost two decades have passed from the time Egan Report has published and nowadays the benefits can be achievable within a lesser time period. However, Smart Market Report (2013) accentuated that expectation of benefits are higher than achievable benefits by implementing lean construction. Hence, a holistic approach to lean implementation ensures obtaining benefits of lean implementation. Many researchers identified benefits of lean to be focused on the value maximisation through whole life consideration (Pearce et al., 2018; Arrayo, & Gonzalez, 2016; Awa et al., 2015; Nesensohn et al., 2014; Koskela et al., 2002). Lean enabled organisations are easy to manage, and they are highly competitive in the industry. Hence, these resources need to be evidently defined for the successful lean implementation. However, the lean implementation is not free from barriers among the construction industry (Avelar et al., 2020; Arrayo, & Gonzalez, 2016; Nesensohn et al., 2014; Shang, & Pheng, 2014; Ogunbiyi et al., 2013; Vilasini et al., 2011). Therefore, the next section discusses the barriers for lean implementation.

2.11.3 Barriers for lean implementation

Even though many researchers criticise the lean implementation, Hines et al. (2004) highlighted that, they neglected the fact that lean continues to develop. Lean has both good views (Bhamu, & Sangwan, 2014; Hines et al., 2004; Rich, & Francis, 1998) as well as contradicting views (Green, 1999). Even though lean provide a good platform for the stakeholders to maximise value for money, embedding lean in an organisation typically requires many changes and is a challenging endeavour (Nesensohn et al., 2014). Rymaszewska (2014) highlighted the importance of lean concept to be tailored to the specific needs of SMEs. A survey conducted by the practitioners of lean implementation revealed that changes to the production environment due to lean have only a 30% success rate and 70% of lean implementations experience decay and return to the original way of doing business (Schipper, & Swets, 2010). This emphasised the lack of implementable strategies to overcome the problems with lean implementation barriers. Table 2.14 summarises the barriers for lean implementation in the construction industry.

Table 2.14: Barriers for lean implementation

Barriers for Lean Implementation	References
Absence of a dedicated implementation team	[15], [27]
Contractual disputes	[16], [17], [19], [20], [22], [23], [24], [25], [29], [30]
Dependency	[16], [19], [22], [24], [25]
Failure to create and communicate urgency	[15]
Failure to monitor and evaluate outcome	[6], [15]
Fear of taking risk	[16], [17], [19], [20], [22], [23], [24], [25], [29], [30]
Fragmentation in construction	[16], [17]
Government related issues and procurement related issues	[2], [3]
High cost of lean training	[13], [17], [27], [28]
High work load	[28]
Ignorance to HRM and development	[4], [16], [19], [22], [24], [25], [30]
Illiteracy	[4], [16], [19], [22], [24], [25], [30]
Inability to quantify benefits of lean	[27]
Inadequate funding of projects	[16], [25], [26]
Inadequate training	[4], [16], [19], [22], [24], [25], [30]
Inflation	[16], [25], [26]
Knowledge-level constraints	[5], [13], [14], [19], [23]
Lack of a clear executive vision	[15]

Barriers for Lean Implementation	References
Lack of a structured methodology	[15]
Lack of ability to work in group	[16], [17], [19], [20], [22], [23], [24], [25], [29], [30]
Lack of an effective communication	[2], [12], [15], [18], [19], [27]
Lack of commitment	[16], [17], [19], [20], [22], [23], [24], [25], [29], [30]
Lack of consultants and trainers in the field	[2], [12], [13]
Lack of cooperation from suppliers	[2]
Lack of training for employees	[2], [13]
Lack of lean awareness among top management	[4], [15], [20]
Lack of lean awareness among workers	[13], [14], [17], [19], [27], [28]
Lack of commitment from middle management	[1], [2], [3], [9], [13], [14], [19], [27], [28]
Lack of Motivation	[28]
Lack of capacities to invest	[2], [3], [8], [13], [15]
Lack of self-criticism	[16], [17], [19], [20], [22], [23], [24], [25], [29], [30]
Lack of supportive HRM policies	[7], [15]
Lack of technical competencies	[4], [16], [19], [22], [24], [25], [30]
Lack of involvement by the top management	[1], [2], [3], [9], [13], [14], [19], [27], [28]
Lack of trust	[16], [17], [19], [20], [22], [23], [24], [25], [29], [30]
Low professional remuneration	[16], [24], [25], [26]
Over-enthusiastic champions	[16], [17], [19], [20], [22], [23], [24], [25], [29], [30]
Perception about profitability through lean	[13], [14], [17], [27]
Poor leadership	[15], [16], [20], [24], [27], [29], [30]
Poor project management	[12], [14], [20], [22], [27], [29]
Quality problems with supplied material	[1], [2]
Time consuming	[14], [17]
Top management resistance	[1], [2], [3], [10], [11], [17], [19], [27], [28]
Traditional procurement and contracts	[16], [17], [20]
Union resistance	[14]
Unstable markets for construction	[16], [25], [26]
Use of traditional management concepts	[17], [19]
Weak communication and transparency	[16], [19], [20], [22], [23], [24], [25], [29], [30]
Work pressure	[13]
Workers' resistance to change	[1], [2], [3], [4], [5], [6], [7], [9], [13], [14], [15], [17], [20], [21], [22], [23], [24], [28], [29]

[1] Rahman et al. (2013), [2] Jadhav et al. (2014), [3] Shang and Pheng (2014), [4] Green, et al. (2008), [5] Pingyu, & Yu (2010), [6] Veiga et al. (2011), [7] Smart Market Report (2013), [8] Pedersen and Huniche (2011), [9] Hines et al. (2004), [10] Sawhney, & Chason (2005), [11] Hagstrom and Wollner (2011), [12] Cudney and Elrod (2010), [13] Aomar (2012), [14] Larsen, & Kao (2008), [15] Abbot, & Aziz (2015), [16] Mossman (2009), [17] Sarhan, & Fox (2013), [18] Thomas, & Thomas (2005), [19] Abdullah, Razak, Abubakar, & Mohammad (2009), [20] Common, Johansen, & Greenwood (2000), [21] Johansen, Porter, & Greenwood (2004), [22] Alarcon, Diethelm, & Rojo (2002), [23] Johansen, Glimmerveen, & Vrijhoef (2002), [24] Alarcón, Diethelm, Rojo, & Calderon (2008), [25] Olatunji (2008), [26] Dulaimi, & Tanamas (2001), [27] Deros and Wahab (2010), [28] Antosz, & Stadnicka (2017), [29] Seymour (2013), [30] Jorgensen et al. (2004)

According to the above table, workers' resistance to change was identified as a key barrier for lean implementation by majority of the researchers. Workers are not easy to educate and sometimes resist changing due to lack of skills and thus, Aziz and Hafez (2015) and Howell and Ballard (1998) noted that the rate of change is the most important lean metric. The costs of lean implementation in construction and the benefits derived are unclear which can be considered as a hindering factor for successful lean implementation. Besides the organisational related issues such as lack of commitment by top management and middle management, SMEs faced problems in lean implementation. Moreover, the organisational culture, i.e., discipline, respect and communication marked as a vital determinant for successful lean implementation. Considering the construction industry, inherent nature of the construction process is noteworthy in lean implementation. However, Green (1999) argued that external economic factors such as pollution, human cost of lean methods and traffic congestion constantly fall outside the boundaries of lean implementation benefits.

To integrate lean in a construction organisation, it is recommended to understand and anticipate barriers that might be opposed to successful implementation, as well as taking hold of those that can help to ensure its success based on similar experiences in other contexts (Cano, Delgado, Botero, & Rubiano, 2015). It is noteworthy to highlight that there are certain barriers in lean implementation in the construction environments which has a high level of product variations and process variations (Powell et al., 2014). Abbot and Aziz (2015) noted that there are more generalised barriers such as lack of capabilities and strategies of individuals, thus reflection of human resource management in lean construction is another notable factor by its absence (Green, & May, 2005). Moreover, as suggested by many of the researchers, another major barrier is the lack of leadership towards lean implementation. Conversely, Pearce et al. (2018) stated that many lean implementation failures indicated the attitudes of managers, lack of knowledge on lean and their benefits among the SME sector as root causes for the failure. Thus, Figure 2.7 shows the managers lack of knowledge as the root cause for the failure on lean as suggested by Pearce et al. (2018).

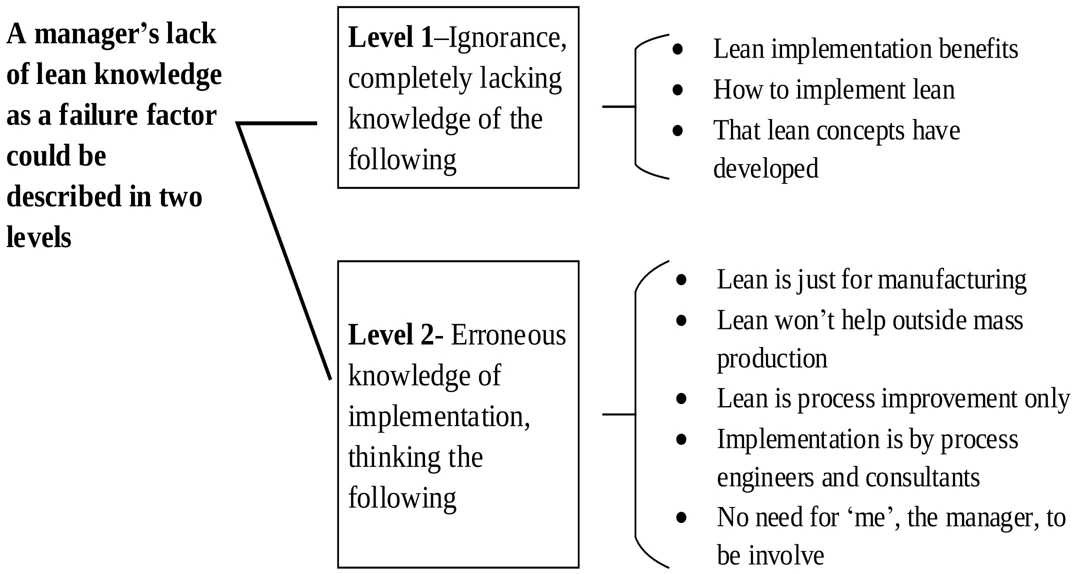


Figure 2.7: Lack of knowledge as the root cause for lean implementation failure

Source: Adapted from Pearce et al. (2018)

A manager of a construction SME plays a vital role in successful lean implementation. Thus, improving the capacities of managers through appropriate attitudinal change will accelerate the lean implementation. However, Rose et al. (2010) and Hines et al. (2008) highlighted that organisational culture, poor decision-making process, use of wrong tool, use of single tool to solve the problems and poor external support will fail the lean implementation in SMEs. Thus, there is a need to guide the construction SMEs in the right path towards successful lean implementation.

The findings of the case study of Silva (2017) revealed that in construction there is no standard, easy-to-use framework for lean implementation, which marks as a barrier for lean implementation. Similarly, construction industry requires an easy to adopt framework for SMEs. Chandrakanthan (2018) stated that there is a 70% - 90% failure rate for lean implementation in Sri Lanka. Chandrakanthan (2018) further highlighted that lean failed due to technical investments made in the name of lean thinking where no groundwork has been done. Consequently, failure rate of lean implementation increases in the construction industry. Therefore, it is vital to explore the factors, which accelerate the lean implementation in construction SMEs. Next section presents a summary of lean implementation drivers for construction SMEs.

2.11.4 Drivers for lean implementation

The literature review identified a range of driving factors for the successful lean implementation in construction SMEs. Table 2.15 presents a summary of drivers as proposed by some of the researchers to enable lean in an organisation.

Table 2.15: Drivers for lean implementation

Drivers for lean implementation	References
Achieve distinctive capability	[5]
Benefits are limited for project level	[2], [4], [7], [12]
Client involvement in the construction project	[1], [10], [12]
Collaboration between project team members	[5]
Developing complementary project objectives	[6]
Developing organisational readiness	[1]
Effective communication and engagement	[3], [8]
Effective communication between organisations	[2], [9], [12]
Efficient use of resources	[2], [5]
Enhance as a technically progressive company	[10], [11]
Experience of the work force	[1], [2], [3]
External support from consultants	[7]
Field support from management	[5]
Flexible organisation structure	[1], [3], [4], [7], [9], [11], [12]
Fluctuating customer requirements	[1], [4], [6], [10]
Freedom for employees	[1], [3], [4], [7], [9], [10], [11], [12]
Frequent changes in supply schedule by customers	[5], [9]
Government incentives for innovative firms	[11]
High cost of energy	[5], [7], [10]
High labour cost	[1], [7], [9], [11], [12]
High level of inventory	[5], [9]
High product variety/ customer specific product	[1], [3]
High risk to the company	[1], [2], [3], [4], [7], [9], [12]
High scraps/ rework and rejections	[5], [9]
Improvements in operations	[1], [7], [9], [11], [12]
Increase the profitability through lean	[9], [10]
Lack of standard operating procedures	[10], [12]
Low capacity to fulfil customers' demand	[5], [6]
Low manpower productivity	[3], [4]
Low quality material suppliers	[3], [4], [6], [8], [12]
Management commitment and capability	[3]
No added competitive advantage for the company	[6]
No blame culture	[5]
Organisational culture and ownership	[8]
Part of the organisation's continuous programmes	[6]
Poor commitment of employees	[2]
Poor skills and capabilities of workers	[1], [3], [4], [7], [9], [11], [12]
Poor workplace organisation	[5], [9]

Drivers for lean implementation	References
Procuring based on design and build method	[5], [11]
Providing adequate resources to support change	[7]
Requirement/Motivation by customers	[6]
Reward system to motivate employees	[9], [10]
Shift to performance based regulations	[7]
Single responsibility for design and construction	[1], [3], [12]
Strategic approach to improvements	[10]
Suppliers take long time to deliver	[2]
Teamwork and joined-up whole systems thinking	[1], [3], [11]
Technical competence of the client	[3], [10]
Transparency	[3], [5]
Unavailability of skilled workers	[1], [7], [9], [11], [12]
Unbalanced workload on different workstations	[2]
Up to date knowledge base	[11]
[1] Salonitisa, and Tsinopoulos (2016), [2] Sangwan et al. (2014), [3] Shang & Pheng (2014), [4] Viagi et al. (2017), [5] Ankomah et al. (2017), [6] Sawhney, & Chason (2005), [7] Ogunbiyi et al. (2014), [8] Abbot and Aziz (2015), [9] Tezel et al. (2017), [10] Tezel et al. (2019), [11] Achanga et al. (2006), [12] Avelar et al. (2018)	

The literature review identified 52 driving factors. Many researchers highlighted that, the benefits of lean are driving the construction organisations for lean implementation. Indeed, due to the problems faced by construction SMEs, they are trying to adopt lean and overcome them through lean implementation. However, these drivers need to be analysed with reference to the Sri Lankan construction SMEs. Correspondingly, Sangwan et al. (2014) highlighted that it will be interesting to identify the lean implementation drivers specific to the context to be successful with lean implementation. Sangawan et al. (2014) further stressed that, identification of the drivers at internal level, external level and policy level will path the way towards identification of strategies to be taken by different stakeholders.

2.11.5 Overcoming lean implementation barriers

There has been a notable growth in lean implementation in the construction industry. However, lean implementation barriers need to be minimised by the construction industry to achieve the benefits of lean implementation (Tzortzopoulos et al., 2020; Ogunbiyi et al., 2013). Shang and Pheng (2014) noted that the lack of a long-term philosophy and the absence of a lean culture in their organisations are the most crucial obstacles to lean practice in the construction industry. The transformation towards lean construction will lead to changes in the culture and in its people (Green et al., 2008). Therefore, lean relies heavily on the skills of the people and how they respond to changes (Koskela, 2020; Sawhney, & Chason, 2005). Moreover, an important gap in the literature is concerned with the lack of understanding of the relationships between the risks in lean implementation (Marodin, & Saurin, 2015). According to Jadhav et al. (2014), lean implementation issues may vary from country to country, work culture of the organisation and geographic location within the country. Rework, uncertainty, labour skills, site conditions and location are some examples of such factors that need further analyses for leaner construction processes (Al-Sudairi, 2007). Even though, construction industry appears to be one of the pioneering industries to be absorbing lean concepts and techniques (Avelar et al., 2020; Shang, & Pheng, 2014), lean do not receive the attention they deserve in the construction industry.

According to Smart Market Report (2013), lack of sufficient knowledge is identified as another key barrier by lean practitioners as well as non-lean practitioners emphasising that more information and education on lean must be provided to the construction industry. Those who have not implemented lean do not fully understand the challenges posed by working with project team members who are not engaged in lean. Similarly, there is a need to have the required resources on hand to work steadily and without interruption as per Howell (1999). This also reinforces the call for necessary individual capacities to enable lean, so that firms understand the full benefits and obstacles they faced in implementing and retaining lean practices and can make informed decisions. It is necessary that companies rethink their business strategies and implement focused strategies (Guzman et al., 2012) to overcome these barriers in order for construction industry to reap the benefits of implementing lean construction (Rooke, 2020; Ogunbiyi et al., 2013). The seminal ideas of lean construction were related to the management of site operations rather focusing on organisation. Consequently, new methods were developed for supply chain management, design management, cost management, and for total project delivery. This process of increasing breadth will eventually lead to the situation where all issues of construction project delivery have a methodical solution based on a new theoretical framework (Koskela et al., 2002).

Most of the knowledge about lean production is tied up in larger companies and researchers have not been spread widely to SMEs (Pingyu, & Yu, 2010) emphasising the need of construction SME oriented researches for lean. Therefore, identification of NVAA and their root causes will eventually increase the path towards lean implementation. Moreover, level of understanding and implementation of lean tools and techniques needs to be analysed among construction SMEs. Indeed the literature confirmed the necessity of investigating the drivers and barriers for a specific context. Therefore, there is a necessity to empirically investigate an implementable framework for construction SMEs focusing enabling lean to overcome the problems faced by construction SMEs. In order to facilitate the empirical investigation, the following research questions were developed:

- What are the NVAA of construction SMEs and their root causes? (RQ2a)
- What is the level of understanding and implementation of lean tools and techniques by construction SMEs in Sri Lankan construction industry? (RQ2b)
- What are the drivers for lean implementation in construction SMEs? (RQ3a)
- What are the barriers for lean implementation in construction SMEs? (RQ3b)

The above identified RQ2a and RQ2b were investigated during EIR-1 and RQ3a and RQ3b were investigated in EIR-2.

2.12 Chapter Summary

A major characteristic of SMEs is considerable and fast growth of the sector which largely contributed to the national economy. Hence, this chapter reviewed the state of the art construction SMEs to identify the challenges faced by them and how lean implementation can solve the challenges. Many researchers highlighted the importance of implementing lean concepts in construction SMEs. However, there are significant problems with the implementation, which required prompt attention.

Section I of Chapter 02 provides and in-depth analysis to construction SMEs. As there was no published definition for construction SMEs, the researcher developed a definition for construction SMEs in Sri Lanka. Accordingly, the category of construction SMEs in Sri Lanka is considered as a contracting organisation, which has a grade from C2 to C6 as per the CIDA contractor registration criteria. Moreover, the challenges faced by SMEs were reviewed in this chapter.

Section II of Chapter 02 has reviewed lean philosophy, lean production and lean construction along with benefits and barriers of lean implementation for construction SMEs to get an in-depth understanding to the formulation of conceptual framework of the study. Review of the evolution of lean concept to construction revealed that, the basis is coming even before the Toyota Motor company. The scientific management theories have largely informed in development of the lean concept.

The lean concept targeted at maximising value, minimising NVAA and continuous improvement in considering the whole life cycle of the project. The literature review confirmed eight types of NVAA under lean as overproduction, inventory, motion, waiting, transportation, over-processing, defect and under-utilised human skills. The commonly adapted lean production principles in the literature are 5 principles specified by Womack and Jones (1996) and Toyota Way 4P principles. Lean Iceberg Model and Shingo Model were also successfully implemented by the lean practitioners. Koskela’s (1992) principles are the frequently adapted lean construction principles in the construction industry and many researchers developed lean construction principles based on Koskela’s principles.

Construction SMEs struggle to implement lean due to lack of capacities. Thus, many SME related literature established the need to build necessary capacities for successful lean implementation. Hence, it is essential to identify capacities necessary to overcome the barriers of lean implementation in the construction industry. As improved lean implantation can be achieved through capacity building, construction SMEs need to focus on lean enabling capacity building in order to be competitive in the construction industry. A review of literature on capacity building and its role in enabling lean for construction SMEs is presented in the next chapter.

CHAPTER 3

CAPACITY BUILDING

3.1 Introduction

Capacity building will improve the individual, organisational and external parties' abilities for enabling lean to better perform in the industry. Thus, this chapter reviews literature on capacity building and its role in enabling lean for construction SMEs. The chapter further presents the definitions of the terms capacity and capacity building. It further describes levels of capacity and capacity building process. As identification of lean capacities could guide organisations to minimise the barriers of lean implementation and to optimise performance in the industry, this chapter reviews the literature on lean enabling capacities and lean enabling capacity building strategies for construction SMEs. This chapter finally presents the conceptual framework developed based on the literature review to guide the empirical investigation.

3.2 Capacities of an Organisation

The following sections review the literature on definitions given for the term 'capacity', levels of capacities and key capacities at each level.

3.2.1 Defining the term capacity

Capacity is a construct that has different meanings in different contexts (Bos, & Brown, 2014; Kaplan, 2000; Goodman et al, 1998). OECD (2006) defined capacity as the ability of people, organisations and society as a whole to manage their affairs successfully. Similarly, United Nations Educational, Scientific and Cultural Organisation (UNESCO, 2011, 2005) and UNDP (2006) defined capacity as the ability of individuals, organisations and systems to perform appropriate functions efficiently, effectively and sustainably. Groot and Molen (2000) identified knowledge, skills, attitudes of individuals, maintenance of operational infrastructures, as some of the capacities of an organisation.

Enemark and Ahene (2002) identified human resources in terms of knowledge, skills and attitudes for the purpose of developing and managing certain areas in the community or an organisation, which ensure long-term sustainability as organisational capacities. Nevertheless, President‘s Emergency Plan for Aids Relief (PEPFAR, 2011) defined capacity as the ability of individuals and organisations or organisational units to perform functions effectively, efficiently and sustainably. However, understanding capacity and performance of individuals demands careful consideration of their role within the organisation. Nevertheless, Merinoa and Carmenado (2012) defined capacity as the existence of resources, networks, leadership and group process skills. In a similar note, Horton et al. (2008) identified two capacities that organisations need to develop as resources and management which has operational and adaptive aspects and thus, need to be continuously maintained.

Nevertheless, absorptive capacity is another term that is in par with capacity. Cohen and Levinthal (1989) defined absorptive capacity as the ability of the firm to learn from external knowledge through the processes of knowledge identification, assimilation and exploitation. Therefore, it ranges to more than the ability of firms to benefit from spill overs, which increase their chances of innovating and the ability of firms to improve their productivity more generally as they assimilate knowledge from the external environment in which they operate (Harris, & Yan, 2019; Bergman et al., 2018).

Majority of the definitions related to United Nations (UN) are focused on capacity with relate to community capacity, whereas few definitions found allied to capacities specific to construction organisations. Most of the definitions agreed that capacities include all the resources of an organisation to carry out tasks successfully. However, Harris and Yan (2019) noted that further reflection and reaction from different parties regarding capacities will undoubtedly alter and enrich the paradigm of capacities. Hence, correct identification of levels of capacities from different perspectives is paramount for an organisation.

3.2.2 Levels of capacities

Matachi (2006) noted that it is crucially important to take account of levels of capacity in a system context, which can be done at least at three levels: (a) Individual, (b) Organisation, and (c) Environment as shown in Figure 3.1.

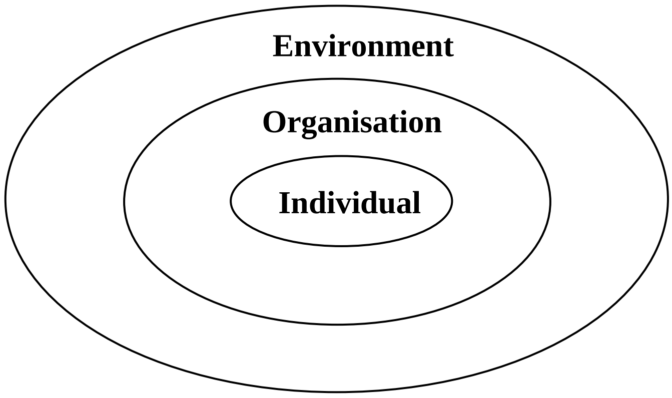


Figure 3.1: Three levels of capacities

Source: UNDP (1998)

According to the figure, capacities of an organisation exist in three levels. Both individual and organisational capacities are affected from the external environment and hence, show in the outer circle. However, Baillie, Bjarnholt, Gruber and Hughes (2008) noted that there are sector/network level capacities in between enabling environment capacities and organisational capacities, as shows in Figure 3.2.

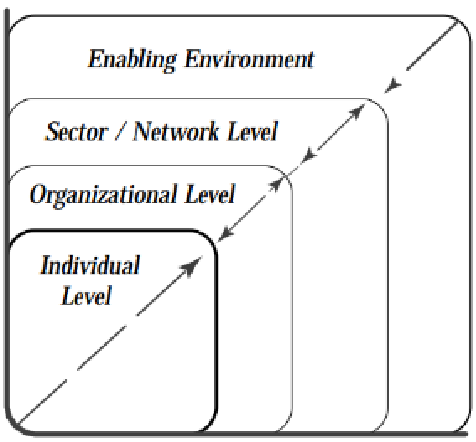


Figure 3.2: Four levels of capacities

Source; Baillie et al. (2008)

However, researchers and organisations such as JICA (2004), Lusthaus et al. (1995), OECD (2006), Matachi (2006), UNDP (1998) and UNESCO (2006) agreed for the three levels of capacities and stated that sector/network level capacities can be included under the environment.

Another categorisation for capacity, which has been divided in to two main groups, related to individual and social capacity is shown in Table 3.1.

Table 3.1: Two levels of capacities

Individual Capacity		Social Capacity	
Technical Capacities	**Behavioural Capacities**	**Behavioural Capacities**	**Contextual Capacities**
• Financial skills • Technology • Political skills • Planning and management skills	• Personal attitudes and skills needed in the relationships between people and groups of stakeholders • Leadership or entrepreneurship	• Commitment • Trust • Network building • Entrepreneurship • Norms • Teamwork • Sense of community • Shared values • Negotiating and political skills	• Vision and strategy • Legal and financial skills or institution building

Source: Merino and Carmendo (2012)

Individual capacity can be discussed under technical and behavioural capacities. Technical capacity is required by organisations to perform their duties. Behavioural capacity is associated with the personal attitudes and skills needed in the relationships between stakeholders (IPMA, 2009), such as leadership and entrepreneurship. Social capacity is needed to promote capabilities that enable an organisation to succeed in the long term (WRI, 2008) which can be categorised further into behavioural and contextual capacities. However, this categorisation is not popular among the capacity building domain due to the lack of focus on the enabling environment and the organisation level capacities.

Therefore, this study focused on individual, organisational and environmental level capacity building in empirical investigation. An in-depth review on above capacities is presented below.

3.2.2.1 Individual level capacity

Capacity at the individual level refers to the will and ability of an individual to set objectives and to achieve them using one's own knowledge and skills (JICA, 2004; Matachi, 2006). However, Kululanga (2012) stated that contributions at this level in capacity building of construction industry refer to how individuals are equipped for the industry with relevant education, training and relevant CPDs. Nevertheless, OECD (2012) defined individual capacity as knowledge and skills of individuals to achieve organisational objectives. This includes the capacity to build relationships, trust and legitimacy (soft capacities) and technical, logistical and managerial skills (hard capacities). These capacities explicitly focus on skill development, building stronger relationships, knowing how, knowing what and co-creation of meaning and understanding (Vallejo, & Wehn, 2016; Jennings, & Wargnier, 2015).

UNDP (2009) identified individual level capacities as the skills, experience and knowledge that allow each person to achieve organisational objectives. Some of these are acquired formally, through education and training, while others come informally, through doing and observing. UNDP further stated that access to resources and experiences that can develop individual capacity are largely shaped by the organisational and environmental factors, which in turn are influenced by the degree of capacity development in each individual.

3.2.2.2 Organisation level capacity

Capacity at the organisation level will determine how individual capacities are utilised and strengthened. It refers to anything that will influence an organisation's performance (Bos, & Brown, 2014; Matachi, 2006). Depending on the size and the complexity of the organisation, types of capacities may vary. The capacities at this level includes individuals with adequate/relevant qualifications, culture for improvement despite project nature of work, partnerships in research initiatives, partnerships in working with others, improvements of firms, new development in the organisations, and having capacity readiness to respond to the future (Tiernan, 2015; Kululanga, 2012; Jin, & Ling, 2005; Sarshar, Haigh, & Amaratunga, 2004).

OECD (2012) defined organisational level capacities as organisational structures and systems that bring individual capacities effectively together. Organisational capacity preserves institutional continuity when staff turnover is high. Another way to think about an organisation's capacities is to distinguish between the capacities that an organisation needs to carry out its day-to-day activities (operational capacities) and the capacities needed for the organisation to learn and change in response to changing circumstances (adaptive capacities) (Horton et al., 2003).

3.2.2.3 Environment level capacity

Capacity at the environment level refers to the environment and conditions necessary for demonstrating capacity at the individual and organisational levels (Tiernan, 2015; JICA, 2004; Matachi, 2006). However, OECD (2012) referred to policy, legal, regulatory, economic and social support systems in which individuals and organisations operate and determined by policies, rule of law, accountability, transparency and flow of information. Similarly, UNDP (2009) defined it as the broad social system within which people and organisations function. It includes all legislations, policies and social norms that govern civic engagement. It is the enabling environment that sets the overall scope for capacity development (UNDP, 2009) and hence identified the state level as a part of the enabling environmental.

Accordingly, multi layered identification of capacities will enable the organisations to re-think the capacity building strategies at different levels of an organisation. Considering the above discussion, this research will focus on these three levels of capacities as one of the basis of the study. Next section discusses the key features of each level of capacity in detail.

3.2.3 Capacities at three levels

Each capacity is different from another capacity. Hence, identification of divergences in each capacity is inevitable to put forward specific strategies for capacity building on an organisation. The capacities identified under individual, organisational and environmental levels are summarised in Table 3.2.

Table 3.2: Capacities under each level

Level	Capacity	Reference
Individual Level Capacities The will and ability to set objectives and achieve them using one's own knowledge and skills	Knowledge	[1], [2], [3], [4], [5], [7], [8], [10], [11], [12], [13]
	Relevant education	[1], [2], [3], [4], [5], [7], [8], [9], [11]
	Technical skills	[2], [5], [12], [13]
	Managerial skills	[1], [2], [5], [7], [8], [9], [10], [11]
	Values & attitudes	[1], [2], [4], [11], [13]
	Willingness to set and achieve objectives	[2], [6]
	Capacity to build relationships	[1], [3], [5], [7]
	Trust and legitimacy	[2]
	Experience	[1], [2], [4], [6], [8], [10], [13]
	Sufficient training	[1], [2], [3], [4], [5], [6], [7], [8], [9], [11], [13]
	Continual professional development	[6], [10], [12]
Organisational Level Capacities Anything that will influence the organisation's performance	Human resources	[1], [2], [5], [10], [13]
	Financial resources	[1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13]
	Physical resources	[1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13]
	Organisational strategy	[1], [2], [7], [10]
	Business know-how	[5], [8]
	Production technology	[1], [2]
	Program management	[1], [5], [6], [13]
	Process management	[1], [2], [9], [10], [11], [13]
	Inter-institutional linkage	[12], [13]
	Collaboration	[1], [2], [3], [4], [5], [10]
	Appropriate communication among members	[4], [7], [11], [13]
	Readiness to respond to future	[1], [2], [13]
	Organisations' effectiveness	[1], [4], [8], [12]
Environmental Level Capacities The environment and conditions necessary for demonstrating capacity at the individual and organisational levels	Legislations, policies and membership rules	[1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13]
	Training programs	[1], [2], [5], [8], [10], [11], [12], [13]
	Customs, cultures, norms	[1], [3], [5]
	Social capital and social infrastructure	[2], [3], [4], [6], [8]
	Capacities of individuals and organisations under environment	[1], [12], [13]
	Transparency and flow of information	[1], [2], [10]
	Accountability	[2], [8], [12]

[1] JICA (2004), [2] Lusthaus et al. (1995), [3] Matachi (2006), [4] Enemark and Ahene (2002), [5] Harsh (2010), [6] UNDP (2009), [7] UNESCO (2006), [8] OECD (2012), [9] Macmillan (2002), [10] Disterer (2002), [11] Sarshar Haigh and Amaratunga (2004), [12] Jin and Ling (2005), [13] Kululanga (2012)

Individual capacities essentially include knowledge, relevant education, managerial skills, experience and sufficient training of individuals. The organisational capacities mainly includes, human resources, financial resources, physical resources, process management and collaboration, which affect the utilization of the resources. Under the definition of environmental capacities, systems and frameworks necessary for the formation and implementation of policies and strategies beyond an individual organisation are the key features. It includes legislations, policies, membership rules and relevant training programs. The above table clearly differentiates the capacities of each capacity level and hence, easy to analyse the existing capacities and new capacity requirement for an organisation.

3.3 Capacity Building in Organisations

The following sections review literature on capacity building definitions, capacity building principles and capacity building process in an organisation.

3.3.1 Defining capacity building

Capacity need to be enforced through capacity building in development projects to gain a more robust structure (UNESCO, 2010; Lusthaus, Adrien, & Perstinger, 1999). According to Morgan (1998, p.6), 'capacity building is a risky, murky, messy business, with unpredictable and unquantifiable outcomes, uncertain methodologies, contested objectives, many unintended consequences, little credit to its champions and long-time lags'. This clearly shows the difficulty in building capacities in an organisation. Based on the capacity building definition provided by UNDP (2012), some fundamental concepts namely multi-level, results-based, change focus, sustainable and self-owned are defined as core concepts for capacity building.

However, some authors have used the terminology capacity development instead of capacity building. According to Horton (2002), capacity building approach has also been named as capacity development. Equally, Eade (2007) stated that, capacity building is a synonym for organisational development. Frequently it is no more than a serious-sounding alternative to 'training'. In contrary, there is a paradigm shift to step beyond conventional training to grasp a capacity building approach. Creating and strengthening capacities of institutions and of networks that link to wider communities is as much a priority as the training of individual practitioners. The result will be stronger organisational frameworks and interfaces between the organisation and the wider environment, enabling individuals, including those outside the organisations, to take more effective actions.

Pearson (2011) identified capacity development as a multi-dimensional process that goes far beyond the transfer of knowledge and skills at the individual level to embrace whole organisations, sectors and systems, and the enabling environment in which they all exist. Over the past decade capacity development has become a concept, an idea which is thought to have captured many ideas and lessons from past development activities. The different views of capacity building are presented in Table 3.3.

Table 3.3: Definitions of capacity building and key attributes

Reference	Definition	Key attributes
Merinoa and Carmenado (2012)	'Capacity building is a cyclical concept related to the development of human, organisational, institutional and social capital'.	[1], [2], [3], [4]
UNESCO (2010)	'Human resource development with organisational and institutional development'.	[1], [2], [3]
FIDIC (2012)	'Enhancing the skills, knowledge and abilities of consulting engineering firms and professionals within firms in the management and development of successful engineering practices'.	[1], [2], [4]
OECD (2006)	'The processes whereby people, organisations and society as a whole unleash, strengthen, create, adapt and maintain capacity over time'.	[1], [2], [4]
TCWF (2001)	'The development of an organisation's core skills and capabilities, such as leadership, management, finance in order to build the organisation's effectiveness and sustainability'.	[2]
PEPFAR (2011)	'An evidence-driven process of strengthening the abilities of individuals, organisations, and systems to perform core functions sustainably, and to continue to improve and develop over time.'	[1], [2], [3]
UNDP (2012)	'The processes through which individuals, organisations, and societies obtain, strengthen, and maintain the	[1], [2], [4]

Reference	Definition	Key attributes
	capabilities to set and achieve their own development objectives over time'.	
WFEO (2010)	'The building of human, institutional and infrastructure capacities to help societies develop secure, stable, viable and sustainable economies, governments, and other institutions through mentoring, training, education, physical projects, the identification and mobilisation of financial and other resources.'	[1], [2], [3]
LaFord, Brown and Macintyre (2002)	'a process or outcome activity that improves the ability'	[1]
Horton (2003)	'An on-going process by which individuals, groups, organisations and societies increase their abilities to perform core functions, solve problems, define and achieve objectives, and understand and deal with their development needs in a broad context and sustainable manner.'	[1], [2], [4]
Lusthaus et al. (1999)	'A continual process of improvement within an individual, organisation/ institution with the objective of maintaining or improving the services being provided.'	[1], [2], [3]
Wescott (2002)	'Enhancement of the skills of people and the capacity of institutions in resources management through education and training'.	[1], [2]
Laverack (2005)	'Development of skills and abilities that enable others to take decisions and actions for themselves.'	[1]
Alaerts et al. (1991)	'Creation of an enabling environment with appropriate policy and legal frameworks, institutional development, including community participation, human resources development, and strengthening of managerial systems.'	[1], [3], [4]
Taschereau (1998)	'An internal process, which may be enhanced or accelerated when an outside group/ entity assists the individual, organisation or institution to improve its functions/ abilities, especially in terms of specific skills.'	[1], [2], [3]
[1] Human resource development, [2] Organisational development, [3] Institutional development, [4] Social capital development		

Karunasena, Amaratunga and Haigh (2010) stated that capacity building need to be placed in two extremes. One extreme place the development of skills of individuals: i.e., knowledge, leadership, through training programs. Other extreme places the integration of systems such as policy making, management and finance. Nevertheless, the key question is which capacity building approaches offer both value for money and the best outcomes need to be scrutinized.

Many of the definitions listed in the above table make reference to community capacity building. There are many different levels of communities. According to Bjaras, Haglund and Rifkin (1991), communities are not necessarily a group of people who are geographically linked, they can also be a group of people who are linked through the same organisation, or who simply share the same basic interest. Hence, in terms of the construction organisations, the researcher considered capacity building definitions related to community to gain a theoretical understanding of the concept by considering construction organisation as a community. Most of the researches agreed that ultimate goal of capacity building is the development of skills, knowledge and abilities in order to achieve the objectives by increasing the resources of the organisation.

This definition of UNDP (1998) has three important aspects: i.e., (i) it indicates that capacity is not a passive state but part of a continuing process; (ii) it ensures that human resources and the way in which they utilised are central to capacity development; and (iii) it requires that the overall context within which organisations undertake their functions will also be a key consideration in strategies for capacity development. Thus, the capacity definition by UNDP (1998) stressed the continuous improvement to build the capacities of an organisation. Correspondingly, Karunasena et al. (2010) and Enemark and Ahene (2003) argued that often capacity issues are first addressed at the organisational level prior individual or environmental level capacities.

3.3.2 Capacity building process

Capacity building is not a linear process. Potter and Brough (2004) noted that capacity building to be identified as a complex process which provides sustainable outcomes (OECD, 2008; Enemark, & Ahene, 2003). Thus, capacity building can be approached systematically using the series of interconnected levels as shown in Figure 3.3.

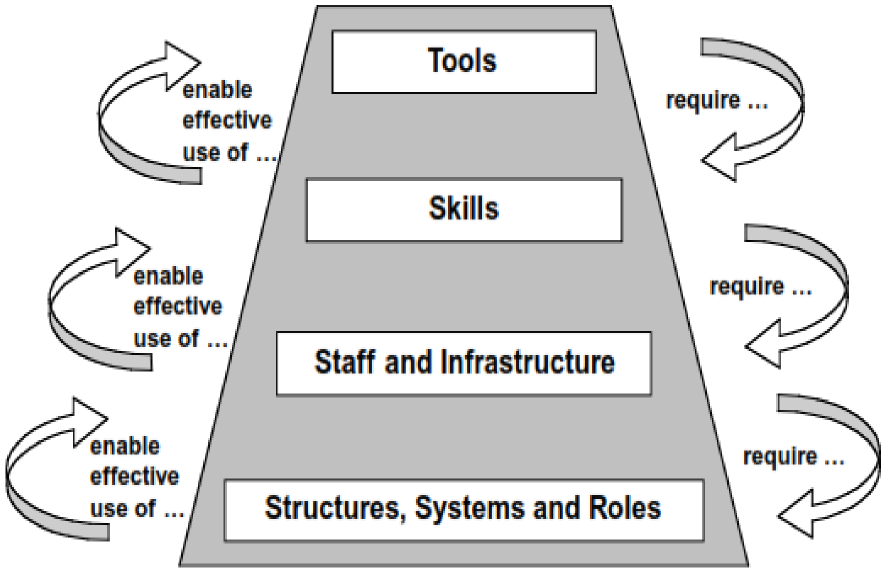


Figure 3.3: Capacity building pyramid

Source: Potter and Brough (2004)

Potter and Brough (2004) identified the sequential need of structures, systems and roles, staff and infrastructure, skills and tools to building up capacities. Therefore, it is vital to explore the capacities in three levels and the strategies to building up them at each level to enable lean. Karunasena and Amaratunga (2016) stated that improving organisation structures and processes related to construction projects are imperative for capacity building process. Thus, people centered capacity building process need to be backed by the organisational structure.

Correspondingly, Lopes and Theisohn (2003) highlighted that motives and incentives need to be aligned with the objectives of capacity building, including through governance systems that respect fundamental rights. Moreover, the intrinsic and extrinsic values of individuals need to be taken in to account when building capacities for enabling lean in an organisation. This was further confirmed by recent study carried out by Małota (2017). Nevertheless, Cooke (2005) developed a framework for building capacities by considering the three capacity levels. The extended version of Cooke’s (2005) framework was presented by Edwards, Kaseje and Kahwa (2016) by adding more dimensions to the structural context as presented in Figure 3.4.

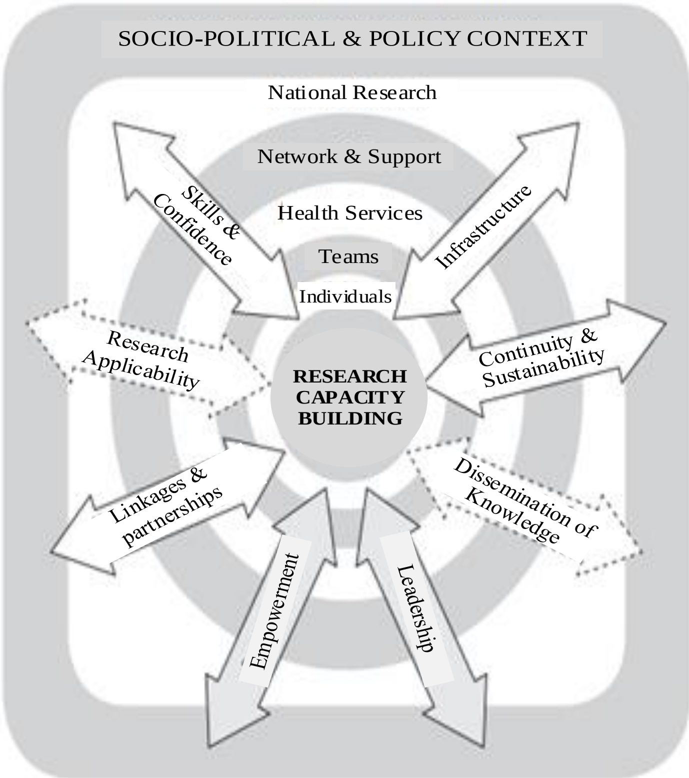


Figure 3.4: Eight dimensions for the capacity building

Source: Edwards et al. (2016)

Cooke (2005) stated that, skills and confidence, infrastructure, continuity and sustainability, leadership, empowerment and linkages, partnerships and collaborations are paramount for the capacity building of an organisation. Consequently, Edwards et al. (2016) added research applicability, dissemination and knowledge transition to the successful dimensions of capacity building framework. Many researchers such as UNDP (2012), Karunasena and Amaratunga (2016), Lopes and Theisohn (2003) and Bolger (2000) directly agreed to the above eight dimensions stated by Edwards et al. (2016).

Yet, continuous monitoring the capacity building process is vital to determine progress, examine intervention effectiveness and assess the accomplishments of the desired outcomes (Karunasena & Amaratunga, 2016; Bates et al., 2011; Cooke, 2005). However, continuous evaluation and improvement is paramount for the successful capacity building.

While initiatives are being successfully implemented, there is a need to monitor and adjust the work to ensure that the work is relevant and useful to the organisation. This continuous monitoring and adjustment is critical according to Banathy (1996), who stated that the design of capacity-building initiatives should be considered as tentative as the nature of the needed intervention will change. However, Baillie et al. (2007) presented similar cyclical stages for capacity building including monitoring and measuring the process of capacity building as shown in Figure 3.5.

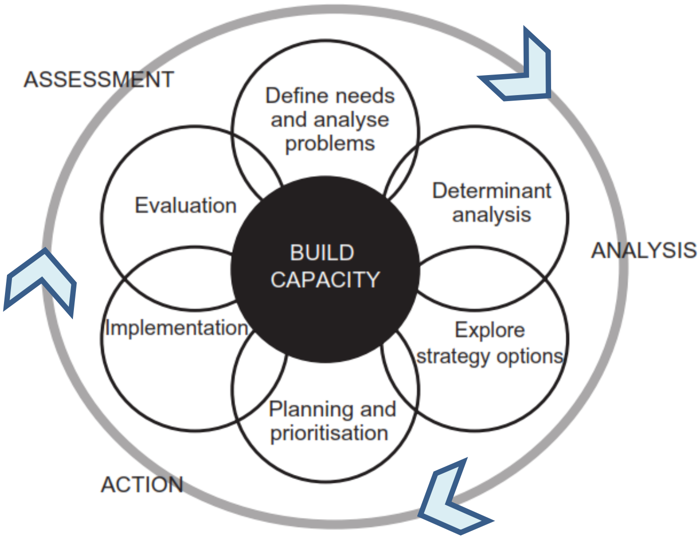


Figure 3.5: Capacity building cycle

Source: Baillie et al. (2007)

According to Baillie et al. (2007), the process initiates by defining the needs and analysing the problems. Then develop determinant from analysis to further explore the strategy options. In contrast to proposal by UNDP (2008), implementation took place after appropriate planning and prioritisation to avoid problems during the implementation. Similarly, evaluation is an essential step in the capacity building process to overcome the problems in the future projects. Continuous improvement is paramount and thus, considered in the above framework too to build the capacities. In a similar note, capacity for why, capacity for whom and capacity for what will be the main questions to be addressed when preparing a capacity building process for a specific organisation. Therefore, the research needs to be more focused on the type of capacity and how to build the capacities in each and every levels of an organisation.

In a similar note, Grainger (2010) mentioned that capacity building requires a leadership education and research role to foster a culture of learning as an enjoyable activity, as something which is personally rewarding, and that benefits customers. Thus, building leadership within the construction SME organisation can be considered as another lean capacity building strategy. Nevertheless, capacity building is not free form barriers and motivators inside the organisation. Hence, addressing issues and enhancing the motivators of capacity building will facilitate the lean implementation.

However, construction SMEs need to consider drivers and barriers for lean implementation when developing lean capacity building strategies. Yet, the requirement of capacities for enabling lean is differ from organisation to organisation. Thus, capacities required by the construction SMEs to enable lean will be reviewed in the next section.

3.4 Lean Capacities for Construction SMEs

Many researchers, including Tezel et al. (2020), Ankomah et al. (2019) and Avelar et al. (2019) proved the benefits that can be gained by construction SMEs through lean implementation. Therefore, it is vital for the construction SMEs to be more aware of lean and be able to inspire their employees, clients and partners in order to attain greater performance (Avelar et al., 2019; Tezel et al., 2017). The implementation of lean in any organisation is a long, on-going and complex process with countless barriers for implementation. Therefore, to implement lean successfully, it is crucial to understand lean concept and capacities necessary for its implementation (Linné, & Ekhall, 2012) by construction SMEs. Hence, the transformation towards lean construction will lead to changes in the culture and in its people (Green et al., 2008), whereas identification of existing capacities and required capacities are paramount for successful lean implementation.

Lean is not just a set of tools and techniques, but at its heart are the people (Ohno, 1988 as cited in Bhasin, 2012). It is the people whose knowledge, intelligence and desire to improve that steers organisations to new levels of continuous improvement

(Hines et al, 2008; Bhasin, 2012). Therefore, lean relies heavily on the skills of the people and how they respond to change (Sawhney, & Chason, 2005; Koskela et al., 2002), which is one of the major barriers for lean implementation by construction SMEs. It is estimated that 70% of lean transformations fail due to the misunderstanding of human interaction and lack of understanding about how people deal with change (Hall, 2006). Thus, a change in mind set is required before embarking on lean implementation (Herrala et al., 2012; Emuze, & Ungerer, 2014). Nevertheless, fundamental in implementing any lean strategy is change of mind-set, and change of organisational culture (Liker, & Meier, 2006). Moreover, Mossman (2015) identified a list of skills and knowledge required from those teaching lean (e.g., leaders, coaches, consultants) and also highlighted the importance of having lean training programs that are: multi-disciplinary, learner centered, and with a focus on developing people and process skills. Hence, applying lean for design and construction in construction SMEs are becoming a highly pertinent issue (Ankomah et al., 2018; Nesensohn et al., 2014).

Hines et al. (2004) mentioned that lean exists at two levels, i.e., the strategic and operational levels. Many companies have their major focus on lean implementation on the shop floor level, without considering lean thinking (Hines et al., 2008), which needs to be overcome. This has clearly indicated the call for defined capacities for successful lean implementation for construction SMEs. Hence, identification of capacities to overcome barriers of lean implementation will add an extra value for construction SMEs to better perform in the industry.

Continuous improvements are important for construction SMEs to stay competitive in a changing environment. This is one of the benefits that companies believe in as a result of implementing lean in their organisations (Shang, & Pheng, 2014; Linné, & Ekhall, 2012). According to Koskela et al. (2002), urgency, leadership, focus, structure, discipline, and trajectory themes are apparent as organisational level capacities that need to be implemented in a construction organisation. Thus, considering them in facilitating the lean enabling capacities for construction SMEs is long overdue.

Managing organisations under lean is different from typical contemporary practice as it has a clear set of objectives for the delivery process, aimed at maximising performance for the customer (Alves et al., 2012; Howell, 1999). Hence, lean enabled organisations are easy to manage and have competitive advantage over other organisations in the industry. However, neither resource nor capacities to enable lean in construction SMEs have been explored. There exists a gap in current literature on how lean concept can be applied by building individual, organisational and environmental level capacities. Moreover, Koskela (2002), Mossman (2009) and Hines et al. (2008) indicated that the essence of enabling lean is optimising the value of the organisation which ultimately reduces NVAA of the organisation through continuous improvement. Hence, lean capacity of construction SME can be defined as:

'Ability of individual, organisational and environmental level capacities to enable lean in order to optimise the value of construction SMEs'

Hence, necessary lean capacities will lead construction SMEs to optimize the benefits of lean implementation through identification of focus areas at each capacity level for enabling lean. However, as discussed under Section 2.4.2, construction SMEs lack even the basic capacities necessary for its function. Thus, it is vital to study on how the capacities of construction SMEs can be built to successful lean implementation.

3.5 Lean Enabling Capacity Building for Construction SMEs

Enabling lean in construction SMEs is paramount to reduce the NVAA in the organisation while increasing the value on the industry. Many researchers including Tezel et al. (2020), Avelar et al. (2020) and Ankomah et al. (2018) justified the importance of implementing lean among construction SMEs through their research findings. Therefore, lean enabling capacity building is a significant area to be reviewed, which will ultimately reduce the barriers for lean implementation of construction SMEs.

Capacity building is not a 'thing' or a commodity that can be reduced to a set of ingredients for a universal recipe prescribing 'how to do it' (Eade, 2007) as it is complex and differs from project to project and organisation to organisation (Wal, & Marks, 2007). However, it is required to customise the capacity building definition for suitable context. Thus, considering the capacity building definitions in Section 3.3.1, capacity building for enabling lean is to improve the lean capacities of the organisation. By considering the definition for lean capacities for construction SMEs, a working definition for lean enabling capacity building for construction SMEs for the research was developed as:

'Developing the ability of individual, organisational and environmental capacities to enable lean in order to optimise the value of construction SMEs'

In order to maximise value, there should be a correct balance between three levels of capacities namely, individual, organisational and environmental levels.

Table 3.4 presents the strategies for capacity building by construction industry.

Table 3.4: Capacity building startegies in construction industry

Capacity levels	Capacity building strategies	Reference
Individual level	• Life long learning driven by an individual employee within a firm • Training aligned to industry needs • Training for individual employees supported by a construction firm • Training influenced by the industry for construction workforce • Training influenced by the state for construction workforce	Tezel et al. (2017, 2020), Ankomah et al. (2019), Kululanga (2012), Sarshar, Haigh and Amaratunga (2004), Macmillan (2002)
Organisational level	• Adopting a culture for improvement despite project nature of work • Eestablishment of effective communication and learning platform • Employing individuals with relevant qualifications • Establishment of the performance appraisal system • Having capacity readiness to respond the future • Pursuing partnerships in research initiatives • Pursuing partnerships in working with others • Sharing best practices with other organisation • Spearheading improvements of firms	Tezel et al. (2020), Ankomah et al. (2019), Kululanga (2012), Nordin et al. (2011), Anand and Kodali (2010), Pingyu and Yu (2010), Liker and Morgan (2006), Kumar et al. (2006), Jin and Ling (2005), Bossink (2004), Sarshar et al. (2004), Macmillan (2002)

Capacity levels	Capacity building strategies	Reference
Environmental level	• Attaching strings of capacity building when financing projects • Clearing technology for diffusion • Encouraging personnel mobility within and outside the construction industry • Encouraging private public interaction • Encouraging professional development of construction workforce • Encouraging research activities • Providing conductive laws for general business environment • Providing conductive policies for general business environment • Providing specific laws for business environment for construction industry • Providing specific policies for construction industry environment	Tezel et al. (2017, 2018), Ankomah et al. (2019), Sisson and Elshennawy (2015), Kululanga (2012), Jin and Ling (2005), Sarshar et al. (2004), Bossink (2004)

Individual level capacities can be built by attending training workshops. Researchers further stressed the importance of life-long learning by the individuals of the organisation. However, the training can be gained by the individuals, if the workshops are available in the organisation or in the environment. In contrast, according to Horton (2002), tools for developing capacities include information dissemination, training, facilitation and mentoring, networking and feedback, to promote learning from experience.

Dora et al. (2012) has confirmed that successful lean implementation requires adequate planning, consistency, flexibility and sector-specific contextual factors. Simply imitating another firm’s plan, organisational structure, training, or problem-solving methods do not guarantee improved operational performance.

Depending on the complexity and size of construction organisations’ capacity building, the initiatives at organisations level further include, pursuing partnerships in research initiatives (Disterer, 2002), pursuing partnerships in working with others (Ankomah et al., 2017), spearheading improvements of firms (Bossink, 2004), seeking new development for an organisations (Macmillan, 2002), sharing best practices with other organisations (Sarshar et al., 2004) and having capacity for readiness to respond to the future (Jin, & Ling, 2005).

Appropriate recruitment of individuals with adequate qualifications and making a culture for improvement within the organisation is paramount for successful organisational change. This was recently emphasised by many researchers in the construction industry including Koskela et al. (2020), Avelar et al. (2020) and Tzortzopoulos et al. (2020). Similar to the findings of Lodgaard et al. (2016), many authors contended the need to assign responsibilities within the pilot programme initially and ultimately within the whole organisation, whereby; it is also evident who is championing the programme. Thus, change agent or the leaders' role needs to be sharpening for positive lean implementation (Nordin et al., 2011; Liker, & Moragan, 2006). Hence, promote lean leadership at all levels were observed by the number of lean metrics.

According to Womack and Jones (1986), besides the organisational level lean related factors (top management commitment, culture and structure), smaller firms faced tough implementation challenges due to skills, human and capital resources, data, and time constraints. What the construction SMEs look for are quick fixes to reduce the time and costs and to increase quality. However, Liker and Morgan (2006) concurred that they almost never create a true learning culture in the organisation, while remaining convinced they had 'gone lean' on the shop floor. Thus, to enable lean and to enhance the results, more research is essential (Lodgaard et al., 2016). Whilst lean is concerned with reducing waste at all levels, it is also about changing corporate culture. Correspondingly, researchers (Koskela, 2020; Nordin et al., 2011; Anand, & Kodali. 2010; Kumar et al., 2006) highlighted the need of developing supplier relationships based on mutual trust and commitment and creating a learning environment for which indices such as, training hours/employee, can provide an approximate barometer.

Badurdeen, Marksberry, Hall and Gregory (2010) pointed out the importance of lean soft skills development for the successful lean implementation. Thus, building soft skills of individuals can be considered as a popular strategy amongst the lean domain. The lean soft skills required for an organisation are summarised in Table 3.5.

Table 3.5: Lean soft skills required for an organisation

Item	Description	Includes
Lean roles	A lean role describes the interface between the person and the organisation.	• Critical in understanding the means for achieving results • Persons working in lean have to know the system • System is responsible for results not the individual
Lean behaviours and traits	Describes how a lean person should act in the organisation.	• Non-confrontational behaviour • Know the system and teach the system (be a coach) • Include others in making decisions • Monitor progress • Encourage contributions • Couples method with results
Lean communication	Basic communication fundamentals in team environments that encourage improvement.	• The process of getting concerned people involved in making decisions. • Critiquing problems, proposals and not the individual.

Source: Adapted from Badurdeen et al. (2010)

Lean roles, lean behaviours and lean communication can be considered as the most important lean soft skills which need to be developed with the time (Badurdeen et al., 2010). Yet, the researchers in the lean domain highlighted that the construction industry professionals required improving the above skills in order to enable lean in the construction industry (Koskela, 2004; Mosssman, 2009: Tommelein, 2014). In a similar note, the leaders must encourage the lean behaviours within the organisation to incorporate the lean culture. Thus, Badurdeen et al. (2010) added that knowledge creation can be achieved within the organisation without even attending specific training programs. Continuous learning is encouraged in the lean culture. Eventually, the organisation becomes a learning organisation by accepting lean. Thus, lean learning refers to how organisations successfully acquire, share, and use knowledge to achieve organisational goals (Sisson, & Elshennawy, 2015). Hence, to create a lean culture, organisations need to improve the learning within the organisation and among the individuals as well.

Kululanga (2012) highlighted that since the majority of indigenous construction companies are small, lack capacities, vision and capital, these problems tend to be exacerbated by the volatile environment in which they operate. Thus, the enabling environment which consists of the construction industry as well as the government, need to support the construction SMEs to build up their capacities. Hence, as given in

Table 3.4, encouragement from the industry and the government is necessary by providing more opportunities to gain adequate knowledge on construction. Yet, unavailability of training programs within the industry marked as a major barrier for lean implementation. Thus, the enabling environment can support lean implementation by organising more workshops related to lean construction.

Undoubtedly, as reiterated by Tzortzopoulos et al. (2020), Gregory (2002) and Liker (2004), lean requires a long-term commitment. Thus, Bhasin and Burcher (2006) emphasised that a medium-sized company would need a minimum of three to five years to start pursuing the lean philosophy. Nevertheless, the process is time-consuming and hence, required the patience among the members in the SME organisation. Correspondingly, Alkhoraif et al. (2019) stressed that the lean maturity level of micro-sized firms is low compared to SMEs. Similarly, SMEs benefited more from lean practices compared to micro-sized company as most of the required basic capacities are available at the SME organisations comparing to micro-sized organisations.

While a large body of literature has arisen to propose cost-effective, sector-specific, easy-to-use frameworks (Anand, & Kodali, 2010; Kumar et al., 2006; Nordin, Deros, Wahab, & Rahman, 2011), none has met the specific needs of construction SMEs. Most of the large-scale organisations have been adopting lean concept and thus, there is plethora of researches to develop lean frameworks. Attempts have been taken to reduce lean barriers through capacity building in China (Gao, & Low, 2014), Middle East (Al-Aomar, 2012), USA (Paez et al., 2005), UK (Sarhan, & Fox, 2013) and India (Ahuja et al., 2018) in construction industry, the focus on construction SMEs capacity building in such frameworks is relatively insufficient.

Similarly, research on lean application in Sri Lankan construction industry is limited to a few initiatives in the past (Pandithawatta et al., 2019; Senaratne, & Ekanayake, 2012; Thilakarathna, & Senaratne, 2012; Senaratne et al., 2010; Senaratne, & Wijesiri, 2008). The focus of these researches were merely deciding the applicability of this concept to construction industry, thus ignore the construction SMEs and capacity building aspects. In order to design a framework that fully addresses the needs of construction SMEs to enable lean, the available frameworks for lean implementation and capacity building in SMEs needs to be analysed. Accordingly, the next section discusses the conceptual framework developed for the study to guide the research.

3.6 Conceptual Framework for Lean Enabling Capacity Building for Construction SMEs

Miles and Huberman (1994, p.18) opined that, 'the conceptual frameworks can be graphical or in a narrative form showing the key variables or constructs to be studied and the presumed relationships between them'. Therefore, this section presents the conceptual framework developed for the study by highlighting the variables of the research.

The literature findings described within the sub sections in the second and third chapters were formulated towards developing the significance of the research problem for construction SMEs. Therefore, to gain the overall picture of the research problem of the study, a conceptual framework was developed. Figure 1.1 in Chapter 1 presented the initial contextual representation of the research intent and that was used as the basis to develop the conceptual framework incorporating the main literature findings. Consequently, three main aspects of the study namely, construction SMEs, lean construction and capacity building were combined through a conceptual framework as present in Figure 3.6 to facilitate the empirical investigation of this study.

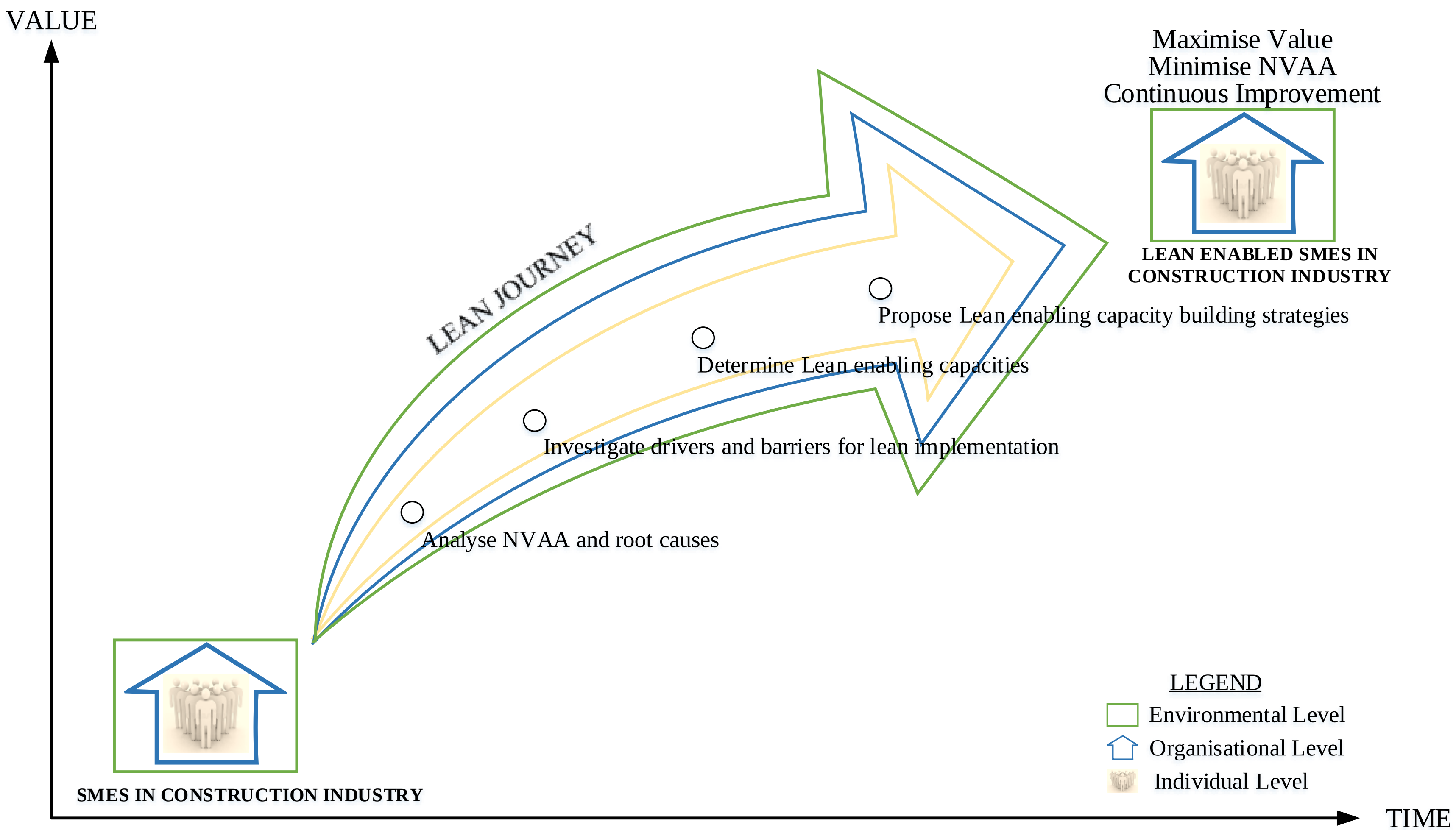


Figure 3.6: Conceptual framework for lean enabling capacity building for construction SMEs

The main consideration of lean is to increase the value of the organisation. Thus, conceptual framework of the study built on a graph presenting time in X axis and value in Y axis. The lean journey starts with respect to the current construction SMEs as presented in the left bottom corner of the grid. Majority of local construction organisations in developing countries lack capacities and cannot meet the demand of construction work. Moreover, high global competition demands construction organisations a higher level of capacity to maintain or increase steadily the performance of the business. In this context, construction SMEs can overcome most of the challenges through lean implementation.

By implementing lean as shown in the middle arrow, pave the construction organisation to reach into lean enabling construction organisation. Most significant characteristics of lean enabled construction organisation are presented in the top right corner of the graph. Therefore, lean journey requires a considerable time period to achieve these characteristics of lean enabled construction (maximise value, minimise NVAA and continuous improvement) and thus depicted in the developed conceptual framework. The middle arrow representing lean journey is divided in to three layers to show the levels of capacities namely individual, organisational and environmental level. Section 3.2.2 further stressed the requirement of analysing the organisation in-terms of these three levels to improve any processes in the organisation.

Undoubtedly, the most acceptable and widely used set of lean construction principles are Koskela (1992) principles. The first principle of the Koskela's (1992) principles is to remove all NVAA by identifying their root causes. Thus, the conceptual framework depicts the initial stage of the lean journey as the identification of NVAA of construction SMEs and exploring their root causes. Nevertheless, successful lean implementation path is likely to be influenced by barriers and drivers which will be the focus of the next stage of the lean journey. Yet, there is no such categorisation for these barriers and drivers in terms of the three levels of capacities of the SME organisation. Therefore, this research is intended to explore the lean implementation barriers and drivers specific to each capacity level in order to seize precautions.

Construction SMEs lack capacities and thus, identification of lean capacities will guide organisations to minimise the barriers of lean implementation and to optimise performance in the industry. Hence, the next stage in the lean journey is on how lean capacities in three levels of the organisation pave the way towards lean enabling construction organisations. Enabling lean in construction SMEs requires an enormous effort of individuals in the organisation. Nevertheless, they need to be supported by the organisation as well as the enabling environment. Currently, there are no government-driven mandates and no large-scale support groups targeting specifically SMEs for lean implementation in Sri Lanka. Hence, lean does not receive the same attention and government support as in some other countries, as reflected in the literature. Therefore, investigating on lean enabling capacity building strategies at three capacity levels of construction SMEs is inevitable for successful lean journey.

Further, this conceptual framework describes a journey towards implementing lean for construction SMEs based on the aforementioned steps. Thus, the questions to be raised and find solutions during the empirical investigations are presented below:

- What are the NVAA of construction SMEs and their root causes? (RQ2a)
- What is the level of understanding and implementation of lean tools and techniques by construction SMEs in Sri Lankan construction industry? (RQ2b)
- What are the drivers for lean implementation in construction SMEs? (RQ3a)
- What are the barriers for lean implementation in construction SMEs? (RQ3b)
- What are the capacities required for enabling lean in construction SMEs? (RQ4)
- What are the strategies for enabling lean in construction SMEs? (RQ5)

Accordingly, the above research questions need to be answered during the empirical investigation (EIR-1 and EIR-2) to develop the final framework of the study in order to achieve the aim.

3.7 Chapter Summary

This chapter explored and documented the definitions for capacity and capacity building to recognize the characteristics associated with capacity building. Following the critical literature review, two working definitions were developed to inform the data collection of the research study. Lean enabling capacities defined as the 'ability of individual, organisational and environmental factors to enable lean in order to optimise the value of construction SMEs'. Lean enabling capacity building can be defined as 'developing the ability of individual, organisational and environmental factors to enable lean in order to optimise the value of construction SMEs' for this research.

The review has identified elements of individual capacities as knowledge, skills, values, attitudes, health and awareness of individuals. Organisational capacities includes human resources, physical resources, intellectual resources, organisational structure and management methods, which affect the utilization of the resources, interaction, collaboration, and communication among members of the organisation and leadership of managers. Moreover, environmental capacities discussed in terms of legislations, policies, membership rules, training programs, capacities of individuals and organisations under environment, transparency and flow of information. Therefore, careful consideration and identification of the lean enabling capacities at all three levels namely individual, organisational and environmental level will accelerate the lean implementation in construction SMEs. This chapter further reviewed the literature on capacity building processes.

Nevertheless, specific capacities need to be carefully identified to overcome the barriers of lean implementation by construction SMEs. The review established lean enabling capacity building for construction SMEs and discussed the key strategies that practice in construction industry. The chapter finally developed a conceptual framework that describes a journey towards implementing lean for construction SMEs to facilitate empirical investigation.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

This chapter aims to present the methodological framework adopted in this research study. The chapter discusses the research philosophy, approach, design and the process adopted by the researcher. It presents the research process that contained the research problem development, literature review, research design, research philosophy, research approach, data collection and data analysis in empirical investigations (EIR-1 and EIR-2) sequentially. Finally, research trustworthiness is discussed in this chapter.

4.2 Research Process

Research methodology can be used for making knowledgeable decisions systematically (Chaudhry, 1991). Thus, selection of a pertinent research methodology is imperative in answering the research questions to achieve the objectives of the research. The aim of methodology is to understand the possible terms in the research process (Brannen, 2005). Therefore, a well-developed research processes will pave the way towards a successful research. Figure 4.1 presents the research process developed for this study.

The research process began with a preliminary literature review to identify the research gap. This is followed by a comprehensive literature review to establish the theoretical understanding on construction SMEs, lean and capacity building concept. Subsequently, EIR-1 was carried out to investigate the challenges in the construction industry, NVAA, their root causes and level of lean implementation by the construction SMEs in Sri Lanka. Consequently, EIR-2 was carried out to determine barriers and drivers for lean implementation for construction SMEs, lean enabling capacities and capacity building strategies to enable lean among construction SMEs in Sri Lanka. The analysed data were then validated using expert interviews. Following sections elaborate the steps carried out in the research in detail.

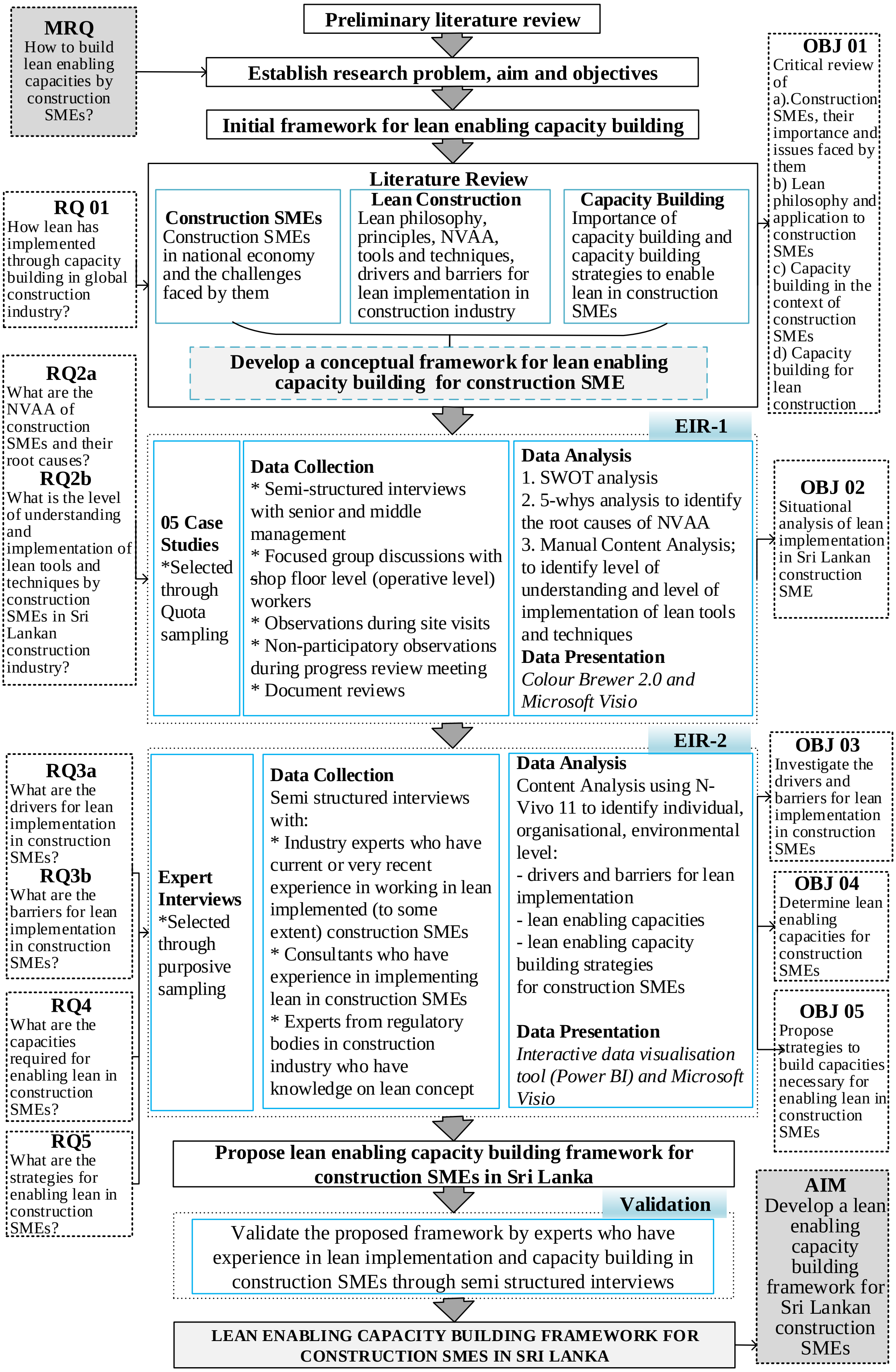


Figure 4.1: Research process

4.3 Research Problem Development

Identification of the research problem at the beginning is paramount in a scientific research. Thus, the precedent sections discuss how the research problem was developed for the research based on the initial impetus and the background study.

4.3.1 Initial impetus

Saunders et al. (2015) stated that a research with a certain interest of the researcher and the capabilities of the researcher to carry out the particular study are vital when commencing a research study. Accordingly, the initial impetus to carry out this study was generated at the researcher's interests, who therefore, selected the research area as 'lean construction' in Sri Lanka. Consequently, the study was narrowed down to the capacity building of construction SMEs in Sri Lanka due to the immense growth and significance of them to the industry and the national economy.

4.3.2 Background study

The aim of background study was to get familiarised with the research area. Hence, the background study reviewed the areas of lean construction, capacity building and construction SMEs. The literature review was conducted using journal articles, conference proceedings, books, government and non-government reports, web sites, newspaper articles, and key word searches using internet search engines. The initial literature review further highlighted the significance of researching the construction SMEs to improve the competitiveness in the construction industry. Similarly, lean construction is trending in the industries globally to minimise the challenges faced by them in order to improve the competitiveness. Thus, next section discusses the research problem developed after the background study.

4.3.3 Research problem

The identification of the significance of SME sector to the Sri Lankan construction industry and the benefits associated with lean construction lead the development of the initial part of the research problem as how to enable lean in construction SMEs in Sri Lanka. Nevertheless, lack of capacities in SMEs causing the premature death within the construction industry and also hinder the lean implementation. Therefore, it is vital to explore how construction SMEs can improve their capacities to enable lean in their organisation. By analysing the initial literature findings, the researcher developed the MRQ in a more comprehensive manner as:

'How to build lean enabling capacities by construction SMEs?'

Subsequently, the aim and objectives were formulated considering the knowledge gaps identified from the preliminary literature review. The aim of the study is '**to develop a lean enabling capacity building framework for Sri Lankan construction SMEs**'

As stated by Yin (2015), defining of research questions and sub questions are paramount to guide the research study. Accordingly, research objectives and questions were formulated as shown in Table 4.1.

Table 4.1: Research objectives and questions developed for the study

Research Objectives (OBJ)	Research Questions (RQ)
OBJ 1- Critical review of: a. Construction SMEs, their importance and issues faced by them b. Lean philosophy and its application to construction SMEs c. Capacity building in the context of construction SMEs d. Capacity building for lean construction	**RQ1** – How lean has implemented through capacity building in global construction industry?
OBJ 2- Situational analysis of lean implementation of Sri Lankan construction SME	**RQ2a -** What are the NVAA of construction SMEs and their root causes? **RQ2b -** What is the level of understanding and implementation of lean tools and techniques by construction SMEs in Sri Lankan construction industry?
OBJ 3- Investigate the drivers and barriers for lean implementation in construction SMEs	**RQ3a -** What are the drivers for lean implementation in construction SMEs? **RQ3b -** What are the barriers for lean implementation in construction SMEs?
OBJ 4- Determine lean enabling capacities for construction SMEs	**RQ4 -** What are the capacities required for enabling lean in construction SMEs?
OBJ 5- Propose strategies to build capacities necessary for enabling lean in construction SMEs	**RQ5 -** What are the strategies for enabling lean in construction SMEs?

The above research questions guided the researcher to achieve the aforementioned aim and objectives of this study.

4.3.4 Development of initial framework of the research intention

Critical reviewing of literature during the proposal development stage strengthened the MRQ of the study by in-depth review of three main areas, i.e., construction SMEs, lean construction and capacity building. Correspondingly, initial framework of the research intention was developed as the primary guidance of the study using the background literature, which is presented in Chapter 1.

4.4 Literature Review

Literature review is a process of exploring the previous research and theories, which sharpened the research topic selection and the methodology adapting to the research (Snyder, 2019; Ridley, 2008; Hart, 1998). As discussed by Ridley (2008), literature review can be defined as a cycle composed of three key components: searching, reading and writing. Accordingly, a comprehensive literature review was carried out to develop a theoretical understanding on construction SMEs, their role in the economy and issues, lean applicability, capacities of construction SMEs and capacity building in lean enabled construction environments. The literature review revealed the existing knowledge of the selected area and exposed the gaps for further research. This was carried out by referring journals, conference proceedings, books, reports, web sites, newspapers, key-word searches with the aid of internet search engines (Google Scholar). The review of literature further confirmed that the requirement of building capacities among construction SMEs to overcome the lean implementation barriers and the significance of creating a lean culture in construction SMEs. Next section discusses the development of conceptual framework of the study.

4.5 Development of Conceptual Framework

A conceptual framework can be identified as a graphical form showing the presumed relationships between the key variables of the study (Miles, & Huberman, 1994). The initial framework of the study developed in Chapter 1 was used as the source in developing the conceptual framework to support the empirical investigation of the study. Thus, conceptual framework for lean enabling capacity building was developed by analysing the aim and objectives of the research, research questions and the main findings of the literature review, as presented at the end of Chapter 3.

The conceptual framework of the study built on a graph presenting time in X axis and value in Y axis, describes a journey towards implementing lean for construction SMEs. The initial stage of the lean journey is the identification of NVAA of construction SMEs and exploring their root causes. Successful lean implementation path is likely to be influenced by barriers and drivers at each capacity level which will be the focus of the next stage of the lean journey. Enabling lean in construction SMEs requires an enormous effort of individuals in the organisation. Nevertheless, they need to be supported by the organisation as well as the enabling environment. Therefore, investigating lean enabling capacities and capacity building strategies at three capacity levels of construction SMEs is inevitable for successful lean journey as presented in the conceptual framework.

4.6 Research Design

An appropriate research design addresses critical challenges in planning and performing a research, from formulating the research problem to the end of the research. ‘Nested’ research model is one way for categorising the research design (Kagioglou, Cooper, Aouad, & Sexton, 2000). Adherence to the nested model confirms that the selected research philosophy, approach, and techniques are compatible with each other and fulfil the requirements of the research (Kulatunga et al., 2008). However, Saunders et al. (2009) presented the overall research methodology in the form of an ‘onion’, in which the thoughts on research problem lie in the centre and thus several layers have to be ‘peeled away’ before coming to the central position. Therefore, ‘research onion’ which provided clarity over the different facets to be analysed in detail when deciding the research methodology, was adapted to this research. Figure 4.2 presents the method selections from each layer of the research onion for the study. This research is positioned in layers of the research onion using red coloured circles.

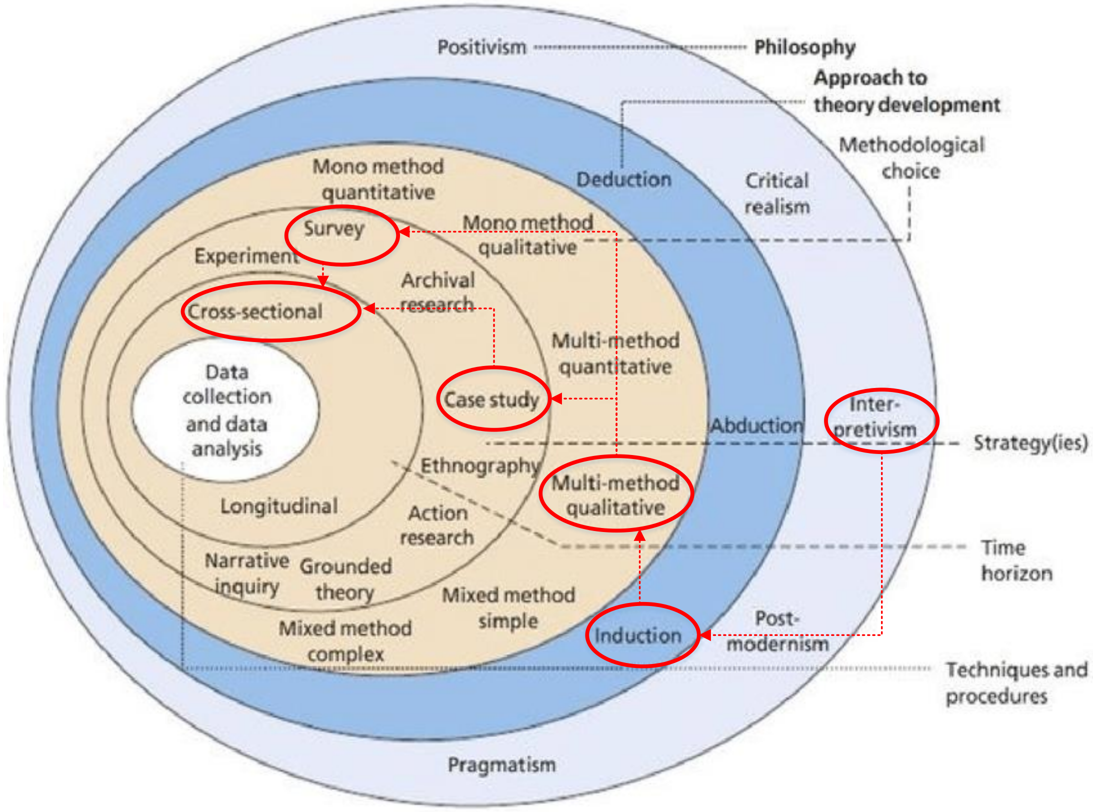


Figure 4.2: Positioning the research study on Saunders (2015) Research Onion

Following section presents a detailed overview for the research design adapted for the study.

4.7 Research Philosophy

The research philosophy adopted for the study contains important assumptions about the way in which the researcher views the world. These assumptions will underpin the research strategy, the methods and appropriate approach for the study. Easterby-Smith, Thorpe and Jackson (2008) stated that inability to comprehend the philosophical issues can lead to quality issues in the research findings. According to Saunders et al. (2009), the philosophy of a research could be discussed under one of the stances of positivism, realism, interpretivism or pragmatism. Further to Saunders et al. (2009), research philosophy is formed by the assumptions of ontological, epistemological and axiological interpretations. Thus, the following sections evaluate how research philosophies are characterised with the three assumptions.

4.7.1 Ontology

'Ontology' is concerned with the researcher's view on the nature of reality (Saunders et al., 2009). The ontological assumption is based on the external world as having a predetermined nature and structure known as "realism" (Johnson, & Duberly, 2000) and the assumption based on the external world not having a pre-determined nature or structure is known as the "idealism" (Gummesson, 1991). Thus, contrary to positivistic research, interpretivism is based on the ontological assumption that the external world does not have a pre-determined nature, but is created by the perceptions and consequences of humans (Kulatunga et al., 2008).

The research requires to closely analyse the NVAA of construction SMEs by becoming part of the environment. In order to have an in-depth understanding, views of different stakeholders involved in each and every level of the organisation require to be considered. Lean culture appreciates the views of any parties involved with the project. Similarly, it is established that these diverse personnel hold a range of understandings towards the activities, which in turn lead to diverse explanations on how to overcome NVAA. Consequently, the person who is directly involved with the project can create a new lean tool or strategy from the experience in the construction industry. Moreover, the study does not intend to influence the research environment and not to use statistical methods as the free flow of ideas where perceptions of individuals were encouraged. Therefore, it can be argued that this research is inclined towards subjectivism than objectivism in the ontological assumptions.

4.7.2 Epistemology

'Epistemology' concerns about the researcher's view on what constitutes acceptable knowledge, in a field of study (Saunders et al., 2009). Easterby-Smith et al. (2008) identify two traditions of philosophies, 'positivism,' and 'social constructivism' where they acknowledge that these philosophies can be positioned in two extreme ends of a continuum. Accordingly, positivists argue that, 'the world exists externally and its properties should be measured through objective measures rather than being inferred subjectively through sensation, reflection or intuition' where social constructivists argue that, reality is determined by people rather than by objective and exterior factors (Easterby-Smith et al., 2008). Nevertheless, social scientists appreciate the diverse views that people place upon their experiences. Therefore, it is claimed that humans are affected by feelings and perceptions and therefore, humans cannot be treated as objects and theories that lead into definite laws.

Researchers such as Alves et al., (2016), Ogunbiyi et al. (2013) and Howell and Ballard (1999), who attempted to explore lean implementation in construction industry and researchers such as Tezel et al. (2017) and Ankomah et al. (2017) who attempt to explore lean in construction SMEs recommended using research philosophical assumptions based on the nature of study. On the other hand, the latest research done in the SME sector by Ankomah et al. (2020), Tezel et al. (2020), Antosz and Stadnicka (2017) and Ansah and Sorooshian (2017) argued that analysis of SME organisation requires an in-depth understanding.

This study requires an in-depth analysis about the construction SMEs within its real-world context relevant to the research question. Consequently, the researcher had to be a part of the environment and interaction was required within it to realise how the actual works carried out in construction SMEs. As discussed in literature review, there is a need to get in to the place (*gemba*) where the value created. Thus, the researcher requires being part of the organisation to explore the NVAA of the organisation of construction SMEs. According to Easterby-Smith et al. (2008), interpretivist lies with the epistemological assumption, that the properties of reality can be measured through subjective measures by examining the perceptions of humans. Hence, construction SMEs perceptions were considered when analysing the data. Therefore, unlike in the positivist research studies, the researcher needs to closely interactive with the environment of the research to analyse the perceptions of construction SMEs. Moreover, when considering the research questions, the need of occupying the epistemological position of subjectivism can be established. As this research involves the investigation of construction SMEs which are generally managed in a more personal way comparing to large companies (Berisha, & Pula, 2015; Hardie, & Newell, 2011; Boltan, 1971), it can be claimed that the epistemological positioning is inclined towards interpretivism in this research study.

4.7.3 Axiology

'Axiology' is a branch of philosophy, which studies judgments about value (Heron, 1996). Saunders et al. (2009) mentioned that it lies with the researcher's view of the role of values in research. Social constructivism offers that the research is value-laden and the positivism offers the researcher should be value free (Healy, & Perry, 2000). According to Kulatunga et al. (2008), the positivist researcher would separate from the research environment and plays the role of an independent observer without involving the research environment and would not allow the values and bias to distort the research findings. Yet, the interpretivist is interfering subjectively through sensation when analysing the empirical data. Therefore, as stated by Easterby-Smith et al. (2008), the choice of 'what to study' and 'how to study' is determined by objective criteria in the value free research. Moreover, he further stated that the choice of value laden research is determined by human beliefs and experiences.

It is assumed that different personnel in these organisations hold a variety of understandings towards NVAA and lean implementation. Thus, arriving of sensible answers may be hard to the researcher. Thus, the researcher's value may be added in obtaining answers for the research questions confirming that, the researcher is being a part of the research and grounded in the value laden position in axiological assumptions. It is recognised that the researcher and the respondents have their own values. Attempts have been made to minimise the biasness and increase the trustworthiness of the research findings as discussed in Section 4.16.

4.7.4 Philosophical stance of the research study

Considering the above discussion, interpretivism recognised as the suitable research philosophy for the study. Different views of construction SMEs on lean construction and capacity building in an organisation need to be considered for this research. Therefore, the study valued and encouraged the free flow of ideas and perceptions of the people, based on their experience within the research environment thus, considers the human interaction as the main driver of the study. Figure 4.3 presents the philosophical underpinning of the study.

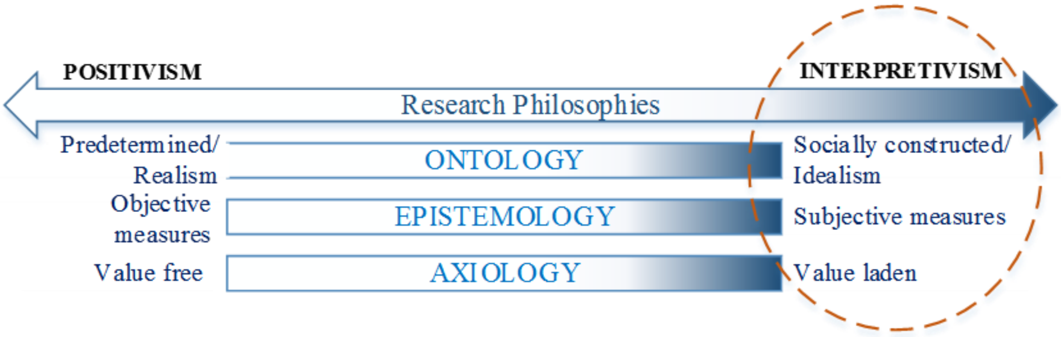


Figure 4.3: Philosophical stance of the research

As shown in Figure 4.3, the study skewed the ontological assumption of ‘reality is socially constructed, but not pre-determined’ and the epistemological assumption of ‘the knowledge is gathered by analysing the views of people’. The study takes the value laden stance in terms of axiology, as it is claimed that the researcher would add value. Thus, the research is in line with the interpretivism philosophy.

4.8 Research Approach

Research approaches facilitated the organising of research activities (Easterby-Smith et al., 2008). Saunders et al. (2013) identified three research approaches as; (a) deductive approach, (b) inductive approach, and (c) abductive approach. As per the recent discussion of Koskela, Paavola and Kroll (2018), research into abduction in construction is still in developing stage. On the other hand, the most widely accepted and used approaches are deductive and inductive approaches among the construction researchers (Koskela et al., 2018).

Deductive research develops a theory/hypothesis and designs a research strategy to test the hypothesis. Similarly, in inductive research, develops a theory, as a result of data analysis from the collected data (Saunders et al., 2009). Abduction is narrowing down a theory and then develops a theory. Lean implementation in construction SMEs received the immense attention around the world. Yet, the research on lean implementation in Sri Lankan context is still in the infancy stage. Thus, it is required to test the acceptability of lean construction in construction SMEs and thus, confirm checking an existing theory in a different context. Accordingly, this study is in line with the inductive approach.

4.9 Methodological Choice

According to Walker (1997), developing an appropriate innovative methodological solution or matching an appropriate research approach to a particular problem is an important research ability. Appropriate methodological choice largely affects the selection of appropriate research strategies to collect data. Many authors define methodological choice in different ways. Creswell (2014) divided the research in to three main clusters of quantitative, qualitative and mixed method. Subsequently, Saunders et al. (2015) introduced six choices in the research onion to be selected for the research.

A quantitative choice is well-matched for research that test theories or explanations and Cresswell (2007) stated that it offers an overall picture of trends and relationships. Conversely, qualitative research is suited for understanding the contexts and explains the mechanisms behind the relationships by investigating the reasons behind their answers (Creswell, 2007). Therefore, Charmaz (2006) stated that this flexibility of qualitative research allows the researchers to analyse the leads that are generated during the research process.

This research is particularly concerned with 'in-depth' understanding on phenomenon and resides within the interpretivism philosophical territory. Hence, surveys and experiments that come under positivism philosophical stance are not appropriate for this study. As the researcher was outside the context (i.e., construction SMEs) in this research, ethnography that necessitates the researcher to be occupied and become part of the setting under study did not seem to be an appropriate strategy for this study. Thus, the qualitative choice is best suited to achieve the objectives of the research.

This research used multi-methods under two staged empirical investigations as follows:

- Empirical Investigation Round 1 (EIR-1): Case Studies
- Empirical Investigation Round 2 (EIR-2): Expert Interviews

4.10 Empirical Investigation Round 1 (EIR-1): Case Study

EIR-1 was aimed to address RQ2a and RQ2b of the study. It is important to select the most appropriate research strategy to address the research questions. Saunders et al. (2009) indicated that, suitable research strategy has to be established considering the research aim and research objectives, the degree of existing knowledge, time and resources availability, and the philosophical stance of the research.

Since the study is of exploratory nature and requires an in-depth investigation, it has been argued that, a case study provides distinct advantages over other strategies (Yin, 2015). Yin (2015) further defined case study research as an "empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p.13).

Case study is preferred when the research questions take the form of "how" and "why". This research was aimed to answer the MRQ "*How to build lean enabling capacities by construction SMEs*?" Thus, MRQ consist of how type of research questions, preferring data collection from case studies. In this research, the researcher has no authority to control the behaviour of construction SMEs. The researcher was only an observer during the data collection. Moreover, there was no possibility to control the behaviour of SMEs to investigate the impact on research findings.

The research in SME community is well acknowledged the use of case studies (Wedawatta et al., 2011; Perren, & Ram, 2004). Furthermore, use of case study in SMEs pave the way towards observing new insights (Chetty, 1996), which is not the case in strategies like large surveys. Similarly, a concept like lean, acknowledge the new insights within the construction SMEs. Tezel et al. (2017), Rezgui and Miles (2010), Sexton, Barrett and Aouad (2006) and Ankomah et al. (2017), have evidently indicated the applicability of case study strategy to be used for data collection from construction SMEs. Therefore, it can be noted that case studies are vital to obtain an in-depth knowledge on SMEs. However, it is challenging to make robust generalisations across the sector due to the inherent nature of the construction SMEs.

4.10.1 Unit of analysis

Identification of unit of analysis is imperative to research design, which is related to the fundamental problem of defining the 'case' (Yin, 2015) and the decision of the unit of analysis is decided by the questions of the research (Remenyi et al., 2003). Nevertheless, the unit of analysis of a case study can range from an individual, group of people, to a process or relationship and it is advisable to establish the unit of analysis similar to a previous study by considering the literature in the subject area rather than establishing it arbitrarily (Yin, 2015; Kulatunga et al., 2008; Remenyi et al., 2003). In par with the research questions developed for EIR-1, the unit of analysis can be identified as lean implemented construction SMEs. The boundary of the study is to identify the scope in determining the limits of data collection (Yin, 2015). Since scope of this study is limited to construction SMEs, the boundary of the research is limited to construction SME in Sri Lanka. Figure 4.4 presents the case boundary and the unit of analysis for the research.

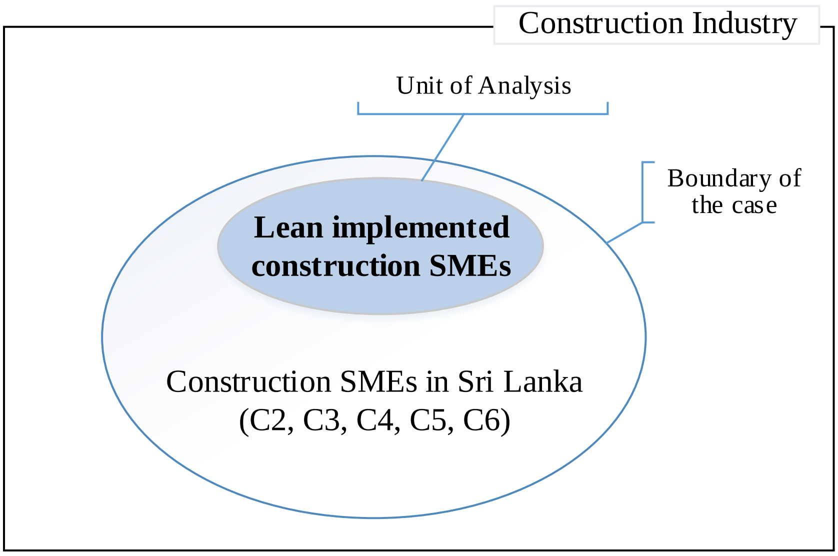


Figure 4.4: Case and the unit of analysis

Yin (2015) defined holistic design (i.e., analyse only the global nature of an organisation) and embedded design (i.e., analyse one or more unit of analysis within a case) to analyse the cases. According to Yin (2015) and Eisenhardt and Graebner (2007), case studies are holistic in nature when no logical sub-units can be recognised. Therefore, the research required to adopt a holistic case study design.

4.10.2 Type of case study

Saunders et al. (2013) indicated that, the research can be grouped into three as exploratory, descriptive and explanatory. Yin (2015) stressed that exploratory case study aims to define the questions and hypothesis of a subsequent study or to determine the feasibility of the desired research procedures. A descriptive case study presents a comprehensive description of a phenomenon within its context, whereas an explanatory case study presents data associated with cause and effect relationships (Eisenhardt, & Graebner, 2007). EIR-1 was developed as a descriptive study as it aims to situational analyse the Sri Lankan construction SMEs. The data collection required an in-depth analysis to the case study organisations to develop SWOT, identify the NVAA, their root causes, level of understanding and implementation of lean tools and techniques.

Yin (2015) stated that single case study design is more suitable for unique, extreme, representative, critical, typical, revelatory and longitudinal cases. Multiple case studies prefer to use more than one case study to collect data. Remenyi et al. (2003) noted the clear benefits that can be gained from multiple case studies to increase the robustness of the research findings.

Accordingly, multiple case study designs are preferable to achieve the expanded generalisability and the possibility of replication. Nevertheless, SMEs are a very heterogeneous group of businesses. The heterogeneous nature of construction SMEs has created number of challenges to get a strong generalisation. Yin (2015) recommended that number of cases should be decided based on how much of literal replications and theoretical replications expected through the study. Literal replication was about predicting similar results, while theoretical replication was about predicting contrasting results for known conditions. Hence, multiple case studies were selected for this study. Following section presents further justifications for the selection of cases for EIR-1 of the study.

4.10.3 Selection of cases

Eisenhardt and Graebner (2007) stated that selecting cases from a population in a case study research should be theoretical sampling comparing to random sampling in hypotheses testing research, which searched for statistical generalisation. Saunders et al. (2009) stated that *'quota sampling'* as entirely non-random and is based on the premise that the sample will represent the population as the variability for various quota variables is the same as that in the population. Quota sampling is therefore a type of stratified sample in which selection of cases within strata is entirely non-random (Barnett, 1991). As discussed by Yang and Banamah (2014), quota sampling conducted in two steps, dividing the whole data set into disjoint groups, and then selecting from each set to select the representative objects.

The category of construction SMEs in Sri Lanka is made up of contracting organisations which have a grade between C2 - C6 as per the CIDA registration (Refer to Table 2.3). Thus, large contractors (CS2, CS1 and C1) and micro level contractors (C7, C8 and C9) have not been considered for the sample.

Construction SMEs have different characteristics based on the grade of the organisation. Thus, a case from each grade was selected to achieve the reliability of the collected data by adhering to quota sampling technique. Therefore, five cases for this study were selected one each from Grades C2, C3, C4, C5 and C6 categories and have been in business for many years to produce contradictory results in achieving theoretical replication.

Nevertheless, as per Eisenhardt and Graebner (2007), the aim of screening is to establish the most appropriate case study for data collection. Accordingly, cases were selected only from construction SMEs in Sri Lanka with the purpose of predicting literal replication which is defined by Yin (2015) as to select similar type of cases to represent the same results. However, by answering to Yin (2015) argument to time consumption for collecting data, the researcher argued that, due to less number of workers in the construction SMEs and involvement of two to three projects at a time reduces the time requirement for data collection.

On the other hand, Mason (2010) indicated that number of cases in the majority of qualitative studies should generally follow the concept of saturation. Accordingly, when the collection of new data did not shed any further light on the issue under investigation, it was referred as the point of saturation. Mason (2010) further stated that saturation was more concerned with reaching the point, where it became "counter-productive" and that "the new" discovered did not necessarily add anything to the overall story, model, theory or framework. In addition, expertise in the chosen topic could reduce the number of participants needed in a study. Yet, the high data saturation experienced during data analysis justified the adequacy of the number of cases selected.

4.10.4 Choice of data collection techniques

Use of multiple sources of data collection techniques ensures the fulfilment of research aim and objectives to a satisfactory level (Robson, 2002). Case study is often referred to as a triangulated research approach (Yin, 2015; Feagin, Orum, & Sjoberg, 1991). Similar to Feagin et al. (1991) and Yin (2015), many of the researchers in the lean lexicon discussed the importance of data triangulation to enable lean in construction industry. The researchers further highlighted that NVAA in a construction project, and level of lean tools implementation can be investigated by employing multiple measures in the construction SMEs. Thus, triangulation is an important research principle, where multiple sources should be used to focus upon a particular problem.

Eisenhardt (1989) elaborated that, interviews, observations, focus group discussions, consultation with experts, document reviews and questionnaire surveys are more dominant in case studies. Many researchers investigating the construction SMEs used the above techniques (Tezel et al., 2020; Tezel et al., 2018; Ankomah et al., 2017; Sexton, & Barrett; 2003; Ribeiro, & Fernandes, 2010; Sexton et al., 2006). However, none of them have specifically elaborated on the best suited technique for SMEs. Table 4.2 presents the data collection techniques carried-out in EIR-1 with their reference codes.

Table 4.2: Data collection techniques used in EIR-1 with their coding

<table>
<tr><th rowspan="2">Data collection technique</th><th colspan="5">Case</th></tr>
<tr><th>CA-A</th><th>CA-B</th><th>CA-C</th><th>CA-D</th><th>CA-E</th></tr>
<tr><td>Conducted 18 semi-structured interviews</td><td>04 interviews</td><td>04 interviews</td><td>03 interviews</td><td>05 interviews</td><td>02 interviews</td></tr>
<tr><td>Carried out 03 focus group discussions</td><td>01 focus group discussion</td><td></td><td>01 focus group discussion</td><td></td><td>01 focus group discussion</td></tr>
<tr><td rowspan="2">Observations made during 11 progress review meetings and 08 site visits</td><td>02 progress review meetings</td><td>01 progress review meetings</td><td>08 progress review meetings</td><td></td><td></td></tr>
<tr><td>02 site visits</td><td>01 site visits</td><td>03 site visits</td><td>01 site visits</td><td>01 site visits</td></tr>
<tr><td>Reviewed documents</td><td colspan="5">1. Consultancy and Contract Documents
2. Progress review meeting minutes
3. Procurement Guidelines, Goods and Works (2006)
4. Organisational charts
5. Daily progress review check lists
6. Training records and Manuals
7. Correspondents</td></tr>
</table>

Data collection through questionnaire survey among SMEs is not practical due to casualised nature of workforce as most of them are illiterate. Therefore, considering the strengths and weaknesses of each technique, semi-structured interviews, focused group discussions, observations and documentary reviews were used to get a more holistic understanding on the phenomenon.

4.10.4.1 Semi structured interviews

Interviews can take various forms. The rigid format of structured interviews will leave no space for further explanations and flexible nature of unstructured interviews will reduce the focus of the data collection process from construction SMEs. Semi-structured interviews avoid the highlighted drawbacks in both extremes. Therefore, semi structured interviews were carried out in selected cases to obtain answers to RQ2a and RQ2b of the study.

A total of 18 members drawn from five cases were interviewed. The interviews included the personnel from top and middle management. Respondents from the sites and head office were interviewed from each case. Medium of language used to conduct interviews with the top management is English, whereas, the researcher was unable to conduct the interview in English with the site management due to their poor understanding of English. Thus, Sinhala medium was used to conduct the interviews. Hence, the researcher had to translate the information before analysing the data. Moreover, in some instances, the participants specifically the top management were interviewed in several rounds to obtain further clarifications.

4.10.4.2 Focused group discussions

Focus groups are discussion-based interviews on specific topics with multiple respondents (Rabiee, 2004; Lane, McKenna, Ryan, & Fleming, 2001). The workers have shown little reluctance to share their ideas during semi-structured interviews with individual workers. They were feeling free and confident to express their honest opinion, when there is a company for them. Accordingly, a total of three focus group discussions (one discussion from each case except two cases) were carried out with multiple workers for approximately one and half hours for each. The researcher was able to get a mix of participants for the focused group interviews conducted at the project sites. All the discussions were recorded using a digital voice recorder with the permission of all respondents to secure an accurate account of the conversations and avoid losing data, since everything cannot be written down during discussion. However, the real names of the case studied organisations and respondents were not revealed in the thesis to maintain the confidentiality.

4.10.4.3 Observations

As stated by Yin (2015), observational evidence is often useful in providing additional information about the topic being studied. The observations can range from formal to casual data collection activities (Yin, 2015). This can formally involve observations of meetings, sidewalk activities and factory work to name a few. Less formally, observations can be done as general site visit (Yin, 2015). Carrying out observations in an informal manner provided a useful method of collecting data without making workers or managers stress-full. The researcher able to visit eight construction projects in the case studied SMEs. During the data collection, several visits to the construction site were made by the researchers following to the need to go '*gemba'*, to see construction sites.

The researcher permitted to attend as a non-participative observer for eleven progress review meetings conducted at construction SMEs. The observation guideline was developed including only the areas, which was observed by the researcher as given in Appendix 3. However, most of the participative personnel requested not to reveal company name or any other information such as profit levels, company strategies, which gives indication of the organisation through the content of the research.

4.10.4.4 Document review

Another data collection technique adopted is the review of documents for data triangulation. Yet, it has proven during the interviews that many of the construction SMEs have poor documentation management systems in place. Thus, a structured way of referring documentation was not planned due to the absence of good documentation practices in construction SMEs. Archival records and documents referred included organisation chart, work instructions sheets, daily progress review check lists, manuals, training records, procurement guidelines to name a few. Moreover, researcher received permission to access the contract documents of the projects and meeting minutes of progress review meetings.

4.10.5 Data analysis

Westbrook (1994) identified content analysis as a method to analyse the qualitative data in a reliable way. Content analysis was a reductive analysis of masses of data, which produced a uniform schema of categories, and facilitated the comparison of the different cases (Flick, 2009). Similarly, coding is the result of raising questions and giving provisional answers about categories and their relations (Douglas 2003). Thus, manual coding entails reading text and extracting user-specified information deemed relevant to its content and/or context (Carley, 1990). Thus, manual coding was employed rather than computerised coding during EIR-1 to analyse NVAA. Case study data were codified, and similar cognitions were taken under a same code for the interpretation.

This study used Williams and Moser's (2019) three-phase coding content analysis method, in which the research results were explored as themes (selective codes) after the creation of open and axial codes.

Douglas (2003) stated that open codes create the basis for later aggregation into concepts (core codes) and are labels given by the researcher to research findings: i.e., influences, functions, activities and events. This initial coding involves the close analysis of data through transcripts being analysed, word for word, line-by-line and phrase-by-phrase. Subsequently, the aim of open coding is to initiate the unrestricted labelling of all data and to assign representational codes to each incident highlighted in the data. According to Williams and Moser (2019), once the open coding has been done, the open codes were regrouped. Axial coding identifies relationships between open codes, for the purpose of building core codes. Williams and Moser (2019) and Douglas (2003) further mentioned that, selective coding needs the identifications of the focal core code, i.e., the central phenomenon emerged from the axial coding process. All other core codes obtained from the axial coding process should be directly or indirectly related to this focal core code. Accordingly, this approach ensured the development of a detailed list of themes for the content analysis (Williams, & Moser, 2019; Kulatunga, et al., 2007), and thus used for this research study. The collected data were analysed as detailed in below.

4.10.5.1 Within case analysis

According to Eisenhardt (1989), within case analysis aim to develop a detailed write-up for each case being studied. The researcher had to deal with an enormous amount of data during a with-in case analysis. However, there was no standard format for a with-in case analysis. The presentation could be narrative descriptions, graphical presentations and tabular displays to name a few. Thus, the ultimate objective was to improve the understanding of the case data and the specific problems in each case. Moreover, with-in case analysis helped to accelerate the cross-case comparison due to the increased familiarity built during the process of with-in case analysis. Within case analysis was done for all five cases following the three levels of coding introduced by Douglas (2003).

4.10.5.2 Cross-case analysis

Cross case analysis was the subsequent step to the within case analysis. As explained by Eisenhardt (1989), the methods used in cross-case analysis driven by the idea that people are not good information processes, where they come up with conclusions based on limited data and results get affected by the vividness of data. This could lead to false or premature conclusions on data with information biases. Thus, there were several tactics to overcome these problems and to carry out a better cross-case analysis. One such tactic was to select categories or dimensions through literature, suggested by research problem or a selection by the researcher. These categories can be used to dig into within group similarities and intergroup differences. Next tactic was to select pairs of cases and analyse the similarities and differences between pairs. The results of these forced comparisons could give result to new categories and concepts. Regarding this study, the first tactic illustrated by Eisenhardt (1989) was used expecting literal replication across the cases. The outputs of within case analysis (SWOT analysis for construction SMEs, NVAAs, implementation of lean tools and techniques at each case) were used as the main input for cross case analysis.

Moreover, findings were analysed across the cases to get a holistic view of lean implementation by the construction SMEs in Sri Lanka. However, the open coding for them is quite difficult to graphically present as most of open codes were '*we have no understanding / slight understanding / average understanding / moderate understanding and good understanding about specified lean tools'.* Therefore, the data were grouped into five sections as '*no understanding, slight understanding, average understanding, moderate understanding and good understanding'* to present the findings. Similarly, in terms of lean tools and techniques implementation, similar type of open codes was derived through within case analysis (e.g: *we have slightly implemented*, *not implemented at all, trying to implement*). Therefore, five axial codes for lean implementation were developed as '*no implementation, slightly implemented, average implementation, moderately implemented and fully implemented'* to present the findings.

According to Bianco, Gasparini and Schettini (2014), use of colour for encoding information can greatly improve the observer's understanding of the information depicted by image and his/her capacity for remembering it. Bianco et al. (2014) further added that colour is pre-attentively observable and hence makes it particularly effective in coding qualitative information. Correspondingly, the data for level of lean tools and techniques implementation were presented using a colour code. Colours were selected based on Colour Brewer 2.0 application to present the qualitative data.

The level of understanding and implementation of lean tools and techniques were discussed to gain an in-depth analysis for the level of lean implementation by construction SMEs in Sri Lanka.

4.10.5.3 SWOT analysis

SWOT Analysis is an analysis method used to evaluate the 'strengths', 'weaknesses', 'opportunities' and 'threats' involved in an organisation (Ommani, 2011; Leigh, 2009). Gürel and Tat (2017) mentioned that, SWOT analysis is a significant tool for situation analysis that helps the managers to identify organisational and environmental factors. By conducting an external analysis, the construction SMEs can identify the critical threats and opportunities in its competitive environment. It also examines how competition in this environment is likely to evolve and what implications that evolution has for the threats and opportunities an organisation is facing. While external analysis focuses on the environmental threats and opportunities facing an organisation, internal analysis helps the construction SMEs to identify its strengths and weaknesses. It also helps an organisation understand which of its resources and capabilities are likely to be sources of competitive advantage and which are less likely to be sources of such advantages (Gürel, & Tat, 2017; Leigh, 2009). Based on SWOT Analysis, organisations can choose the appropriate strategy. Therefore, data collection and data analysis were carried out using SWOT analysis to get the status quo of construction SMEs in Sri Lanka.

4.10.5.4 Five-whys (5-Whys) analysis

Ohno (1988) stated that the 5-Whys technique was developed within the Toyota Motor as a critical component of its problem-solving training to determine the root cause of a problem by repeating the question 'Why?' as presented in Figure 4.5.

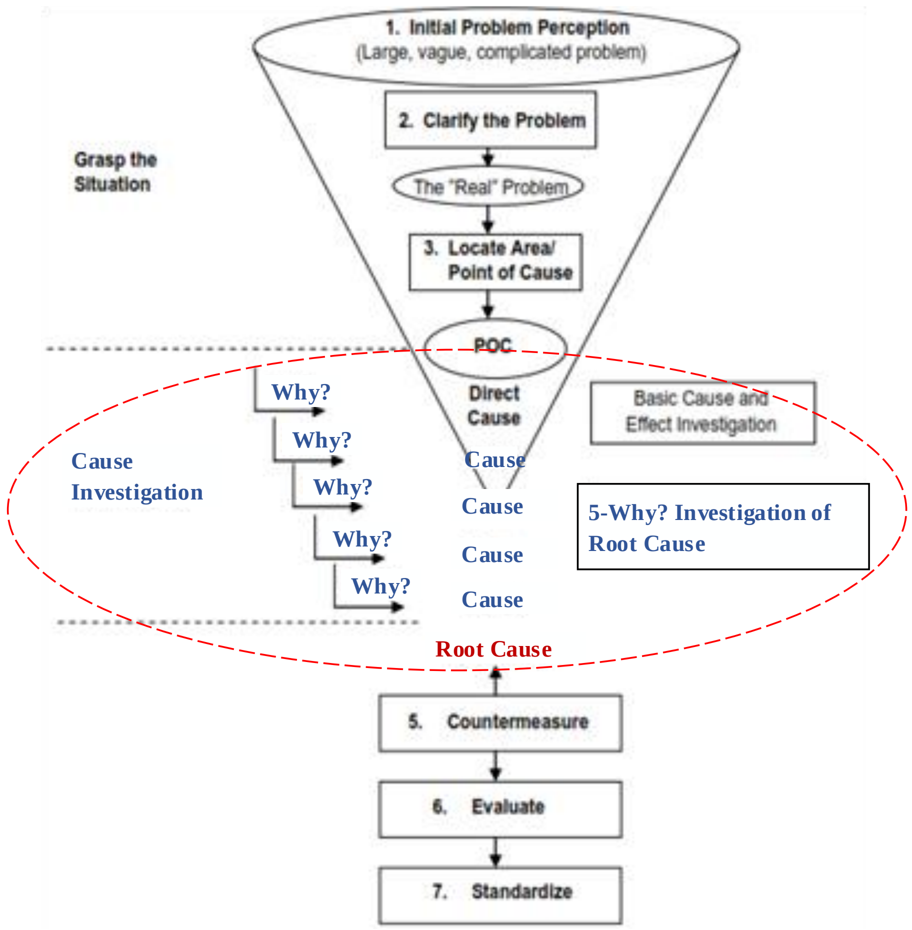


Figure 4.5: Toyota's practical problem-solving process

Source: Liker (2004)

The case data were collected and analysed using 5-Whys analysis to identify commonalities from their diverse experiences. According to Ohno (1988), root causes are hidden under more obvious symptoms, and only by unpeeling the layers of the problem can the root be found. Similarly, Tommelein (2015) highlighted the importance of going to '*gemba*' and repeatedly asking 'Why' to explore the root cause to improve the system. Murugaiah et al. (2010) stated that the application of the 5-Whys analysis provides a fact-based and structured approach to problem identification and focuses on both reducing and eliminating NVAA. Hence, 5-Whys analysis was used to identify the root causes for NVAA of construction SMEs.

4.11 Empirical Investigation Round 2 (EIR-2): Expert Interviews

EIR-2 of the research is aimed to provide answers to the following questions of the research.

- RQ3a - What are the drivers for lean implementation in construction SMEs?
- RQ3b - What are the barriers for lean implementation in construction SMEs?
- RQ4 - What are the capacities required for enabling lean in construction SMEs?
- RQ5 - What are the strategies for enabling lean in construction SMEs?

The above questions need in-depth qualitative information as they try to get answers to 'What' questions. Burns (2000) stated that ethnography approach is suited to analyse the behaviour over a period of time within a natural environment, whereas Keraminiyage (2005) mentioned that the researcher tries to solve the problem by being a part in the problematic environment in action research. However, due to the limitations in the nature of construction SMEs, those strategies are not practical for the research study. Thus, interviews with the experts in the construction industry were used for EIR-2 of this study.

4.11.1 Choice of data collection techniques

Lean is still in the infancy stage in Sri Lankan construction industry. In this context, questionnaire survey with large sample is not practical considering the unavailability of large population who has lean awareness in Sri Lankan construction industry. Further, this study warrants an in-depth understanding and investigation in to the 'what' questions. Interviews compared to questionnaires are more powerful in eliciting narrative data that allows the researcher to investigate respondent's views in greater depth (Kvale, 1996). This allows the respondents to speak and express their own thoughts, experiences and feelings. Hence, the research identified interviews as the most suitable method for EIR-2 data collection.

Interviews can be mainly classified as unstructured, semi-structured and structured. In structured interviewing, little flexibility is allowed in the way the questions are asked or answered (Fontana, & Frey, 2000) and does not consider the differences in social context or individuals that can influence the responses. An opposite approach to the above is to use unstructured interviews. Unstructured interviews are carried out in the style of general discussions (Thomas, 2011; Fossey, Harvey, McDermott, & Davidson, 2002) and are governed for their ability to provide greater breadth of data.

Both Noor (2008) and Thomas (2011) stated that semi-structured rather than structured interview enables sufficient flexibility to approach, while still covering the research questions. Sekaran (2003) stated that semi-structured interviews enable to clarify doubts, adapt the necessary questions, ensure the response by repeating the questions and recognise the non-verbal clues from the respondent in face-to-face interviews.

As highlighted by Glendon et al. (2006), the process depends on the facilitator's ability to build rapport with respondents and to extract relevant information within a limited time, while keeping the discussion on track. Based on the recommendation of Glendon et al. (2006), the discussion was initiated by inquiring about the background information and the general work procedures of the respondents and it was then gradually extended. This initial discussion considered as an ice-breaking mechanism in getting the respondents to open up about the actual NVAA. In some instances, the participants were interviewed multiple times for further clarifications. All the discussions were recorded using a digital voice recorder with the permission of participants to secure an all responds and avoid losing data as writing everything is impractical in an interview process. Subsequently, interview transcripts were developed to generate codes from collected data. However, actual names of the organisations and the respondents were not revealed in this thesis to maintain confidentiality.

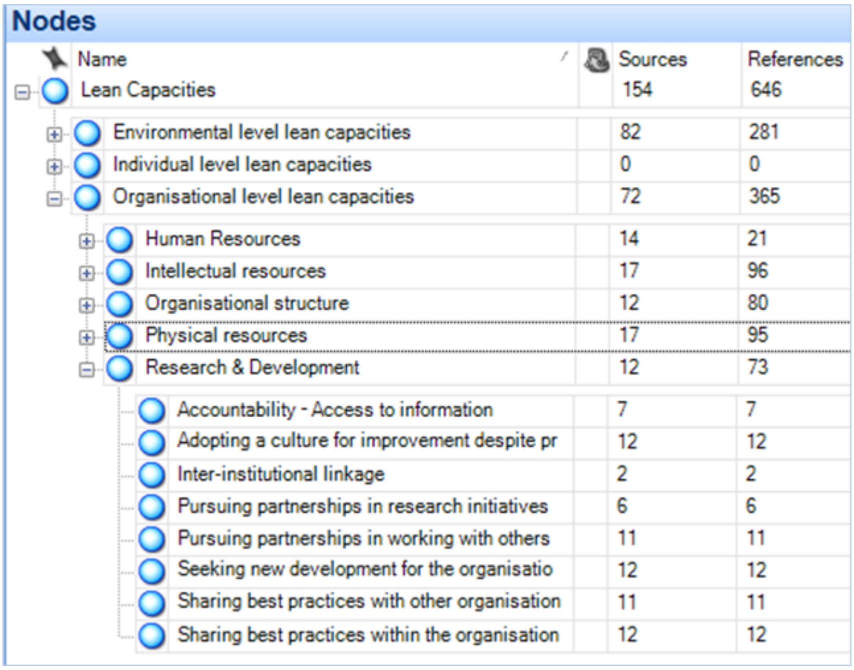
4.11.2 Selection of the sample

Sampling methods are much important when the data collection for the entire population becomes practically constrainable (Marshall, 1996). Therefore, purposive sampling, which defined under non-random sampling techniques, was adopted. According to Etikan, Musa, and Alkassim (2016), use of non-random sampling ensures in-depth information on subject areas from area experts. Thus, semi-structured interviews were conducted with the industry experts who have current or very recent experience in working in lean implemented construction SMEs, consultants who have experience in implementing lean in construction SMEs and experts from regulatory bodies in construction industry who have knowledge on lean concept.

Twenty-four (24) industry experts were selected who possesses more than 15 years of experience in the construction industry. However, their experience and exposure to lean concept were at diverse levels. Most of them have undergone at least training programmes or CPD sessions on lean. In some instances, the participants were interviewed several times for further clarifications and all interviews were digitally voice recorded and the author took notes during the interview.

4.11.3 Data analysis

Casterle, Gastmans, and Bryon (2012) highlighted that, the most challenging stage in the research process is the data analysis stage. Moreover, during this stage, particular themes will be identified and they will be quantifying their occurrence in an objective way. Content analysis is a frequently used analysis technique (Hsieh, & Shanon, 2005) to establish the relationships between concepts. Moreover, content analysis can be used to produce a uniform schema of categories, which facilitated the comparison (Flick, 2009). Therefore, code-based content analysis was established for EIR-2 as it allows convenience data analysis process. This study used Williams and Moser's (2019) three-phase coding content analysis method, in which the research results were explored as selective codes after the creation of open and axial codes. However, Morris (1994) stated that, manual coding is not reliable as it consumes a considerable time. Hence, the computer-based software N-Vivo 11 developed by QSR (Qualitative Solutions and Research Limited) was used in this study and Figure 4.6 presents a sample screen shot of Nvivo analysis.


Nodes

Name	Sources	References
Lean Capacities	154	646
Environmental level lean capacities	82	281
Individual level lean capacities	0	0
Organisational level lean capacities	72	365
Human Resources	14	21
Intellectual resources	17	96
Organisational structure	12	80
Physical resources	17	95
Research & Development	12	73
Accountability - Access to information	7	7
Adopting a culture for improvement despite pr	12	12
Inter-institutional linkage	2	2
Pursuing partnerships in research initiatives	6	6
Pursuing partnerships in working with others	11	11
Seeking new development for the organisatio	12	12
Sharing best practices with other organisation	11	11
Sharing best practices within the organisation	12	12

Figure 4.6: Screen shot of Nvivo analysis

Nvivo used for coding and simplifying the collected data with graphical representation of interpreting relationships, Nvivo further speed up the time taken for analysing the unstructured data to facilitate the research study.

Nevertheless, the findings from the review of literature were also considered when analysing the content of the transcribed interview data. This allowed synthesising the literature to identify any divergence of theory into practices. Further, interactive data visualisation tool, Power Bi (refer Figure 6.6 for an example) and Microsoft Visio (refer Figure 6.3 for an example) were used to present the analysed data.

4.12 Final Framework

Following an initial framework of the research intention (refer Figure 1.1), the researcher went through on incremental process of developing the framework namely, conceptual framework and final framework successively. Final framework was developed by incorporating the research findings of EIR-1 and EIR-2 to the conceptual work. The developed framework was further verified for the external validity by presenting to three subject matter experts, who have prior experience in construction SMEs and industry regulatory bodies.

4.13 Deriving Conclusions and Making Recommendations

All research findings were concluded to present the strategies to lean enabling capacity building for construction SMEs in Sri Lanka. Conclusions were derived together with a comparison to available literature presented in Chapters 2 and 3 as detailed out in Chapter 7. This was referred to as 'pattern matching' by Yin (2015), which improve the internal validity of the research, when the empirically concluded result coincided with the predicted pattern in literature. Thereafter, contributions to knowledge were presented under theoretical contribution and methodological contribution. Finally, empirical contributions were stated as the recommendation to the industry and further research areas to the academics and practitioners.

4.14 Thesis Writing

The final stage of the research study is the writing up of the thesis. However, this is being progressively carried out throughout the research process. Nevertheless, the write-up was initiated in an explanatory manner in the beginning and narrowed down towards the latter stages. Both journal and conference publications made by the researcher were useful in writing the thesis.

4.15 Role of the Researcher

There was a possibility of researcher's personal, emotional, ideological and political dimensions impacting research positively and negatively. According to Al-Natour (2011), level of impact was high in a qualitative research with a philosophical underpinning of axiology being value laden. Therefore, it was important to clearly identify and make an account on the role of the researcher, positioned in the interpretive paradigm.

The researcher has seven years of experience in the academia related to quantity surveying. In addition, researcher has industry experience in quantity surveying and lean consultation for some SME organisations in Sri Lanka. The researcher had prior experience in working in construction SME projects in Sri Lanka. Further, the reviews received for the publications add an extra value for the outcome of the research. Moreover, the researcher had the opportunity to meet and discuss with lean construction legends including Koskela, Tommelein, Tariq and Mossman in International Group for Lean Construction (IGLC) 2018 conference in India. Thus, the researcher her-self improved the knowledge in lean construction. Accordingly, there can be some transfer of values of the researcher to the empirical data collection done through observations and interviews and data interpretation done through qualitative content analysis, despite all the measures taken to improve consistency of the research. However, prior experience of the researcher on construction SMEs and lean was helpful to make fast and accurate judgements.

4.16 Research Trustworthiness

The criticism towards research is unavoidable. Therefore, it is vital to establish the validity and reliability of the study. The next section discusses the validity and reliability of the research.

4.16.1 Validity

Validity is concerned with the integrity of the conclusions that are generated from the research (Bryman, 2008). Validity is defined by Collis and Hussey (2009) as the 'extent to which the research findings accurately reflect the phenomena under study' (p.64). Wedawatta et al., (2010) and Eisenhardt and Graebner (2007) noted the importance of articulating the beginning (research questions), middle of the research (data collection and data analysis), and the end points (conclusion) of a research study. Further, Yin (2015) discusses three variants of validity as 'construct validity', 'internal validity' and 'external validity'. Table 4.3 summarises how this research sought to achieve validity and reliability.

Table 4.3: Methods used for establishing validity and reliability

Test	Description	Methods used in the research
Construct validity	Establishing the correct operational measures for a particular study	• Use of multiple sources of evidence • Establishing chain of evidence (e.g., case study protocol, interview transcripts, coding structures) • Review of draft case study reports by key informants • Establishing a suitable research methodology

Test	Description	Methods used in the research
Internal validity		• Do pattern matching • Use triangulation
External validity	Findings of a particular study are generalisable beyond the immediate case study	• Review of key literature • Use of replication logic (05 case studies) • Validate the framework with industry experts
Reliability		• Use of case study protocol (EIR-1) • Documenting all operational stage of the research • Expert opinion method

According to Yin (2015), construct validity relates to establishing the correct operational measures for the. Thus, literature review, case study, interviews and document review were used to ensure the construct validity. Interview transcripts were further reviewed by the interviewees ensuring that their views were correctly recorded. This was further noted by Yin (2015) to achieve external validity. Bestowing to Yin (2015), establishing a definite research methodology from inception to completion of the research study is another way of achieving construct validity, which has been successfully obtained from this chapter.

External validity refers to ability of research findings to generalise beyond the boundaries of the study (Yin, 2015). A review of key literature, map the findings to literature and compare research findings at several stages of data collection can be considered as mean of achieving the external validity. Moreover, the final framework was verified with three experts for the external validity.

Triangulation involves the use of several sources of evidences during the research study and combination of qualitative and quantitative techniques to effectively compare the strengths of each measure and act accordingly (Robson, 2011; Haigh, 2004). Four types of triangulations were stated by Denzin (2006), i.e., theory triangulation (comprehensive literature review extended beyond the construction management body of knowledge), data triangulation (adopting different data collection and analysis methods) and methodological triangulation (adopting three rounds of data collection techniques with different methods to suit the context) and observer triangulation. Theory triangulation, data triangulation and methodological triangulation were achieved during the research study. However, observer triangulation was problematic to achieve in a doctoral study, as there was single researcher involved with the study.

4.16.2 Reliability

Reliability involves determining the operations of a study which can be repeated to obtain the same results and proposed to adopt a case study protocol to achieve the reliability. Though, Yin's (2015) definition, is much promising to researchers with positivist stance, it may not be willingly applicable by researchers with interpretivist or pragmatic stances. The reason behind this difference is impact to the research process made by the perceptions and world views of the researcher. Therefore, Remenyi et al. (2003) noted that, there are challenges in reproducing the same results in those researches. Therefore, many researchers stated the need of transparency of the research through good practice guidelines (Yin, 2015; Saunders, 2009; Easterby-Smith et al., 2008; Remenyi, 2003) including keeping records of activities (Robson, 2011) which can be obtained by recording every operational phase in the research study.

4.16.3 Generalisation of the research findings

The issue of generalisation was a frequent criticism of research that the results would not be widely applicable in real life. Yin (2015), in particular, refused that criticism by presenting a well-constructed explanation of the difference between analytic generalisation and statistical generalisation. Further to the author, analytic generalisation is done by using a previously developed theory as a template against, which the empirical results of the case study were compared. This contrasts with the normal statistical generalisation expected in a quantitative research. Accordingly, as described by Yin (2015), in this study, analytic generalisation was done by referring previously developed theories on lean implementation and capacity building in SMEs by different researchers as a basis against, which the empirical results were compared.

4.17 Chapter Summary

This chapter summarised the research methodology used for the study. The chapter initiated with discussing the research process developed for the study. It was established that the aim and objectives of this research could be achieved through a more qualitative approach and thus, the research is inclined towards the interpretivism stance. This research shared ontological, idealist assumptions in the interpretive paradigm for the study to collect, analyse and validate the data. Lean enabling capacity building in construction SMEs facilitate the ontological assumption of reality as a social construction. Therefore, subjective qualitative means of knowledge creation were expected with detail descriptions, following the axiological assumptions of more valuable input from the researcher on the research process. This led to the epistemology of understanding, how the social reality about lean enabling capacity building in construction SMEs was created.

Research design, research philosophy, research approach, methodological choice, research strategies, research techniques and procedures were discussed with the appropriate justification within the chapter. Accordingly, Empirical investigation was carried out in two rounds as EIR-1 and EIR-2. EIR-1 was conducted using five case studies to investigate the SWOT of construction SMEs, NVAA and their root causes and level of lean implementation by the construction SMEs in Sri Lanka. EIR-2 carried out as semi-structured interviews with experts to gather data on barriers and drivers for lean implementation, lean enabling capacities and capacity building strategies to enable lean among construction SMEs in Sri Lanka. EIR-2 was followed by semi-structured interviews with experts to validate the framework. The chapter justified the use of semi-structured interviews, focus group interviews, observations and documentary review within the cases to facilitate effective data triangulation. Finally, conclusion deriving and write up were presented along with the research trustworthiness. Within each stage of the research, the justifications for selecting the aforementioned research approach and data collection and analysis techniques have also been provided.

CHAPTER 5

SITUATIONAL ANALYSIS OF LEAN IMPLEMENTATION IN CONSTRUCTION SMEs IN SRI LANKA (EIR-1)

5.1 Introduction

EIR-1 focused on objective 2 in order to investigate the current situation of lean implementation in Sri Lankan construction SMEs. The chapter initiates by presenting the background of EIR-1. Subsequently, the chapter presents the case study finding through the status of construction SMEs in Sri Lanka to explore the need of enabling lean among construction SMEs. Thus, a SWOT analysis will be presented in this regard. The 5-Whys analysis of NVAA in construction SMEs in Sri Lanka is presented and discussed in detail by highlighting their root causes in this chapter. This is followed by an analysis of the level of lean implementation in construction SMEs in Sri Lanka in terms of understanding and implementation of lean tools and techniques by construction SMEs. Finally, the discussion of the findings will be presented for SWOT analysis, NVAA and implementation of lean tools and techniques in construction SMEs.

5.2 Background of EIR-1

The objective of EIR-1 is to analyse construction SMEs to answer questions:

RQ2a - what are the NVAA of construction SMEs and their root causes?
RQ2b - what is the level of understanding and implementation of lean tools and techniques by construction SMEs in Sri Lankan construction industry?

Therefore, multiple case studies were conducted to address the research questions. Qualitative phenomenological case study analyses focusing on the interpretation of the multiple views of participants of the cases were considered in EIR-1 to collect the data.

5.2.1 Profile of case study organisations

The focus of the research was limited to small and medium contractors in the Sri Lankan construction industry. This was desired due to the aim of the study and the inherent nature of the construction industry. In order to investigate the present situation of lean implementation by construction SMEs in Sri Lanka, EIR-1 was conducted by selecting five construction SMEs, located in the Western Province in Sri Lanka selected through Quota sampling method. In sample selection for EIR-1, the Construction Industry Development Authority (CIDA) contractor registration and grading scheme was taken into consideration, since this scheme has a well-established screening process for the capabilities of prospective contractors to determine their ability to undertake different types and sizes of projects. The contractor selection was limited to Grades C2 to C6 as per the CIDA grading, where C2 as medium contractors and C3 to C6 as small contractors. Table 5.1 summarises the profile of the selected construction SMEs.

Table 5.1: Profile of case study construction SMEs

Case	CA-A	CA-B	CA-C	CA-D	CA-E
Grade	C2	C3	C4	C5	C6
No. of years in the business	34	15	22	10	06
No. of workers	50	40	45	20	20
No. of projects in hand	11	05	04	03	03
Types of projects involved	Specialised in building construction, designing & construction of swimming pools, waste water treatment plants. Cater as sub-contractor for large contractors	Specialised in building construction. Cater as sub-contractor for large construction organisationss	Specialised in building construction and cater as sub-contractor for large construction organisationss	Involving both public and private sector projects building constructions. Cater as sub-contractor for large construction organisations	Involving both public and private sector projects building constructions and mainly focusing on house constructions
Procurement methods practiced	Traditional method with measure and pay contract. Rarely practicing design and build projects	Traditional method with measure and pay contract.	Traditional method with measure and pay contract.	Traditional method with measure and pay contract. Rarely practicing design and build projects	Traditional method with measure and pay contract

All five SMEs are specialised in building construction and involving in both government and private projects. Cases CA-A, CA-B, CA-C and CA-D cater as sub-contractors for large construction organisations, where, case CA-E mainly focuses on individual construction projects and rarely provide sub-contracting services to large construction organisations. Moreover, all the cases have experience on traditional measure and pay procurement method and cases CA-A and CA-C have a few experience on design and build projects. However, CA-A being specialised in swimming pool constructions and supply of waste-water treatment plants and plumbing, preferred design and build projects. Therefore, the different characteristics of the sample reinforce the quality of the data collected for the study. Thus, the detail description on data collection techniques used is presented in below sub sections.

The details of the table present that medium sized contractor has over 15 years of experience. Yet, CA-B confirmed that, they started small and gradually climbed up the ladder. Further to CA-B, it took plenty of time to reach the medium level due to the challenges they faced during the past. However, CA-D and CA-E contractors are still in the infancy stage having less than ten years of experience in the construction industry. Thus, identification of entry barriers and how much they are struggling in the industry to retain can be observed easily. Nevertheless, all five SMEs signified NVAA in their projects and the implementation of lean tools and techniques in their organisations.

The empirical data collection methods adopted within the case studies were, semi-structured interviews, focus group interviews with project participants, non-participant observations (during progress meetings and field visits) and study of documents of the project, which will be discussed in detail in the next section.

5.2.2 Details of techniques used for data collection

5.2.2.1 Semi Structured Interviews

Semi structured interviews were carried out face-to-face with the workers and managers in selected cases. Interviews were structured to obtain answers to the RQ2a and RQ2b. The interview guideline developed for EIR-1 has two parts, where Part-1 focuses on NVAA of construction SMEs and Part-2 focuses on lean tools implementation in construction SMEs (Refer Appendix 2). Table 5.2 provides the profile of interviewees participated in the semi-structured interviews carried out in the case studies.

Table 5.2: Profile of interviewees of the semi-structured interviews

Case	Code	Interviewee (Designation)	Number of years of experience	Role within the organisation
CA-A	RA-1	Chairman	Total 34 years in construction industry. Over 30 years up to date at Case A.	Overall responsible person for construction at Case A organisation while providing leadership to the board to carry out works effectively and efficiently
	RA-2	Project Manager	Total 20 years in construction industry. Over 09 years up to date at Case A.	Responsible for overseeing all construction operations through planning, execution, monitoring, control and closure of activities at Case A. Responsible for timeframe targets and budget.
	RA-3	Assistant Quantity Surveyor	Total 34 years in construction industry. Over 12 years up to date at Case A.	Responsible person to carry out construction works effectively within the given budget and the time frame at Case A organisation
	RA-4	Engineer	Total 15 years in construction industry. Over 08 years up to date at Case A.	Responsible person to carry out construction works at a given time frame without any failures at Case A organisation
CA-B	RB-1	Managing Director	Total 18 years in construction industry. Over 12 years up to date at Case B.	Overall responsible person for construction at Case B organisation while providing leadership to the board to carry out works effectively and efficiently
	RB-2	Project Manager	Total 16 years in construction industry. Over 08 years up to date at Case B.	Responsible for overseeing all construction operations through planning, execution, monitoring, control and closure of activities at Case B. Responsible for timeframe targets and budget.
	RB-3	Technical Officer	Total 22 years in construction industry. Over 10 years up to date at Case B.	Responsible person to get the work done from the shop floor level workers and handling the sub-contractors to Case B organisation.
	RB-4	Technical Officer	Total 14 years in construction industry. Over 10 years up to date at Case B.	Responsible person to get the work done from the shop floor level workers and handling the sub-contractors to Case B organisation.
CA-C	RC-1	Chairman	Total 17 years in construction industry. Over 13 years up to date at Case C.	Overall responsible person for construction at Case C organisation while providing leadership to the board to carry out works effectively and efficiently
	RC-2	Director	Total 30 years in construction industry. Over 10 years up to	Overall responsible person for construction at Case C organisation while providing leadership to the board

Case	Code	Interviewee (Designation)	Number of years of experience	Role within the organisation
			date at Case C.	to carry out works effectively and efficiently
	RC-3	Quantity Surveyor	Total 15 years in construction industry. Over 10 years up to date at Case C.	Responsible person to carry out construction works effectively within the given budget and the time frame at Case C organisation
CA-D	RD-1	Director	Total 20 years in construction industry. 10 years up to date at Case D.	Overall responsible person for construction at Case D organisation while providing leadership to the board to carry out works effectively and efficiently
	RD-2	Project Coordinator	Total 25 years in construction industry. Over 06 years up to date at Case D.	Overall responsible person for construction at Case B organisation while providing leadership to the board to carry out works effectively and efficiently
	RD-3	Senior Technical Advisor	Total 40 years in construction industry. Over 09 years up to date at Case D.	Advising for construction activities at Case D organisation while providing technical know-how to carry out works effectively and efficiently within the organisation
	RD-4	Technical Officer	Total 18 years in construction industry. Over 10 years up to date at Case D.	Responsible person to get the work done from the shop floor level workers and handling the sub-contractors to Case D organisation.
	RD-5	Technical Officer	Total 10 years in construction industry. Over 05 years up to date at Case D.	Responsible person to get the work done from the shop floor level workers and handling the sub-contractors to Case D organisation.
CA-E	RE-1	Director	Total 20 years in construction industry. 06 years up to date at Case E.	Overall responsible person for construction at Case E organisation while providing leadership to others to carry out works effectively and efficiently
	RE-2	Technical Officer	Total 05 years in construction industry. Over 04 years up to date at Case E.	Responsible person to get the work done from the shop floor level workers and handling the sub-contractors to Case E organisation.

A total of 18 members selected from case studied construction SMEs were interviewed. This included the personnel from managerial level as well as from the middle management. Respondents from head office and site management were interviewed in each case. The experts hold positions as: Chairmen, Managing Directors, Project Managers, Engineers and other technical level staff. The researcher was able to interview the Managing Directors of all the case study organisations and hence, was able to interview the responsible person whom will directly make the strategic and significant operational decisions. However, in order to understand the root causes of NVAA in projects carried out by construction SMEs, interviews with technical level people are important. The medium of language used to conduct interviews with senior management was English whereas the researcher was unable to conduct the interview in English with the technical staff due to their poor understanding of English. Thus, Sinhala medium was used to collect data from them. Hence, the researcher had to translate the information before analysing the data. Moreover, in some instances, the participants were interviewed multiple times to obtain further clarifications.

5.2.2.2 Focus group discussions

The purpose of focus group discussions is to gather data to identify the NVAA in the projects, their root causes and identifying the lean tools and techniques practice in the projects by the shop-floor level workers of the case study organisations. When the workers are interviewed individually, they were reluctant to share their ideas. This was experienced during semi-structured interviews carried-out with workers. Therefore, it was decided to use focus group discussions with workers as focus groups are discussion-based interviews on specific topics with multiple respondents. Thus, they were felt free and confident to express their honest opinion regarding the area of discussion as there was a company for them.

Accordingly, total of three focus group discussions (one discussion sessions from each case except two cases, CA-B and CA-D) were carried out with multiple workers in which group discussions were carried out approximately one and half hours. This was in expectations that the respondents may feel free to express their honest opinion regarding the area of discussion. During focus group discussions, some respondents expressed their willingness towards collectively answering with two or three colleagues for the question given in the interview guideline (refer Appendix 2). Some respondents highlighted that use of a group to discuss the usage of lean tools and techniques within the organisation are more effective than answering individually.

All focus group discussions were recorded using a digital voice recorder with the permission of respondents to secure an accurate account of the conversations and avoid losing data since everything cannot be written down during interview.

However, to maintain confidentiality, the actual names of the organisations and the group discussion participants were not revealed in the thesis. Table 5.3 present the profile of the participants involved in focus group interviews.

Table 5.3: Profile of the participants involved in focus group discussions

FG Code	Participant Code	Participant	Permanent/ Temporary	Number of years of experience	Role within the organisation
FG-A	FA-1	Mason	Permanent	Over 15 years in construction industry. 10 years up-to-date at CA-A	Execute all tasks related to construction process of the project.
	FA-2	Bar-bender	Permanent	Over 20 years in construction industry. 05 years up-to-date at CA-A	Responsible for the reinforcement bar bending activities of the project.
	FA-3	Casual labourer	Permanent	Nearly 05 years in construction industry. 03 years up-to-date at CA-A	Work in the bar bending machine.
	FA-4	Casual labourer	Permanent	Nearly 05 years in construction industry. All 5 years at CA-A	Work with the mason to help for brick bindings at the site. Execute all tasks related to excavations in the project.
	FA-5	Casual labourer	Temporary	Over 01 years in construction industry. All 5 years at CA-A	No specific job to perform. Involved in any of the routine tasks assigned by the mason
FG-C	FC-1	Labour sub-contractor	Permanent	Over 10 years in construction industry. 04 years up-to-date at CA-C	Supplying labour to the project. Managing the labour gang provided by him.
	FC-2	Mason	Permanent	Over 10 years in construction industry. 05 years up-to-date at CA-C	Execute all tasks related to construction process of the project
	FC-3	Unskilled labourer	Permanent	Over 05 years in construction industry. 04 years up-to-date at CA-C	Work with the mason to help for brick bindings at the site. Execute all tasks related to excavations in the project
	FC-4	Unskilled labourer	Permanent	Over 05 years in construction industry. 02 years up-to-date at CA-C	No specific job to perform. Involved in any of the routine tasks assigned by the superiors
FG-E	FE-1	Mason	Permanent	Over 10 years in construction industry. 05 years up-to-date at CA-E	Execute all tasks related to construction process of the project

FG Code	Participant Code	Participant	Permanent/ Temporary	Number of years of experience	Role within the organisation
	FE-2	Unskilled labourer	Permanent	Over 05 years in construction industry. 02 years up-to-date at CA-E	Work with the mason as a helper. Execute all tasks related to construction of the project
	FE-3	Unskilled labourer	Temporary	Over 02 years in construction industry. 01 years up-to-date at CA-E	No specific job to perform. Involved in all of the routine tasks assigned by the superior

The senior management of CA-B and CA-D did not allow the researcher to conduct interviews with their shop floor level workers. Thus, only, three focus group interviews were conducted with the other three cases (CA-A, CA-C and CA-E). The researcher was able to get a mix of participants for the focus group interviews conducted at the project sites.

5.2.2.3 Observations

As stated by Yin (2015), the observations can range from formal to casual data collection activities. Yet, observations protocol can be developed as part of the case study protocol. This can formally involve observations of meetings, sidewalk activities and factory work to name a few. Less formally, observations can be made during the visits to the sites during other evidences are being collected (Yin, 2015). During the focus group discussions with workers, it was realised that majority of them lives with unnecessary fear towards managers and they are not speaking even the problems they are facing at the sites. In a similar note, they had the feeling that the researcher was there to find out who is to be blamed in case of a mistake or their misbehaviours. Nevertheless, senior management of the organisation have not as much of idea in terms of the works/tools carried out at the shop floor level. Although, respondents of the interviews have mentioned that the shop floor workers are to blame for the causes of NVAA at the projects, senior management attitudes towards the improvement will affect the lean implementation. Hence, carrying out observations provided a useful method of collecting data without making shop floor workers or managers stressful. Yet, the researcher received the permission to attend as a non-participative observer for some of the progress review meetings conducted at the construction SMEs as present in Table 5.4.

Table 5.4: The details of the progress review meetings attended by the researcher

Case	PR Code	Location	Participants	Details of the progress review meeting
CA-A	PRA-1	Progress review meetings held at head office of CA-A	Managing Director Project Managers Site Quantity Surveyors Structural Engineers	Progress review meeting which is held once in every month. The representatives of the projects participate to discuss the progress of their projects. Reporting the interim payment applications to the Director
	PRA-2	Progress review meetings held at Site office of CA-A	Project Manager Structural Engineer Site Quantity Surveyors Technical Officers	Progress review meetings held at Site office. Generally, 2 site meetings for a month are conducted at the site to discuss the progress and problems they are faced at the sites.
CA-B	PRB-1	Director's meeting held at the head office of CA-B	3 Directors of CA-B Senior adviser of CA-B	All three Director of CA-B gathered to discuss the progress of their projects. Top level discussion on strategies to adopt at the project levels
CA-C	PRC-1	At the head office in Colombo	Director Project Managers Site Quantity Surveyors Adviser of CA-C 2 Directors from mother company	Progress review meeting which is held in the first week of each month. Reporting the interim payment applications to the Director. The senior management advice on the strategies to follow up in the respective projects to overcome the problems faced. Providing targets at the project levels for the project managers for the next meeting.
	PRC-2	Progress review meetings held at a Site office of CA-C	Director Project Manager Site Quantity Surveyor 02 Technical Officer	Progress review meetings held at Site office, in every week. Generally, 3 site meetings for a month are conducted at the site to discuss the progress.
	PRC-3	Director's meetings held at head office of CA-C	Director 2 Directors of CA-C mother company Senior Technical Adviser of CA-C	Director of CA-C and 2 Directors representing mother company along with the Senior Technical Advisor gathered to discuss the progress of their projects, the delays of the projects and cost-overrun of the projects. Top level discussion on strategies to adopt at the project levels to overcome the problems.
	PRC-4	Progress review meetings held at a Site office of CA-C	Director Project Manager Site Quantity Surveyor	Progress review meetings held at Site office, in every week. Generally, 3 site meetings for a month are conducted at the site to discuss the progress. The project was getting delayed and sudden meeting arranged. Director was checking the problems at the site and advice accordingly.

Case	PR Code	Location	Participants	Details of the progress review meeting
	PRC-5	Progress review meetings held at a Site office of CA-C	Director Project Manager Site Quantity Surveyor Technical Officer	Progress review meetings held at Site office, in every week. Generally, 3 site meetings for a month are conducted at the site to discuss the progress of the delayed project.
	PRC-6	Progress review meetings held at a Site office of CA-C	Director Project Manager Site Quantity Surveyor 02 Technical Officer	Progress review meetings held at Site office, in every week. Generally, 3 site meetings for a month are conducted at the site to discuss the progress of the delayed project. This is a follow-up meeting for the project
	PRC-7	Project Stakeholder meeting for one of the CA-C project held at the site	2 members from Client 4 members from consultant team including architects, engineers and resident manager) Director and Project Manager of CA-C	All project stakeholders (Client/ Consultant/ Contractor) are meeting to discuss the progress of different parties. Further discuss about the preceding of the project. Solving the problems with designs, cost, new materials, etc.
	PRC-8	Progress review meetings held at a Site office of CA-D	Project manager Engineer 2 Technical Officers	Progress review meetings held at Site office, in every month. Generally, 2 site meetings for a month are conducted at the site to discuss the progress.

The researcher had the opportunity to attend eleven progress review meetings of the selected cases. The observation guideline was developed including only the areas, which need to be observed by the researcher as given in Appendix 3. However, the researcher has taken all the measures to keep the identity of the company and the respondents confidential. Moreover, the researcher had the opportunity to visit the sites (*gemba walk*) of the case study construction SMEs and make observations. Table 5.5 presents the details of the sites visited by the researcher.

Table 5.5: The details of the sites visited and observed by the researcher

Case	Site visit Number	Location	Type of site
CA-A	SVA-1	Five-star hotel in Battaramulla	Building project at five-star hotel in Battaramulla. Construction of a new restaurant near to a lake in the hotel premises.
	SVA-2	Five-star hotel in Colombo 03	Sub-contractor for construction of swimming pool in a five-star hotel at Colombo 03. CA-A is specialised in construction of swimming pools.
CA-B	SVB-1	Auditorium in Colombo 07	Refurbishment of Auditorium at a private school in Colombo 07. CA-B is responsible for refurbishing a burned auditorium. CA-B has to take special precautions to ensure the minimum disturbance to the neighbouring buildings in the school. Had to take majority of a work after school

Case	Site visit Number	Location	Type of site
			hours.
CA-C	SVC-1	Apartment building at Wellawatta	Sub-contractor for construction of ten storied apartment building at Wellawatta. CA-C is responsible to carry out the structural work of the building. The building located near to coastal area. Problems due to corrosion of rebar at the site, rain and the wind patterns at the location.
	SVC-2	House construction at Colombo 07	Construction of a super luxury three storied house for CEO of a renowned international bank in Sri Lanka. The construction took place near independence square. The client hired two firms to act as the client and the consultant to the project. Construction responsibility lies with CA-C. The house consists with many new construction methods and materials. Thus, CA-C had to face many problems from the Client and the Consultant.
	SVC-3	Apartment building at Hawlock town.	Sub-contractor for construction of 07 storied apartment building at park road, Hawlock Town. CA-C is responsible to carry out the structural work of the building. The project located in high residential area. CA-C had to take special precautions to ensure the minimum disturbance to neighbouring buildings.
CA-D	SVD-1	Science lab at Mount Lavinia	Construction of two storied science lab for a school in Mount Lavinia. This is a public school and the design in provided by the government. CA-D is responsible for the construction of a building. Short duration project, yet the approval process is too long.
CA-E	SVE-1	House at Homagama	Construction of two storied house at Homagama for a private owner. The project is a design and build project, where the CA-E is responsible for all design and the construction of the house.

The researcher was able to visit eight construction sites to collect data. All of them were located in Western Province. The case study organisations show interest to bid for the projects in Western Province. Moreover, most of the projects were sub-contracting to large scale projects and all were construction of building projects. These cases show less interest in bidding for road construction projects. As CA-A is specialised in swimming pool construction, the opportunity received fort CA-A to get work is quite high comparing to other cases.

The key aspects planned to observe during the progress review meetings and site visits are type of NVAA in the construction projects and the type of lean techniques that practicing in reality by the different levels of project participants. It will further help researcher in analysing the construction SMEs and identifying the causes of NVAA in the construction projects.

5.2.2.4 Document review

Another data collection technique adopted in EIR-1 is the document review. The aim of document review is to gather further data that was not able to collect from above methods. Further, this data collection technique was support data triangulation. Yet, it is proven during the interviews that many of the construction SMEs poor in documentation management, though they are claimed so. Thus, a structured way of referring documentation was not planned due to the absence of appropriate documentation practices in this construction SMEs. Archival records and documents referred included organisation chart, work instructions sheets, daily progress review check lists, tender documents of the projects, minutes of the progress review meetings, manuals and training records. These documents helped to identify the challenges faced by construction SMEs, and the strategies taken to solve the problems, which will help in exploring the NVAA and the root causes for these problems. Moreover, the document review added identification of the existing capacities of the organisations.

5.3 SWOT Analysis of Sri Lankan Construction SMEs

Construction SMEs in Sri Lanka currently face large number of challenges to retain their market position. Hence, it is vital to analyse the current situation of Sri Lankan construction SMEs. There is a need to analyse the situation of construction SMEs with respect to possible threats as well as the opportunities to improve their strengths and overcome the weaknesses. To succeed in the construction industry, weaknesses must be overcome through strength and threats must be transferred into opportunities to build up the capacities of the organisations. Therefore, Section 4 in EIR-1 guideline (refer Appendix 2) aimed to identify the strengths, weaknesses, opportunities and threats of construction SMEs in Sri Lanka to get a holistic view on the current status of construction SMEs in Sri Lanka. Figure 5.1 presents EIR-1 findings through a SWOT analysis that discusses the current situation of construction SMEs in Sri Lanka. The case study reference for the factor identification for SWOT analysis is provided in Appendices 4 to 7.

INTERNAL FACTORS

STRENGTHS

- Less capital requirement
- Flexible cash flows
- Small number of workers
- Easy to train people
- Better control of the resources
- Quick reactions to problems
- Entrepreneurial Culture
- Independent workforce
- High flexibility and resilience to the dynamic changes
- Independent business firm
- Easy handling of workers
- Competitive advantage over large companies

WEAKNESES

- Lack of Capital
- Budget overrun
- Lack of cost controlling techniques
- Delaying payment
- Lack of value addition
- Unable to meet the market demand
- Decreasing productivity
- High rate of collisions and accidents
- Design failure/ changes
- Increase of waste in projects
- Quality deficiencies in the output
- Difficulties in technology transfer
- Limited use of information technologies
- Time overrun & missed deadlines
- Internal policies and strategies of the parent organisation
- Difficulties in meeting regulations and policies of professional bodies
- Lack of qualified professionals
- Insufficient research and development
- Lack of strategic leadership
- Lack of motivation in the workforce
- Limited resources
- Limited networking
- Instability of the construction processes
- Lack of H & S awarenes

EXTERNAL FACTORS

OPPORTUNITES

- Special loan schemes form government and private bank
- Low interest rates for projects
- Tax reductions
- Availability of funds for research and innovations
- Adding value to products (knowledge, services)
- Available of training programs for SMEs
- Availability of human resources
- Availability of new process improvement methodologies
- Special incentives from the government
- Supportive legislations
- Professional bodies accreditations
- Increasing public awareness about SMEs

THREATS

- Difficulties in access to finance
- Significant increase of energy cost
- High cost of labour, materials and equipment
- High interest rates
- Equipment and material unavailability
- New construction technologies
- Lack of skilled workers
- Migration of Sri Lankan construction workers to neighbouring countries
- Poor Quality of material and equipment
- The demand of bribe by politician
- Continuous change in regulations
- Occupational health/ safety related laws
- Instability of the political environment
- Taxations
- Unfavorable procurement methods
- Monopoly created by large construction companies
- Increasing competition within construction SMEs
- Lack of access to international markets
- Unfavourable weather conditions
- Negative attitudes towards SMEs stability

Figure 5.1: SWOT analysis for construction SMEs in Sri Lanka

Accordingly, following sections discuss the strengths, weaknesses, opportunities and threats identified during EIR-1 for the construction SMEs.

5.3.1 Strengths

The case study references for the identified strengths are given in Appendix 4. According to the respondents, construction SMEs has a competitive advantage over large construction companies due to the size of the organisation. As construction SMEs are working on projects that are small in size, capital requirement is less, which is based on a financial strength of the organisation. During the SVC-2, the researcher visited the site with RC-2, one of the workers said '*there is a problem with the sand delivered yesterday. Many sea shells can be seen. Are we going to use that for column concreting?'* Correspondingly, RC-2 confirmed not to use that for column concreting and asked the workers to use it for the concrete bed. At the same time, RC-2 called another supplier and requested sand from them. Similar situations were observed during SVA-2, SVE-1 and PRC-2 confirming that the construction SMEs can quickly react to the problems within the site. Entrepreneurial culture, independent workforce, independent business firm and easy handling of workers were identified by RA-1, RB-1 and RB-2 as the managerial strengths of construction SMEs. Nevertheless, weaknesses of construction SMEs could dilute the above-discussed strengths.

5.3.2 Weaknesses

The analysis of weaknesses of construction SMEs with case study references are given in Appendix 6. Lack of capital, budget overrun, delay in payment and the high cost of construction were the financial weaknesses of construction SMEs. This was further confirmed by RD-1 and RD-3 stating that, '*unlike large contractors, lack of cost controlling techniques is practiced by the construction SMEs'*. Technical weaknesses include decreasing productivity, estimation errors, high rate of collisions and accidents, design failure/changes, an increase of waste in projects, quality deficiencies in the output, workmanship issues, time overrun and missed deadlines, limited use of state-of-the-art technologies and inability to meet the market demand. Hence, these weaknesses will increase NVAA within the organisation. Inadequate knowledge/techniques on process improvement and difficulties in technology transfer marked as the reasons for not implementing new construction tools and technologies within the construction process.

RD-1 highlighted that, '*our mother company requires us to follow the same set of policies and procedures applied to other organisation, without even thinking the limited resources available for us'*. Thus, the requirement of following the internal policies and strategies of the parent organisation is another barrier to the independent development of the child construction SMEs. In most of the projects, construction SMEs work as the sub-contractor to a large construction company. Moreover, there are difficulties in meeting regulations and policies of professional bodies. As stated by RA-1, '*CIDA as the governing body of construction industry is changing the regulations from time to time…adopting pre-requisites as stated in the Conditions of Contract is difficult*'. Therefore, RA-1, RD-2 and RD-3 further emphasized that, even though the government provides special loan schemes for construction SMEs, less support from the government for improvements can be identified. Although appropriate management of human resources marked as another success factor for any organisation, construction SMEs have a massive number of managerial weaknesses due to improper management of human resources. However, due to lack of qualified professionals and skilled labourers in the field, construction SMEs are unable to get even the necessary number of workers. Limited networking within the construction industry and slow adoption to continuous change of client's requirements is another weakness of construction SMEs and hence, RE-2, RB-1, RA-1 and RD-2 claimed that, construction SMEs have no capacity to face the changing requirements. Moreover, they have limited resources and facilities and hence, construction processes are unstable at all the times. Furthermore, lack of health and safety (H&S) awareness and poor H&S measures were identified as the reasons for the increase of H&S issues. Yet, plenty of opportunities are available in the industry to overcome the weaknesses.

5.3.3 Opportunities

The analysis of opportunities available for construction SMEs with case study references are given in Appendix 5. Special loan schemes offered by government and private banks provide at low-interest rates for projects. The Ministry of Finance and Planning, Sri Lanka has developed a special loan scheme for SME Sector through Chamber of Young Lanka Entrepreneurs (COYLE), Sri Lanka Chamber of Small Industry, CIDA and many of the private and government banks to uplift the SME sector. According to RA-1 and RB-1, '*SMEs are getting tax deductions for some of their projects, materials, etc*'. Nevertheless, availability of targeted funds for research and innovations is another financial opportunity that SMEs can get to enhance their efficiency and productivity through new technology. Thus, many respondents (RA-2, RB-1, RD-1, RD-3 and RB-2) highlighted that, the emergence of new technologies change the traditional way of doing the businesses and hence, value addition to the product is enormous. Although RA-1 and RC-1 doubted the availability of human resources, majority of respondents agreed on the availability of human resources as a technical opportunity for construction SMEs. RB-1 highlighted the availability of large number of training programs for construction SMEs. However, RC-2 contended that the training programs are not target oriented. Similarly, RA-1, RD-1, RD-2, RE-1 appreciated the seminars and workshops conducted by CIDA Sri Lanka for the benefit of construction SMEs.

Furthermore, accreditations from professional bodies reinforced the quality of the projects carried out by construction SMEs. RA-1 added that '*CIDA*, *National Construction Association of Sri Lanka (NCASL), Ceylon Institute of Builders (CIOB), Chamber of Construction Industry Sri Lanka (CCI) constantly advices to improve the quality of the projects*'. Hence, RA-1, RC-2 and RD-1 highlighted the importance of getting accreditations from recognised authorities and institutions. Moreover, increasing public awareness about SMEs was highlighted as another opportunity for construction SMEs by many respondents.

5.3.4 Threats

The analysis of threats identified for construction SMEs with case study references are given in Appendix 7. The findings revealed that the cost of hiring trainers/experts is excessively high for the construction SMEs, although they are available in the field. Difficulties in access to finance sources and significant increase of energy cost are some of the constant threats in the industry for both construction SMEs as well as large construction organisations. Yet, high costs of construction including the high cost of labour, material, and equipment, hidden cost (back up, problem-solving and solutions) were added by all respondents as a constant issue for construction SMEs. As highlighted by RD-1, '*although government provides funding for construction*

SMEs at low interest rates, availability of funds and competitiveness in obtaining them is problematic for construction SMEs'.

Construction SMEs faced problems due to unavailability and quality of equipment and material used for their projects. Moreover, RA-1 highlighted that '*availability of skilled workers and migration of them to neighbouring countries as a massive threat to the success of the organisations*'. Furthermore, as noted by RB-2, new construction technologies replace the human works and hence, large construction companies tend to invest in new technologies rather sub-contracting.

RD-1 stated that '*in some instances, even though we are eligible to get the job, we don't get the job due to the corruption in the industry*'. Hence, there is a high impact for construction SMEs due to corruption in the industry. Undoubtedly, all respondents agreed that, due to the monopoly created by large construction companies, there is a deficiency in the construction industry. Hence, to retain in the marketplace, construction SMEs have to face a huge competition. This is marked as the prevalent threat for construction SMEs as per the views of the respondents. Moreover, unfavourable weather conditions and changing environment negatively influences the success of construction SMEs in Sri Lanka.

Accordingly, all of the respondents from the case study organisations clearly stated the weaknesses and threats in the construction industry. Moreover, the respondents highly emphasised the challenges they are facing due to these threats and weaknesses. However, they identified limited number of strengths and opportunities of being a construction SME. This was proven by a Managing Director (RC-1) of CA-A, by stating '*we have lot more problems to be addressed than spending the time to enjoy the benefits that can be gained by being a SME in this sector'.* Conferring to Koskela et al. (2014), the conventional systems used in the industry pursue the 'task' of project completion, however, neglect minimisation of non-value addition and maximisation of value. Thus, identification of these NVAA and finding root causes for their NVAA will be the starting point of lean implementation journey for construction SMEs. Therefore, the next section discusses the NVAA identified for construction SMEs in Sri Lanka.

5.4 Non-Value Adding Activities in Construction SMEs

The different types of wastes summarised by a review in Table 2.5 were used to investigate the NVAA and the root causes for those NVAA in construction SMEs using question 3 of the interview guideline developed for EIR-1 (Refer Appendix 2). According to Tommelein et al. (2015), there is a need to continuously ask '*why*' to find the root cause of a problem. Therefore, during EIR-1, the researcher used 5-Whys analysis to identify the root causes behind the eight types of NVAA in their projects and the findings are discussed below. Each identified NVAA and the causes identified during EIR-1 are presented with (X/Y) values as per the example given in Figure 5.2.

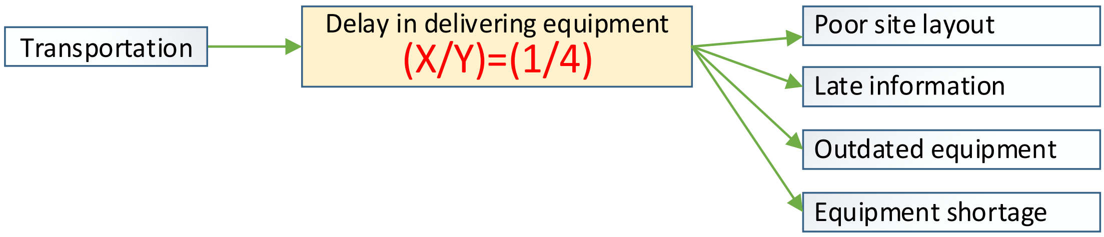


Figure 5.2: Example of presentation of NVAA and causes

In the above figure, X represents the number of effects (incoming arrows) each NVAA is responsible for and Y represents the number of causes (outgoing arrows) created by each cause, in order to identify the significance. The following sections discuss the causes and effects of NVAA in construction SMEs based on 5-Whys analysis. Accordingly, 5-Whys analysis was prepared for all NVAA in construction SMEs using a Sunkey diagram as presented in Figure 5.3. It shows all the interconnections and the interdependencies between NVAA and their causes in construction SMEs. However, the developed sunkey diagram was redrawing using Microsoft Visio to increase the readability of the 5-Whys analysis as presented in Figure 5.4.

Refer Appendices 8 to 11 for further details on developed 5-Whys analysis for construction SMEs.

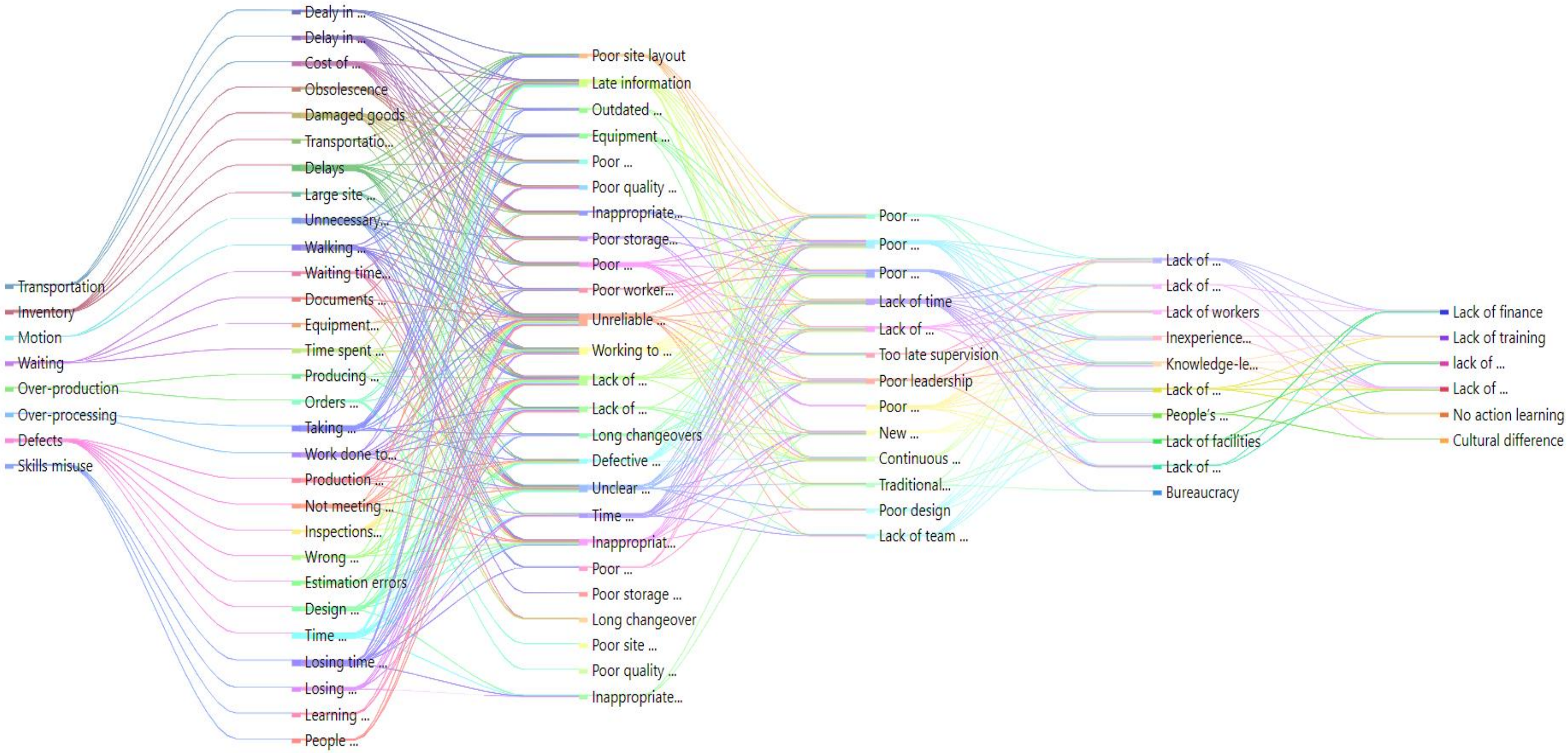


Figure 5.3: Sunkey diagram developed for 5-Whys analysis for NVAA in construction SMEs

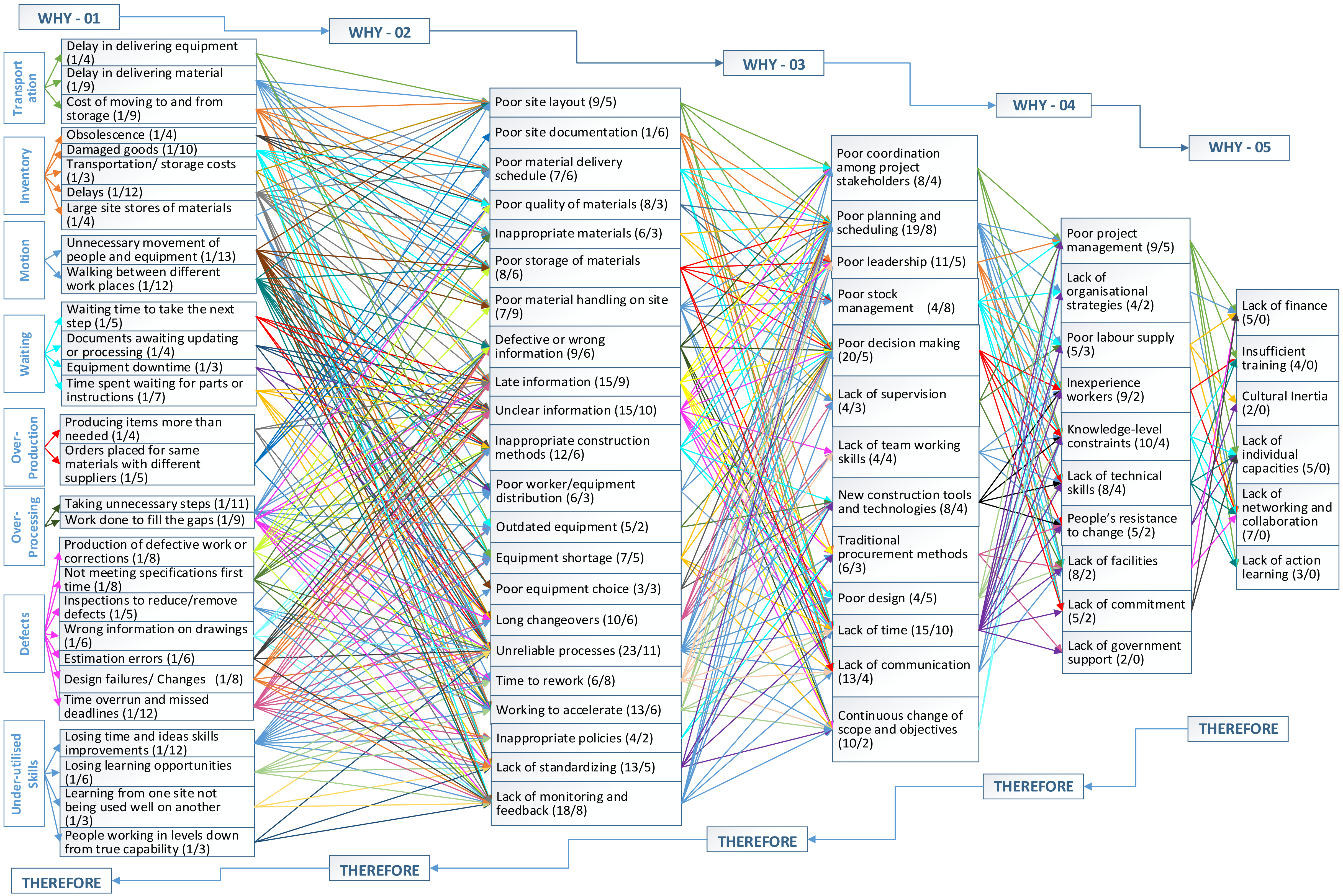


Figure 5.4: 5-Whys analysis for NVAA in construction projects of SMEs

5.4.1 WHY 1

Literature identified eight main categories of NVAA in a construction project as transportation, inventory, motion, waiting, over production, over processing, defects and under-utilised human skills (refer Section 2.6.2). During the semi-structured interviews, the researcher asked the respondents to identify the first level causes (Why 1) behind eight types of wastes. Accordingly, findings of the case studies identified 29 causes that can be attributed to the eight types of NVAA in projects of construction SMEs. Refer Appendix 8 for further details.

As per the findings, inventory, waiting, defects and under-utilised human skills considered as the most significant types of NVAA in construction SMEs, as they have 5, 4, 7 and 4 numbers of outgoing arrows respectively. NVAA due to defects was considered as significant by both senior and middle management as it directly affects both cost and time of the project. Getting the employees to reach their full potential at work under stressful conditions is a tough challenge (Dobre, 2013). Similarly, RA-1, RB-2 and RC-1 emphasized that people who are working one or two levels below their true capability leads to the waste of skills utilisation. Although senior management has thoroughly emphasized that learning from one site being used well on another, participants of the focus group discussion (FA-1, FA-2, FA-3, FC-1, FC-2, and FE-1) disagree on this regard. Moreover, FC-1 mentioned that they are losing learning opportunities due to high workload.

According to RA-1, RB-1 and RC-1, neither over production nor over processing has been a major issue for construction SMEs. However, the analysis of project documents revealed the evidences for over production and over processing in all projects. Yet, RA-1 and RB-1 have not been clearly identified them as NVAA. Nevertheless, the research findings accentuated case CA-A as the company with the highest lean maturity which has less NVAA. Case CA-E was identified as the company with least lean maturity where the employees themselves unaware of the steps involve in the processes and thus majority of NVAA can be identified in the projects. However, the presented data is not sufficient to provide justification for the lean maturity as it involves further studies. Consequently, most significant causes were the factors which responsible for more NVAA in the project (large number of outgoing arrows as per Figure 5.4). Correspondingly, the research identified delay in delivering material (9), cost of moving to and from storage (9), unnecessary movement of people and equipment (13), walking between different work places (12), taking unnecessary steps (11), work done to fill the gaps (9), not meeting specifications first time (8), time overrun and missed deadlines (12) and losing time and skills improvements (12) as the main causes. In the next step (WHY 2), the reasons for these causes were explored.

5.4.2 WHY 2

The above identified 29 causes of NVAA can be attributed to individually or in combination of 22 factors. Refer Appendix 9 for further details.

Out of the 22 factors identified, 10 factors; poor site layout (9), defective or wrong information (9), late information (15), unclear information (15), inappropriate construction methods (12), long changeovers (10), unreliable processes (23), working to accelerate (13), lack of standardizing (13) and lack of monitoring and feedback (18) considered as the noteworthy causes for 'WHY 2'. As construction SMEs are limited to small projects or subcontracting projects of large organisations, they need to wait for information, resulting in significant NVAA. Correspondingly, the pressure caused by large organisations compels SMEs to accelerate their work, which lead to generate more NVAA. This was further highlighted by FA-3 stating, '*senior management thinks we can do everything within few days…we are not machines, but humans, so we will not be able to work at this speed...there will be mistakes definitely*'. Thus, FE-1 and FC-1 too agreed highlighting that accelerating work without an appropriate plan, will lead to many NVAA in the projects. The respondents emphasized that long changeovers is another reason for them to accelerate other steps. Correspondingly, it is found during the PRC-1, that '*a sudden breakdown of one of the computers at site office of CA-A, has delayed the office works for more than two weeks'.* Thus, long changeovers in the projects need to be overcome.

Lack of standardising, monitoring and feedback within SME organisations has worsened the situation. Use of inappropriate construction methods was identified as another significant cause as part of 'WHY 2'. Thus RA-1, RB-1 and RC-2 stated that, use of traditional methods will turn out the processes to be unreliable. Out of the 22 causing factors, most significant causes were poor material handling on site (9), late information (9), unclear information (10), unreliable processes (11), and lack of monitoring and feedback (8). Causes for these factors were examined during the next stage (WHY 3) of the overall analysis.

5.4.3 WHY 3

The identified causes for '*Why 2*' above were further questioned to investigate the next level causes. Refer Appendix 10 for further details.

Accordingly, most of the factors to answer 'WHY 3' were caused by poor planning and scheduling (19), poor decision making (20), poor leadership (11), lack of time (15), lack of communication (13). There, the respondents stressed the need of improving skills of individuals in the construction SMEs. Moreover, RC-1 and RD-1 stated that '*lack of time due to high work load has created additional NVAA within the construction SMEs*'. On the other hand, RA-1, RC-2 and RC-3 identified continuous change of scope and objectives (10) as another key cause for NVAA within construction SMEs. Coincidently, this was further proven in the PRA-1 and PRC-3 meetings where the client was responsible for the scope changes of the projects. Thus, RC-2 insisted the '*need of involving client during the design stage to minimise the NVAA occurred in latter stages of the project*'. This emphasised the need of client's values as the main focus of the project. Similarly, practicing of traditional procurement methods has restricted the involvement of contractor to the design stage. As stated by RA-1, '*we are the one who make the final constructions, not the consultant…he is just giving the instruction without getting our concerns on build-ability and other related problems in the construction site*'. Therefore, many respondents insisted the need of getting the contractor involvement from the beginning of the project to minimise NVAA.

Further, the respondents have added poor coordination among project stakeholders, poor stock management, late supervision, lack of team working skills, and poor design to this list of causes. These causes can be easily minimised through implementing basic lean tools within the organisation by improving the flow of activities. However, at this stage, most of the respondents (RA-1, RA-2, RC-1, RC-2 RD-1, and RE-1) undoubtedly agreed and RA-2 stated that '*most of the construction SMEs used out-dated tools and equipment'*. Further, during the focus group discussions, FA-1 stated '*…even though there are new construction methods available in the construction industry (Ex: use of machines for plastering), we can work better than those machineries*', highlighting their preference to use the traditional methods of constructions. Therefore, the construction SMEs are following conventional construction methods rather updating with the state-of-the-art technologies in the construction industry which in turn leading to many NVAA.

Yet, out of the 13 factors identified during the empirical study, the noteworthy causes are the lack of time (10) and, poor planning and scheduling (8), which has more causes as depicted in Figure 5.4. Therefore, the study further questioned 'why' during the next phase to identify the root causes.

5.4.4 WHY 4

The researcher further questioned and continued the 5-Whys analysis. Refer Appendix 11 for further details.

The respondents in particular the middle management (RB-4, RC-3 and RD-2), emphasized that lack of operative project management skills and methodology (9) and lack of organisational strategies (4) as the main causes to answer 'WHY 4'. As confirmed by RC-3, '*the senior management need to take strategic decisions to overcome the problems such as poor design, poor leadership, poor stock management, lack of team working, etc.*'. Similarly, many respondents (RA-1, RA-2, RB-1, RC-2, FA-1 and FC-2) claimed that knowledge level constraints (10) of the individuals of the construction SMEs further producing most of the problems. This fact was further confirmed during the PRA-2 and PRC-4. When senior management discussed about the cash flow of the project, Technical Officers show neither an interest nor necessity to even to discuss and provide their suggestions. Similarly, RC-1 stated that, '*it is very difficult to convince something to shop floor level workers due to the knowledge level differences'*. Therefore, lack of technical skills (8) was highlighted by many of the respondents emphasising the need of improving technical skills of individuals in the construction SMEs, which is relevant to both senior management to shop floor level workers. Nevertheless, senior management contended that lack of workers (5) and inexperience workers (9) were constant issues for construction SMEs due to the lack of human resources in the construction industry.

According to RD-2, '*our workers don't like to change from the work they are currently doing. If we try to assign new tasks for them, they will go out of our organisation*'. This is mainly due to the fact that, change in organisation will highlight the weaknesses of the individuals. However, the construction SMEs need to find ways to change the mind set of people emphasising the people's resistance to change (5) as a significant cause to answer 'WHY 4'. Therefore, converting to a no blame culture by construction SMEs will reduce many NVAA in the construction SMEs. Moreover, lack of commitment (5) of individuals will further affect to reduce NVAA.

Most of the respondents (RA-1, RA-3, RD-2, RC-1, RC-2, FA-1, FA-3 and FC-2) claimed that the lack of facilities (8) as a major cause for most of the NVAA. RA-3 stated that, '*not like large construction organisations, we don't have enough resources and facilities at the project levels*'. Correspondingly, RC-2 voiced, '*availability of state-of-the-art technologies in the project level will reduce most of the problems such as waiting, defects and inventory in construction projects*'. Therefore, a considerable attention is required to provide at least the basic facilities for construction SMEs to reduce their NVAA. Nevertheless, the respondents claimed bureaucracy (2) as an uncontrollable cause for the above listed causes. Therefore, external environment needs to support the construction SMEs to reduce NVAA. Consequently, there is a need to analyse the reasons for these identified causes.

Accordingly, knowledge-level constraints (4), lack of technically skilled workers (4) and lack of effective project management methodology (5) were the most significant causes, which required more attention from construction SMEs.

5.4.5 WHY 5

The interviews were further continued and the root causes (fifth level causes) identified for the NVAA. Refer Appendix 11 for further details.

According to research findings, lack of finance (5), insufficient training (4), cultural inertia (2), lack of individual capacities (5), lack of networking and collaboration (7) and lack of action learning (3) were identified as the root causes at the end of 5-Whys analysis. Networking and collaboration will offer construction SMEs the opportunity to learn new trends and technologies in the construction market and get expert opinions to overcome NVAA in their construction organisations. However, unlike large construction organisations, construction SMEs '***lack capacities in networking and collaboration'***, which caused the most significant root cause for majority of NVAAs. This was further confirmed by RD-1 who is also a Director in a large contracting organisation. RD-1 mentioned that, '*our mother organisation (large contracting organisation - CIDA grade CS2) allow workers to attend conferences and sometimes we collaboratively carried out few researchers specially on pre-cast construction from which every-body can share the knowledge with one another. Yet, being a SME, we cannot do so. No enough capacities. No time, no money, no staff to carry out the works at the site'.* Therefore, the workers neglected the opportunity to learn from others in the same field and get corrected the mistakes done by them which can be countered as NVAA.

Nevertheless, Respondents from CA-A, CA-B, CA-C and CA-D undoubtedly agreed '***lack of finance***' as the main reason for most of the NVAA of their organisations. They highlighted that, if they have enough money, they can send the workers to get a good training to improve the workforce of the organisation. Correspondingly, '***insufficient training***' and '***lack of individual capacities***' were identified as another two root causes for NVAA of construction SMEs. As per Table 2.3, annual turnover of the organisations was barely managed for the precedence year. This was proven through the documents (annual report of the company) reviewed during the data collection process. Thus, no extra money allocated for the training of individuals. However, the researcher observed some leaflets on training workshop conducted by CIDA pasted on the notice board of a project. This was proven that, though, the organisations lack money, they tried to encourage the workers to get sufficient training. However, the workers were reluctant to attend the workshops. This was clearly proven during the focus group interviews had with the workers. FA-1 stated that '*the senior management is not caring about our-selves, sometimes sending emails to attend workshop. But we have to make the payment'*. Similarly, FE-2 stated that, *'Do you really think that we have enough money and time to attend the training programs?*' Undoubtedly, most of the participants of the focus group agreed to this. Yet, the workers realised that they are far below the required capacities to carry out the works. FC-1 noted, '*time and money is the biggest problem we have. Organisations neither give a good salary, nor a good time to rest with our family. So of course, there will be problems with our works even we don't have time to try our selves when there is a problem*'. Therefore, most of the NVAA rooted to '***lack of action learning***' among workers of construction SMEs. Action learning among workers is paramount to be succeeded in lean implementation. Yet, encouragement given for action learning among workers by senior management is very rare to be seen.

Nevertheless, the researcher realised that '***cultural inertia***' is another root cause among workers for NVAA. Most of the workers in SMEs show their reluctance to change. They believed that, use of new technologies and tools will make them downgraded in front of the others. On the other hand, most of the workers practiced only one or two activities for a considerable time period. Thus, they hesitate to change the work that carried out by them. RD-2 stated that '*we tried to exchange the works of each other. But they came with their union leaders to oppose our initiations. So we don't need any more troubles as we have quiet lot to be taken care of being a construction SME*'. Therefore, most of the participants undeniably agreed to change the way people think to minimise the NVAA in construction SMEs.

Serpell et al. (1995) mentioned that the NVAA can be occurred due to controllable and uncontrollable root causes. Correspondingly some of the listed root causes are controllable, where as some are uncontrollable. Most of the SMEs take no notice of NVAA arising due to preventable internal causes; hence miss the opportunity to reduce the cost of the project. The main uncontrollable cause is the cultural inertia when comparing to other lean implemented countries. People resist changing their attitudes towards construction due to cultural inertia. However, appropriate change management strategies have the potential to address the above-mentioned cultural inertia. All other listed root causes are controllable.

The causes identified under 'Why 3', 'Why 4' and 'Why 5' collectively can be considered as the major causes for construction SMEs in Sri Lanka and should inform the development of capacities necessary for an organisation to implement lean**.** Hence, construction SMEs in Sri Lanka require identifying the gaps in their organisations' capacities to reduce NVAA. Therefore, efforts towards capacity building for construction SMEs are an important step to overcome the NVAA. As per the findings of Bajjou and Chafi (2020), the noteworthy NVAA categories for the construction industry are delays, rework, unused employee creativity, long approval process, and waiting. However, the analysis depicted that the notable NVAA categories for Sri Lankan construction SMEs are inventory, waiting, defects and under-utilised skills.

Nevertheless, identification of current level of lean implementation is paramount in deciding the required lean capacities. Thus, the next section discusses the level of lean implementation in Sri Lanka.

5.5 Lean Tool Implementation in Construction SMEs

Lean tool and techniques can be defined as a method or activity that fulfils the requirements of minimising NVAA and/or maximising value through continuous improvement. This section mainly focuses on investigating the respondent's knowledge and understanding of lean concept and tools (refer Appendix 2). Respondents gave a range of answers to the question '*What is lean*?' Chairman of

CA-D organisation (RD-1) mentioned that *'Lean is basically what you only do, the essential and effective processes we keep it in house. And the rest we do with minimum wastage, value engineering and minimum environmental foot print'*. The respondent has a general idea of the essence of lean as he confirmed a participation of workshop on TPS. A Managing Director of CA-C (RC-1) stated, '*Lean means JIT. That's how you tell. Isn't it? That (JIT) need to be going from hand in hand'*. In a similar note, RD-2 too identified lean as a set of tools and highlighted the JIT as one of the main tools for lean implementation. On the other hand, highlighting the benefits of lean construction, RB-1 stated that '*I don't know the exact definition for lean, but it is a process improvement methodology…you can include them in your projects to make the processes more efficient'*. Similarly, RC-2, RD-3, RE-1 referred to lean as a method to increase the efficiency and productivity of the construction project. Therefore, it was confirmed that respondents' awareness on lean is at diverse levels.

Moreover, by highlighting the benefits of lean construction to SMEs, RD-1 stated, '*lean is a good path to motivate foreign investors to invest in Sri Lankan construction sector and to work with local contractors and consultants as it minimises the waste of resources'*. Nevertheless, RC-1, RC-2 and RA-1 agreed with RD-1 further emphasized the reduction of project risk for all stakeholders. Therefore, RC-2 added that, the contractors get further opportunities to stabilise their cash flow through lean method implementation. RA-1 stated that, '*our quality of product is good, however there is a need to increase the quality through application of new methodologies...As we are experiencing high overhead cost, there is a need to reduce it through application of this kind of a concept'*. Most of the respondents indicated that lean implementation has a direct contribution to reduce NVAA. Similarly, RB-2 stated, '*we are putting our efforts towards minimising the non-value-adding activities'*. In addition to that, RA-3, RB-2 and RE-1 added, increase constructability, increase quality of the project as some of the outcomes gain through the lean tool implementation in Sri Lankan construction industry. However, the way RA-1 introduced lean stands out most of all other definitions. RA-1 defined, '*from the construction industry point of view, lean is all about trying to bring a fragmented* *industry together… through lean tool implementation'*. Therefore, this shows the people's epistemological stance on lean construction. Hence, it is evident that most of the respondents believe lean as a specific tool and not as a philosophy.

The researcher further investigated about the awareness of respondents on lean tools and techniques. Thus, question 5 of the interview guideline focuses on the awareness and implementation of lean tools and techniques among the construction SMEs. The researcher used the attached glossary of the lean tools and techniques (refer Appendix 2) to discuss the identified lean tools and techniques during the literature review.

For the question "What is your level of understanding of the following tools and techniques?", respondents were given answers as '*we have no understanding/ slight understanding/ good understanding/ average understanding/ modified understanding about specified lean tools'*. Therefore, the data were categorised into five sections as '*no understanding, slight understanding, average understanding, moderate understanding and good understanding'* to present the findings. As discussed in methodology Section 4.10.5, Bianco et al. (2014) proposed to use of colour for encoding information to greatly improve the observer's understanding of the information depicted by image and his/her capacity for remembering it. Bianco, et al (2014) further added colour is pre-attentively observable and hence makes it particularly effective in coding qualitative information. Accordingly, the data were presented using a colour code as given in Figure 5.5.

No understanding	Slight understanding	Average understanding	Moderate understanding	Good understanding

No implementation	Slightly implemented	Average Implementation	Moderately implemented	Highly implemented

Figure 5.5: Colour coding used to present lean tools and techniques

Table 5.6 presents the level of understanding of lean tools and techniques by respondents and Table 5.7 presents the level of implementation in their sites and organisations.

Table 5.6: Level of understanding of lean tools and techniques by construction SMEs

Tool	Level of Understanding					Tool	Level of Understanding					Tool	Level of Understanding				
	A	B	C	D	E		A	B	C	D	E		A	B	C	D	E
Eight wastes identification						Supplier involvement in design						Daily schedule adherence					
Value Identification						Customer involvement in						Long term contract					
Kaizen						Simplicity						"Error proof" equipment					
Continuous Flow						Total Quality Management						Small lot size					
Cellular manufacturing						Total productive maintenance						Continuous flow					
U-shape line						Preventive Maintenance						Time Based Competition					
Just in Time (JIT)						Work standardization						Integrated project Delivery					
Kanban						JIDOKA/ Automation						Building Information					
Single piece flow						Heijunka – Production						SMART Goals					
5S						Synchronize/Line Balancing						Quality Function Development					
Visual management						Work Structuring						Statistical Process Control					
A3 problem solving						Multi-Process Handling						Nemawashi					
Fishbone analysis/ Ishikawa						Power NAP – Japanese						HoshinKanri/Policy					
5W & 2H						Poka Yoke						Balance Score card System					
Plan–do–check-act (PDCA)						Setup time reduction						Reverse-phase scheduling					
DMAIC model						First Run Studies						Choosing by Advantage (CBA)					
LAMDA model						Time and Motion Study						Target Value Design					
Lean Six Sigma						Bottleneck Analysis						Design 3P					
Process mapping						Gemba walk						Pull Planning					
SMED						Genchi Genbutsu						Takt-Time Planning					
Last Planner system						Andon						Check Sheet					
Value Stream Mapping						OEE						Pareto Analysis					
Root Cause Analysis (RCA)						Rules of release						Check Points and Control					
Takt Time calculation						Spaghetti Chart						Failure Mode and Effects					
FIFO inventory						Target value design						Value Engineering					
Concurrent Engineering						Milk man course						Daily meetings					
Step change/ kaikaku						Global 8D						Worker Participation					
Supplier development						ChakuChaku						Suggestion box					
Supplier base reduction						Team Work						Feedback box					
Jishuken						Cross functional teams						Whats app / any other app					
Workforce commitment						Training						Coaching KATA					

Table 5.7: Level of implementation of lean tools and techniques by construction SMEs

Tool	Level of Implementation					Tool	Level of Implementation					Tool	Level of Implementation				
	A	B	C	D	E		A	B	C	D	E		A	B	C	D	E
Eight wastes identification						Supplier involvement in design						Daily schedule adherence					
Value Identification						Customer involvement in design						Long term contract					
Kaizen						Simplicity						“Error proof” equipment					
Continuous Flow						Total Quality Management						Small lot size					
Cellular manufacturing						Total productive maintenance						Continuous flow					
U-shape line						Preventive Maintenance						Time Based Competition					
Just in Time (JIT)						Work standardization						Integrated project Delivery					
Kanban						JIDOKA/ Automation						Building Information modelling					
Single piece flow						Heijunka – Production levelling						SMART Goals					
5S						Synchronize/Line Balancing						Quality Function Development					
Visual management						Work Structuring						Statistical Process Control					
A3 problem solving						Multi-Process Handling						Nemawashi					
Fishbone analysis/ Ishikawa						Power NAP – Japanese						HoshinKanri/Policy deployment					
5W & 2H						Poka Yoke						Balance Score card System					
Plan–do–check-act (PDCA)						Setup time reduction						Reverse-phase scheduling					
DMAIC model						First Run Studies						Choosing by Advantage (CBA)					
LAMDA model						Time and Motion Study						Target Value Design					
Lean Six Sigma						Bottleneck Analysis						Design 3P					
Process mapping						Gemba walk						Pull Planning					
SMED						Genchi Genbutsu						Takt-Time Planning					
Last Planner system						Andon						Check Sheet					
Value Stream Mapping						OEE						Pareto Analysis					
Root Cause Analysis (RCA)						Rules of release						Check Points and Control Points					
Takt Time calculation						Spaghetti Chart						Failure Mode and Effects Analysis					
FIFO inventory management						Target value design						Fail Safe for Quality					
Concurrent Engineering						Milk man course						Daily meetings					
Step change/ kaikaku						Global 8D						Worker Participation					
Supplier development						ChakuChaku						Suggestion box					
Supplier base reduction						Team Work						Feedback box					
Jishuken						Cross functional teams						Whats app / any other app					
Workforce commitment						Training						Coaching KATA					

Table 5.6 presents the respondents understanding on the areas of lean tools and techniques. Accordingly, RA-1, RB-1, RC-2, RD-1 and RD-2 have quite well understood on 5S, value engineering, team working, training, daily meetings and check sheets. However, majority of construction SMEs are unaware of the tools and techniques available in the industry. RA-2 noted that, '*some of these names are not familiar to us. But we are practicing them at the site*'. Thus, some of the techniques listed above are followed by them in ad-hoc manner without knowing the technical term and benefits that can be gained through the implementation. Considering Table 5.6 even though they have a good understanding on some of the tools, poor implementation can be seen. When the researcher questioned about implementation of 5S, RD-1 stated that '*Yes, we are following 5S. It is a pre requisite for most of the projects. So, we have to follow them even though we don't want to spend time on it. We have lot more works to be carried out rather wasting our time on cleaning the sites'.* This statement clearly shows the current understanding of project participants and their views with respect to the implementation. This is similar to most of the respondents. They believe that the implementation of lean is a waste of time as well as costly. This demonstrates the poor understanding of benefits of lean construction within the construction SME sector.

Even though Last Planner with Planned Percentage Complete (PPC) is the most popular lean construction tool widely used by other countries, none of the respondents were aware of the method. However, during the PRA-1, PRC-3 and PRC- 6, the participants were discussing about '*Master plan of the project'* prepared using MS Project. This is the "*phase scheduling stage*" as discussed in the last planner method. All other stages of last planner methods are not practiced by construction SMEs.

When the researcher asked about the Gemba walk, RA-2, RC-1 and RA-3 mentioned that *'What is that, can you please tell us again?'* Alike, RB-3, RC-3 and RD-2 stated 'w*e never have heard about that technique'.* Similarly, many of the listed techniques in the table were alien to most of the respondents. Particularly when asking about the Japanese words like, Kaikaku, Jidoka, Heijunka, Poka Yoke, HoshinKanri, Jishuken, they directly replied as '*no'* without even uttering any further justifications. However, the researcher tried explaining the meaning behind most of the tools and techniques. Subsequently, most of the respondents including RA-1, RA-2, RB-2, RB-3, RD-1, RD-2 and RC-1 agreed to partial implementation of them within their organisations. Therefore, it can be evident that many tools have been implemented in an ad-hoc manner within the construction SMEs.

As suggested by Ankomah et al. (2017), Building Information Modelling (BIM) is still at the partial implementation stage for construction SMEs. In Sri Lankan construction industry, BIM is still at the infant stage. RD-1 said that '*Yes, we have implemented BIM in our mother company, but it is limited to Revit implementation in one project. For that project also mother-company had to hire an expert from Japan. The total cost allocated for that implementation is very high. So as C4 company, we are not in a position to allocate that much of money for new addition.* Hence, even large construction organisations in Sri Lanka have not fully implemented BIM for their projects due to high investment cost and lack of expertise in Sri Lanka. Therefore, implementation of BIM is too far for construction SMEs in Sri Lanka.

Even though Arroyo, Tommelein and Ballard (2015) discussed the immense benefits that can be gained by using Choosing by Advantage (CBA) (refer Section 2.11.1), none of the respondents aware about this method. However, when the researcher discussed about the method, RA-1, RC-1 and RA-2 mentioned that they rarely follow '*cost benefit analyses'* instead of Choosing by Advantage. However, this clearly shows that SMEs concern only on cost and neglecting all other factors (As discussed in Section 2.11.5). Therefore, construction SMEs have less awareness in the area of applicable lean tools and techniques for their organisations.

Even though workforce training is conducted within the organisations, there is a lack of going forward beyond the specified norms by the government. When it comes to small sized contracting firms, they even are not fulfilling the legislated training requirement. Therefore, they always stagnated within the same capacity without having a capacity enhancement. Similarly, the implementation of most tools and techniques are limited to contract documents and inspections. This was proven by the statement of RC-2, '*there is a need to show the training programs conducted by us for our employees. 5S is a pre-requisite. However, we are not in a position to allocate neither money nor time for training programs. But we have mentioned in the project documents we are providing everything. Otherwise, it will be difficult to renew the memberships of many organisations. If they are coming for inspections, we are cleaning the sites and properly arranging everything to show off'.* Thus, mind sets of the people needs to be changed to enable lean in an organisation in the first instance.

Even though, many respondents have the awareness on eight NVAA, lack of initiations can be seen with regards to the implementation. Correspondingly, value is limited at project document stage only. Nevertheless, as presented in Table 5.7, most of the popular lean techniques have not implemented in the projects done by construction SMEs in Sri Lanka.

However, as discussed in the lean lexicon, suggestion box or feedback box is essential for any organisation particularly to get the ideas from bottom-line work force. Yet, most of the workers fear of giveaway their suggestions directly to the senior management. Hence, many respondents agreed to have a suggestion box on site. However, RC-1 stated 't*here is no point of keeping a suggestion box in the site. Most of our labourers cannot read or write properly. Also, they don't have a proper idea on what to do. They just follow up the instructions given'.* Similarly, another respondent from Case D noted *'It is a waste of allocating money for even a box. My workers will not spend their time on giving suggestions for improvements'.* This statement clearly demonstrated the poor understanding of labours with regards to the benefits that can be gained by implementing lean tools and techniques. Furthermore, senior management too hesitate to spend their time and additional money for lean implementation. However, some SMEs have their own ways of getting workers involve in decision making such as suggestion box and giving responsibilities to work by them-selves.

The construction industry professionals practice their own ways of identifying the NVAA by using customised methods. As mentioned by RB-1, RC-1 and RA-2, they are using WhatsApp for visual management within the site it-self. Nevertheless, the implementation of lean tools and techniques in construction SMEs are still at the infancy stage.

Even though some construction SMEs portrayed a good understanding on certain lean tools, lack of efforts have been taken for implementation. Accordingly, they had quite well understanding on basic lean tools such as 5S, value engineering, team working, training, daily meetings and check sheets. The findings further confirmed that some of the techniques are followed by them in ad-hoc manner without realisation of the benefits that can be gained through the implementation. Thus, incorrect implementation leads to create many other NVAA among the construction SMEs. Conversely, the findings emphasised that majority of construction SMEs are unaware of lean tools and techniques available in the industry. The analysis has clearly shown that, very few numbers of professionals have their own ways of identifying the NVAA by using customised methods where use of WhatsApp for visual management within the sites was well acknowledged by the researcher. Yet, the time spent to customise a tool for minimising NVAA was limited to projects documents of the majority of construction SMEs.

5.6 Discussion of Findings – Empirical Investigation 1 (EIR-1)

The overall discussion on findings of EIR-1 is presented below.

5.6.1 Discussion on SWOT analysis of construction SMEs

Construction SMEs are seen as playing a crucial role in the economy in terms of creating jobs contributing to economic growth and stability, still, keep one step below the large construction companies. Therefore, analysis of construction SMEs is vital for successful lean implementation. Choice and use of strategic planning tools and techniques in SMEs by Kalkan and Bozkurt (2013) praised about the simplicity and practicality of SWOT analysis when comparing to other strategic planning tools. Gürel and Tat (2017) further added that SWOT as a valuable management tool, which may be easily absorbed with good effect into the realities and practicalities of an organisation's existing planning and strategy formulation processes. Therefore, use of SWOT analysis portraits the current situation of Sri Lankan construction SMEs. Accordingly, EIR-1 revealed 12 strengths, 12 opportunities, 24 weaknesses and 20 threats pertaining to construction SMEs in Sri Lanka.

Out of the identified strengths, small number of workers and flexible cash flows considered as the highly noted factors for construction SMEs. Similarly, Windapo et al. (2020), Deyshappriya and Maduwanthi (2020), Ravindra (2019), Berisha and Pula (2015), and many more researchers agreed the flexibility of SMEs due to small number of workers in the organisations. As construction SMEs are working on small and medium scale projects, there is flexibility in the cash flows. However, unlike large contracting organisations, very few number of construction SMEs is benefitted from the flexibility of cash flow.

Moreover, EIR-1 noted low interest rates for projects, availability of training programmes for SMEs and increasing public awareness about SMEs as important opportunities available for construction SMEs in Sri Lanka. As highlighted by Kapugamage and Gajanayaka (2020), even though there are low interest rates for SMEs in Sri Lanka, obtaining them required a lengthy documentation process.

As stated by Ofori and Toor (2012) and Barrett and Sexton (2003), lack of cost controlling techniques, design failures and time overrun are perpetual weaknesses of construction SMEs in any country. Similarly, EIR-1 confirmed them as highly noted weaknesses of Sri Lankan construction SMEs, which need to be overcome through strategic planning. Moreover, EIR-1 added lack of qualified professionals, lack of resources, lack of strategic leadership and limited networking as further noteworthy weaknesses of construction SMEs. Moreover, Ankomah et al. (2019) and Avelar et al. (2019) stated the need of overcoming organisational weaknesses by construction SMEs for successful lean implementation. Therefore, these weaknesses need to be considered in the developing lean enabling capacity building strategies for construction SMEs.

Most of the SMEs in developing countries highlighted access to finance as a major constraint (Ankomah et al., 2020; Kululanga, et al., 2015; Awa et al., 2015; Dalberg, 2011). Many researchers including Ravindra (2019) and Athukorala (2017) stressed the difficulties in access to finance by Sri Lankan SMEs in manufacturing industry. Similarly, EIR-1 confirmed that, SMEs in Sri Lankan construction industry too struggling for financing their projects.

Nevertheless, high cost of labour (Rymaszewska, 2014; Ofori, & Toor, 2012), lack of skilled workers (Agwu, & Emeti, 2014; Barrett et al., 2006), instability of the political environment (Kulemeka et al., 2015), unfavourable procurement methods (Saka, & Chan, 2020), monopoly created by large organisations (Tezel et al., 2020; Kululanga, et al., 2015), lack of access to international market (Windapo et al., 2020; Bennett, 2014) and negative attitudes towards SMEs (Kissi et al., 2020; Ulubeyli et al., 2018) were confirmed in EIR-1 as the noteworthy threats for construction SMEs in Sri Lanka.

To succeed in the construction industry, weaknesses must be overcome through strength and threats must be transferred into opportunities to build up the capacities of the organisations for successful lean implementation. Next section discusses the NVAA of construction SMEs identified in EIR-1.

5.6.2 Discussion on NVAA of construction SMEs

Many researchers stressed the importance of identification of NVAA for lean implementation in the construction industry (Avelar et al., 2019; Emuze, & Saurin, 2015; Mossman, 2009; Koskela, 1992). Lean principles of Koskela (1992) further necessitate the identification of NVAA as the first step to be carried out in lean implementation. Nevertheless, identification of NVAA is very subjective as stated by the respondents during EIR-1. Thus, construction SMEs require to analyse their organisation to identify the NVAA applicable to their organisation and need to work accordingly. As mentioned by Womack and Jones (1996), Howell (1999), Oppenheim (2004) and Mossman (2009), NVAA are anything other than the minimum required for mission assurance whereas includes all inefficiencies in a system as well as causes of these inefficiencies. Therefore, not only identification of NVAA, but also there is a need to explore the root causes. As discussed in Section 4.10.5, Tommelein's (2015) 5-whys analysis was used to identify the root causes.

The developed 5-whys analysis based on the NVAA in construction SMEs in Sri Lanka identified the root causes through EIR-1. Accordingly, inventory, waiting, defects and Under-utilised human skills were identified as the most noteworthy NVAA categories by the respondents during EIR-1 (refer Section 5.4). Even though Antosz and Stadnicka (2017) stated that the most significant NVAA categories were waiting, unnecessary movements and machine failures, unnecessary movements have not marked as significant comparing to other categories. However, agreeing to Alves et al. (2012) and Bolviken et al. (2014), the researcher contended that, under-utilised human skills are common among the construction SMEs in Sri Lanka. Conversely, as suggested in Section 2.10.3 and conceptual framework (Figure 3.6), the initiation for lean implementation is to explore the NVAA in a construction SME organisation. Thus, the '5-Whys analysis' can be used to identify the NVAA relevant to SME organisation as well as the root cause particular to their NVAA. In contrast, the causes for NVAA were rooted around lack of finance, insufficient training, cultural inertia, lack of capacities of individuals, lack of networking, and collaborations and lack of action learning. Therefore, these root causes create the majority of the problems faced by the construction SMEs. According to researchers, lack of finance considered as a continuous challenge for construction SMEs (Ankomah et al., 2020; Kululanga, et al., 2015; Awa et al., 2015; Wedawatta et al., 2011; Dalberg, 2011). EIR-1 findings too confirmed that lack of finance as one of the root causes for NVAA in construction SMEs. Even in the Sri Lankan literature, Ravindra (2019) and Athukorala (2017) identified lack of finance as a major issue among SMEs in Sri Lanka. Thus, there is a necessity to identify the ways to address this root cause to minimise NVAA.

The literature further stressed that insufficient training among construction SMEs is leading to many NVAA (Ankomah et al., 2020, Kululanga, 2012). Coincidently, EIR-1 findings too emphasized lack of training as a root cause for construction SMEs in Sri Lanka. Similarly, as highlighted by Dave and Koskela (2009), majority of problems faced by construction SMEs can be overcome through good networking and collaboration within the construction industry. Therefore, literature confirmed another root cause identified for NVAA in Sri Lankan construction SMEs.

Lack of capacities of individuals is another root-cause that escalate the NVAA in construction industry according to Singh et al. (2010), Ofori and Toor (2012) and Saka and Chan (2020). Similarly, Tezel et al. (2020) highlighted lack of action learning as another reason for NVAA among construction SMEs. EIR-1 findings too established these two factors as root causes for Sri Lankan construction SMEs. Moreover, Ankomah et al. (2017) proposed action learning as a lean tool to minimise NVAA, which require less monetary investment to implement and can be fully implemented by construction SMEs. Therefore, there is a need to consider the probability to use action learning as a strategy to implement lean in construction SMEs in Sri Lanka.

According to Salem and Zimmer (2005), Diekmann et al. (2005) and Johansen and Walter (2007), culture of an organisation was inculcated in to the lean construction principles. Nevertheless, cultural inertia is a context specific root cause identified for the increase of NVAA among construction SMEs in Sri Lanka. There is lack of literature which highlighted cultural inertia as a root cause for construction SMEs. This is due to the differences in the cultural context in countries. Lean Iceberg model by Hines et al. (2008) as well as the Shingo model (Shingo, 2012) highlighted the importance of culture for successful lean implementation and need to minimise the NVAA in an organisation. Conferring to culture, Westerner's culture is differ comparing to culture in East Asia countries as clearly stated by Womack and Jones (1996) in 'Lean Thinking' and Liker (2004) in 'Toyota Way' book. Therefore, 'culture' acts as a leading role in identification of capacities and strategies for lean implementation explicit to a given context. Hence, there is a need to identify lean capacities and strategies for Sri Lankan construction SMEs by considering the Sri Lankan culture.

In terms of the employees in construction SMEs, the respondents believed that by identifying NVAA would increase the effectiveness of value-adding activities. Further, an increase of quality of the production process was identified as vital by the respondents during EIR-1. In addition, respondents highlighted that these initiatives will ultimately reduce cost of construction. The respondents further indicated that, through minimising NVAA, the construction process become shorter with reduced lead times. Thus, construction SMEs can be used this 5-whys analysis to identify their NVAA and root causes applicable for their organisation. Nevertheless, there is a need to overcome the problems by implementing lean. EIR-1 findings confirmed that, the construction SMEs in Sri Lanka are still at the infancy stage. Hence, there is a need to build up the capacities to enable lean in construction SMEs. Thus, there is a need to ascertain how the identified root causes for the NVAA can be overcome by investigating lean capacities for construction SMEs. Thus, EIR-2 will be used to investigate the lean enabling capacities and strategies to build lean enabling capacities for construction SMEs.

5.6.3 Discussion on lean tools and techniques for construction SMEs

Implementation of lean can be synonymised as implementation of lean tools by some researchers (Sarhan, & Fox 2013; Pons, 2013). Thus, a considerable attention is required to identify the available lean tools and techniques for Sri Lankan construction SMEs. EIR-1 investigated the identified 93 lean tools and techniques from literature with regard to understanding and implementation in the Sri Lankan construction SMEs. Lean practices related to customer engagement, employee involvement and productive maintenance are more prevalent among SMEs than practices related to employee involvement. By considering the employee's epistemological stance on lean construction, it is evident that most of the respondents believe lean as a specific tool and not as a philosophy. Nevertheless, by considering the working definition developed for this study, '*A method fulfilling the requirements of minimising NVAA and/or maximising value*', it is confirmed that, construction SMEs can develop their own lean tools and techniques.

Even though many researchers argued that construction SMEs lack financial capacity to implement lean tools and techniques (Antosz, & Stadnicka, 2017; Ansah, & Sorooshian, 2017; Rymaszewska, 2014; Ankomah et al., 2019), bestowing to Ankomah et al. (2018), construction SMEs too can initiate implementing them. According to the findings of Ankomah et al. (2018), SMEs can implement some lean tools, such as the Last Planner and 5S, which will not require a huge sum of money.

Researchers such as Rose et al. (2011) and Salem et al. (2005) have confirmed that tools such as 5S, Kanban cards, SMED, Kaizen, increased visualisation, Last Planner, daily huddle meetings, first-run studies, poka-yoke, and Andon are the least costly, and can be implemented by SMEs. A review of the literature on the other lean construction tools (5-Whys, concurrent engineering, Choosing by Advantages, A3 report, the Ishikawa diagram, LBMS, Heijunka and VSM) shows that these tools as not being capital-intensive, and therefore within the reach of SMEs. Hence, Sri Lanka as a developing country can initiate the lean implementation with the lean tools that require less monetary investment by construction SMEs.

Nevertheless, many of the studies highlighted that SMEs have applied 5S concept. Similarly, Antosz and Stadnicka (2017) agreed that SMEs, which have implemented the lean philosophy in Poland use mostly 5S method, which require a less monetary investment to implement. Researchers such as Ankomah et al. (2018), Rose et al. (2011) and Salem et al. (2005) have confirmed that tools such as 5S, Kanban cards, SMED, Kaizen, increased visualisation, Last Planner, daily huddle meetings, first-run studies, Poka-yoke, and Andon are the least costly, and also can be implemented by SMEs.

Nevertheless, as per EIR-1 finding, the tools given in Table 5.6 show the awareness and Table 5.7 presents the level of lean implementation. The findings clearly emphasized the less implementation of lean tools and techniques by construction SMEs in Sri Lanka. Even though they have considerable understanding on some of the lean tools and techniques, they have taken few steps with regard to implementation of tools in the construction SMEs. However, findings of EIR-1 further confirmed that, similar to other countries, some of the lean techniques are being practicing in an ad-hoc manner by the construction SMEs. Accordingly, some phases of last planner and gemba walk are practiced by Sri Lankan construction SMEs too. Nevertheless, there is a need to identify the context specific tools and techniques for Sri Lankan construction SMEs through an appropriate empirical study. Therefore, there is a need to subsequently validate these lean construction tools.

However, this research will facilitate the construction SMEs to building up the capacities to implement the specific lean tool for their organisation through EIR-2. The findings further confirmed the need of learning and good practice transfer within the industry to improve the awareness of lean tools and techniques, which need to be considered in the developing lean enabling capacity building framework.

5.7 Chapter Summary

This chapter presented findings of EIR-1 of the research study. The number of cases was limited to five with a robust process of data collection, using four data collection techniques (semi-structured interviews, focused group interviews, observations and documentation) allowing adequate data triangulation followed by ample data saturation during case analysis.

The chapter presented the current situation of Sri Lankan construction SMEs through a SWOT analysis. EIR-1 revealed 12 strengths, 12 opportunities, 24 weaknesses and 20 threats pertaining to construction SMEs in Sri Lanka. Consequently, construction SMEs can get the advantage of small number of workers, flexible cash flows, low interest rates for projects, availability of training programmes for SMEs and increasing public awareness about SMEs. Similarly, construction SMEs need to pay attention to lack of cost controlling techniques, design failures, time overrun, lack of qualified professionals, lack of resources, lack of strategic leadership and limited networking, high cost of labour, lack of skilled workers, instability of the political environment, unfavourable procurement methods and monopoly created by large organisations.

Then the chapter discussed the need of enabling lean among construction SMEs and thus presented a 5-Whys analysis for NVAA in construction SMEs in Sri Lanka. The findings demonstrated that all the NVAA categorised in literature chapter namely transportation, inventory, motion, waiting, over-production, over-processing, defects and under-utilised human skills can be identified from the activities of construction SMEs. Yet, the noteworthy categories were inventory, defects, waiting and under-utilised human skills from the studied cases, which requires consideration of causes over other categories. The causes for NVAA were rooted around insufficient training, cultural inertia, lack of capacities of individuals, lack of networking and collaborations, lack of action learning and lack of finance, which need to be minimised for successful lean implementation. Finally, the chapter discussed about the current level of lean implementation in construction SMEs in Sri Lanka by their understanding and implementation of lean tools and techniques in the case study organisations.

Accordingly, EIR-1 findings emphasised that, there is a less implementation of lean tools by construction SMEs in Sri Lanka. Even though they have considerable understanding on some of the lean tools, the implementation of them is still at the early stage where some phases of last planner and gemba walk were practicing by in an ad-hoc manner by Sri Lankan construction SMEs. The findings recommended the implementation of lean tools that are not being capital-intensive and require less monetary investment. Therefore, it will address the challenge of financing problem among Sri Lankan construction SMEs. Nevertheless, there is a need to identify the capacities and strategies required to accelerate the lean tools and techniques implementation in Sri Lankan construction SMEs.

CHAPTER 6

DEVELOPMENT OF LEAN ENABLING CAPACITY BUILDING FRAMEWORK (EIR-2)

6.1 Introduction

Chapter 6 presents the findings of EIR-2 that focused on providing answers for Objectives 3, 4 and 5 of the research. Hence, the chapter begins with a detailed introduction to EIR-2 including the profile of interviewed experts. Then the chapter discusses the findings of EIR-2, including the individual, organisational and environmental level factors limiting and driving the lean implementation. This is followed by the lean enabling capacities for construction SMEs at each level and the lean enabling capacity building strategies that can be implemented by construction SMEs at three levels. Finally, the lean enabling capacity building framework was developed and the discussions of EIR-2 outcomes are presented.

6.2 Background of EIR-2

This section starts with presenting research questions used in EIR-2 to achieve the objectives of the study. The section then presents the structure of the expert interview guideline and then provides the profile of the experts to provide an in-depth understanding about the sample of the study. The section finally presents the data analysis techniques used in EIR-2 in detail.

6.2.1 Research questions used in EIR-2

EIR-2 of the research is aimed to provide answers to following research questions:

RQ3a - What are the drivers for lean implementation in construction SMEs?
RQ3b - What are the barriers for lean implementation in construction SMEs?
RQ4 - What are the capacities required for enabling lean in construction SMEs?
RQ5 - What are the strategies for enabling lean in construction SMEs?

The above research questions were used to achieve Objectives 3, 4 and 5 of this research study.

6.2.2 Structure of the expert interview guideline

In order to find answers to the research questions, an interview guideline was prepared with six sections addressing the above aspects of the research (refer Appendix 12). The first and second sections of the interview guideline were aimed at obtaining the general information from interviewees covering the experience and qualifications of the interviewees. Drivers and barriers for lean implementation of construction SMEs were gathered through the questions in the third section of the interview guideline. Fourth and Fifth sections were focused on lean enabling capacities and capacity building strategies for construction SMEs respectively. The interview guideline was mainly focused on the development of lean enabling capacity building framework for construction SMEs.

6.2.3 Profile of the experts

The data collection technique adopted in EIR-2 is semi-structured interviews with construction industry experts, who have experience on lean implementation in SMEs in Sri Lanka. Accordingly, 24 experts were selected through purposive sampling. Interviewees included Managing Directors and Chairmen of SMEs, lean consultants, Senior Project Managers and Senior Quantity Surveyors. Table 6.1 provides the profile of interviewees.

Table 6.1: Profile of experts who involved in interviews

Code	Designation	Industry Experience
E1	Chairman	Civil engineering graduate, currently running a family business. Total 34 years in construction industry. Over 20 years up to date in SME sector. Hold positions in government and private organisations.
E2	Managing Director	Mechanical engineering graduate and a Pilot. Managing Director of a construction SME. Total 17 years in construction industry. Over 10 years up to date in SME sector.
E3	Managing Director	Quantity Surveying graduate, partnering with a construction SME. Total 22 years in construction and 10 years up to date in SME sector.
E4	Project Coordinator	Civil Engineering graduate. Total 17 years in construction industry. Over 12 years up to date in SME sector.

Code	Designation	Industry Experience
E5	Senior Technical Advisor	Civil Engineering graduate working in construction SME. Total 30 years in construction industry. Over 10 years up to date in SME sector.
E6	Project Coordinator	Engineering graduate with total 20 years' experience in construction industry. Over 10 years up to date in SME sector.
E7	Managing Director	Civil Engineering graduate, total 24 years in construction and 20 years in Construction SMEs. Currently in large construction company.
E8	Managing Director	Quantity Surveying graduate, total 20 years in construction and 20 years in Construction SMEs. Currently in large construction company.
E9	Assistant General Manager	Engineering graduate, total 28 years in construction and 18 years in Construction SMEs. Currently in large construction company.
E10	Head – Contract and Procurement	Quantity Surveying graduate currently in large construction company. Total 20 years in construction and 15 years in construction SMEs.
E11	Senior Quantity Surveyor	Quantity Surveying graduate currently in large construction company. Total 17 years in construction and 10 years in construction SMEs.
E12	Chairman	Civil Engineering graduate, total 25 years in construction and 18 years with Construction SMEs. Currently in large construction company.
E13	Managing Director	Civil Engineering graduate, total 26 years in construction and 20 years with Construction SMEs. Currently in large construction company.
E14	Managing Director	Quantity Surveying graduate, total 20 years in construction and 15 years Construction SMEs. Currently in large construction company.
E15	Chief Executive Officer	Retired Officer in Forces, currently working in a government authority for construction professionals. Total 25 years in construction and 10 years' experience in construction SMEs.
E16	Chairman	From an engineering background. Total 20 years in construction and 10 years with Construction SMEs. Currently working in a leading regulatory authority in construction.
E17	Director	From a Mechanical engineering background. Total 17 years in construction and 10 years with construction SMEs.
E18	Managing Director	From Civil Engineering background. Total 30 years in construction and 15 years with Construction SMEs. Currently working in a leading regulatory authority in construction.
E19	Head – Standard Operating Systems	Total 15 years in construction and 10 years with construction SMEs. Have 20 years' experience in advising for lean implementation in construction and manufacturing organisations.
E20	Senior Executive	From a Mechanical engineering background. Total 17 years in construction and 10 years with construction SMEs. Have 07 years' experience in advising for lean implementation in construction and manufacturing organisation.
E21	Senior Professor	From Civil engineering background. Total 32 years in construction and 05 years with construction SMEs. Have 20 years' experience in advising for lean implementation in construction organisations.
E22	Operational Manager	From Mechanical engineering background. Total 18 years in construction and 10 years with construction SMEs. Have 12 years' experience in advising for lean implementation in construction and manufacturing organisations.
E23	Managing Director	From Civil engineering background. Total 20 years in construction and 10 years with construction SMEs. Have 15 years' experience in advising for lean implementation in construction and manufacturing organisation.
E24	Managing Director	From Civil engineering background. Total 17 years in construction and 10 years with construction SMEs. Have 07 years' experience in advising for lean implementation in construction and manufacturing organisation.

The above experts were selected based on their lean awareness and experience in the construction industry. Accordingly, experts with more than 17 years of experience who have engaged with small and medium scale construction projects in Sri Lanka were selected as the interviewees. However, their experience and exposure to lean concept were in diverse levels. Majority of the interviewees had experience in lean implementation in construction projects and also undergone training programmes and/or CPD sessions on lean concepts. Collection of in-depth information from the experts was conducted until data saturation is reached.

6.2.4 Analysis of the findings

The data collected through semi-structured interviews were analysed using code-based content analysis to compare and contrast the similar and diverse opinions given by the experts. Computer based software N-Vivo 11 developed by QSR was used for coding and simplifying the gathered data. Nevertheless, literature review findings were revisited when analysing the interview findings to identify any differences of theory and practices. Further, interactive data visualisation tools, Power Bi and Microsoft Visio were used to present the research findings. EIR-2 findings are presented from Sections 6.3 to 6.6.

6.3 Drivers for Lean Implementation

The first question of Section 3 in interview guideline was aimed to identify the individual, organisational and environmental level drivers to support lean implementation in construction SMEs in Sri Lanka. The respondents highlighted the importance of strengthening these drivers to accelerate the lean implementation process. E12 mentioned that *'we have number of problems which need to be solved by implementing lean. On the other hand, we have seen the number of benefits the companies gained by implementing lean… both critical problems and benefits will drive the lean implementation for SMEs'*. Adding to that, E9 stated '*SMEs have a favourable condition to implement lean'*. The mind map developed for drivers is presented in Figure 6.1. The following sections present those drivers in detail.

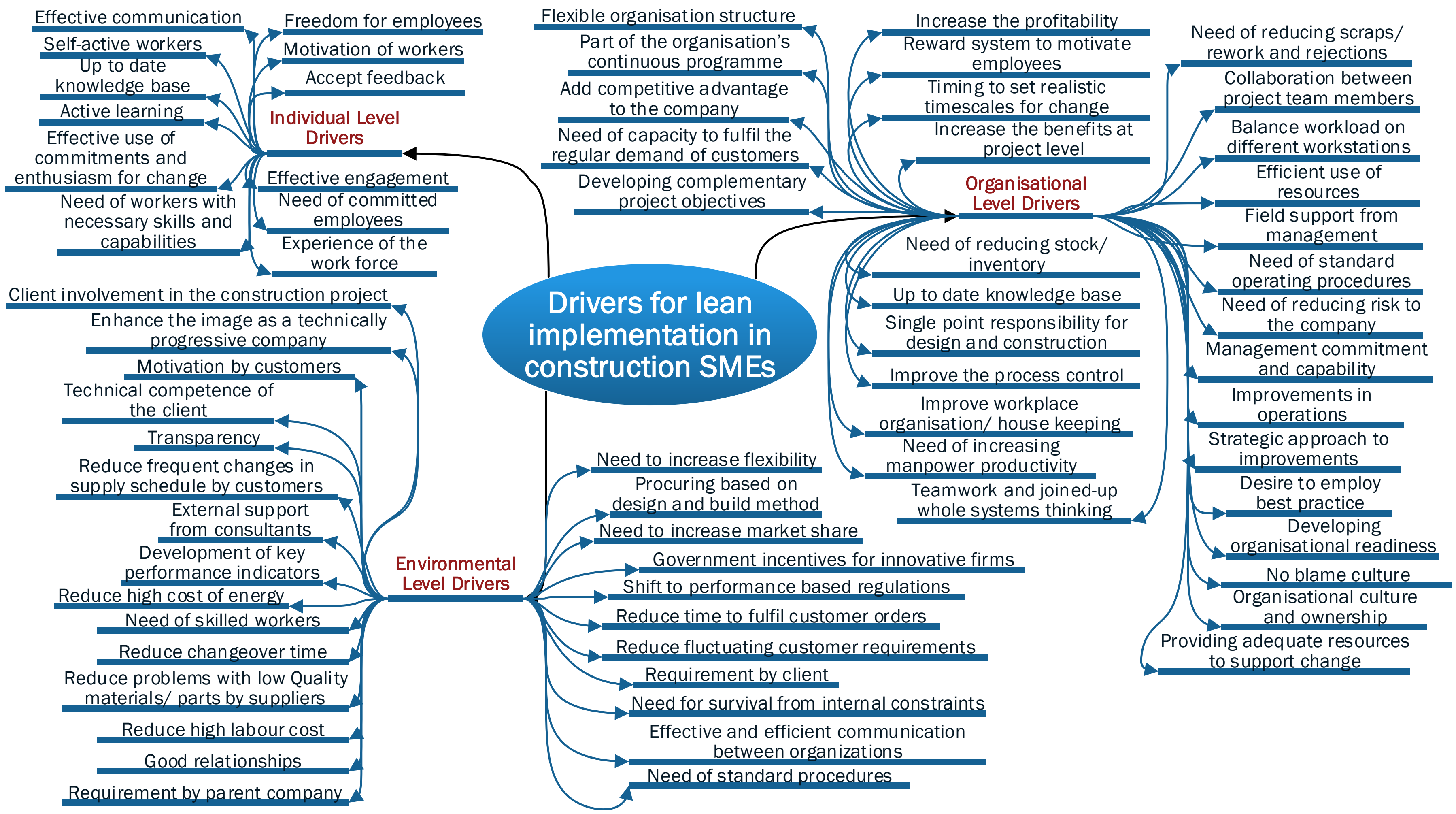


Figure 6.1: Mind map for lean implementation drivers

6.3.1 Individual level drivers for lean implementation

The question was aimed to identify the drivers at the individual level in practicing lean in construction SMEs. Most of the experts undoubtedly agreed that the main driver for lean implementation is the individual workers and a summary of drivers are presented in Table 6.2.

Table 6.2: Individual level drivers for lean implementation

Parent Node	Child Nodes		Sources	References
Individual level drivers	ID1	Freedom for employees	22	22
	ID2	Experience of the work force	21	21
	ID3	Need of workers with necessary skills and capabilities	20	20
	ID4	Need of committed employees	17	17
	ID5	Active learning	17	17
	ID6	Accept feedback	10	10
	ID7	Motivation of workers	5	5
	ID8	Self-active workers	5	5
	ID9	Up to date knowledge base	5	5
	ID10	Effective engagement	4	4
	ID11	Effective communication	4	4
	ID12	Effective use of commitments and enthusiasm for change	1	1

Most of the experts stated that having relatively a few number of employees within the construction SMEs as a managerial strength since, handling of workers within the organisation is easy compared to large construction firms. Moreover, 22 experts noted '***freedom for construction SMEs'*** as a significant driver for lean implementation. Similarly, experts added '***experience of the work force'*** as a driver for lean implementation. E2 from top management added, '*In most of the construction SMEs, the top management is consisting with very experienced professionals. Most of them including my-self have the exposure in large construction organisations, particularly lean implementation'*.

The experts highlighted that, individuals have to re-think of the current problems they have at their hands and how to overcome them by incorporating lean. According to literature, one of the main barriers for lean implementation is lack of skills and capabilities of workers. Hence, the lean experts added the '***need of workers with necessary skills and capabilities'*** as a driver for the individuals in the organisation.

E2 explained by highlighting the need of optimising the resources at the organisation. Similarly, E1 and E2 emphasised that the '***need of having committed employees***' will drive the top management to rethink and accelerate lean implementation to increase the profit levels of construction projects.

Another driver identified by experts is '***active learning***' of workers. Yet, E15 claimed that '*active learning is applicable to construction SMEs as they have a few number of workers involved comparing to large company. So, whenever they don't know something, the management encouraged them to learn by themselves to carry out the tasks assigned for them*'. However, the researcher further questioned about the success of active learning for medium organisation over small construction organisations. Moreover, E19, E20, E21, E22 and E24 claimed the importance of ***'accepting feedback'*** within the organisation as well as in project to drive the employees towards the successful lean implementation. In contrary, E15 expressed that, '*maintaining a no blame culture where people accepting feedback is a difficult task for construction SMEs*'. If the individuals accepting feedback, it will drive the lean change allowing workers to work freely and thus, SMEs can accelerate the lean implementation process.

E3 voiced that '*we have good reward system to motivate our employees… but they don't know how to get the maximum out of it… We have given full freedom for our workers to try new things'*. However, only 5 experts agreed to '***motivation of workers***' as a driver. As argued by E12, reward systems to motivate employees are not properly practicing in construction SMEs. Nevertheless, freedom for initiation and '***self-active workers***' at construction SMEs are identified as other drivers. However, E20 and E15 opposed to this stating '*due to lack of individual attention within the construction firms, people could misuse the freedom given for them to carry out their work*'. On the other hand, four experts (E3, E2, E4 and E7) agreed that '***up to date knowledge base***' within the company will intensify the lean implementation. Consequently, construction SMEs can identify NVAA and they can treat them accordingly by using the updated knowledge. They further added that the awareness of new tools and techniques will speed up creating their own methods to suit the problems at hand. Although, '***effective communication', 'effective engagement of works' and 'effective use of commitments and enthusiasm for change of workers'*** are marked as drivers for lean implementation, few experts agreed towards them. Yet, in order to achieve benefits out of individual level drivers, they need to be supported by the organisational level drivers as discussed below.

6.3.2 Organisational level drivers for lean implementation

Construction SMEs must have a clear understanding on the organisational level drivers for successful lean implementation. Table 6.3 presents the summary of parent and child nodes for organisational level drivers for lean implementation.

Table 6.3: Organisational level drivers for lean implementation

Parent Node	Child Nodes		Sources	References
Organisational level drivers	OD1	Flexible organisation structure	24	24
	OD2	Need of reducing risk to the company	23	23
	OD3	Need of increasing manpower productivity	22	22
	OD4	Improve the process control	20	20
	OD5	Unbalance workload on different workstations	20	20
	OD6	Need of standard operating procedures	20	20
	OD7	Desire to employ best practice	20	20
	OD8	Improve workplace organisation/ house keeping	17	17
	OD9	Reward system to motivate employees	15	15
	OD10	Efficient use of resources	10	10
	OD11	Need of capacity to fulfil the regular demand of customers	10	10
	OD12	Improvements in operations	7	7
	OD13	Increase the profitability	7	7
	OD14	Increase the benefits at project level	7	7
	OD15	Need of reducing stock/inventory	7	7
	OD16	Need of reducing scraps/ rework and rejections	7	7
	OD17	Add competitive advantage to the company	5	5
	OD18	Organisational culture and ownership	5	5
	OD19	Collaboration between project team members	5	5
	OD20	Teamwork and joined-up whole systems thinking	5	5
	OD21	Field support from management	5	5
	OD22	Management commitment & capability	5	5

Parent Node	Child Nodes		Sources	References
	OD23	Providing adequate resources to support change	5	5
	OD24	Single point responsibility for design and construction	5	5
	OD25	No blame culture	5	5
	OD26	Developing organisational readiness	4	4
	OD27	Part of the organisation's continuous programme	4	4
	OD28	Up to date knowledge base	4	4
	OD29	Developing complementary project objectives	3	3
	OD30	Strategic approach to improvements	3	3
	OD31	Timing to set realistic timescales for change	2	2

E12 stated that '*If the organisation has positive drivers, they need not to worry about lean implementation. You have almost all the required organisational capacities'*. Thus, many experts expressed their views on drivers within the construction SMEs. All the experts agreed that the '***flexible organisation structure***' will drive the lean implementation in construction SMEs. E1 added that '*not like large companies, our hierarchy is somewhat horizontal… good communication is there between each layer… easy to handle employees due to the simple organisational structure, which is paramount for successful lean implementation'*. Therefore, the organisational structure will positively affect the lean implementation. Moreover, E18 added '*Now a days, due to the government instability, not only SMEs, but even large construction firms are facing a huge risk of continuing the jobs. We have to look into new tools and techniques, which will help us to reduce this risk*'. In responding, one of the benefits of lean implementation is the continuous stability, in a problematic situation. Hence, '***need of minimising high risks****'* will drive the lean implementation.

In Sri Lankan construction industry, there is a scarcity of skilled labour. Thus, experts insisted that the construction SMEs had to hire workers with lower capacities. There is low manpower productivity in the construction SMEs. E1 and E21 stated that they are unable to get the maximum input from the workers particularly at the site. However, E15 added that '*we tried different techniques to empower the employees'*. Hence, '***need to enhance manpower productivity***' of the construction SMEs demanded them for lean implementation.

Most of the projects done by construction SMEs include houses, school buildings and other small-scale projects where, the clients prefer in giving a single point responsibility for design and construction. As stated by E4, 'O*ur clients prefer for design and built projects as they can pass the total responsibility for us. We also can work without any hassle when there is less variations'.* Further to E4, construction SMEs have plenty of time to try out lean tools and techniques. They can decide where to and when to apply these techniques as the '***process control***' of the project lies within the hands of construction SMEs.

The research findings further showed that weak process control and '***unbalanced workload on different workstations***' as discussed in the literature will directly affect the lean implementation. Correspondingly, E13 stated that '*not like large construction organisations, we don't have standard operating procedures at the organisations like TQM, TPM, ISO standards. The construction activities are not control by one party, but different parties will do'.* In the same way, E23 added, *'very less attention is giving for the overall process by the workers, rather controlling the whole processes. Sometimes, head office workers have less work comparing to workers at site'.* Therefore, most of the experts undoubtedly agreed to the '***need of standard operating procedures****'* and '***desire to employ best practice***'. Thus, they marked as critical organisational drivers. The researcher also identified the need of standards for construction SMEs as another driver from above findings. Construction SMEs understood that they are lacking standard operating procedures such as TQM, TPM, and ISO. Yet, most of these standards can be acknowledged as lean tools.

Accordingly, many experts highlighted the need of having lean tools like 5S in their organisation. One of the top-level managers, E2 passed the blame to their middle management and claimed '*last week I have given one of my important letter to the senior engineer at the site. But when I asked about the letter in this week, he was unable to find that letter. This is very common all the times at the site'.* In the similar note, E14 added '*you should visit our sites and check. There is a very small site office and two third of office is filled with documents. Most of them are not in use. But if we want to find something, it is like digging gold'.* Thus, '***improving***

workplace organisation' in a way to support works without any trouble and marked as another driver for lean implementation.

Experts highlighted availability of '***reward system to motivate employees***' as a driver for lean implementation. However, as opposed by E14, the preference of top management towards reward system within the organisation is debatable. Some of the experts from top management put forward this issue and highlighted the need of recognition to motivate employees. Moreover, E11 emphasised the availability of incentive scheme as a driver for lean implementation.

In addition, most of the experts contended the need of resources for successful lean implementation. E15 noted, '*Do you think that we have enough resources to implement lean?... We don't need to worry about the requirement comparing to large organisations. But we have to manage the available resources within the company'.* However, there is a need to provide resources to support the lean implementation. Further, many agreed to availability of adequate resources as a driver for lean implementation. E3 acknowledged the importance of having resources highlighting that '*most of the time we are lacking resources such as good quality equipment at the organisation. Some SMEs have good quality equipment which are hiring from their parent organisations*' by referring to his SME organisation, which is a branch of a large construction organisation. E12 uttered, '*even though we have resources, if we don't know to get maximum usage of resources, you will fail. We are trying to control the resources at the best we can. Our Managing Director him-self are checking everything including procurement of material, equipment, hiring workers to make sure that all we have is the best utilised'.* Moreover, E12, E3 and E5 clearly stated that the top management should get the maximum usage of their available resources. Consequently, '***efficient use of resources***' was identified by ten experts. Similarly, ten experts added that they do not have enough resources to fulfil the demand by the customers. Consequently, E3 disclosed that '*we were unable to get the bid of a good government project due to unavailability of three Chartered Engineers in the schedule of the bidding documents*'. Similarly, lack of both soft and hard resources within the organisation directly affects the demand of the customers.

Thus, having enough '***capacity to fulfil the regular demand***' of customers encourages the construction SMEs to look for the ways to increase their capacities.

E16, currently working in a government organisation stated that with the boom in the construction industry, there is a rise of construction SMEs in terms of the works they carried out. Moreover, E20 added that, they are trying to improve their operations at their best capacity and looking for the opportunities in the field to improve their business. Hence, continuous ***'improvement in operations***' will guide them towards the lean implementation. Nevertheless, only seven experts revealed their agreement for the above and specifically mentioned the field support the workers getting from management is the main reason for their continuous improvement. Accordingly, the support from management too can be considered as an indirect organisational driver for successful lean implementation. Yet, only seven experts agreed the above and E1 mentioned '*even at this stage, we are not in a position to increase the profit level. If we can increase the profits by anyhow, we can allocate some money for lean implementation. This may be to buy some good equipment, machineries which can increase the productivity'.* Thus, '***increase of profit***' can be considered as an additional driver.

Consequently, the need to '***increase the benefits at project level***' is another driver for lean implementation. Many experts highlighted that '***high level of stock/inventory'*** and '***high amount of scraps/rework and rejections***' will largely affect the profit levels of the SMEs. E5 added '*sometimes we will not be able to get what we spent on construction. It is good to withdraw some of the tenders rather carry on the projects. Then again, we have to think about our good will. Even at a very low level of profit margins or loss, we have to carry on the work. But if we can find a way to overcome these problems, undoubtedly we wanted try them*'. Thus, the need to overcome the problems which affected the profit can be considered as an organisational driver for construction SMEs in Sri Lanka.

One of the major issues that the construction SMEs always face is lack of competitive advantage in the construction industry. According to Porter (1989), in order to gain the competitive advantage, the organisation should gain either cost leadership or differentiation or a combination of them. Yet, neither the cost leadership, nor the differentiation is properly achieved by the construction SMEs. Thus, the experts mentioned that they understood the benefits of getting competitive advantage through lean implementation. Thus, importance of '***having competitive advantage for the company***' will drive the construction SMEs in search of new lean tools and techniques for the organisation.

As expressed by the experts, less number of participants involve in a project drive lean implementation. Accordingly, '***organisational culture and ownership***', '***collaboration between projects team members***', '***teamwork and systems thinking***', '***field support from management***' and '***management commitment and capability***' are identified as the organisational drivers for construction SMEs by the experts.

Similarly, '***providing adequate resources to support change***', '***single point responsibility for design and construction***', '***no blame culture***' in the organisation, '***developing organisational readiness***', think as a '***part of organisation's continuous programme***', '***up to date knowledge base***', '***developing complementary project objectives'*** and '***strategic approach to improvements***' were agreed by few of the experts. Similarly, E2, E17 and E22 added that '***setting realistic timescales for change'*** as another organisational driver for construction SMEs. E23 argued that, '*we try to manage the little time we have within the busy schedule. If we have additional time, we are trying to reconsider the project program developed by our workers. Especially timing… Most of the time in the industry, the program is prepared in ad-hoc manner without giving realistic time scales. But we are trying to achieve the realistic time scales and it will minimise the waste in the organisation'.* Thus, the more they planned, the less they have to do for successful lean implementation. In particular, lean tools like last planner system required adequate planning with realistic time scales. Hitherto, some of the organisation mentioned that they are capable of time planning and thus, the identified it as a driver for their organisation. However, in order for organisations to achieve benefits out of abovementioned drivers, they need to be supported by the environmental level drivers as discussed in the next section.

6.3.3 Environmental level drivers for lean implementation

Both individual level and organisational level drivers need to be backed up by a favourable environment for enabling lean in construction SMEs. Therefore, the researcher further questioned about the environmental level drivers for lean implementation and Table 6.4 presents the summary of empirical findings.

Table 6.4: Environmental level drivers for lean implementation

Parent Node	Child Nodes		Sources	References
Environmental level drivers	ED1	Reduce high labour cost	23	23
	ED2	Need of skilled workers	22	22
	ED3	Reduce high cost of energy	22	22
	ED4	Reduce problems with low Quality materials/ parts by suppliers	21	21
	ED5	Need to increase market share	21	21
	ED6	Need for survival from internal constraints	20	20
	ED7	Need of standard procedures	17	17
	ED8	Reduce fluctuating customer requirements	14	14
	ED9	Client involvement in the construction project	13	13
	ED10	Technical competence of the client	12	12
	ED11	Motivation by client	12	12
	ED12	Effective and efficient communication between organisations	12	12
	ED13	Good relationships	10	10
	ED14	Requirement by client	10	10
	ED15	Requirement by parent company	10	10
	ED16	Development of key performance indicators	5	5
	ED17	Procuring based on design and build method	5	5
	ED18	Enhance the image as a technically progressive company	5	5
	ED19	Government incentives for innovative firms	5	5
	ED20	External support from consultants	5	5
	ED21	Reduce changeover time	5	5
	ED22	Need to increase flexibility	5	5
	ED23	Reduce time to fulfil customer orders	5	5
	ED24	Reduce frequent changes in supply schedule by customers	4	4
	ED25	Shift to performance-based regulations	3	3
	ED26	Transparency	3	3

The construction SMEs have frontage on many issues to retain in the construction industry despite the premature death. The most critical driver agreed by all the experts is how to optimally utilise the labour force to face the '***high labour cost***'.

Furthermore, they are struggling in working with few numbers of workers at sites. Correspondingly, E10 said that, '*the cost of labour is very high nowadays. We cannot hire more workers. They are highly demanding and hence, we cannot afford to pay for extra workers'*. In a similar note, E1 voiced that '*There is a scarcity of skilled labourers in the industry. People prefer to work in other industries than in construction. Not like construction, manufacturing industry nowadays providing food and transportation even for their shop floor level workers'*. According to 22 experts, '***need of skilled workers***' drive the organisations to optimally utilise the work force through implementing lean. 22 experts identified the cost of energy as the intolerable resources and thus, they are willing to implement any feasible mechanism to reduce the energy cost of the organisations. Therefore, another factor which drives lean implementation can be identified as the eager to '***reduce the high cost of energy***'.

Experts indicated the '***problems with the materials supplied by the suppliers/sub-contractors***' as a critical issue that need to be overcome through implementing lean. E21 stated, '*most of the time we are getting low quality materials from our suppliers. They are trying to sell the best to the large construction companies and we are getting only the left over'*. Similarly, E17 added that the suppliers take long time to deliver and hence, the projects get delayed. Correspondingly, E1 who aware about JIT techniques and mentioned that, '*I know about JIT. We can ensure the timely delivery by implementing JIT, So, we want to implement JIT'*. Therefore, the need to address the aforementioned critical issues with suppliers drive the construction SMEs towards lean implementation and '***improve their market share***'.

Through lean implementation, SMEs can enhance value adding activities, increase productivity and profitability and as a result, have spare time for look in to new project opportunities. Further, more of time to fulfil the customer needs will encourage the construction SMEs to look for new methods to enhance quality, minimise cost and ensure on time delivery. Nevertheless, '***lack of standard procedures***' practiced in the construction industry was identified by 17 experts. Correspondingly, E3 highlighted that most of the SMEs in Sri Lankan construction industry prefer to follow established standards rather than the standards developed by them. Thus, 5S concept is one of the basic standards highlighted by the E3 and E16 towards this issue. However, even 5S concept is not properly practicing in the industry. Therefore, there is a need to have a well-established standard developed by the relevant authorities to encourage the lean implementation in Sri Lanka.

Nonetheless, the problems due to the customer's side are insisting the construction SMEs to look for a path to change the existing approaches of way of doing the business. Conferring to the issue stated by E13, '***fluctuating customer requirements***' will directly affect the business environment. Moreover, construction SMEs are not ready to face the changing environments. E22 stated that '*every day the industry is evolving. New products and machines are coming to the industry'*. However, SMEs are not in a position to use and adapt them quickly. Hence, E12 and E15 agreed that construction SMEs must create a leaner environment to address these issues.

Unlike large construction organisations, '***client involvement in the construction projects***' is higher among construction SMEs. There will be only client and the contractor for many of the small-scale projects. Thus, E15 and E17 emphasised that client directly approach the construction SMEs. Similarly, E2 highlighted that the '***technical competence of the client***' and '***motivation by client***' will be an added advantage for the organisation to drive lean implementation. In contrary, E16 stated that '*the most difficult thing to handle is the client'*, whereas E12 argued that '*we have good clients with sound knowledge and thus they are ready to listen. We can easily convince them towards the lean implementation'*. However, only 12 experts identified the technical competence of the clients as a driver for lean implementation.

Moreover, experts mentioned that the availability of '***effective communication between organisations***' will drive the lean implementation within the SME sector. Accordingly, E1 noted that, '*we have a good community within the SME sector. If someone gets to know about a new material or equipment, we used to share it with others*'. Similarly, E3 added, '*we discuss the current problems we have when we meet our competitors and we try to get the solutions from them'*. Thus, the availability of good communication channels to share the benefits that can be gained through lean implementation will motivate the construction SMEs. However, to have a good communication between the organisations, it is vital to have good relationships. Thus, ten experts agreed that there are ‘***good relationships’*** among the SMEs. Nevertheless, E16 contended that *‘availability of good relationships is very subjective’*. Correspondingly, E12 stated ‘*during some periods we are very friendly, but if we missed a bid to one of the competitors, then we are not good with each other. We don’t want to share our secrets with them’*. Even though, sound relationships can be considered as a driver to implement lean, it varies from time to time and organisation to organisation.

In a similar note, E15, E16 and E20 highlighted that there is a ‘***requirement by the client***’ to implement waste minimisation practices to reduce the project cost. Hence, despite the SME’s preference, they had to implement lean to gain the additional benefits. Similarly, E2 added, ‘*It is a requirement of our mother company to implement lean tools and techniques in all 08 companies’*. Similarly, E12 mentioned, ‘*if the mother company requires us to implement anything, they provide necessary resources for our company. So, we are happy to implement them’*. Moreover, E17 from a government authority stated that some of the standards like ISO and 5S are pre-requisites for group of companies and hence, they need to implement. Thus, the ‘***requirements imposed by the parent company’*** can be marked as another driver to implement lean in SMEs.

Another major barrier for lean implementation is unavailability of norms to decide the KPIs for the organisations. Accordingly, E16 of the government authority indicated the availability of norms in the construction industry, which can be taken as the performance indicators for the construction SMEs. Adding to that, 15 experts identified the continuous ‘***development of key performance indicators’*** as another driver. In contrast, E7 voiced that the industry is not yet in a position to shift to performance-based regulations. Many agreed that ‘***procuring based on design and build method***’ will be an added advantage for the projects to implement lean.

As construction SMEs are still at the progressive stage in the construction industry, E1 emphasised the ‘***need to enhance the image as a technically progressive company***’. In a similar note, E8 expressed that, ‘*not all large construction companies* *have implemented lean in their organisation. So as a SME company, if we implement lean and demonstrate others how good we at work, there is a tendency to increase the recognition among the community and thus can increase the market share in the industry'*. Therefore, this will be a supplementary benefit to the SMEs. Moreover, the experts of the government institutes, E15, E16, E17 and E18 stated that the '***government has introduced incentives***' for innovative firms. It includes the tax benefits and monetary benefits, to name a few. Thus, the organisations are motivated to implement lean and gain the incentives from government. However, as stated by E2, limited number of construction SMEs have awareness about these incentives.

The availability of '***external support from consultants***' in the industry was identified by the few numbers of experts. Accordingly, E3 added '*we can get the help from the consultants on how to implement lean in the projects. If they can instruct us on the methods and tools to be used, we are happy to follow them'.* Similarly, E9 voiced, '*we don't have that much of money to implement on lean. But we can spend some money in the beginning to get consultants from the industry, who are willing to help us'.* Therefore, the availability of consultants in the Sri Lankan construction industry will drive the lean implementation. In addition, experts added '***reduce changeover time***', '***need to increase flexibility***', '***reduce time to fulfil customer orders***', '***reduce frequent changes in supply schedule by customers***', and '***shift to performance-based regulations***' as drivers for lean implementation. Moreover, only E15, E16 and E21 stated that the availability of '***transparency'*** as a driver for lean implementation.

6.4 Barriers for Lean Implementation

The perception of the stakeholders on the lean implementation can be elaborated based on the barriers that are identified by the experts. All the experts have accepted that there are multiple barriers retarding the implementation process. As discussed in the literature, lean implementation is subjected to number of barriers and thus, the next question was "What are the barriers for lean implementation in construction SMEs? (RQ3b)". The experts identified barriers at individual, organisational and environmental levels and findings are discussed in detail below. A mind map developed as presented in Figure 6.2 for barriers for construction SMEs in Sri Lanka.

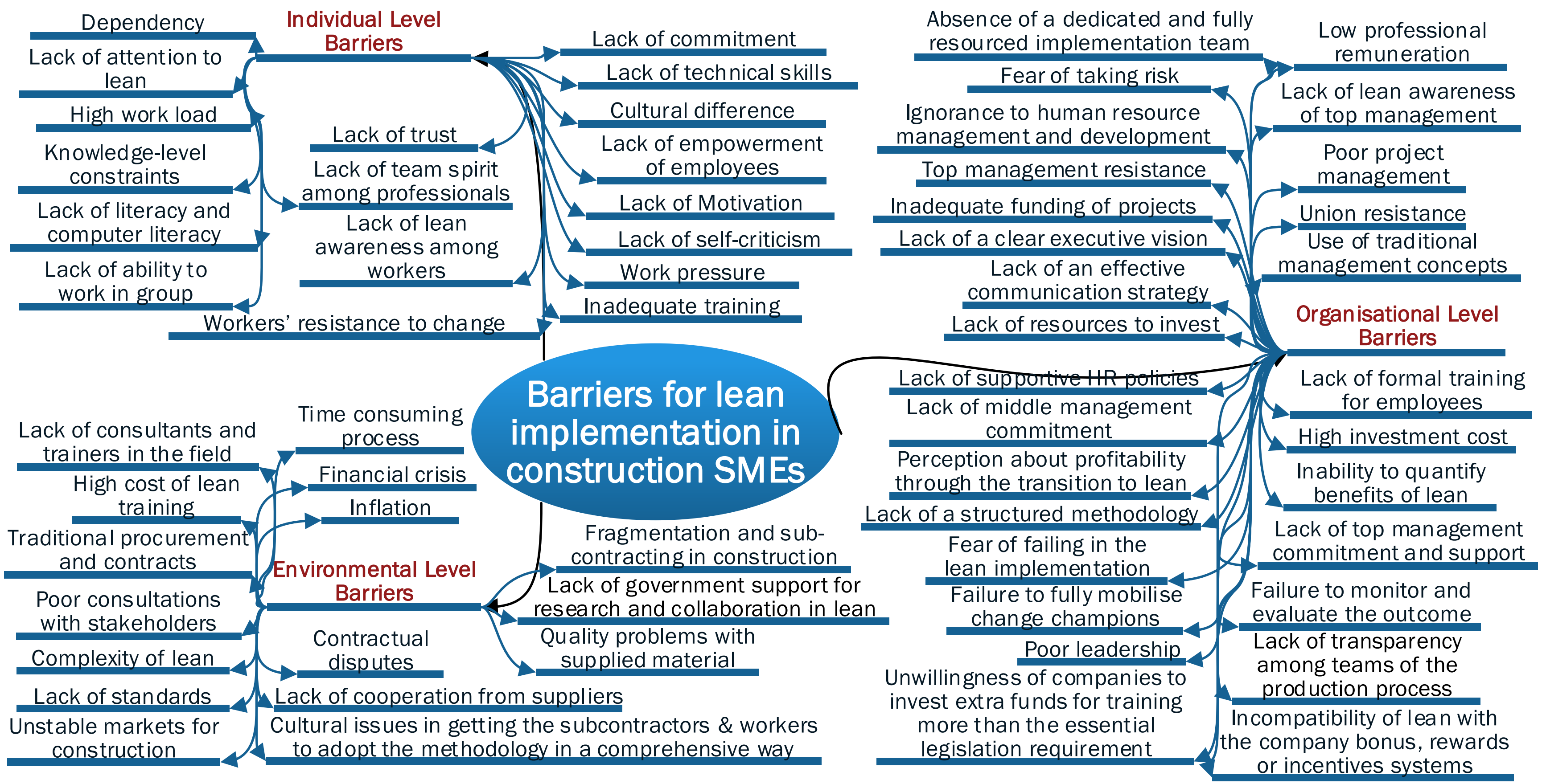


Figure 6.2: Mind map for barriers for lean implementation

6.4.1 Individual level barriers for lean implementation

According to literature findings, most of the significant barriers lie within the individuals of construction SMEs. Table 6.5 presents the summary of the individual level barriers for lean implementation in construction SMEs.

Table 6.5: Individual level barriers for lean implementation

Parent Node	Child Nodes		Sources	References
Individual level barriers	IB1	High work load	24	24
	IB2	Work pressure	24	24
	IB3	Lack of lean awareness among workers	23	23
	IB4	Inadequate training	22	22
	IB5	Knowledge-level constraints	22	22
	IB6	Workers' resistance to change	22	22
	IB7	Lack of attention to lean	19	19
	IB8	Lack of commitment	19	19
	IB9	Lack of motivation	19	19
	IB10	Lack of technical skills	19	19
	IB11	Lack of literacy and computer literacy	18	18
	IB12	Lack of team spirit among professionals	15	15
	IB13	Lack of ability to work in group	14	14
	IB14	Lack of trust	14	14
	IB15	Dependency	12	12
	IB16	Lack of empowerment of employees	5	5
	IB17	Lack of self-criticism	5	5
	IB18	Cultural difference	3	3

Even though top management insist on implementing lean, middle level and bottom level workers are struggling to complete the routine works which exceed their working limits. Thus, 24 experts undoubtedly agreed that the '***high work load***' assigned for the workers hinder the lean implementation. Thus, reasoning above by E2 stated that, the high work load in the SMEs is due to the practice of conventional methods and unawareness of the NVAA at the construction sites. Hence, the experts stressed the need to update with new tools and technologies to minimise NVAA and thus make a stress-free working environment. In a similar note, E9 stated that, '*Due to high work load at the sites, our workers are struggling to manage the work pressure, time constraints, cost constraints, and we have to address all of them'*. Therefore, '***work pressure***' of the employees will act as a barrier for lean implementation. As per E21, SMEs have no spare time to think on benefits of lean and realise the need of changing the current way of doing business.

Unlike individual drivers, the experts are interested in uttering the barriers for lean implementation. Undoubtedly, most of the experts recognised '***lack of lean awareness among workers***' and '***inadequate training'*** as the most significant barriers for individual level lean implementation. E2 stated that in many SMEs, even the top management has lack of lean awareness. As per E16, most SMEs identified lean as a set of tools and techniques only. However, the benefits of the lean can be gained only through the identification of the essence of lean philosophy. In contrary, E22 added, '*Implementing new methods are very difficult in our construction industry. Only a few number of experts available, misunderstanding on lean concept, extensive cost of lean implementation and unavailability of lean techniques will hinder the lean implementation in Sri Lanka'.* E22 further identified lean as a new concept and E15 added that the knowledge on lean need to be acquired through sufficient training. Yet, E2, E5, E13 and E14 highlighted that the training received for workers on lean is not adequate for them to properly implement lean. Similarly, the experts highlighted that '***knowledge level constraints***' of workers in the construction SMEs hinder the successful lean implementation. E12 highlighted it stating '*the workers we have are with different knowledge levels. So, it is very difficult to implement new methods and techniques for them. The effort we have to take is very high due to that*'.

Moreover, many experts highlighted that the most difficult factor is the '***workers resistance to change'***. 22 experts agreed for this and only two opposed highlighting the less number of workers in the construction SMEs. Yet, the human nature is difficult to change the way they are doing the business. Correspondingly, E2 added, '*we don't need to worry about the threat from unions like in large construction companies as we have very few numbers of employees. But they don't like to change from the work they are currently doing. If we try to assign new tasks for them, they will go out of our organisation. So, it is difficult to retain workers in the organisation and we don't want to let them go out of the organisation*'. Thus, E4 added that the top management resists implementing new strategies like lean due to high labour turnover in the construction industry. Furthermore, E12 stated that the workers resist changing due to the fear of failing assigned new task. However, the construction SMEs must find the ways to change the mind set of people. Nevertheless, '***lack of attention to lean***', '***lack of commitment'*** and '***motivation'*** identified as other barriers for lean implementation. E1 said that '*most of our workers never ever want to commit for the works that is carried out by them… they don't want to learn new things… the problem is with the generation… Unlike old days, our workers are not interest to spend their time on learning'*. Hence, majority of experts (19) emphasised this issue and thus need to consider the strategies to motivate individuals in an organisation to implement lean.

As contended by E16, even the top management is trying to improve the capabilities of employees by conducting trainings, very few numbers of employees will be benefited by attending training programs. Nevertheless, when the researcher questioned about the types of training programs they attended, E2 stated that, most of them are only technical workshops. Therefore, even the top management not realise the importance of improving soft skills of the employees for the successful lean implementation.

Even though the construction SMEs allocated budget for training program for their workers, E13 added that, the '***level of technical skills'*** they have is not adequate. According to E1, '*SMEs are trying to learn the basics of construction where the industry is trying to update them*'. Therefore, current situation in the Sri Lankan construction industry will largely affect the construction SMEs. Similarly, '***lack of literacy and particularly computer literacy'*** of construction work force in SME sites is at a very low level and thus, acts as a barrier for lean implementation. As noted by E14, some of the bottom level workers even cannot properly read a sign board at site. Thus, E5 and E14 doubted about implementing lean tools and techniques like 5S with these workers. On contrary, E1 highlighted the importance of using visual management in lean construction stating, '*we use symbols to convey the message to the shop floor level workers*'. Moreover, unavailability of computers at sites is another issue for construction SMEs noted by E12 and E14. E12 further added that, some sites even have no computers where some have only one computer. Therefore, lack of computer literacy of workers is marked as another barrier for lean implementation.

The leaner organisations must empower the team work as per the literature. However, most of the experts stated that there is '***less team spirit among professionals'*** in SMEs. E7 mentioned that team needs to be responsible for the works carried out by each and every individual in the team. However, E15 indicated that people would like to '*pass the ball'* to any person when there is a problem. Similarly, E12 added '*one of the major barriers to implement lean is the inability of employees to work in groups. People prefer to work on their own rather working as a group'*. Thus, 15 experts identified the '***lack of ability to work in group***' as a factor, which hinder lean implementation.

Conferring to experts, lack of soft skills of employees was identified as another barrier for lean implementation. As highlighted by E1, not only to work in a team, but also to trust each other is vital for lean implementation. Nevertheless, many experts identified that '***lack of trust'*** among the workers in Sri Lankan construction industry hinder the lean implementation. In a similar note, the experts identified '***dependency****'* as another barrier for lean implementation. Respectively, E16 said that '*our workers are not in a position to work by their own. They always depend on others which ultimately affect any implementation*'. Nevertheless, some experts highlighted, due to '***lack of empowerment of employees***', the workers hesitate to work on their own. Therefore, inability of workers to work on their own will directly affect the cost and time of the project.

One of the important qualities of a lean implemented project is to accept feedback for continuous improvement. However, E2 highlighted that the workers are not accepting their mistakes and unhappy to receive feedback. 15 experts agreed and identified this as a major barrier for lean implementation. Conferring to the above, E4 highlighted '*We don't want our workers to resign from our projects. If we try to show their mistakes they will go to another project'*. Thus, '***lack of self-criticism'*** within the employees will not encourage them for continuous improvement and largely affect the initiation of lean within the organisation. In a similar note, E18 stated that our workers resistant to work like Japanese due to the '***cultural difference***' between Sri Lanka and Japan. However, by highlighting the issue of Sri Lankan workers, E8 noted '*always our payment bills will be delayed. They always wanted to delay their payment bills. They don't even want to finish it beforehand. That's the mind sets of our people. They don't realise that you have to manage your time'*. Yet, changing the mind-sets of Sri Lankans will be the prevalent issue to implement lean in their projects, as deliberated by the experts. Thus, a significant role is there to play by each and every individual of the construction SMEs for successful lean implementation.

6.4.2 Organisational level barriers for lean implementation

Table 6.6 presents the organisational level barriers for lean implementation within construction SMEs.

Table 6.6: Organisational level barriers for lean implementation

Parent Node	Child Nodes		Sources	References
Organisational level barriers	OB1	High investment cost	24	24
	OB2	Unwillingness of companies to invest extra funds for training	22	22
	OB3	Lack of formal training for employees	20	20
	OB4	Lack of top management involvement (commitment and support)	20	20
	OB5	Top management resistance	20	20
	OB6	Lack of lean awareness of top management	18	18
	OB7	Lack of middle management commitment	17	17
	OB8	Inability to quantify benefits of lean	17	17
	OB9	Perception about profitability through the transition to lean	17	17
	OB10	Fear of failing in the lean implementation	17	17
	OB11	Fear of taking risk	16	16
	OB12	Failure to monitor and evaluate the outcome	15	15
	OB13	Incompatibility of lean with the company bonus, rewards or incentives systems	15	15
	OB14	Lack of sympathetic and supportive HRM policies	15	15

Parent Node	Child Nodes		Sources	References
	OB15	Low professional remuneration	15	15
	OB16	Lack of resources to invest	15	15
	OB17	Poor project management	12	12
	OB18	Lack of strategic leadership	12	12
	OB19	Ignorance to human resource management and development	5	5
	OB20	Inadequate funding of projects	5	5
	OB21	Lack of a clear executive vision	5	5
	OB22	Union resistance	4	4
	OB23	Lack of an effective communication strategy	4	4
	OB24	Lack of transparency among teams of the production process	4	4
	OB25	Absence of a dedicated and fully resourced implementation team	3	3
	OB26	Failure to fully mobilise change champions	3	3
	OB27	Lack of a structured methodology	3	3
	OB28	Use of traditional management concepts	3	3

The most significant organisational barrier identified by majority of experts is the '***high investment cost'***. Accordingly, all experts agreed that they are not in a position to bear the cost of lean implementation in current Sri Lankan context. E2 uttered high cost of lean training workshops conducted in the Sri Lankan context. Similarly, E23 highlighted the unavailability of lean experts in the construction industry. Yet, training on lean construction is still at its early stages and thus, the cost of lean training is very high.

As per E14, even the training programs conducted at lesser costs available in the industry, lack of participation of construction SMEs can be seen. Thus, E2 mentioned that '*our organisation doesn't have extra money for the training programs. But there is a rule from the Ministry of Labour to have minimum hours of training for employees. We are trying to achieve that'*. Construction SMEs are '***not willing to invest extra funds for training'*** more than the essential legislation requirement. Yet, contradicting to E2, E16 from government authority said that '*We are trying to conduct training programs free of charge for the construction SMEs. But very few participants can be seen'*. Therefore, it can be evident a reluctance from construction SMEs to participate these training programs and gain the benefits. All experts agreed that there is a ***lack of formal training for employees*** among construction SMEs. Correspondingly, E10 voiced, '*the biggest problem we have is lack of time and cost for training. So sometimes we are unable to conduct at least one training program per year for our workers. But we are trying to send them for programs conducted by government authorities'*. Further, E12 highlighted that there is a mismatch between the training provided to workers and the actual work that has been carried out at site. Therefore, E12 highlighted the lack of training with in-built action learning for construction SMEs. Thus, this clearly shows the reluctance of SMEs to organise training programs to improve their capacities. Hence, SME's unwillingness to provide training for SMEs and lack of formal training is marked as barriers for lean implementation.

Management commitment and support is imperative for lean implementation. Yet, the experts identified '***lack of top management involvement'*** and '***top management resistance'*** as barriers for lean implementation. E1 mentioned that, '*I think we are in a more stable position compare to other SMEs, so we don't need to go for lean construction and we are not sure about the benefits that can be gained by investing money*'. Hence, the Directors and other top-level workers' '***unawareness of lean concept****'* and its benefits hindered the lean implementation. However, 19 experts pointed about the '***lack of commitment by middle management***'. E17 stated clearly that the problem exists with middle management not top management or shop floor workers. Correspondingly, E3 specifically, named the project managers inability to control the project as the biggest barrier. Not only project managers, E15 added '*all senior level workers need to work hard towards lean implementation and this is not practice in current construction SMEs'*. According to E6, this may be due to the uncertainty of the benefits and their training and experience is not sufficient to provide them with the ability to manage change in thinking, responsibilities and roles. Mossman (2009) believes that the problems exist with the middle management and not with the top management. For middle managers, the benefits are not very clear and their training and experience is not sufficient to provide them with the ability to manage change. Therefore, there is a need to consider on improving soft skills particularly of the middle management for successful lean implementation.

As discussed above, lean awareness among both top management and middle management is at a very low level. Thus, there is '***inability of them to quantify the benefits'*** that can be gained through implementing lean. Correspondingly, E8 said that, '*the SMEs will be questioned, what will be gained if reduce waste at site? How much they can gain? Will their profit increases? If not, they really do not want to think about lean'.* According to E2, most of the Sri Lankan construction SMEs identified profit as the value for their organisation. Thus, there is a need to convince the benefits in terms of time and money they can save by implementing lean.

In a similar note, the experts highlighted that the construction SMEs are not willing to take risks. 17 experts agreed to unwillingness towards taking risks. As elaborated by E7, the fear of SMEs is the '***perception about profitability through transition to lean***'. E4 underlined the problem with adjusting to the changing environment. As highlighted by experts, there is a '***fear of failing in the lean implementation***'. Hence, '***reluctant to take the risk***' is hindering the lean implementation. Therefore, individual employees as well as the organisations have a doubt on the outcome through transition to lean. Yet, according to E2, there is lack of ways to monitor and evaluate the outcome through lean implementation in the Sri Lankan construction industry. Therefore, 15 experts identified '***failure to monitor and evaluate the outcome'*** as another organisational level barrier for lean implementation. On contrary, E12 added that, failure to create and communicate the need of urgency by organisation towards lean is worsening the situation.

Even though SMEs have an understanding of some lean tools, the implementation of them is at infant stage. Thus, E10 stressed that, '*we are not sure about the benefits we gained by implementing lean. We have already implemented 5S. How are we to identify how much we save by implementing 5S? Is there any mechanism to calculate the saving by implementing lean?*' Alternatively, Mossman (2009) identified increased productivity, reduced time and accidents as the benefits for top management from implementing lean concept. However, top management has less awareness about these benefits in Sri Lankan SMEs. Therefore, the experts contended towards lean implementation by highlighting the absence of an appropriate mechanism to evaluate the benefits of lean construction for SMEs.

The experts further stated the '***incompatibility of lean with the company bonus, rewards and incentives systems'*** as another barrier for lean implementation. According to expectancy theory of Macdler (2000), the instrumentality is significant to motivate the employees in an organisation. Correspondingly, the top managers obliged to promise for the rewards or incentives for the workers to get the works done. Yet, as per E12, most of the workers in Sri Lankan construction SMEs will motivate working towards lean, if the top management promised for an incentive after the implementation. However, the current condition is contrary to the required condition as there is an incompatibility of the organisations' rewards system for lean implementation. Nevertheless, the construction SMEs struggle to finance their projects and hence, E4 highlighted that they are not in a position to allocate more money as incentives. Therefore, '***lack of supportive HRM policies'*** within the organisation marked as another barrier for lean implementation by 10 experts. Therefore, E12 mentioned that '*the core of lean implementation is the human resources. You should know how to get work done from your employees by properly managing them*'.

One of the extrinsic values of employees is a good remuneration. Yet, E14, E16 and E22 highlighted that, construction SMEs in Sri Lanka are suffering due to the problems with salaries and thus, good professionals/workers tend to work in large construction organisation. Hence, the qualifications of the workers in SMEs are not at a standard level. This was confirmed by 10 experts and highlighted as a reason for hindering lean implementation. When the researcher further questioned about the reason for having '***low professional remuneration'***, E1 highlighted the '***lack of resources to invest'*** as the major issue. Correspondingly, E12 stated that '*we would like to implement lean and get the benefits through lean implementation. But we don't have enough resources for that. We don't have human resources, financial capacity and technical know-how*'.

Not only the hard resources, but also the soft resources like ***'project management'*** and '***leadership'*** marked as one of the important skills of an organisation to implement lean. Yet, 20 experts identified this as a major barrier for lean implementation. E10 justified stating, even the large construction organisations create many NVAA in the organisation due to lack of project management. According to Figure 5.6, another main root cause for NVAA is poor project management and lack of strategic leadership. Bestowing to that, E8 stated, '*there is no proper mechanism in the organisations to identify the problems in the activities. So, it is very difficult to attend all the issues by my-self* '. Thus, construction SMEs need to make the processes more reliable and required to standardise the processes to ensure the smooth work flow at the organisation.

The experts further added, '***ignorance to human resource management and development***', '***inadequate funding of projects***', '***lack of a clear executive vision***', '***union resistance***', '***lack of an effective communication strategy***', '***lack of transparency among teams of the production process***', '***absence of a dedicated and fully resourced implementation team***', '***failure to fully mobilise change champions***', '***lack of a structured methodology***' and '***use of traditional management concepts***' as organisational barriers for lean implementation. Nevertheless, the SMEs need to rethink on how to overcome these organisational barriers which eventually benefitted to overcome both individual and environmental level barriers.

6.4.3 Environmental level barriers for lean implementation

Table 6.7 presents the organisational level barriers for lean implementation within construction SMEs.

Table 6.7: Environmental level barriers for lean implementation

Parent Node	Child Nodes		Sources	References
Environmental level barriers	EB1	Lack of consultants and trainers in the field (Specialists)	24	24
	EB2	High cost of lean training	22	22
	EB3	Unstable markets for construction	22	22

Parent Node	Child Nodes		Sources	References
	EB4	Lack of cooperation from suppliers	20	20
	EB5	Quality problems with supplied material	19	19
	EB6	Poor consultations with stakeholders	19	19
	EB7	Lack of standards	17	17
	EB8	Fragmentation and sub-contracting in construction	15	15
	EB9	Cultural issues in getting the subcontractors and workers to adopt the methodology in a comprehensive way	10	10
	EB10	Lack of government support for research and collaboration in lean	8	8
	EB11	Traditional procurement and contracts	5	5
	EB12	Financial crisis	5	5
	EB13	Time consuming process	5	5
	EB14	Inflation	3	3
	EB15	Contractual disputes	3	3
	EB16	Complexity of lean	3	3

All the experts agreed that problems in the construction environment will negatively affect the lean implementation process. The most critical barriers identified by the experts is the '***lack of lean consultants and trainers'*** in the field. Hence, even the construction SMEs urge to implement lean, lack of lean experts in the field will hinder the lean implementation. Correspondingly, E15 mentioned that, '*introducing new concepts to the Sri Lankan construction industry is not an easy task. Lack of professionals related to lean, misconceptions, lack of knowledge about lean approach, limited availability of technologies and products and high initial cost will act as barriers which hinder the implementation. However, some barriers can be controlled with the available enablers… attention needs to be paid on identifying those barriers that are mitigated through lean implementation'*. Therefore, there is a need to increase the number of experts in the Sri Lankan construction industry to upsurge the lean implementation.

E15 stated that, the industry is struggling to work with few numbers of lean experts at hand. E3 and E8 stated that, sometimes they have to hire lean trainers from manufacturing industry and hence, the '***cost of lean training is quite high'*** for construction SMEs. Similarly, E20 stated '*the cost of lean is very high nowadays. So we are not in a position to hire trainers. They are highly demanding and hence, we cannot afford to pay for extra workers'*. Yet, the costs of applying lean implementation and the benefits derived from it are ambiguous and uncertain. Thus, the experts emphasised the need of the construction industry to rethink on how to overcome this issue by providing more lean trainers to the field. In a similar note, E11 concerned the time it takes to become lean and gaining the benefits through lean implementation. The findings of EIR-2 revealed that in construction, there is no clear, standardized, easy-to-use framework for lean implementation available which also considers sector specific barriers. Besides the organisational factors, E2 and E15 underlined that smaller firms face tough implementation challenges due to human and capital resources, data, and time constraints. Thus, the experts agreed to lack of time and money lead to '***unstable market for construction SMEs'***. Similarly, E2 highlighted that there is a fluctuating demand and supply in the industry and thus facing difficulties in predicting the cost of projects. Thus, experts identified the instability of the construction industry as a major barrier for lean implementation.

Experts indicated the problems with the supplied material by the suppliers/sub-contractors as a critical issue that can be overcome by implementing lean. As uttered by E7, suppliers are trying to neglect the SME sector and they always highlight the issue of payment delay which consider as another sector specific barrier. Similarly, the experts highlighted that ***lack of corporation from suppliers***, '***quality problems with supplied materials'*** and '***poor consultation with supplied materials'*** as the environmental level barriers for lean implementation among construction SMEs.

Nevertheless, '***lack of standard procedures'*** practiced in the construction industry was identified by 15 numbers of experts. Thus, unavailability of correct standards in the industry marked as a barrier for the construction SMEs to discover new standards for their organisations. Nevertheless, '***fragmentation and sub-contracting in construction'*** is another barrier in the industry. Even though, Mossman (2009) contended that fragmentation can be taken as a driver to implement lean in the construction, E5 stated that Sri Lankan construction SMEs are working under the monopoly created by large construction organisations. Moreover, experts added '***cultural issues in getting the subcontractors and workers to adopt the methodology in a comprehensive way***' as another barrier for lean implementation.

Nevertheless, '***lack of government support for research and collaboration in lean***' will impede the lean implementation in construction SMEs. Factors such as '***traditional procurement and contracts***', '***time consuming process***', '***financial crisis***', '***inflation'***, '***contractual disputes'*** and '***complexity of lean***' were identified by experts as other barriers for lean implementation in the construction industry. Majority of experts agreed that the construction industry needs to think beyond the existing level and develop the strategies to overcome the above barriers.

Construction SMEs are trying to overcome their individual barriers, organisational barriers and environmental barriers by implementing lean. However, there is a need to identify the lean capacities required by the construction SMEs to overcome the aforementioned barriers. Hence, the next section presents the lean capacities identified from EIR-2 for construction SMEs in Sri Lanka.

6.5 Lean Enabling Capacities

The next section of the interview guideline is mainly focused on developing a lean enabling capacity building framework. Therefore, RQ4 - What are the capacities required for enabling lean in construction SMEs? and RQ5 - What are the strategies for enabling lean in construction SMEs? were raised by the researcher. The findings were categorised under individual, organisational and environmental level capacities required for enabling lean and discussed in detail below.

6.5.1 Individual level lean capacities

As discussed in the Research Methodology chapter, the researcher used open coding, which is the first level coding as quoted by the experts to identify the lean capacities necessary to be built by individuals in construction SMEs. Nvivo11 was used for coding and MS Visio was used to graphically present the mind map. The research findings presented in Figure 6.3 shows the mind map with seven axial codes (highlighted in red) along with the related open codes for individual level lean enabling capacities for construction SMEs.

Figure 6.3: Individual level lean enabling capacities

According to the experts, there is an important role to be played by each and every individual in the organisation. The findings were presented under seven criterions as discussed below.

6.5.1.1 Communication skills for enabling lean

The experts emphasised that good verbal, non-verbal and visual ***communication*** of employees are essential for lean implementation within the construction SMEs (Refer Appendix 13.1 for Nvivo analysis). One of the identified barriers for lean implementation is improper communication within the parties of the organisation. Thus, E2 highlighted the need of improving the communications of the different parties with different attitudes. Further, E12 and E14 identified the ability to negotiate with employees and active listening to the importance of lean implementation as another important factors to change the mind set of people.

6.5.1.2 Lean thinking

Critically analyse a problem and derive a solution are imperative for continuous improvement. Hence, lean experts suggested ***lean thinking*** as one of the most important capacity that needs to be improved by employees (Refer Appendix 13.2 for Nvivo analysis). Similarly, E4 stated the need of individuals to be adoptable for the changing conditions and also, E15 noted that they can select the most suitable lean tools for problematic conditions. Hence, there is a requirement to improve the logical thinking ability. Moreover, as emphasised by E1 and E22, common sense and practical judgement is paramount to analyse a problem and implement suitable lean tools and techniques for their organisation. E1, E2, E12, E14 and E22 agreed that research interest on lean is not up to a satisfactory level among the construction SME sector. However, researching on lean tools and techniques is another factor to be considered, which ultimately improve diagnostic and troubleshooting ability of the individuals.

6.5.1.3 Lean leadership

The term leadership plays a major role in lean implementation (E11). Managing Director E3 clearly highlighted the importance of having a project manager (PM) or a leader at site to drive the lean implementation. E1 elaborated that, "*I want a PM to think and act as the captain of the ship where they feel total responsibility and also accountability for the failure/success (Impact analysis/value engineering) of the project. This is not being in practice in Sri Lankan context'.* Similarly, E12 blamed stating '*like I said, we are creators of individual work of arts. But in doing the creation, we need to manage the limited amount of resources. So, in my opinion, the better you manage your resources, the more capacity you bring*'. Thus, one of the important lean capacities that individuals in construction SMEs should have, is the lean ***leadership*** (Refer Appendix 13.3 for Nvivo analysis). According to the respondents, the leader needs to be accountable for the outcome, appreciate people, drive change management, command attention and shares the big picture with others. However, E23 stated that this is not limited to senior management and the middle management. Even the floor level management and shop floor level workers need to become self-leaders in order to drive the lean implementation as per E22 and E17. Hence, E1 emphasised the need of changing the working philosophy of individuals by having a visionary leadership.

6.5.1.4 Positive attitudes towards lean

According to E20, '*sometimes your project manager says, 'see how they price this? We cannot do this at this rate. What I expect from the project manager is to (yes estimation can be wrong) do an impact analysis of the pricing. What are the alternatives? Can we do the value engineering? These are the things which are difficult to change overnight'*. Therefore, there is a need to change the way people think and the way people approach the project as emphasised by E12, E22, E16 and E14. Moreover, being proactive, confident and optimistic employees will help to develop the lean culture within the organisation. As emphasised by E1 and E22, willingness to learn by people will make sure that the employees get the sufficient knowledge to accelerate the lean implementation. Therefore, ***positive attitudes*** towards lean are need to be built up by the individuals (refer Appendix 13.4 for Nvivo analysis). Thus, lean thinking and building lean attitudes can be considered as another lean enabling capacity for individuals.

6.5.1.5 Lean knowledge

One of the major lean implementation barriers is the lack of lean awareness within the organisation. Therefore, experts stressed the need of lean knowledge on the concept and technical know-how for construction SMEs. According to E19 and E20, they need to be trained to ascertain knowledge by doing and get sufficient training on lean tools. E5 highlighted this issue with an example stating *'when we hire* *graduates, they are very technical. No doubt about that. But they are not practical. Because, they have not taken the efforts to study these processes. So, what I am suggesting is, when you are sending these people, not just to sit in the site but to learn the entire process of construction by involving'.* Thus, ability to learn by doing and applying what is learnt is noted by the experts.

According to E6, management needs to be strategic when recruiting employees. Nevertheless, E14 and E17 stressed the need of having a record of their employees' skills, knowledge and experience that gained both formally and informally. This can be used to develop the KPIs for individuals as well as for selecting suitable lean tools and required training methods. Hence, '***lean knowledge***' (Refer Appendix 13.5 for Nvivo analysis) identified as another lean capacity for individuals in the construction SMEs.

6.5.1.6 Team working skills

As per E16, the implementation of lean cannot be done solely by an individual player. Thus, E1 highlighted the need of many parties to effectively involve to be succeeded in lean implementation. Hence, E7 stated, '*there is a requirement of different level of attentions to detail than what the rule of thumb target. Thus, employees need to help each other to be successful lean implementation*'. Therefore, ***team working skills*** (Refer Appendix 13.6 for Nvivo analysis) is considered as another lean capacity to be developed by individuals. E2 highlighted an example from a site stating, '*we have an issue where sometimes when we are bidding for projects, estimating was done through a team of employees... the bidding process will require different level of attentions to details. However, our estimation was not enough most of the time… Thus, need to liaise with team members to provide a good output'.* The respondents stressed the need of employees to be collaborative, accept feedback and should have the capacity to cover at problematic situations through establishing interpersonal relationships and networking with the team members. Therefore, the construction SMEs need more experienced employees who can influence others towards success.

6.5.1.7 Lean ethics

The respondents stated that the employees need to be punctual, reliable, and honest. E10 voiced, '*If I had independent, multitasking two employees who follow directions and achieve deadlines, I could have implemented most of the specified lean tools and techniques in the construction sites. But the problem we have is people are lazy and not in the mood of maintaining a to-do list and schedule their day today work'.* Hence, maintaining good business etiquette is imperative for successful lean implementation. The experts further added that, workers need to be self-directed, self-monitoring, self-supervising and stay on task to achieve the objectives of the lean implementation. However, according to E14, E19 and E23, workers in the construction industry are always under pressure in spite of the size of the organisation. Hence, E14, E19 and E23 highly stressed the importance of workers to work under pressure. Otherwise, lean implementation will fail in the initiation stage. Therefore, ***lean ethics*** identified as another category of individual level lean capacities for construction SMEs (refer Appendix 13.7 for Nvivo analysis).

Nevertheless, the individual lean capacities are critically affected by the actions taken by organisations. Thus, the next section presents the organisational level capacities for construction SMEs identified in EIR-2.

6.5.2 Organisational level lean capacities

The next question raised was the type of organisational level capacities required for construction SMEs. The researcher used open coding as quoted by the respondents to identify the lean enabling capacities at organisational level for construction SMEs. The identified open coding was further categorised into five axial codes. Nvivo11 was used for coding (refer Appendix 14 for Nvivo analysis) and MS Visio was used to graphically present the mind map as shown in Figure 6.4. It shows five axial codes (highlighted in red) along with the related open codes for organisational level lean enabling capacities for construction SMEs.

Figure 6.4: Organisational level lean enabling capacities

Accordingly, the organisational level lean enabling capacities identified were lean workforce, physical resources, organisational strategic plan towards lean, organisational lean culture and reward system, and R&D as discussed in detail below.

6.5.2.1 Lean workforce

The most important capacity that an organisation should has, is the ***lean workforce*** (Refer Appendix 14.1 for Nvivo analysis) as per the respondents of the research. Under this capacity, the respondents highlighted the importance of having and developing individuals with lean knowledge and skills. However, the experts highlighted the role of managers following in an organisation and hence, added availability of lean leaders as another important lean capacity at organisational level for construction SMEs.

6.5.2.2 Organisational strategic plan towards lean

Even though, construction SMEs have both physical and human resources, there is a need of a strategic plan towards lean in the construction SME (Refer Appendix 14.2 for Nvivo analysis). The experts added the need of internal business processes management plan in the organisation. They stressed the need to include plans for project management, waste management, operations management, office management in this regard. E2 from a SME stated '*In modern industry, there are very good tools and techniques to specifically itemise your action and give specific cost for the item that can be formulated it to the cost estimate. But in Sri Lanka, we are still practicing the conventional methods to prepare the estimates due to the poor management within the organisation'.* Hence, E12 and E23 agreed to construction project management plan, risk management plan and financial management plan within the organisation to develop new strategies for SMEs. E1, E2, E3 and E6 added that business development and growth plans are paramount to the organisation. Hence, the employees' awareness about the problems and possible remedies behind the lean implementation is necessary to increase the value. Moreover, all respondents emphasised the need of in-house lean knowledge and skills development programmes in this regard.

6.5.2.3 Organisational lean culture and reward system

The experts recommended of having reward and recognition system for lean implementers to motivate the employees within the organisations. Accordingly, E5 highlighted that this will encourage employees practicing new tools and techniques. Therefore, E1, E12, E23, and E14 stated that well defined organisation structure with communication paths, flow of power, authority and responsibilities within the organisation needs to be available in the organisation. However, E18, E20 and E23 highlighted that the organisations to be a learning organisation and need to maintain a lean culture. As stated by E2, the organisational policies and procedures need to be flexible enough for employees to initiate efforts towards lean implementation. Henceforth, no blame culture within the organisation needs to be maintained.

According to E5, this will support people to ask anything at the same instances. Conferring to E18, this will articulate the organisation to face unexpected problems and hence able to identify the suitable lean method to overcome the problems. Therefore, ***organisational lean culture and reward*** (refer Appendix 14.3 for Nvivo analysis) can be identified as an organisational lean capacity for construction SMEs.

6.5.2.4 Physical resources

Most of the experts agreed that the construction SMEs required not only soft skills of people but also adequate ***physical resources*** to achieve the successful lean implementation (Refer Appendix 14.4 for Nvivo analysis). E2 mentioned that '*as a SME, our working capital is very low. We don't have extra money to purchase advanced equipment to automate the systems, materials such as PPVC, etc. If we have enough resources, we already have implemented lean in our projects'*. Therefore, availability of physical resources is paramount to construction SMEs. Further, as deliberated by E22, '*working capital is required only to cover up the additional costs of training. You don't need extra money to implement lean and gain the benefit*'. Thus, financial capability of the construction SMEs has not been acknowledged by majority of experts. Similarly, E13 added '*there is no way we can implement JIT in our projects. We need sound logistics, good supply chain with experienced subcontractors, inventory management system to successfully implement this type of lean techniques'.* In addition, E3 and E14 highlighted the availability of good ERP system in the organisation will accelerate the lean implementation. As highlighted by E12 '*there should be a place for everything and everything must be in its appropriate place*'. Agreeing to E12, E14 stressed that, there is a need optimise the available space by comfortably store items. Further, E4 confirmed that stating '*things (material, equipment, etc.) and people (managers, technicians, clerical, etc.) need to have a committed place in the organisation*'. Thus, all respondents agreed the need of optimally utilisation of existing resources for successful lean implementation.

6.5.2.5 Research and development (R&D)

The respondents identified ***R&D*** within the organisation as an organisational level lean capacity (Refer Appendix 14.5 for Nvivo analysis). Therefore, construction SMEs should have good inter-institutional linkages. This was proven by E17 stating that '*by sharing best practices within the organisation and other organisations will help our employees to identify their wastes. They will find the possible solutions for their problems'.* Hence, the construction SMEs required to minimise their NVAA by employing new improvements. Adopting a culture for improvement despite project nature of work is hence an added advantage for leaner organisation. This will further help seeking new research for the organisations. Consequently, E5 added that the employees in the lean organisation will be able to pursue partnerships in research initiatives as well as partnerships in working with others. Bestowing to E15 and E16, Authorities such as CIDA are willing to help the SMEs to conduct research by providing grant schemes specially developed for SME sector. Thus, most of the barriers as discussed under Section 6.4 for lean implementation can be solved by construction SMEs. However, E16 further added that, construction SMEs need to work hard to obtain the research grants from the government. However, despite the fact that the organisation culture helps implementing lean, there is a need to be backed by adequate environmental capacities. Thus, next Section 6.5.3 discusses the environmental capacities required for construction SMEs.

6.5.3 Environmental level lean capacities

The researcher further questioned about the environmental level lean capacities from the experts. Nvivo11 was used for coding the environmental level lean enabling capacities (Refer Appendix 15 for Nvivo analysis). The identified open coding was further categorised into four axial codes and used MS Visio to graphically present the mind map as shown in Figure 6.5. It presents the identified four axial codes (highlighted in red) along with the related open codes for environmental level lean enabling capacities for construction SMEs.

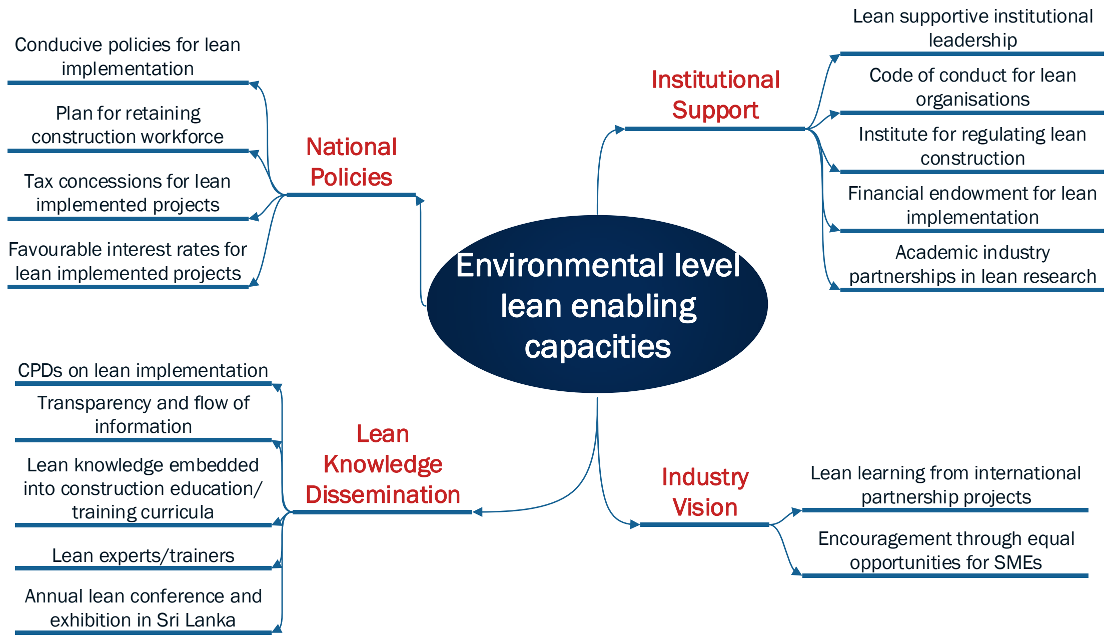


Figure 6.5: Environmental level lean enabling capacities

Accordingly, the axial codes for environmental level lean capacities named as institutional support, national policies, lean knowledge dissemination and industry vision. Thus, next sections discuss the identified environmental level lean capacities in detail.

6.5.3.1 Institutional support

The respondents acknowledge the need of ***institutional support*** for successful lean implementation in construction SMEs (Refer Appendix 15.1 for Nvivo analysis). As per experts, lean supportive institutional leadership needs to be available for construction SMEs. This was proven by E16 from CIDA, stating that '*We are happy to get the leadership to initiate programs on lean and we want to help construction SMEs. We would like to change the way we are working to introduce lean for construction SMEs. But only problem we have is financial problems'*. Hence, this further shows that, although the authorities want to help construction SMEs, they have budgetary issues. Moreover, E22 commented the need of strategies for funding lean experts. Moreover, construction SMEs are not in a position to sponsor lean conferences. Unquestionably, E22 stated the need of a mechanism to draw funds from large construction organisations for funding lean conferences. Then both large construction organisations as well as construction SMEs will be benefited by attending lean conference. Therefore, as per experts (E2, E8, E12, E14, E20), there is a need to have financial endowment for lean implementation which will eventually motivate construction SMEs and accelerate lean implementation in the Sri Lankan construction industry.

According to E20 and E23, similar to manufacturing industry (Institute for Lean Management Sri Lanka), construction industry needs an institute for regulating lean construction. E20 highlighted that '*to where they should inform when there is a problem in lean implementation*'. Consequently, experts highlighted the importance of having a lean code of conduct for construction SMEs. As most of SMEs show interest on regulating lean, E20 and E14 highlighted the need of a separate institute to carry on works related to lean construction with the help of government and CIDA.

As noted by E21, accessibility of norms in the environment will speed up the lean implementation within the construction SMEs. Correspondingly, E21 further added '*construction SMEs have the problem of conducting research. They have less capacity comparing to large construction organisations. Thus, developing norms by themselves is difficult. For an example, KPI for construction processes, or else for people is not readily available in the market. However, as research institutes, we can develop these norms and construction SMEs can use them'.* Hence, availability of norms and guidelines can be reckoned as a way of accelerating lean implementation among construction SMEs.

Nevertheless, private public interactions in terms of inter/intra-industry research activities and dissemination/exhibitions of research activities were identified as another institutional support by the respondents. By analysing these factors, institutional support identified as an environmental lean capacity for construction SMEs. However, this needs to be backed with appropriate national policies as discussed in the next section.

6.5.3.2 National policies

The respondent added ***national policies*** as a lean enabling environmental level capacity (Refer Appendix 15.2 for Nvivo analysis). E15, E16 and E18 highlighted the need of having conducive policies for any construction business organisation. According to E5, the government can make certain lean tools and techniques as pre-requisites to encourage lean implementation in construction projects. When the researcher asked about the implementation of 5S, E12 clearly mentioned '*Yes, we have properly implemented 5S. It is a pre-requisite in the contract document'.* Therefore, if it is an obligation, construction SMEs are compelled to follow it under any circumstances. This marked as a way of increasing lean implementation within the SME sector.

One of the leading problems faced by construction industry today is lack of construction workforce in Sri Lanka and hence, identified it as a major barrier for lean implementation. Therefore, E13 emphasised the need of having strategic plan to retain the workforce. Similarly, E12 added one reason for lack of workers as the preference for smart/ government jobs rather than work in construction industry due to the pension scheme offered for the government workers. Similarly, E1 added temporary nature of jobs, daily wages, dark and difficult job as the reasons for lack of construction workforce. Hence, E23 suggested the government to initiate a plan for retaining construction workforce. This will encourage people to get involve with construction projects. Subsequently, construction SMEs have skilled workers to carry out their day today works as well as the lean implementation. Moreover, there is a need of having a good procedure for professional development of construction workforce. Thus, E16 added the awareness of lean and experienced in lean projects to be added to the marking criterion. Correspondingly, E16 and E17 agreed on having lean qualifications in obtaining CIDA grading.

E4 noted that, '*What are we getting, if we implemented lean? Do we get money or something? The benefits that can be gained by implementing lean are not clear cut. So we need tangible benefits within a shorter period'.* Henceforth, the construction SMEs expects some tangible benefits by implementing lean. Otherwise, according to

E12, the workers as well as top management will not be able to realise the significance of lean for their organisation. Nevertheless, E20 added the short construction periods of the projects will not be apparent the benefits of lean implementation. Yet, the availability of tax concessions for lean implemented projects will motivate the construction SMEs in implementing lean. E20 and E2 further added, similar to hotel projects, if tax concessions are available from BOI, at least for some materials, the construction SMEs will definitely attempt lean implementation.

Most of the experts agreed that lack of finance of construction SMEs as a major barrier for lean implementation. According to E1, most of the projects are financed through loans and hence, there is a reluctance to allocate money for lean initiations. Therefore, E2, E3 and E6 noted that availability of favourable interest rates for lean implemented projects will loosen up the burden of construction SMEs in financing their lean implementations.

6.5.3.3 Lean knowledge dissemination

Lean knowledge dissemination identified as another important environmental level lean capacity that necessitates for successful lean implementation (refer Appendix 15.3 for Nvivo analysis). According to the experts, lack of awareness on lean construction is marked as a major barrier for lean implementation. Hence, there is a need for lean awareness programs specifically for construction SMEs. E4 stated, '*we don't know about lean that much. So, you name some of the ways we can get knowledge about lean. Are there any specific lean programs for us? How much normally they charge to attend the programs?'* Therefore, the experts suggested the need of targeted CPDs on lean implementation for construction SMEs in the Sri Lankan context.

As highlighted by E22, in manufacturing industry, considerable amount of lean awareness programs are conducted in Sri Lanka. Correspondingly, E20 confirmed the above highlighting the systematic implementation of lean in manufacturing industry in Sri Lanka. However, E22 further stressed that, these programs are expensive and thus organisations are not willing send their employees to attend these programs. This further emphasized the need to conduct programs at concessional rates for construction SMEs. Therefore, availability of CPDs for SMEs at concessional rates is a noticeable lean capacity.

E14 highlighted the need of transparency and flow of information within the industry as a lean capacity. E5 reasoned out stating that, this will help to reduce bribe and corruptions within the industry. Thus, as per E12, most of the challenges faced by construction SMEs can minimise by saving the money that goes out as bribes. Hence, they have more time and money to allocate for lean implementation. The industry ought to have sufficient lean experts and trainers. As stated by E10, E15 and E16, the experts should include both academic researchers in lean as well as experienced lean workers. During the interview, E2, E3, and E6 showed their interest in implementing lean and requested the names of the lean experts in Sri Lanka to hire for their projects as they clearly stated that Sri Lankan construction industry can hardly find lean experts. Therefore, E4 stressed the need of lean experts as well as the trainers in the industry to help construction SMEs to show the path towards successful lean implementation.

E20 stressed the need of developing curricula for educating and training construction workforce towards lean implementation with the help of lean experts in the industry. Thus, embedding lean knowledge into construction education/training curricula need to be established to increase the lean awareness. E1 emphasised the importance of having lean construction conference in Sri Lanka. Specifically, E1 suggested IGLC conference as a good forum for construction industry professionals to get involve with lean construction initiators. Most of the lean experts are joining this conference in every year and they are conducting workshops for disseminating knowledge for successful lean implementation. The researcher had the opportunity to take part the IGLC 2018 conference, which was held in India, and recognise the acknowledgement given by the Indian construction industry. Therefore, need of a lean conference and exhibitions in Sri Lanka with lean pioneers will be an added advantage for lean implementation for construction SMEs.

6.5.3.4 Industry vision

Industry vision identified as another important environmental level lean capacity that necessitates for successful lean implementation (Refer Appendix 15.4 for Nvivo analysis). According to the respondents, there is a monopoly created by a few number of large companies in Sri Lankan construction industry. Therefore, the centre of attention of government as well as the construction industry is large construction companies. Therefore, there is a need to provide adequate attention from government for construction SMEs during this monopolistic situation. Many of the experts highlighted that, even though construction SMEs largely contributed to the GDP of the country, poor attention have been given towards the SME sector. In a similar note, E10 noted, '*government has special benefits for large construction organisations. Those who are in the CS2, CS1, C1 category are the beneficial party'.* Nevertheless, due to the monopoly created by large construction organisations is hindering the lean implementation. Therefore, availability of equal opportunities for construction SMEs is highlighted by the experts to enable lean and get the required benefits to the organisation.

As stated by E10, '*the government is compelled to encourage SMEs as well as lean construction*'. Consequently, E12, E14 and E22 emphasised the need of encouragement through equal opportunities for SMEs. Nevertheless, E1 highlighted the less involvement of construction SMEs in international partnership projects. In a similar token, E2 extended the lean learning that can be gained through international partnership projects. Therefore, the availability of foreign workers who has the awareness of lean will be an added advantage for Sri Lankan construction SMEs. Hence, ***industry vision*** can be marked as a lean capacity required for construction SMEs.

In summary, individual level lean enabling capacities were communication skills for enabling lean, lean thinking, lean leadership, positive attitudes towards lean, lean knowledge, team working skills and lean ethics. Lean capacities for organisational level were lean workforce, organisational strategic plan towards lean, organisational lean culture & reward system, physical resources and R&D. Environmental level lean enabling capacities were categorised in to four as institutional support, national policies, lean knowledge dissemination and industry vision.

The next section discusses the identified strategies for lean enabling capacity building for construction SMEs in Sri Lanka.

6.6 Lean Enabling Capacity Building Strategies

The researcher further asked from experts about the strategies for building lean enabling capacities for construction SMEs (refer Section 5 in interview guideline for EIR-2 in Appendix 12). The collected data were further categorised under the strategies for lean enabling capacity building at individual, organisational and environmental levels in construction SMEs. Hence, the next sections present the strategies at three different levels.

6.6.1 Individual level strategies for lean enabling capacity building

The findings of EIR-1 confirmed seven, five and four lean enabling capacities for individuals, construction SMEs and environment respectively. As per E14, '*you cannot ask the way to build their capacities in just one way; there is so much they have to do to build their capacities*'. Similarly, E20 added '*the capacities cannot be built up overnight. You need to realise the need and as a whole you need to develop every possible aspects*'. Thus, there is a requirement for building strategies within the individuals of the construction SMEs for successful lean implementation. Refer Appendix 17 for individual level lean enabling capacity building strategies along with identified node structure. Figure 6.6 presents the chord diagram for individual level lean enabling capacity building strategies against three levels of lean enabling capacities.

Accordingly lean learning, monitor & report progress, start lean by doing, lean skills development, use existing capacities and lean knowledge dissemination were identified as the individual level strategies for enabling lean in construction SMEs. Nevertheless, the detail discussion is given in the next section.

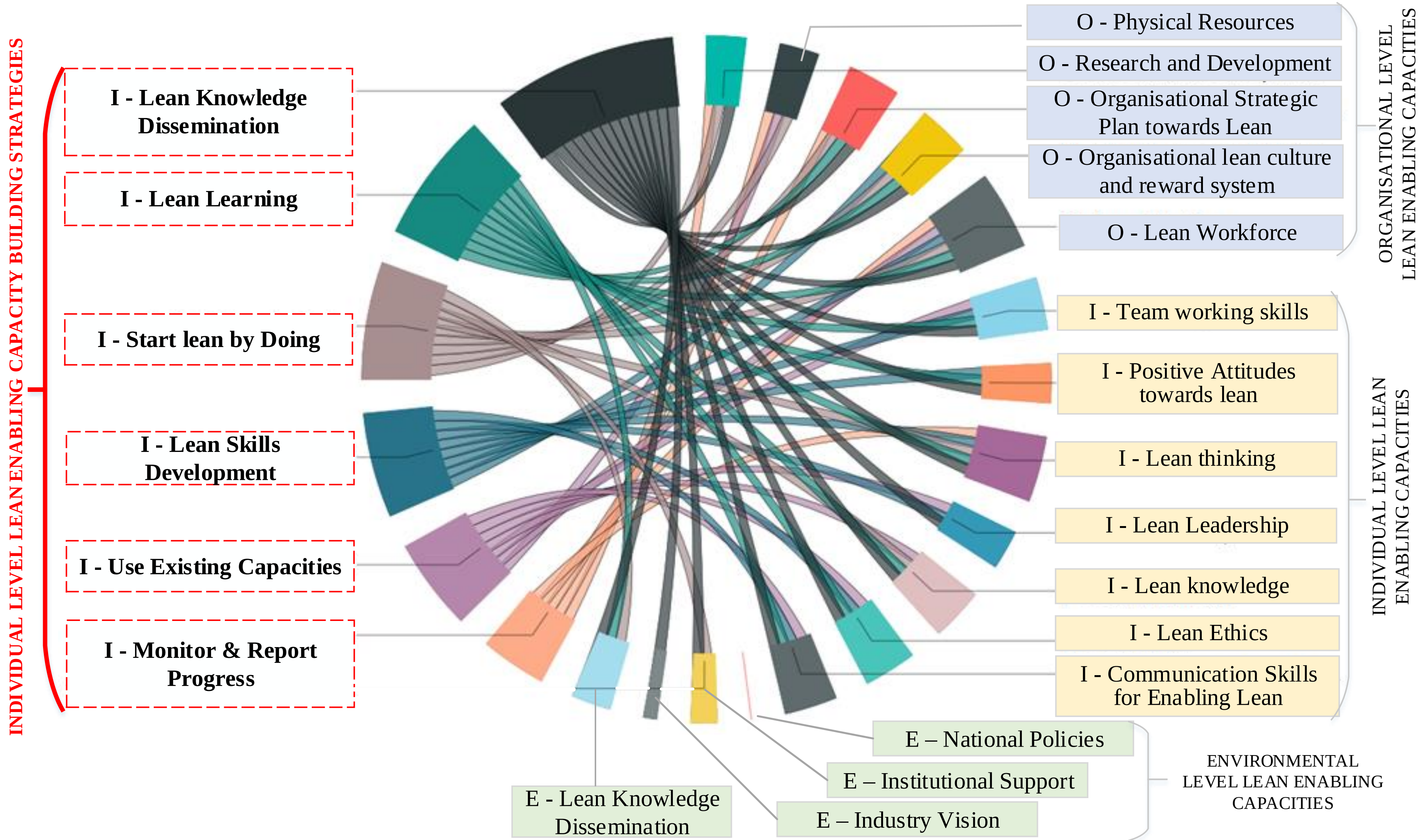


Figure 6.6: Individual level lean enabling capacity building strategies

6.6.1.1 Lean learning

One of the major characteristics of lean organisations is continuous urge on learning. All experts had unanimously agreed that there are good learning opportunities available in the construction industry which supports construction SMEs in building lean capacities (refer Appendix 17.1 for Nvivo analysis). E7 and E20 added the importance of strengthening the learning within the organisation by employees. Therefore, the employees need to ensure to get adequate learning through adequate training. E13 mentioned that, '*learning makes people aware on the possible alternatives available in the industry. It gives the courage for them to propose new improvements for the work they carried out*'. E2 added that, '*we need to continue learning not the way we are doing now. It needs to be done in an appropriate way*'. Hence, genuine commitment and interest in lean learning will confirm that the individual can build their lean thinking, lean knowledge, lean ethics and positive attitudes towards enabling lean. Correspondingly, lifelong learning of individuals needs to be maintained for successful lean implementation. E21 stated that, '*construction professional bodies should pay attention on the advantages of the lean implementation and increase the awareness through learning from CPD sessions*'. Hence, experts admired continuous improving of acquired skills and knowledge to build lean capacities by individuals. Therefore, lean learning by individuals will help building a lean workforce and develop organisational strategic plan to enable lean. Consequently, it will build the organisational lean culture. The experts further emphasised the need of lean learning for lean knowledge dissemination.

6.6.1.2 Monitor and report progress

As per the experts, construction SMEs need to monitor and report the individual progress (Refer Appendix 17.2 for Nvivo analysis). E15 stated that, '*our workers need to monitor during the working hours. Otherwise, they will not work at their best'*. Similarly, E8 added '*we should give them targets from the beginning from which we can time to time check whether they achieve them or not. Otherwise, how are we going to make sure that they have done the work assigned to them*?' Nevertheless, E2 stated '*even we are sending our workers to training programs, some* *of them skip the programs and take that as a leave day. So, we need to prepare a method to monitor the progress of them after these training programs'.* However, the researcher contended that, checking progress after training programs such as lean awareness, tools and techniques are acceptable. On contrary, it is difficult to check the progress after attending soft skills development programs, which requires a considerable time and organisations need to maintain a suitable mechanism to monitor and report the progress of individuals in the firm. Thus, it required continuous improvement to suit the required lean capacities of individuals. Therefore, taking corrective actions for individual improvements will demonstrate the achievability of lean thinking. Moreover, the organisational capacities such as lean workforce, R&D can build through monitoring and reporting progress.

6.6.1.3 Start lean by doing

During the semi-structured interview had with the experts, they clearly indicated the importance of initiating lean with pilot projects (Refer Appendix 17.3 for Nvivo analysis). They can select basic lean tools as discussed in Section 2.10.4. This was proven by E12 stating that, '*the implementation should start from the site. At least you should start with 5S implementation. Proper implementation needs to be there. They slowly can progress to the higher order level lean tools*'. Therefore, construction SMEs need to make better use of existing capacities to start lean implementation. Subsequently, construction SMEs will be getting lean knowledge. Thus, they can build up or strengthen existing capacity to implement new lean tools and techniques by building lean knowledge. Therefore, the experts agreed that all five organisational lean enabling capacities can be built through starting lean by doing.

6.6.1.4 Lean skills development

As discussed in Section 6.5.1, training sessions are paramount to improve the lean capacities like lean thinking, positive attitudes, lean leadership and lean ethics. Thus, attending CPD programmes on lean skills development conducted by professional trainers were stressed by the experts. Correspondingly, development of lean skills will improve the problem-solving skills of employees and will change the attitudes of individuals towards lean. E2 stated that, '*our people expecting to bloom flowers within two three days. They don't have the patience to wait for a period to see the flowers. This mind-set needs to be changed as soon as possible. Otherwise, we will follow the same traditional way of doing businesse*s'. Therefore, E3 stated that, people should not rush for short-term results and respect the value system and foster self-esteem. E12 uttered '*now the construction paradigm has shifted. Especially after the war, some construction companies struggled with the existing capacities. So, for construction SMEs, this is a very tough situation. But they should know how to manage them'.* Hence, there will be difficult stretches during the journey towards lean. Yet, there is a need to stay engaged under difficult circumstances by individuals to achieve the benefits of lean implementation. Therefore, lean skills development by individuals will help creating organisational lean culture as well as and develop organisational strategic plan to enable lean in construction SMEs. Refer Appendix 17.4 for Nvivo analysis for lean skills development.

6.6.1.5 Use existing capacities

Any individual required to develop the existing capacities before developing new capacities. Thus, the individuals required to develop their existing capacities in the first instance to encourage the lean implementation. Refer Appendix 17.5 for the summary of how experts mentioned the need of using existing capacities. E11 stated that '*we have many good workers in the site but reluctant to do a good job. Unless giving a good monetary reward, they will not show their colours at the site'.* This was proven during the situational analysis of construction SMEs (refer Section 5.4) where underutilisation of skills was counted as one of the critical issues amongst the construction SMEs in Sri Lanka. Therefore, there is a need to make the better use of existing capacities to build lean knowledge, lean leadership, lean ethics and communication skills for enabling lean. In contrary, the experts suggested to develop new capacities among the available construction workers at site rather recruiting new workers for the site. Moreover, to build a lean workforce in the construction SMEs, the experts underlined the need of using existing capacities. The experts further highlighted the need of organisational capacities and environmental capacities to get the maximum use of existing individual capacities.

6.6.1.6 Lean knowledge dissemination

The experts highlighted the importance of ***lean knowledge dissemination*** for employees (Refer Appendix 18.6 for Nvivo analysis). According to E9, as construction SMEs are having few numbers of employees, provide training for them is easy compared to large contractors. However, to build up lean capacities, E2 and E17 stated that, the construction SMEs should encourage their employees as well as the management to get trained to improve ability to perform functions. E6 said '*the major problem of our labour force is not having appropriate lean knowledge. They need to be trained from an acceptable institute'.* Similarly, E16 added '*We have number of programs which can train the labours as well as the owners of the company'.* This clearly shows the availability of training programs which aligned to construction industry needs. Therefore, a need stands up to encourage employees to be cautious to identify the available programs and attend to get the lean knowledge. E15 and E16 further added that, most of the government programs are conducted free of charge or at very low rates for construction SMEs, thus, highlighted the need to get the benefits of being SMEs in the construction industry. Nevertheless, E2, E13 and E22 added the importance of training construction workforce as lean trainers by way of disseminating lean knowledge. In a similar note, E15 and E16 added that, '*they can participate lean awareness CPD programs as a resource person*' which help improving lean leadership, team working and communication skills for enabling lean in the construction industry. According to the experts, lean capacities like lean thinking, positive attitudes, lean leadership and lean ethics can be improved by attending in-house trainings programs. Therefore, lean knowledge dissemination will pave the path towards building organisational lean culture and lean workforce.

6.6.2 Organisational level strategies for lean enabling capacity building

Organisational level strategies manifest the most important, yet, difficult level to build lean capacities. The discussed lean capacities at all three levels can be achieved through implementation of strategies as shown in Figure 6.7 (Refer Appendix 18 for Nvivo analysis of organisational level lean enabling capacity building strategies).

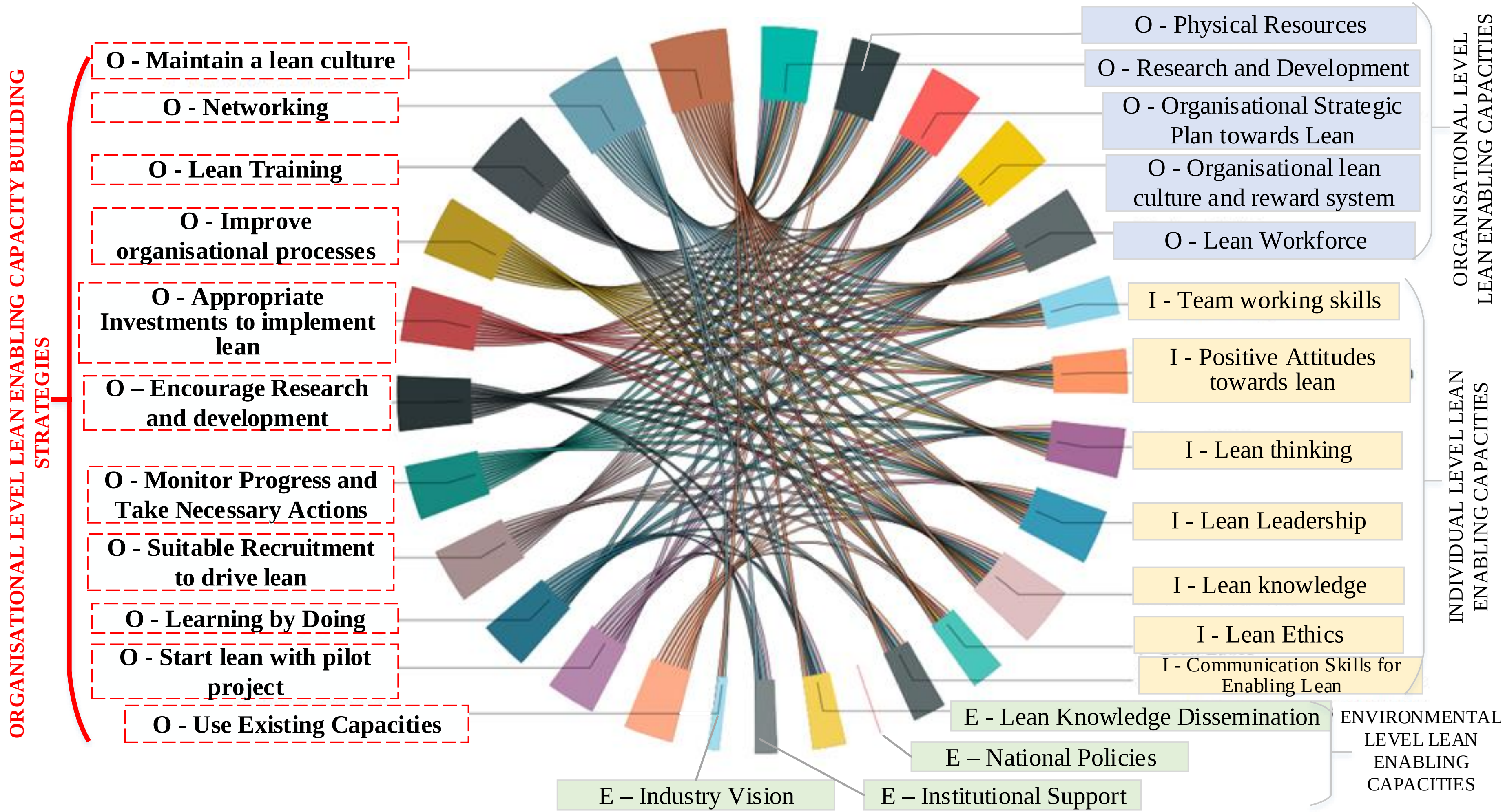


Figure 6.7: Organisational level lean enabling capacity building strategies

According to Figure 6.7, eleven strategies were identified for lean enabling capacity building strategies at organisational level and discussed in detail below

6.6.2.1 Monitor progress and take necessary actions

Construction SMEs need to monitor and report the progresses of each and every individual at the organisation (Refer Appendix 18.1 for Nvivo analysis). E15 noted that, '*our workers have to be monitored during working hours. Otherwise, they will not work at their best'.* Similarly, E22 added '*we should give them targets from the beginning from which we can check whether they achieve them or not*'. However, organisations need to maintain a suitable mechanism to monitor and report the progress of individuals in the firm. Alternatively, the experts highlighted the importance of establishing KPIs for monitoring progress from which they have their own norms for preparing productive targets for individuals in the company. Correspondingly, there is a need to report the individual progress against the achieved KPIs to the senior management to make sure that they are working at their best to achieve targets. Correspondingly, this will pave the path towards taking necessary actions to correct the deviations in the achieved KPIs.

Accordingly, as per Figure 6.7, all organisational level and individual level lean enabling capacities except lean ethics and communication skill can be built through progress monitoring. However, there is no such impact to environmental level lean enabling capacities.

6.6.2.2 Learning by doing

Experts have given multiple opinions to address this issue in conventional practice (Refer Appendix 18.2 for Nvivo analysis). As per E5, labour performances are highly depending on the consistency of the working method that they adopt. Simplifying this argument, E11 noted that, the regular changes in the construction process diminish the performance level, since it takes time for adjustments. According to E1, the material wastes and defects in works are high during this period of adjustment. All these opinions prove that, a consistent construction process brings productivity to the project by eliminating NVAA. As uttered by E19 and E20, there is a need to let people learn from errors. Thus, E23 stated that '*by doing what you learnt at the university will show the practical problems, and will learn how to overcome practical problems*'. By confirming the above, E2 added '*What I feel is they need to learn by doing at site. Only 20% will add what you learnt beyond the site*'. Thus, there is a need to let people even the top management work at the site to learn not only solutions for the problems they faced, but also to identify the NVAA.

Consequently, it could build individual level (lean knowledge, lean thinking, positive attitudes towards lean), organisational level (R&D, organisational lean culture, lean workforce) and environmental level (lean knowledge dissemination and institutional support) lean enabling capacities.

6.6.2.3 Maintain a lean culture

Most of the individual lean capacities as well as organisational capacities can be achieved through maintaining a lean culture within the organisation (Refer Appendix 18.3 for Nvivo analysis). Many experts expressed their willingness for adapting a culture for improvement despite project nature of work. This was confirmed by E2 stating that, '*we always think about how to complete the given project or the task given only. We are bound by the time and cost restrictions. So, we are not taking any steps towards improvements. It needs to be changed with the time'*. In order to maintain the lean philosophy within the organisation, there is a need to adapt a culture for improvements. Employees need to be encouraged for improvement by providing sufficient incentives and need to maintain a no blame culture. Correspondingly, E19 underlined, if employees make some mistakes it needs to be discussed properly with them. E19 further added, to create a no blame culture, there is a need to maintain a problem-solving culture through addressing the issues in a systematic way. E20 stated on not finger pointing to the person when there is a problem, but finger point to the process to maintain the no blame culture. Moreover, E2 established this by stipulating that '*frank dialogue with employees and a collective culture of transparency are essential for the success of lean implementation within the construction SMEs. People expect support from us. So, we need to be friendly with them and should provide the expected recognition for them'*. E19, E1, E6 and E12 added to maintain the '*trust of* *trees*' within employees. As a result, E20 said that, negotiation and agreement with team members will be easy within the organisation. However, majority of the experts agreed on enhancing communication and coordination to develop the lean capacities. Therefore, the organisation needs to adopt a lean supportive culture.

According to E23, people expect respect from the top management and they need to be taken as a part of the organisation. Thus, majority of experts agreed that, transparency needs to be achieved within the organisation. Therefore, as per E19, the first thing to do is developing the attitudes of all who involve with the organisation. In order to maintain the lean culture, construction SMEs need to reinforce behavioural guidelines to avoid backsliding. According to lean experts, this can be done by the leaders in the organisation. Thus, responsible leaders will inspire their institutions and societies to work accordingly.

Nevertheless, maintaining a lean culture will support to build up all individual and organisational level lean enabling capacities. The experts further emphasised that, industry vision and lean knowledge dissemination can be built through maintaining a lean culture.

6.6.2.4 Networking

Although R&D marked as one of the ways to building lean capacities, single handed researches cannot be taken as the best practices for R&D within the organisation. Hence, the experts stated that, a group of people would be ideal for researching to develop the capacities. Hence as an initiation, they need to pursue partnerships in working with others in the organisation. Thus, E16 stated '*you need to work with others. Need to listen to others. Also, you need to share the achievements of your investigations. Show others the problems faced by you'*. Therefore, it is crucial sharing best practices within the organisation as well as with other organisations. E8, E9 and E10 highly emphasised the need of construction SMEs to discuss with large construction companies on how they implement lean and the problems they faced during the implementation. Correspondingly, the lean knowledge will transfer from main contractor (large) to sub-contractor (SME). As noted by E1, '*most of the foreign* *contractors such as Chinese, Japanese contractors are practicing in Sri Lanka. So, our contractors can learn from them*'. Therefore, E1, E3 and E12 emphasised the need of networking with foreign contractors to transfer their knowledge to Sri Lankan workers. Thus, there is a need to encourage networking (Refer Appendix 18.4 for Nvivo analysis) to learn on the available lean tools, and techniques and their methods of implementing. Consequently, as per Figure 6.7, except lean ethics all other lean enabling capacities at all three levels can be built through good networking.

6.6.2.5 Appropriate investments to implement lean

According to the findings, many lean experts expressed the need of appropriate financial allocation for lean implementation (Refer Appendix 18.5 for Nvivo analysis). E12 added '*you need to carefully control your available money. Choose the exact place to be invested. Also, better if you can hire a business analyst for construction SME who can guide on long term investments*'. Thus, construction SMEs need to invest on new materials, new equipment as well as new employees for their organisation. However, construction SMEs needs to fully utilise their human resources. Hence, well established positive incentives within the organisation will motivate the employees for successful lean implementation. As uttered by E7, the employees need to be motivated to find solutions for their problems. However, as discussed in lean tools and techniques in Section 5.5, the employees can create their own tools and techniques for the organisation. Therefore, experts suggested investing in lean tools that give both short-term and long-term benefits for the construction SMEs. Accordingly, as per Figure 6.8, all organisational lean enabling capacities and individual level lean enabling capacities except lean thinking and communication skill can be built through appropriate investments.

6.6.2.6 Suitable recruitment to drive lean

The experts highlighted the need of employing individuals with adequate and relevant qualifications to the organisation (Refer Appendix 18.6 for Nvivo analysis). As construction SMEs lack human resources, there is a need to employ the best to get the maximum benefits to the organisation. E7, E10 and E13 highlighted that there is a need to recruit qualified people who are practical in nature. E7 further extended that, '*when they graduate, they are very technical. No doubt about that. But they are not practical as they have not taken the effort to study these processes. So, what I am suggesting is, when you are sending these people, not just to sit in the site but to learn the entire process of construction*'. Similarly, E2 added *'when you come out as an engineer, you should be able to apply what is relevant in the industry now to the problem at hand'.* Therefore, senior management has to play a vital role with this regard during the recruitment process. They need to check the practicality of the applicants before employing them to the firm.

Other than the appropriate recruitment of employees, experts emphasised the need of having a lean expert for the organisation. According to E19, this person will be the change agent for the organisation who can develop the pathway towards successful lean implementation. Nevertheless, E4, E12 and E21 emphasised the need to have a change manager. However, at the moment, there is lack of lean consultants in Sri Lankan construction industry. Hence, E19 further suggested construction SMEs to recruit a team with two change agents; one as a lean expert and the other one as an experienced construction professional. Thus, the combination of these two will be beneficial for successful lean implementation. Nevertheless, all organisational capacities can be built through suitable recruitment. Moreover, lean knowledge and lean ethics of individuals can be developed through a change agent. However, this has no direct impact on environmental level capacities.

6.6.2.7 Encourage research and development (R&D)

Lack of R&D within the organisation identified as a barrier for lean implementation. Therefore, to gain more benefits within the organisation, experts suggested that senior management need to encourage R&D in the organisation (Refer Appendix 18.7 for Nvivo analysis). Therefore, E15 emphasised the need of construction workers and the senior management to seek new development for the organisation. As there are many tools and techniques as well as new materials and technologies available in the construction industry, researching will provide the best possible alternative for their problems and it will be leading improvements within the organisation. As stated by 34 years experienced E1, '*All our workers understood my point. But they were not sure to whom they go to. What I feel is onsite actually only 25% of policy requirement. 75% beyond the site... It's at the design table. For that you need to investigate the opportunities as well as the options available in the Sri Lankan context'*. Thus, construction SMEs can find their own ways of researching within the organisations as well as they can pursuing partnerships in research initiatives with other large players in the industry. In contrary, E10 and E7 mentioned about the lack of time to attend research activities due to high work load. However, E5 noted, if construction SMEs require to develop lean capacities, they have to manage their work regardless of the high work load. Therefore, they need to look at the big picture and consequently identify the areas which required researching to encourage lean innovations.

Accordingly, R&D will help building all organisational capacities. Individual capacities such as lean thinking, lean leadership and lean knowledge could be built through R&D. Moreover, continuous R&D will help building lean knowledge dissemination as well.

6.6.2.8 Start lean with pilot project

The lean experts clearly indicated the importance of start lean with pilot projects within the organisation (Refer Appendix 18.8 for Nvivo analysis). This was proven by E2 stating that, '*the implementation should start from one site but not limited to one project or head office. At least you should start with 5S implementation. If it is successful, they can go for another basic lean tool'*. The experts further emphasized the necessity of developing a proper implementation plan for construction SMEs with all possible method statements, type of lean tools to be implemented, the order of the implementation with appropriate project stakeholders' involvement, to name a few. Therefore, development of a strategic and operational plan for lean implementation is paramount to start lean. Consequently, it will build up individual level (lean knowledge, lean thinking, lean leadership), organisational level (R&D, organisational lean culture, lean workforce, organisational strategic plan) and environmental level (lean knowledge dissemination, institutional support) lean enabling capacities.

6.6.2.9 Lean Training

The experts highlighted the importance of organising training for employees within the organisation (Refer Appendix 18.9 for Nvivo analysis). As confirmed by E3, '*our organisation has few numbers of permanent employees. So, providing trainings for them is not a big issue. But where can we find the experts?'* The responsibility lies with the government to increase the number of lean construction experts as well as lean awareness training programs available as stressed by E19. However, to build up lean capacities, construction SMEs should encourage their employees as well as senior management to be trained to improve ability to perform functions. As per E15, there is a need to organise in-house programs which clearly shows the requirement of training programs aligned to construction industry needs.

E1, E7, E12 and E5 emphasised to obtain services of lean trainer(s) for these in-house training programs. E7 further highlighted that '*there are many lean coaches who are consulting both construction industry and manufacturing industry organisations'*. Therefore, a need stand up to encourage employees to be cautious to identify the available programs and attend to get the lean knowledge. Moreover, as noted by E8, E12 and E14, the organisation can encourage the individuals to attend training programs.

The construction SMEs further can organise sessions on success stories within the organisation as well as with other organisation. The experts highlighted the need of sharing the problems faced during the implementation and sharing the remedies taken to overcome those problems. By confirming the fact, E12 noted '*we are having morning team briefing every day before starting our work. During that time, we are discussing about the problems we had yesterday and the planned works for the day. It takes only 15 minutes and team consist of less than 10 members*'. Therefore, to build up lean capacities, SMEs need to develop daily, monthly, yearly programs for training and development. Nevertheless, lean training will build up all individual and organisational level lean enabling capacities. The experts further emphasised that lean knowledge dissemination can be built through lean training.

6.6.2.10 Use existing capacities

One of the change managers of a lean implemented project (E19) stated that '*people can be changed*' in contrast to the lean barrier stated by most of the construction SMEs. E19 claimed the requirement of welcoming ideas of people to make the change success for lean implementation. It needs to be started with making small changes which is paramount. E21 further added, '*before we hire new people, we need to utilise our existing resources. We should create a plan to improve our available resource'.* Hence, many experts highlighted the need of strengthening the existing human capacity for building lean capacities.

Consequently, E20 proved that construction SMEs will become conscious to eliminate old or inappropriate capacities from their organisation. Moreover, construction SMEs will be able to creatively use the capacities. E13 added '*we have enough equipment at our projects. But some of them are not working properly. Need some modification. We don't have enough money to buy new equipment. So only thing we can do is repair and get use of them*'. Therefore, small modifications for equipment at hands will address the issue of allocating more money in building lean capacities. Yet, E12 added the necessity of having capacity for readiness to respond to the future. Hence, the basic way to start building organisational lean capacities is with the existing capacities of the organisation. Therefore, lean implementation required to start with analysing the organisational existing capacities (Refer Appendix 18.10 for Nvivo analysis). By doing so, physical resources and organisational strategic plan towards enabling lean can be built. Moreover, all individual level lean enabling capacities can be built through using existing capacities.

6.6.2.11 Improve organisational processes

Improving organisational processes related to construction projects are paramount for the success of lean implementation. Thus, many experts agreed to empower the employees to improve the organisational processes of construction SMEs (Refer Appendix 18.11 for Nvivo analysis). Accordingly, many experts emphasised the need of redesign organisational processes by eliminating NVAA. Thus, as per E1, correct integration at each and every level of the construction organisation will not be challenging comparing to large construction organisations due to horizontal hierarchy of the organisation. Therefore, broad-based participation and a locally driven agenda are required within the organisation to implement lean and to achieve the benefits of lean implementation. E5 stated '*we have allowed our people to come up with new ideas. If it is within an acceptable budget, we want to try. So that's how we use WhatsApp to communicate the progress of the projects from which we can reduce the extra time allocation for site visits. Also, it provides additional benefits too'.* Therefore, providing space for innovation will accelerate the lean implementation.

As discussed in literature, one of the most difficult things to change is the mind set of people. However, the lean experts highly contended the importance of changing the attitudes of people through education and communication; participation and involvement; facilitation and support; negotiation and agreement; manipulation and co-optation; explicit and implicit coercion as described in Harvard Business Review (2010). E21 further added motivation as a way of changing the attitudes of people. E21 further explained that, '*we have to give something in return for the workers who involve in the process of lean implementation. It might be something with a good monetary value which is the cheered one by our people. Or else we need to motivate them by at least giving good encouraging phrases'.* The researcher agreed the need of motivation requirement to change the attitudes of people in construction SMEs. However, according to E2, E3 and E15, individuals preferred to get financial benefits rather than a phrase of encouragement from the top management. This was further confirmed by the researcher during EIR-1 had with the workers at the site. Therefore, construction SMEs needs to rethink about workers, and analyse the ways of motivating the workers and design conducive policies and procedures for lean implementation.

E17 said that, '*there needs to be enough resources within the organisation to smoothly flow the works of the organisation. So, construction SMEs needs to be vigilant with regards to the resources management'.* Hence, investing in infrastructure to enable smooth and effective management of construction is important to be considered in smooth implementation of lean in an organisation. Moreover, E20 emphasized on not to rush for short term results by stating '*our people want benefits within a month or a two. They don't have the patience to wait for a considerable period to gain the benefits. Thus, construction SMEs need to scan locally and globally and they need to reinvent locally to address the problems in lean implementation*'. Correspondingly, E15 and E23 added that knowledge cannot be transferred and hence, needs to acquire by construction SMEs. Therefore, as stated by E2, the construction SMEs needs to be stay engaged under difficult circumstances to avoid the back sliding from the lean implementation. Similarly, E13 added, the need of remain accountable to ultimate beneficiaries.

In addition to that the experts highlighted the importance of recruiting people who are willing to learn which ultimately add value to construction SMEs. In contrast, E6 stated that, construction SMEs to be concerned on the staff retention as well. E13 stated '*our people think this organisation as a training school. They come, get trained and directly move to another company'.* Hence, organisations had to incur a huge cost on training new workers. Similarly, E10 questioned the researcher about the University graduates and E10 further said that, '*do you think there are students whom interested to learn about BIM and working to our company? If there is any, I would like to hire. But I don't need people leaving quickly from our organisation'.* Therefore, an appropriate attention needs to be given when recruiting people. Some of the companies get in to at least two years contracts with them to make the workers retain in the organisation. Therefore, construction SMEs need to develop a good recruitment policy that support employing individuals with lean knowledge and attitude. Consequently, as per Figure 6.7, except environmental level lean enabling capacities, all other lean enabling capacities can be built through improving organisational processes.

6.6.3 Environmental level strategies for lean enabling capacity building

Lean integration has forced the construction SMEs to rethink of their projects. This has generated new set of activities which are more in line with their projects. Figure 6.8 presents the environmental level lean enabling capacity building strategies identified to build all three levels of capacities, as per the experts of the study.

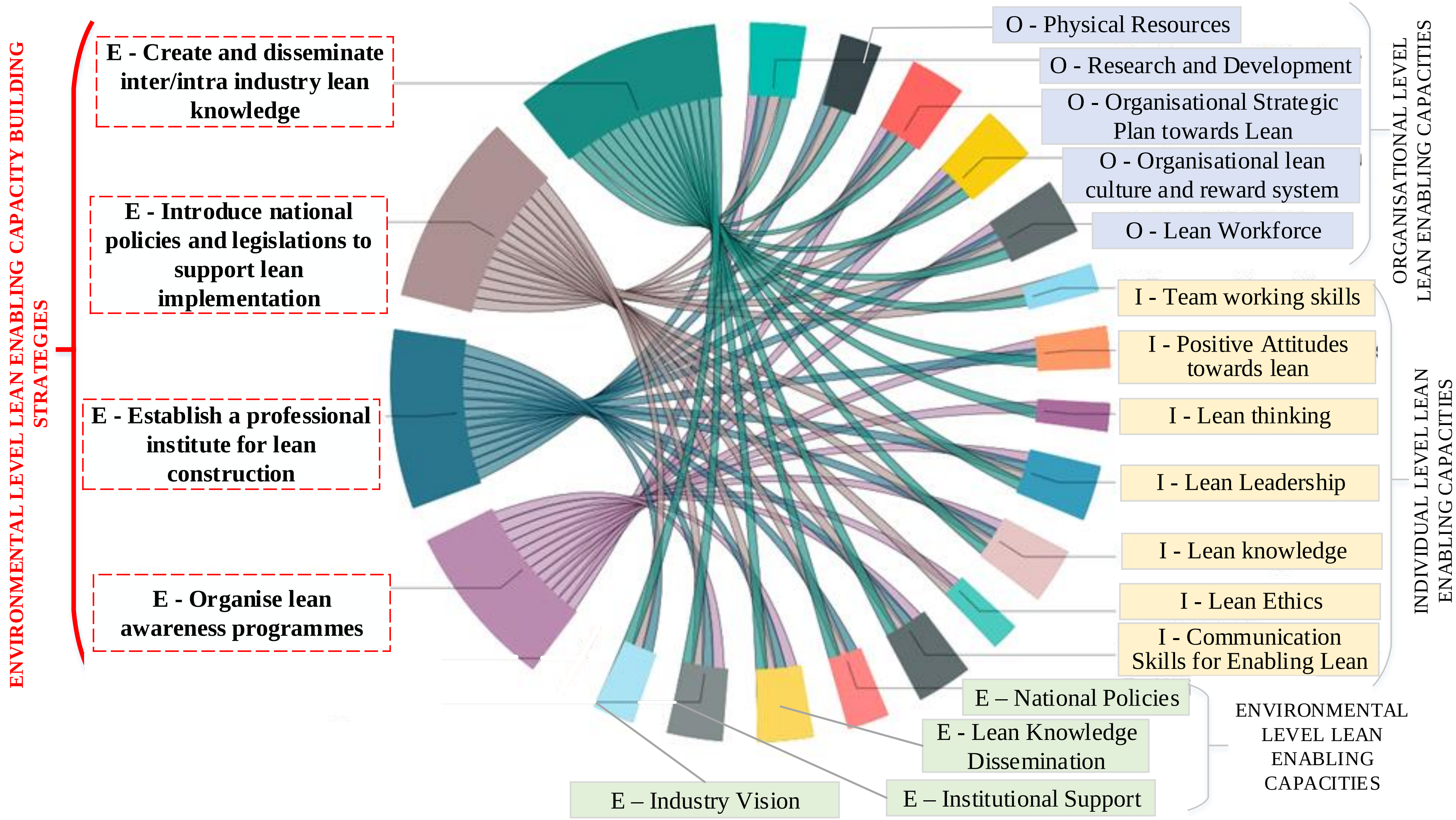


Figure 6.8: Environmental level lean enabling capacity building strategies

Refer Appendix 19 for Nvivo analysis for the summary uttered by the experts. An expansive responsibility brings into external environment in enabling lean among construction SMEs. Nonetheless, majority of the experts agreed that the favourable lean environment needs to be sharpened by the construction industry as well as the government. The experts agreed that lean enabling capacity building in construction SMEs can be driven by the construction industry which includes, CIDA, non-government institutes, professional institutes, large construction organisations to name a few. The government involvement also identified as an enabler, which can positively influence the implementation of lean within construction SMEs. Thus, the initiatives that can be taken for building lean capacities are discussed in the next section.

6.6.3.1 Establish a professional institute for lean construction

Refer Appendix 19.1 for Nvivo analysis for establishing a professional institute for lean construction. E10 stated that, '*use of standardised buildings, procedures, materials and components let the labours to adopt a same set of activities to execute their work. This will result in labour specialisation which is considered as a leading productivity factor'*. Thus, the workers need to be networked with the other workers for successful lean implementation. Hence, E1 and E19 highlighted the importance of developing a best practice guideline for lean implementation for sites and SMEs and particularly developing a lean code of conduct for construction SMEs. Therefore, this code of conduct will guide construction SMEs for successful lean implementation.

However, the preparation of lean code of conduct cannot be done only by CIDA. It needs the lean help. Correspondingly, E1 said, '*manufacturing industry has a Lean Manufacturing Institute. So why can't we have one for the construction industry. They can regulate the good lean practices*'. Hence, it is vital to establish a professional institute for lean construction to regulate the lean implementation. The experts indicated the availability of belt systems in lean manufacturing institute and construction industry can introduce a belt system to educate individuals.

Even though, there is a need to increase the number of training programs, E17 doubted about the quality of these training programs conducted at the construction industry level. Thus, the professional institute for lean construction need to consider developing lean experts. They can get the help from experienced construction professional as well as lean trainers of other industries. Many experts had intensified the contribution of the lean trainers towards the lean implementation. Therefore, there is a need to train more lean construction experts. However, E5 added '*rather training new lean professionals from the universities, it is easy to train the existing construction professionals. They have the construction knowledge. So continuous lean training will make them experts in the field'.* Hence, within a shorter period of time, the industry can increase the number of lean construction experts. Yet, E10 mentioned that, this will not going to be that easy due to the knowledge level constrains within the industry. However, CIDA can find suitable trainers, academia from the industry as well as from other industries to encourage lean awareness for professional development. On the other hand, E20 said that '*government need to think of how to incorporate this lean subject to university syllabus. The best is to conduct a lean degree at the government university level to increase the lean awareness'.* Thus, the introduction of lean related university courses would be helpful to increase the number of lean experts in the Sri Lankan construction industry.

Accordingly, all individual level, organisational level and environmental level lean enabling capacities except team working skills can be built through establishing a professional institute for lean construction.

6.6.3.2 Organise lean awareness programmes

Organise lean awareness programmes for construction workforce is one of the prominent strategies that mentioned by experts (Refer Appendix 19.2 for Nvivo analysis). Except E9, all other experts noted that conducting training programmes, which deliver lean education will positively contribute to increase the number of lean implemented projects. However, E9 stated that, the training needs to be fulfilled by the organisation it-self due to the uncertainties of the construction industry. However, both individuals as well as organisational lean capacities can be built by getting sufficient training from the industry. According to E19, the availability of training sessions at Sri Lankan level to get lean awareness is not up to the expected level. Hence, it is vital to increase the number of sessions organised by industry to increase the lean implementation within the construction industry. Moreover, E20 added that they can encourage construction SMEs by conducting CPDs on lean construction. Particularly, E19 stated that, if the industry can conduct these CPDs for construction SMEs at a reasonable rate, there will be more participants compared to the current scenario. Thus, lean knowledge dissemination and institutional support can be built by conducting sessions on lean awareness, principles, and tools for construction SMEs. Many experts contended the lack of CPDs within the construction industry as environmental level lean implementation barriers. Hence, construction industry needs to take necessary actions to encourage the professional development. E15 stated that, '*Similar to green construction, we need to market lean within the construction professionals by comparing to manufacturing industry'*. Thus, experts stated the importance of encouraging personnel mobility within and outside the construction industry for successful lean implementation.

Construction industry can influence the government to incorporate lean construction into the syllabus of university education to increase the number of lean experts. They further can develop an industry driven curricula for educating and training construction workforce. In response, E19 said, '*The integration of lean construction education in to the syllabus of university students will be an advantage to carry out those newly introduced approaches'*. They specifically mentioned that, as lean construction is relatively new to Sri Lankan context; embedding lean knowledge into construction education/training curricula will increase the lean knowledge of construction workforce.

Accordingly, all organisational level and individual level lean enabling capacities except team working skills and physical resources can be built through organising lean awareness programmes. Moreover, lean knowledge dissemination and institutional support too can build through organising lean awareness programmes.

6.6.3.3 Create and disseminate inter/intra industry lean knowledge

Environmental capacities can be built by encouraging inter/intra-industry research activities. Refer Appendix 19.3 for Nvivo analysis of the summary of how experts uttered on the inter/intra-industry research activities. The experts too agreed the need of inter/intra-industry research activities. Correspondingly, E12 voiced '*we would like to conduct research with large contractors even with lean practitioners of manufacturing industry, to find out most suitable lean tools and techniques for our organisations'.* Thus, construction industry can introduce new grants and schemes towards encouraging inter-intra research activities. Moreover, it is vital to develop research capacity in construction. The experts further added the need of private public interactions towards success of lean implementation. E14 mainly considered about the fact that exchanging lean experts among the partnerships. Respectively, E2 discussed about the need of building partnerships and collaborations as a means of building capacities by mechanisms which exchange skills and practice knowledge. E2 further added '*some of the organisations can exchange the lean expertise, some can exchange tools or some even can exchange equipment'.* Therefore, a good understanding between the organisations will help to reduce most of the barriers identified for the lean implementation. Consequently, the industry can encourage lean learning from local and international partnership projects.

According to E2, E3 and E19, the construction industry can encourage dissemination of research activities. Moreover, E12 stressed the need of publicising the research conducted on lean construction to identify the new trends and solutions for lean constructions. This can be achieved through conducting research conferences and exhibitions. In particular, attending these conferences by construction SMEs will assist identification of suitable nominees for lean initiations. This was experienced by the researcher during a conference held in Sri Lanka. One of the Directors of construction SMEs (Grade C4) expressed his willingness to hire the researcher as a lean consultant for his organisation. The Director highlighted the requirement of organising more interactive session with industry practitioners and academics. Similarly, E19 added '*university students' research findings need to be shared with* *us. Then we know at least these types of lean tools and techniques are available in the industry'*. Irrespectively, E2 uttered '*I am also graduated from a government University; I don't believe that much on the applicability of university research findings to practical scenarios. I preferred to have sessions with lean practitioners*'. Then both parties can freely discuss their problems and probable solutions, thus emphasising the need of encouraging academic industry partnerships in lean research.

Organising inter-intra industry research activities and dissemination is paramount for success of lean implementation. Thus, government need to allocate financial endowment for lean research, conferences and exhibitions. Further, government can organise inter/intra industry lean success stories. As stated by E2, '*there are lot more to learn from manufacturing industry. If government can organise programs to share their path towards successful lean implementation, it will be very much beneficial for construction SMEs'.* Thus, government can help building the lean capacities by providing enough financial support for the construction SMEs. In addition, respondents contended the need of getting maximum usage of academia for the successful lean implementation. The construction industry can increase the usage of academics for R&D. In the similar way, a respondent who attended the IGLC conference expressed the importance of conducting research in Sri Lanka to increase the lean implementation. Hence, industry required funds to host such a large-scale conference. Therefore, they can get funds from large construction organisations for hosting IGLC conference which will be benefitted for both large and SMEs in construction industry. Consequently, it will encourage lean learning from local and international partnership projects. Accordingly, all individual level, organisational level and environmental level lean enabling capacities except lean ethics can be built through creating and disseminating inter/intra industry lean knowledge.

6.6.3.4 Introduce national policies and legislation to support lean implementation

The summary of suggestions for policies and legislations to support lean implementation is given in Appendix 19.4 for Nvivo analysis. The experts expressed the need of providing conductive policies for general business environment and exclusively for construction industry environment. According to E1, the construction workforce needs to be regulated through these policies. E15 stated considering the response to lack of lean training, '*owners of construction SMEs need to show the written standards incorporated by the government to motivate them for organising training to increase the lean capacities'*. Therefore, government can initiate lean implementation by enacting specific laws for construction SMEs to build up the lean capacities. Correspondingly, experts noted that, the government can support government institutes and non-government institutions to standardise construction industry.

To develop a lean code of conduct, construction industry required the support from government. Thus, as per E7, government can allocate funds from their budget for establishing a professional institute for lean construction. Hence, legislations, policies and standards need to be developed in favour of lean implementation in construction SMEs. The experts further added the need of integrating external inputs into national priorities, processes and systems which can be driven by the government of the country. The experts highlighted that the government must financially support the construction SMEs for lean implementation. The experts contended the importance of conveying the opportunities given by government for financing projects of construction SMEs. Similarly, the experts added that government can provide loans for construction SMEs at concessional rates by considering the monetary and fiscal policies of the government. They can further allocate more funds for lean awareness program from which can be passed to CIDA as well any other institutes for organising these programs. However, E12 and E23 stressed the need of introducing KPI-driven lean investment plans for construction SMEs in order to confirm the real value for the investment.

E14 said the motivation given by government will largely affect the rate of lean implementation. According to E1, similar to green building construction, government should think of providing tax reductions for lean implemented projects. Hence, as per E16, construction SMEs will be very concern on the benefits that can be gaining by tax reduction rather benefits gaining by implementing lean. This is due to the lack of awareness on lean benefits and direct affection of taxes to the profits of projects. However, government can provide tax concessions for lean implemented projects.

According to E1, '*It's good to import people from India and Bangladesh for construction industry. We don't have enough people to work. The young generation in Sri Lanka expect white collar jobs only. Others will try to ride a taxi to find money'.* Thus, government needs to think of strategies to retain the construction workforce. Consequently, E6 said '*This is due to the uncertainties of the construction workers. They need to create a suitable environment to carry out the work. People prefer retirement plans available in the government sector'.* Hence, government should think of introducing retirement plan for construction workers for retaining construction workforce.

Currently, in Sri Lankan context, most of the projects are following the measure and pay procurement method. Yet, in lean lexicon, IPD approaches that support lean method are very much acknowledged. One of the reasons highlighted by E10 is, difficult to make continuous changes in conventional method. According to E12, '*design will be done by a set of architects. Because of that, number of variations can be seen in our projects. If we are doing the design and construction, there will be minimum number of variations*'. Hence, as per E12, it is difficult to make any adjustments at the design table it-self, as two entirely different parties will do the design and the construction. Thus, there is a need to encourage implementing IPD approach that support lean within the construction SMEs. Moreover, as per E2, E3 and E15, there is a need to ensure equal opportunities for construction SMEs in public funded projects similar to large construction organisations. The experts emphasised that, all individual level, organisational level and environmental level lean enabling capacities except lean thinking and positive attitudes towards enabling lean can be built through introducing national policies and legislation to support lean implementation.

In a summary, the identified lean enabling capacities and lean enabling capacity building strategies can be mapped as presented in Table 6.8. This table was presented to three subject matter experts for final external validation.

Table 6.8: Summary of lean enabling capacities and lean enabling capacity building strategies

Lean Capacities \ Lean Enabling Capacity Building Strategies	Lean learning	Lean knowledge dissemination	Lean skills development	Use existing capacities	Start lean by doing	Monitor and report progress	Improve organisational processes	take necessary actions development	Learning by doing	Maintain a lean culture	Networking	Appropriate investments to implement lean	Suitable recruitment to drive lean	Encourage R&D	Start lean with pilot project	Lean training	Use existing capacities	Establish a professional institute	Organise lean awareness programmes	Create and disseminate inter/intra industry lean knowledge	policies and legislation to support lean implementation
Communication skills for enabling lean	x	x	x	x					x	x	x		x			x	x	x	x	x	x
Lean thinking	x	x	x		x	x	x	x	x	x	x			x	x	x	x		x	x	
Lean leadership		x	x	x		x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
Positive attitudes towards lean	x	x	x			x	x	x	x	x	x	x				x	x	x	x	x	
Team working skills	x	x	x	x		x	x	x		x	x	x	x			x				x	x
Lean ethics	x	x	x	x		x	x			x		x	x			x	x		x		x
Lean knowledge	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lean workforce	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Physical resources				x	x	x	x	x		x	x	x	x	x		x	x	x		x	x
Organisational strategic plan towards lean	x	x			x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
Organisational lean culture and reward system	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x
R&D		x			x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x
Institutional support		x							x		x			x	x			x	x	x	x
National policies																		x		x	x
Lean knowledge dissemination		x			x				x	x	x			x	x	x		x	x	x	x
Industry vision	x	x			x					x	x							x		x	x

6.7 Validation of Findings

The summary of the mapping of lean enabling capacities with the lean enabling capacity building strategies were tested for the external validity by presenting to three experts, who have very good knowledge on lean implementation and are extensively, engaged in construction SMEs and industry regulatory bodies. The profile of the experts is given in Table 6.9.

Table 6.9: Profile of experts participated for validation

Code	Designation	Industry Experience
VE1	Managing Director	• Mechanical engineering graduate, currently running a family business. • Managing Director of a reputed construction SME. • Total 20 years in construction industry. • Over 18 years up to date in SME sector. • Hold positions in government and private Institutes. • Deputy Committee Member of NCASL. • Hold diverse experiences in local and international construction industries. • Participated for many national level and international level training programs on lean production and implemented lean concept in projects.
VE2	Professor / Chairman	• Professor in Civil Engineering. • Chairman of a construction SME. • Total 30 years in construction industry. Over 15 years' experience in construction SMEs. • Chartered Engineer and a Fellow member of IESL. • Hold positions in government and private institutes. • Secretary, State Ministry of Rural Roads and other Infrastructures • Served as the Secretary to the State Ministry of Urban Development. • Member of the consultative committee and steering committee of CIDA. • Hold diverse experiences in local and international construction industries. • Have experience in conducting lean research and providing lean consultancy services to the construction industry in Sri Lanka.
VE3	Assistant General Manager	• Quantity Surveying graduate and CIMA passed Finalist, holding post graduate qualifications. • Currently working as the Assistant General Manager on Estimation and Contracts. • Chartered quantity surveyor and Council member of IQSSL. • Total 15 years in construction industry and 10 years' experience in SME sector. • Visiting lecture and a guest speaker in construction management. • Hold diverse experiences in local and international construction industries. • Have experience in conducting lean research and providing lean consultancy services to construction industry in Sri Lanka.

The above experts were selected based on their lean awareness and experience in the construction industry. Accordingly, all three experts have more than 15 years of experience and engaged with small and medium scale construction projects in Sri Lanka. However, their experience and exposure to lean concept were in diverse levels. As the final step in the investigation, Table 6.8 was presented to the above experts for the final validation.

All the experts confirmed that the identified lean enabling capacities and lean enabling capacity building strategies are valid and applicable for construction SMEs in Sri Lanka. However, some additional suggestions were given for the mapping of lean capacities and strategies given in Table 6.8.

- All three experts undoubtedly agreed to the identified individual strategies against the identified lean enabling capacities at all three levels.
- VE1 highlighted the importance of starting lean with pilot projects to build R&D within the organisation. Indeed, VE2 confirmed this stating, '*if we start doing only you will be able to identify the areas which need further improvements*'. Therefore, both experts noted the development of research through starting lean.
- As highlighted by all three experts, there is a need to hire lean expert for the organisation. Correspondingly, VE3 stated that, '*lean expert will guide the individuals in the construction SME to develop their lean ethics*'. Therefore, suitable recruitment to drive lean will develop lean ethics of individuals of the organisation.
- VE1 and VE2 identified the importance of making better use of existing capacities to develop the team working skills of individuals.
- VE2 and VE3 added that, lean ethics can be built through encouraging lean learning from local and international partnership projects. Therefore, creating and disseminating inter/intra industry lean knowledge will lead building lean ethics of the individuals.

These were considered in developing the final lean enabling capacity building framework of the study.

6.8 Discussion of Findings

This section initiates by comparing the identified barriers and drivers for lean implementation for construction SMEs against the literature findings. This is followed by lean enabling capacities and lean enabling capacity building strategies at three levels are discussed in detail. Subsequently, lean enabling capacity building framework for lean implementation is presented.

6.8.1 Barriers for lean implementation in construction SMEs

The implementation of lean in an organisation is over-loaded with lean implementation barriers. Therefore, many authors as discussed in Section 2.11.3 identified lean implementation barriers in construction industry. Similarly, the researcher categorised the lean implementation barriers into three levels as presented in Sections 6.4.1, 6.4.2 and 6.4.3. To identify the newly added or removed lean implementation barriers for construction SMEs, EIR-2 findings were compared with the literature findings on lean implementation barriers. Figure 6.9 shows the summarised version of the lean implementation barriers for construction SMEs in Sri Lanka.

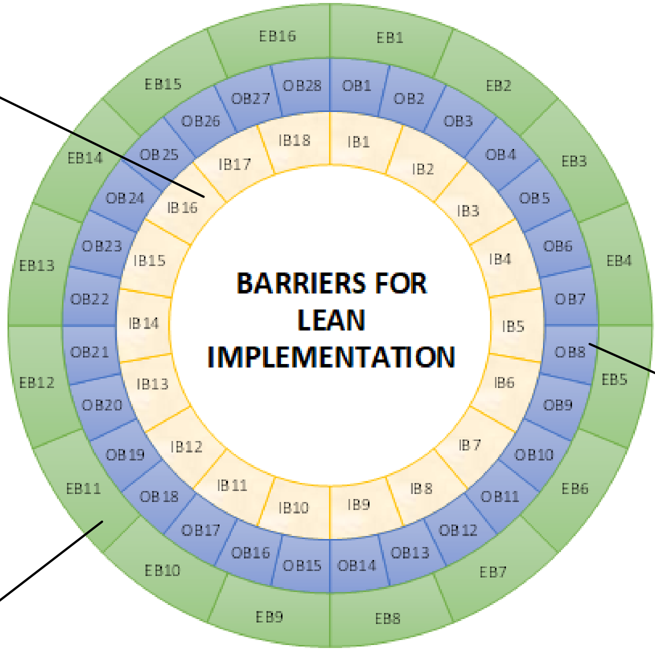
The inner circle represents the individual barriers for lean implementation as numbered from IB1 to IB18. The middle circle in blue colour divided into 28 sections to incorporate the identified organisational barriers for lean implementation (OB1 to OB28). Similarly, the outer circle in green represents the environmental level barriers (EB1 to EB16).

INDIVIDUAL BARRIERS

- High work load
- Work pressure
- Lack of lean awareness among workers
- Inadequate training
- Knowledge-level constraints
- Workers' resistance to change
- Lack of attention to lean
- Lack of Motivation
- Lack of technical skills
- Illiteracy and computer illiteracy
- Lack of team spirit among professionals
- Lack of ability to work in group
- Dependency
- Lack of trust
- Lack of commitment
- Lack of empowerment of employees
- Lack of self-criticism
- Cultural difference
- Creativity
- Over-enthusiastic champions

ENVIRONMENTAL BARRIERS

- Lack of consultants and trainers
- High cost of lean training
- Unstable markets for construction
- Poor consultations with stakeholders
- Lack of standards
- Fragmentation and sub-contracting
- Lack of government support for research and collaboration in lean
- Financial crisis
- Time consuming process
- Inflation
- Contractual disputes
- Complexity of lean
- Lack of cooperation from suppliers
- Quality problems with supplied material
- Cultural issues in getting subcontractors to adopt the methodology
- Traditional procurement and contracts
- Financial crisis



ORGANISATIONAL BARRIERS

- High investment cost
- Lack of formal training for employees
- Lack of top management involvement
- Top management resistance
- Lack of lean awareness of top management
- Lack of middle management commitment
- Inability to quantify benefits of lean
- Perception about profitability through the transition to lean
- Fear of failing in the lean implementation
- Fear of taking risk
- Failure to monitor and evaluate the outcome
- Lack of sympathetic and supportive HR policies
- Lack of resources to invest
- Poor project management
- Lack of strategic leadership
- Ignorance to human resource development
- Inadequate funding of projects
- Lack of a clear executive vision
- Union resistance
- Lack of transparency among teams of the production process
- Failure to fully mobilise change champions
- Lack of a structured methodology
- Use of traditional management concepts
- Unwillingness of companies to invest extra funds for training
- Low professional remuneration
- Incompatibility of lean with the company bonus, rewards or incentives systems
- Lack of an effective communication strategy
- Absence of a dedicated and fully resourced implementation team
- Failure to create and communicate a sense of urgency

- XXX - both literature and EIR-2
- XXX - only from EIR-2
- XXX – only from literature

Figure 6.9: Summary of barriers for lean implementation in Construction SMEs

According to the above figure, the literature findings of the barriers were categorised into three levels of capacities during EIR-2. There was a lot of literature (Sarhan, & Fox, 2013; Abbot, & Aziz, 2015; Shang & Pheng, 2014; Ankomah et al., 2019) on lean implementation barriers for construction industry, which are compatible with the lean implementation barriers for Sri Lankan context. Nevertheless, lack of attention to lean (IB7), lack of commitment (IB8), lack of trust (IB14), lack of empowerment of employees (IB16), lack of self-criticism (IB17) and cultural differences (IB18) were identified as added barriers for individual level lean implementation barriers for construction SMEs in Sri Lanka. Although Ankomah et al. (2018) identified lack of creativity as an individual level barrier, the experts of the study confirmed that, the creativity within the individuals as a driver for lean implementation as discussed in Section 6.3.1. According to Mossman (2009) and Sarhan and Fox (2013), over-enthusiastic champions is a lean implementation barrier in their countries, however, due to the unawareness of lean in construction industry in Sri Lanka creates no champions at the moment. Thus, none of the experts agreed to availability of champions in the industry and agreed to absence of champions in neither construction SMEs nor construction industry.

Most of the organisational lean implementation barriers identified in literature were confirmed during EIR-2. Nevertheless, experts added lack of middle management commitment (OB16) and top management commitment and support (OB19) in the Sri Lankan construction industry as barriers for lean implementation. Experts of the study clearly said that '*top management of the construction SME organisations show the willingness to implement lean without any resistance. But no support or commitment for successful lean implementation*'. Thus, agreeing to Bertelsen and Koskela (2004) and Chiarini (2012) argument on top management resistance as a barrier for lean implementation. However, many experts pointed the finger towards the middle management as ascertained by Mossman (2009) by specifying that the problem exists with middle management not top management or shop floor workers. They further added, inability to quantify benefits of lean (OB8), failure to monitor and evaluate the outcome (OB12) as barriers for lean implementation. This is due to the fact that the lean construction is still in the infancy stage for construction industry in Sri Lanka. Thus, there is no good mechanism in the industry to identify the benefits of lean implementation.

Due to the financial crisis in the country, Sri Lankan construction industry is struggling to retain the employees at their organisations. Yet, they are receiving a small remuneration. Hence, incompatibility of lean with the company bonus, rewards or incentives systems (OB13) and low professional remuneration (OB15) were further added to the list of organisational barriers for lean implementation by the experts. Chiarini (2012) stated that the availability of implementation team within the organisation as a driver for lean implementation. However, unwillingness of companies to invest extra funds to provide training for their workers more than the essential legislation requirement (OB2), lack of an effective communication strategy (OB23) within the organisation, and absence of a dedicated and fully resourced implementation team (OB25) were stated by the construction experts in the industry as organisational lean implementation barriers.

According to many researchers (Tezel et al., 2020; Ankomah et al., 2019; Nesensohn et al., 2014; Viana et al., 2012), embedding lean construction in an organisation typically requires several changes and is a challenging endeavour. Thus it requires the sense of urgency to be succeeded in the lean implementation. However, experts insisted the need for implementing lean in their organisations. Thus, failure to create and communicate a sense of urgency identified by Abbot and Aziz (2015) was repudiated from the list of organisational barriers for lean implementation.

Mossman (2009) highlighted that the fragmentation in the construction industry was responsible for both individual as well as organisational level lean construction barriers. Correspondingly, the experts of the study clearly stated that there are problems with the supply chain in Sri Lankan construction industry. Thus, lack of cooperation from suppliers (EB4) and quality problems with supplied material (EB5) were further added to the list of environmental lean barriers. In a similar note they added, cultural issues in getting the subcontractors and workers to adopt the methodology in a comprehensive way (EB9) due to lack of literacy of the workers. Even though lean promotes integrated procurement systems (Arrayo et al., 2017;

Dave et al., 2016) as discussed in Section 2.5.2, still Sri Lankan construction industry follow the traditional procurement and contracts (EB11) which in turns as a barrier for lean implementation. The construction experts further insisted on the current financial crisis (EB12) as an environmental barrier for lean implementation which in turns affected to both organisations as well as all individuals.

Nevertheless, construction SMEs that managed these barriers effectively has a higher probability of lean implementation successfully. The identification of barriers is not sufficient for successful lean implementation, thus required to identify the drivers for lean implementation. Consequently, next section discusses the summary of drivers for lean implementation.

6.8.2 Drivers for lean implementation

There are some notable direct and indirect advantages that arise from successful lean implementation. Correspondingly, attainments of benefits through lean implementation drive the lean implementation within the construction SME sector. In a similar note, the problems faced by construction SMEs, insisted to looking for new process thus drive the lean implementation. The comparison of identified drivers for lean implementation in construction SMEs in Sri Lanka as per EIR-2 with the literature finding is presented in Figure 6.10.

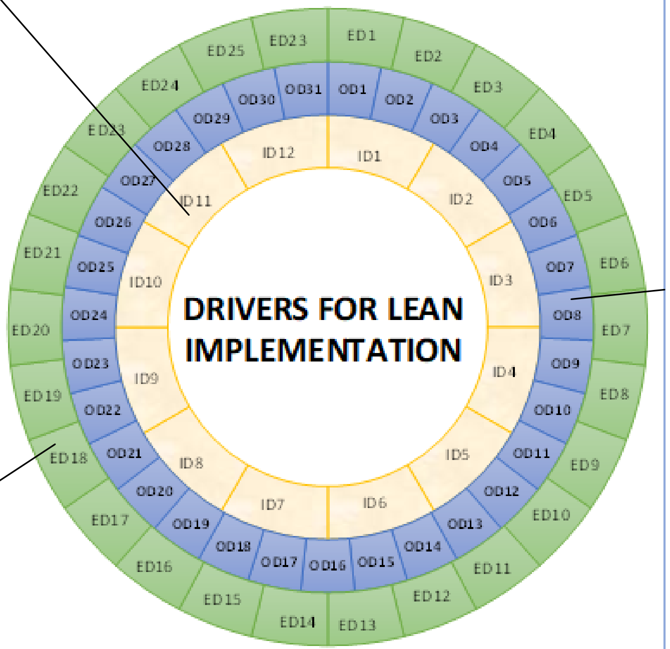
The inner circle in orange colour represents the individual drivers for lean implementation. The drivers were numbered from ID1 to ID12. The middle circle in blue colour divided in to 31 sections to incorporate the identified organisational drivers for lean implementation (OD1 to OD31). Similarly, the outer circle in green represents the environmental level drivers (ED1 to ED23).

INDIVIDUAL DRIVERS

- Freedom for employees
- Need of committed employees
- Active learning
- No blame culture
- Motivation of workers
- Reward system to motivate employees
- Up to date knowledge base
- Effective engagement
- Effective communication
- Effective use of commitments for change
- Experience of the work force
- Need of workers with necessary skills and capabilities

ENVIRONMENTAL DRIVERS

- Reduce high labour cost
- Need of skilled workers
- Reduce high cost of energy
- Reduce problems with low Quality materials
- Need to increase market share
- Need of standard procedures
- Reduce fluctuating customer requirements
- Effective communication between organisations
- Good relationships
- Requirement by client
- Development of key performance indicators
- Procuring based on design and build method
- Government incentives for innovative firms
- External support from consultants
- Reduce changeover time
- Need to increase flexibility
- Reduce time to fulfil customer orders
- Reduce frequent changes in supply schedule
- Client involvement in the project
- Technical competence of the client
- Shift to performance based regulations
- Transparency
- Enhance the image as a technically progressive company
- Need for survival from internal constraints
- Motivation by client
- Requirement by parent company



- XXX - both literature and EIR-2
- XXX - only from EIR-2
- XXX – only from literature

ORGANISATIONAL DRIVERS

- Flexible organisation structure
- Need of reducing risk to the company
- Improve the process control
- Unbalance workload on different workstations
- Desire to employ best practice
- Improve workplace organisation/ house keeping
- Reward system to motivate employees
- Efficient use of resources
- Need of capacity to fulfil the regular demand of customers
- Improvements in operations
- Increase the profitability
- Increase the benefits at project level
- Need of reducing stock/inventory
- Collaboration between project team members
- Teamwork and joined-up whole systems thinking
- Management commitment & capability
- Providing adequate resources to support change
- Single point responsibility for design and construction
- No blame culture
- Part of the organisation’s continuous programme
- Up to date knowledge base
- Developing complementary project objectives
- Strategic approach to improvements
- Timing to set realistic timescales for change
- Need of increasing manpower productivity
- Need of standard operating procedures
- Need of reducing scraps/ rework and rejections
- Add competitive advantage to the company
- Organisational culture and ownership
- Field support from management
- Developing organisational readiness
- developing complementary project objectives
- being part of the organisation’s continuous programme

Figure 6.10: Summary of drivers for lean implementation at each capacity level

The literature findings have not clearly defined these drivers suitable for each capacity level. Thus, the researcher was able to group the drivers to three capacity levels during EIR-2. Chiarini (2012) evidently showed that, comparing to large construction organisations, the construction SMEs have flexibility in adopting new knowledge and techniques. Thus, freedom for employees (ID1) was identified as individual level driver for lean implementation. In a similar note, most of construction SMEs in Sri Lanka originated by a very experienced professional from the construction industry. All the experts at the top management have more than 15 years of experiences in the construction industry. Thus, experience of the work force (ID2) inculcated for lean implementation. Other than the literature confirmation, EIR-2 was able to identify need of workers with necessary skills and capabilities (ID3) as an individual level driver for lean implementation. This was further proven by many researchers (Tezel et al., 2017; Rymaszewska, 2014; Agwu, & Emeti, 2014; Chiarini, 2012) highlighting the lack of capacities of construction SMEs. Correspondingly, Sri Lankan construction industry too has the same problem and the respondents identified this problem as an individual level driver for lean implementation due to the fact that lean implementation will increase capabilities of the employees of the organisation as stated by Antosz and Stadnicka (2017).

Organisational culture and ownership (OD18), field support from management (OD21) and developing organisational readiness (OD26), compared to large construction organisations drive the lean implementation within the organisation it-self. Nevertheless, developing complementary project objectives and being part of the organisation's continuous programme were not entertained by the respondents during the detailed survey.

As discussed in Section 5.3, Sri Lankan construction industry is affected by low manpower productivity (OD3), lack of standard operating procedures (OD6) and high scraps/ rework and rejections (OD16). Therefore, construction SMEs are willing to overcome the above problems by implementing lean. Hence, they drive the construction SMEs in enabling lean. Moreover, situational analysis provided in Section 5.3 clearly noted that, there is no added competitive advantage for the SMEs.

Nevertheless, Aziz and Hafez (2013) suggested that, by implementing lean, the organisations will be getting the competitive advantage. Therefore, the need to get competitive advantage (OD17) identified as organisational level driver for construction SMEs in Sri Lanka.

The experts were added the need for survival from internal constraints (ED6), motivation by client (ED11), requirement by parent company (ED15), enhance the image as a technically progressive company (ED18) and transparency (ED26) to environmental level drivers for lean implementation. According to Womack and Jones (1996), Koskela et al. (2014) and Dave et al. (2016), the client play a significant role in order to be succeeded in lean implementation. Therefore, the literature identified list were further strengthened by adding client involvement in the construction project (ED9), technical competence of the client (ED10) and shift to performance-based regulations (ED25) for environmental level drivers for lean implementation.

As per the findings of Ofori and Toor (2012), construction industry in any country suffers due to the high labour cost (ED1), unavailability of skilled workers (ED2) and high cost of energy (electricity or fuel cost) (ED3). Equally, Sri Lankan construction industry too is suffering with these problems and emphasised the need of overcoming them through implementing lean.

According to Shang and Pheng (2014), the drivers and barriers for lean implementation in construction industry depend on the context. Yet, construction SMEs require to identify them, with regards to explore the required lean capacities in a specific construction SME organisation. Thus, the next section discusses the lean enabling capacities.

6.8.3 Lean enabling capacities

The researcher defined lean capacities for the research as the ability of individual, organisational and environmental factors to enable lean in construction SMEs. Thus, a need arises in identifying lean capacities for construction SMEs. The categorisation is continued as individual, organisational and environmental level capacities required for enabling lean. The holistic understanding of lean enabling capacities is paramount for successful lean implementation. Thus, Figure 6.11 presents the summary of findings with regards to lean capacities for construction SMEs.

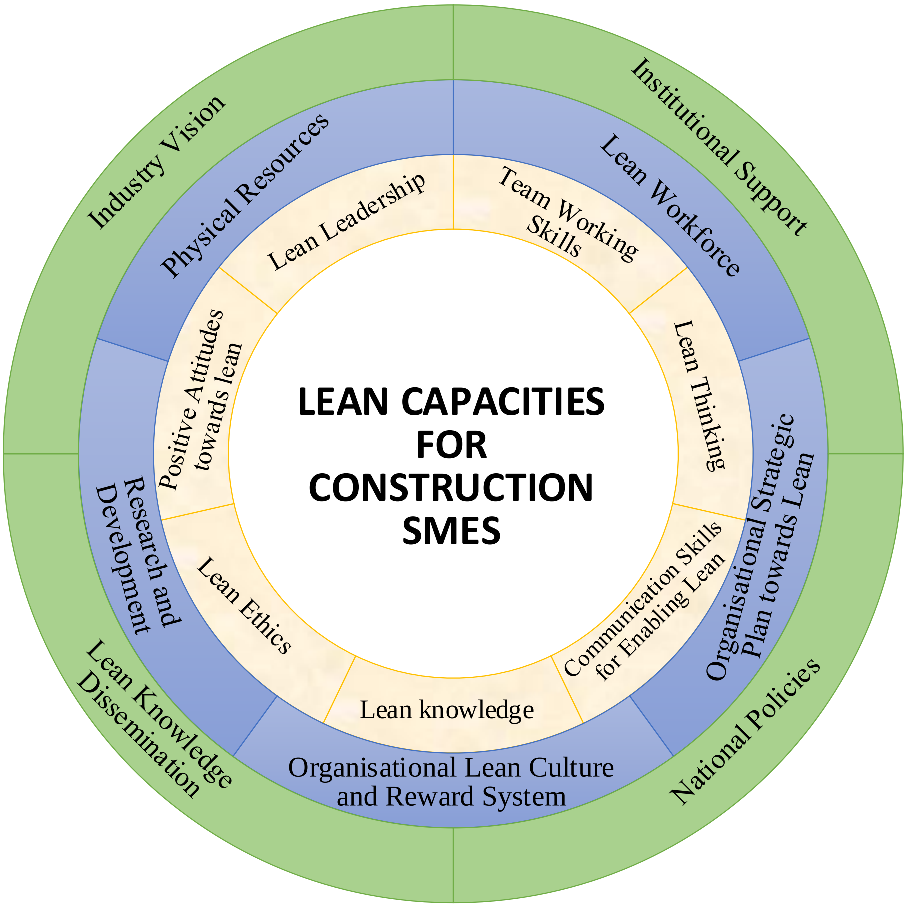


Figure 6.11: Summary of lean capacities for construction SMEs

The inner circle in orange colour represents the individual level lean enabling capacities for lean implementation as shown in Section 6.5.1. It included communication skills for enabling lean, lean thinking, lean leadership, positive attitudes towards lean, lean knowledge, team working skills and lean ethics. One of the main similarities of all five set of lean principles discussed under Section 2.8 is the focus of individuals in the organisation. This was highly emphasised in lean principles such as TPS (Ohno, 1988), 4P model (Liker, 2004), Lean Iceberg model (Hines et al., 2008) and the Shingo model (Shingo-Institute, 2012). Undoubtedly, most of the literature agreed the need of lean knowledge among individuals in the organisation and thus, the findings of the research. Similarly, underwater line enabling aspects in Lean Iceberg model highlighted by Hines et al. (2008) were compatible with most of the individual as well as organisational level lean enabling capacities.

Nevertheless, many experts emphasised the need of lean ethics of individuals, which is hardly found in the literature. As stated by Samaraweera et al. (2018), values and attitudes that promote critical reflection and continuous improvement are required among the individuals of the organisation for improving the processes. Thus, by confirming the five principles of Womack and Jones (1996) and Koskela et al. (2002), improving the individuals in the construction SMEs is paramount, highlighting lean ethics and communication skills for enabling lean.

The middle circle in blue colour divided into five sections to incorporate the identified organisational level lean capacities for lean implementation. It comprises of lean workforce, organisational strategic plan towards lean, organisational lean culture & reward system, physical resources and R&D. Many Researchers (Badurdeen et al., 2010; Shang, & Pheng, 2014; Sarhan, & Fox, 2013) emphasised the need of an organisational lean culture and reward system to encourage lean implementation in construction industry and compatible with the empirical findings. Moreover, Sarhan and Fox (2012) argument on creating a learning organisation is acknowledged by the empirical findings. Additionally, cultural enablers were ingrained among other aspects in the Shingo model emphasising the need as an organisational level capacity. Nevertheless, to develop a lean culture, appropriate reward system is essential as per many researchers (Mossman, 2017; Bhasin, & Burcher, 2006; Aziz, & Hafez, 2013). EIR-2 further identified lack of motivation in construction SMEs; particularly lack of reward system is weakening the lean implementation. Therefore, organisational lean culture and reward system need to be backed by organisational strategic plan towards lean.

Nevertheless, there is lack of literature on creating organisational strategic plan towards lean implementation among construction SMEs. Thus, the findings added that organisational strategic plan to be inclusive of lean knowledge & skills development programmes, financial management plans, internal business processes management plan, construction project management plan, risk management plan, business development and growth plan, and particularly plan for value creation through supply chain integration. Most of the literature (Jadhav et al., 2014; Pingyu, & Yu, 2010) is concerned with creating value within the construction phase only. Therefore, by affirming to Koskela et al. (2002) explanation on TFV theory and need of supply chain integration (Johansen, & Walter; 2007; Hines et al., 2004; Koskela et al., 2002), the findings noted plan for value creation through supply chain integration under organisational strategic plan towards lean implementation.

As stated by Deyshappriya and Maduwanthi (2020), Kapugamage and Gajanayaka (2020) and Ravindra (2019), SMEs in Sri Lanka need to concern on increasing the allocation of money for process improvements. Even though, Jadhav et al. (2014), Shang and Pheng (2014), Aomar (2012) and Rymaszewska (2014) stressed high cost of lean as a barrier for lean implementation, the findings revealed that, financial capacity is only a small ration among organisational lean capacity, which comes under physical resources. Therefore, lean implementation will not largely need extra money as resemblance to Ankomah et al. (2017) and Tezel et al. (2018). Similarly, lean workforce comprised with individual lean enabling capacities further strengthens the lean implementation in the organisation. As highlighted in Lean Iceberg model, the individuals need to be supported by lean leaders. This was further underlined by Abbot and Aziz (2015) and Koskela et al. (2002). According to Tzortzopoulos et al. (2020), to deploy lean, a 'top down' strategic approach is essential and the senior team must be committed to give consistent leadership over the long term. Therefore, lean leadership is figured to be an enabling individual level capacity.

The outer circle in green represents the environmental level lean capacities for construction SMEs (refer Figure 6.11). The circle divided in to four as institutional support, national policies, lean knowledge dissemination and industry vision. As per Kululanga (2012) and Tezel et al. (2017), the external environment plays a substantial role to support both organisational level and individual level lean enabling capacities. Correspondingly, the empirical findings highlighted that environmental level lean enabling capacities will affect the capacities of other two levels. However, lean does not receive the essential attention and support from governments in many countries as reflected in the literature (Ankomah et al., 2020; Tezel et al., 2018; Kululanga, 2012). This was further proven by the less attention given in lean principles (Section 2.8.2) and lean models (Sections 2.8.1, 2.8.3, 2.8.4 and 2.8.5) in literature. Even less attention is given in the lean construction principles (refer Table 2.10). The findings of the research fill the knowledge gap through identification of four environmental level lean enabling capacities. Accordingly, lean knowledge dissemination and institutional support were highly emphasised by the experts, which need to be an immediate action for successful lean implementation by construction SMEs.

Identification of the lean capacities encouraged the construction SMEs to identify the lean enabling capacity building strategies for lean implementation. Thus, the next section discusses the lean enabling capacity building strategies identified during the research study for construction SMEs.

6.8.4 Lean enabling capacity building strategies for construction SMEs

Through literature and empirical investigation findings, the suitability of lean implemetation for construction industry and particularly for construction SMEs was established. There were many studies (Ankomah et al., 2020; Tezel et al., 2017, 2020; Avelar et al., 2019) suggesting that lean has potential to deliver the projects more productively within the budget for the construction SMEs. Hence, it was further identified that the lack of capacities for construction SMEs hinder the lean implementation. Yet, lean capacity buiding definition developed for the research is the developing of ability of individual, organisational and environmental factors to enable lean in order to optimise the value of construction SMEs. Therefore, the summary of identified lean enabling strategies are presented in Figure 6.12.

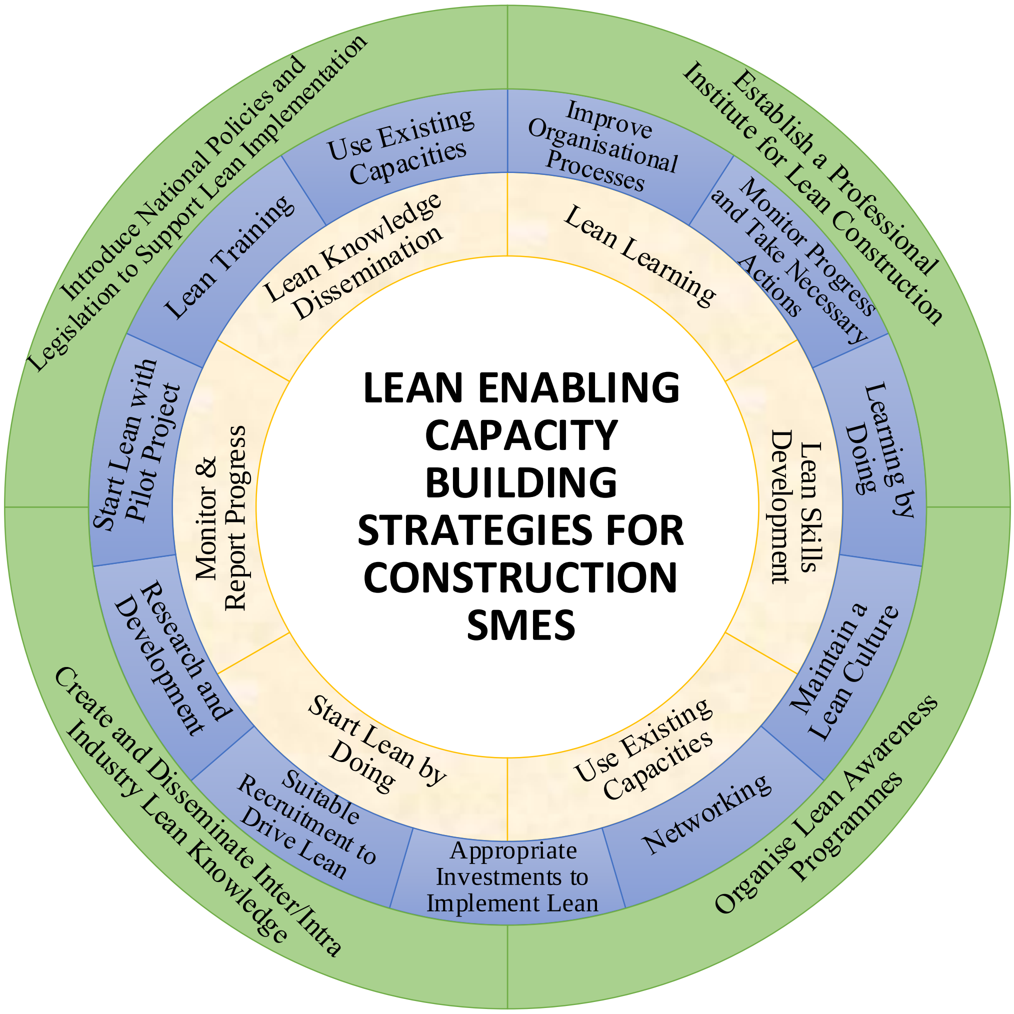


Figure 6.12: Summary of lean enabling capacity building strategies for construction SMEs

According to Figure 6.12, the inner circle in orange colour represents the individual level lean enabling capacity building strategies as discussed in Section 6.6.1. According to Jennings and Wargnier (2015), individual level capacity building strategies explicitly focus on skills development, building stronger relationships, knowing how, knowing what and co-creation of meaning and understanding of the employees in the organisation. Thus, supportively, the research identified lean learning, start lean by doing, lean skills development and lean knowledge dissemination to affirm the explanations given by Jennings and Wargnier (2015). Moreover, building soft skills of individuals can be considered as one of the critical strategies amongst the lean implementation initiatives (Sawhney, & Chason, 2005;

Ankomah et al., 2020). Therefore, the research emphasised the lean skills development.

Nevertheless, monitor and report progress is a newly added area to be considered for individual level lean enabling capacity building, confirming the continuous improvement by Womack and Jones's (1996) lean principles and Koskela's (1992) lean construction principles. This will further encourage the construction SMEs to minimise NVAA in the construction project. One of the root causes for NVAA in construction SMEs is the lack of individual capacities (Section 5.4.5). Therefore, rather creating new capacities, the research is emphasising the better use of existing capacities and strengthening existing capacities in both individual level and organisational level. Nevertheless, continuously improving lean knowledge, lifelong lean learning and genuine commitment and interest in lean learning were identified under lean learning during the research study. Thus, the individual learning will affect both organisation as well as the environment as a whole to improve the lean construction. The individuals can participate lean awareness programmes as resource persons, and train construction workforce as lean trainers. Consequently, construction SMEs can share lean knowledge and best practices with others in the industry. Thus, lean knowledge dissemination is a noteworthy individual strategy for lean implementation, where literature incidentally agreed.

The middle circle in blue colour divided in to eleven sections to incorporate the identified organisational level lean enabling capacity building strategies for construction SMEs. The identified strategies will improve organisational processes, monitor progress and take necessary actions, learning by doing, maintain a lean culture, networking, appropriate investments to implement lean, suitable recruitment to drive lean, R&D, start lean with pilot project, lean training and use existing capacities.

Conducting R&D is a paramount requisite to enable lean (Tezel et al., 2020, Ankomah et al., 2019 and Salem et al., 2005). Leadership and critical thinking skills are some of the necessary focus areas in building the required knowledge. Moreover, experts valued continuously maintaining the acquired skills and knowledge to build individual capacities as confirmed by Badurdeen et al. (2010). However, the findings highlighted that monitoring of the progress of lean implementation after individuals' attend lean awareness programs is important. Yet, it is difficult to examine the progress after attending skills development program as it is time consuming and organisations need to maintain an adequate mechanism to monitor and report the progress of individuals in the firm. Thus, use of existing capacities, appropriate investments to implement lean, maintain a lean culture, networking, and learning by doing can be considered as important organisational level strategies to build the lean enabling capacities. This was further confirmed by the studies of Alarcón et al. (2011), Avelar et al. (2019), Sarhan et al. (2017) and Dave et al. (2016).

The elements presented by Hines et al. (2008) in Lean Iceberg model (as discussed in Section 2.8.4) are compatible with most of the individual as well as organisational level lean enabling capacities. Accordingly, the above water line elements are easy to build, yet can be misleading if the below water line elements (i.e., strategy & alignment, leadership, behaviour & engagement) are not in place, which is the real challenge when it comes to capacity building. However, they are the main focal capacities to be built through improving organisational processes and maintaining a lean culture within the organisation.

As discussed in Table 2.9 (comparison of traditional and lean project delivery systems), most of the characteristics are facilitated in the capacity building strategies. Consequently, lean learning by individuals, learning by doing, maintaining a lean culture and networking are enabled with the learning in lean project delivery system. Similarly, during the decision making in lean project delivery system, downstream players are involved in upstream decisions. Thus, it is facilitated in maintaining a lean culture in the organisation

The four key characteristics (flexibility, localised demand, good labour relations, and low capital requirement for entry) that recommend by Hilderbrandt (1971), has been informed in developing the lean enabling capacity building strategies. Prominently, flexibility and good labour relations were imperative in maintaining a lean culture in the organisation.

OECD (2012), UNESCO (2011) and UNDP (2009) defined organisational level capacity building as improving organisational structures and systems that bring individual capacities effectively together. Therefore, improving organisational processes is emphasised as a noteworthy strategy by all the experts. Consequently, redesign of organisational processes by eliminating NVAA, allow access to information to relevant parties within the organisation, develop an organisational structure that support lean implementation, integration of activities at various levels to address complex problems and develop a recruitment policy that support employing individuals with lean knowledge were defined as ways to improve the organisational processes.

Moreover, hiring a lean expert for organisation is further stressed by the experts highlighting the ability of lean expert to accelerate the lean initiation in the organisation. However, due to lack of lean experts available in the Sri Lankan construction context, construction SMEs needs to rethink the possibility of hiring a lean expert. However, instead of recruiting a lean expert, they can make an existing worker a lean expert through providing necessary lean training. Incidentally, the importance of training for improving individual level lean capacities such as lean thinking, positive attitudes, lean leadership and lean ethics were highlighted by Lopes and Theisohn (2003), Alves et al. (2016), Ankomah et al. (2020) and Kululanga (2012). Therefore, lean training and start lean by doing can be considered as highly influential strategies for building lean enabling capacities among construction SMEs.

The outer circle in green represents the environmental level lean enabling capacity building strategies for construction SMEs. The circle divided into four sections as establish a professional institute for lean construction, organise lean awareness programmes, create and disseminate inter/intra industry lean knowledge and introduce national policies and legislation to support lean implementation. As discussed by Kululanga (2012) and Ranadewa et al. (2018), external environment can assist the SMEs to build the required lean enabling human capacities. Similar to the findings offered by Tezel et al. (2019), the suggestion to form a steering committee at sectorial/national level to look into lean implementation at SMEs is emphasised by the findings of this research. Similarly, encouragement for professional development by government enables individuals to build their lean capacities. Moreover, embedding lean knowledge into construction education/training curricula are highlighted by the experts of the study. Many researches (Ankomah et al., 2020; Tezel et al., 2018; Kululanga, 2012) were contended the less attention given to lean principles (refer Section 2.8) in literature for building lean enabling capacities. The findings of the research fill the knowledge gap through convincing the strategies for building them.

According to Zhou (2016), many SMEs have become important players in large supply chain networks and SMEs either voluntarily or have been forced to apply lean to gain and sustain competitive advantage. Similarly, the external environment can introduce national policies and legislation to support lean implementation through allocating more funds for lean awareness programmes. However, the experts contended the need of introducing KPI-driven lean investment plans for construction SMEs and developing appropriate legislation, policies and standards for lean implementation by the enabling environment as noteworthy strategies for enabling lean.

6.9 Framework for Lean Enabling Capacity Building for Construction SMEs

The essence of lean philosophy is maximising value, minimising NVAA and continuous improvement within the organisation. Thus, to climb up the ladder in enabling lean in the organisation, construction SMEs required identifying the NVAA in the first instances and exploring the barriers and drivers for lean implementation. Correspondingly, the organisation requires identifying the lean capacities requirement and consequently developing the lean enabling capacity building strategies to be successful in lean implementation. Nevertheless, EIR-2 identified the strategies for building lean enabling capacities (refer Section 6.6). Thus, the summary of research findings is presented in lean enabling capacity building framework in Figure 6.13.

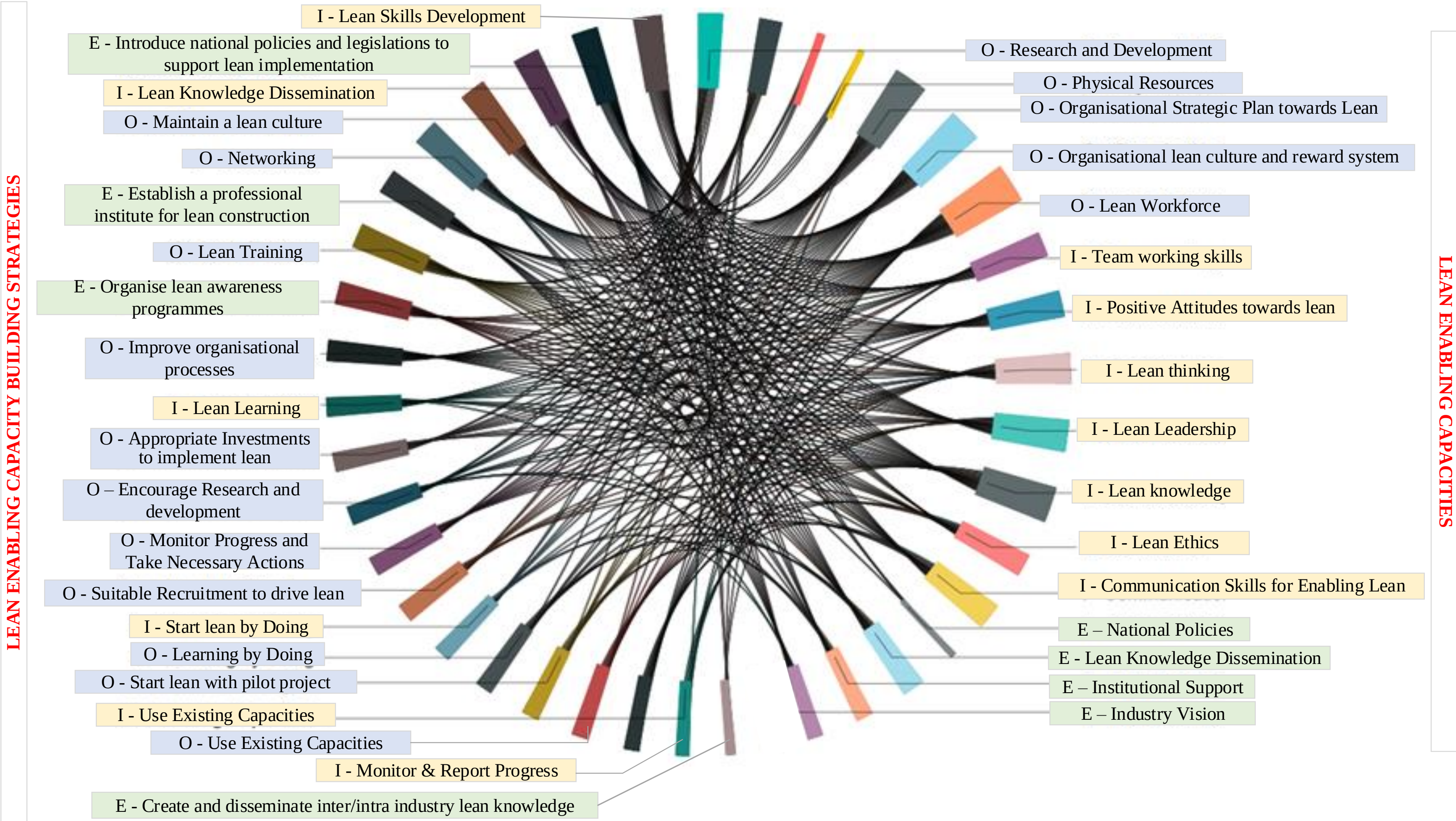


Figure 6.13: Lean enabling capacity building framework for construction SMEs

According to Figure 6.13, the left-hand side of the framework presents the lean enabling capacity building strategies under three levels, namely individual, organisational and environmental levels. They were mapped to the individual, organisational and environmental level lean enabling capacities presented in the right-hand side of the framework. However, there is no linear relationship among them as there are interdependencies exist among three levels, i.e., individuals, organisations, and external environment. Nevertheless, lean capacities at individual level required the lean enabling capacity building strategies at environmental level. This can be proven by availability of training programs in the environment where individual can attend the programs to improve their individual capacities (refer Section 6.5.1). Thus, it is vital to have a holistic understanding on lean enabling capacities and strategies for successful lean implementation.

According to Koskela (1992), the first principle of lean construction is to identify NVAA of the organisation. Hence, without identification of NVAA, enabling lean in an organisation is intolerable. Nevertheless, the 5-Whys analysis can be used by construction SMEs to identify NVAA applicable for their organisation and consequently will be able to explore the root causes. The research developed 5-Whys analysis based on the NVAA in construction SMEs in Sri Lanka as a result of EIR-1 of the study. The NVAA were rooted around lack of finance, insufficient training, cultural inertia, lack of capacities of individuals, lack of networking and collaborations, and lack of action learning.

Moreover, these root causes create the majority of the problems faced by the construction SMEs. Thus, there is a need to overcome the problems by implementing lean. Hence, there is a need to build up the capacities to enable lean in construction SMEs. Hitherto, the findings of EIR-2 revealed the lean capacities (refer Section 6.5) and strategies to build lean capacities (refer Section 6.6) for construction SMEs. Thus, there is a need to ascertain how the identified root causes for the NVAA can be removed through suggested capacity building strategies.

The first root cause is ***'lack of finance'*** be influenced by organisational level and environmental level lean enabling capacities. Accordingly, researchers

(Wonglimpiyarat, 2017; Awa et al., 2015; Ofori & Toor, 2012; Rymaszewska, 2014) argued the lack of finance as a cause for majority of the problems faced by the construction SMEs. Therefore, suitable recruitment in the organisation and improvement of organisational processes will reduce the existing expenditure of construction SMEs. Consequently, construction SMEs have money to invest on organisational lean enabling capacity building strategies. In a similar note, appropriate investments and R&D within the organisation will further reduce the cost of the organisation. Thus, the pertaining root cause for NVAA in construction SMEs of lack of finance can be minimised. Nevertheless, the government has to play a major role in addressing the lack of finance issue of construction SMEs, which is one of the root causes. The government can reduce the external expenditure of construction SMEs such as taxes as highlighted by Athukorala (2017) and cost of materials as highlighted by Kamal and Flanagan (2014). Therefore, construction SMEs have money for investing on lean implementation. Thus, introduce national policies and legislations to support lean implementation are governed to back the construction SMEs in reducing the NVAA caused by lack of finance.

Lack of lean training (IB12 and OB14) is identified as a lean implementation barrier for Sri Lankan construction SMEs during EIR-2. Similarly, during EIR-1, ***'insufficient training'*** identified as a root cause for NVAA among construction SMEs, which need to be overcome by identifying the appropriate lean enabling capacity building strategies. However, insufficient training is influenced by both individual level and organisational level lean enabling capacities. Thus, the employees in a construction SME need to build the individual level strategies including lean learning, monitor & report progress, start lean by doing, lean skills development, use existing capacities and lean knowledge dissemination to minimise the problem of insufficient training for construction SMEs. In a similar note the SMEs has to reflect on how to minimise the issue of insufficient training within the employees. Consequently, construction SMEs have to reconsider on networking, appropriate investments to implement lean, suitable recruitment to drive lean, R&D, start lean with pilot project, lean training and use existing capacities to lessen the training requirement of the organisation to minimise the NVAA.

Another root cause identified during the empirical study on NVAA in construction SMEs is the '***cultural inertia***'. As depicted in the Lean Iceberg model, Hines et al. (2008) stated that, the effective strategy and alignment can only be delivered through strong leadership which, in turn, will only be successfully realized in a positive organisational culture that is receptive to learning and improvement. Similarly, the Shingo Model in Section 2.8.5 too highlighted the importance of culture for successful lean implementation and need to minimise the NVAA in an organisation. Bestowing to Salem and Zimmer (2005), Diekmann et al. (2005) and Johansen and Walter (2007), culture of an organisation was inculcated into the lean construction principles as shown in Table 2.10. Therefore, a need arises for a change from existing culture to a lean culture for successful lean implementation. Yet, the Sri Lankan construction SMEs marked cultural inertia as a root cause for NVAA. This was further confirmed by the barriers for lean implementation among the SMEs.

Even though Sri Lanka is considered to be a very traditional country, there are plenty of ways to overcome the cultural inertia for successful lean implementation. To overcome the cultural inertia there is a need of respect for people (Mossman, 2017; Miles, 1997) as the foundation for them. Yet, this can be overcome by creating a lean culture where, letting people to make mistakes and learning which will create a confidence within the employees. This is further elucidated in start lean by doing by individuals of the SMEs to fade away the cultural inertia. Further, the organisation can support through maintain a lean culture, learning by doing, start lean with pilot project and lean training. However, the enabling environment needs to cater the construction SMEs to overcome the cultural inertia through organise lean awareness programmes, and create and disseminate inter/intra industry lean knowledge. Although, organisational and environmental level lean enabling capacity building strategies are highly influential towards minimising cultural inertia, the ability of the construction SMEs will decide the true success of lean implementation.

Hither to the respondents of EIR-1, ***'lack of individual capacities'*** was identified as a root cause for majority of NVAA. Thus, communication skills for enabling lean, lean thinking, lean leadership, positive attitudes towards lean, lean knowledge, team working skills and lean ethics need to be built in order minimise NVAA caused by lack of individual capacities. This was discussed in detailed in Section 6.5.1.

One of the barriers identified by the experts during EIR-2 is lack of consultants in the industry (EB1) and thus, there is a poor consultation among the other stakeholders (EB8). Thus, **'*lack of networking and collaboration*'** were rooted amongst the six causes for NVAA relevant to Sri Lankan construction SMEs. Hence, the construction SMEs need to encourage R&D, networking, maintain a lean culture, lean training, and improve organisational processes to minimise the NVAA and thus accelerate the lean implementation. However, similar to other root causes, this needs to be in par with environmental level strategies. Therefore, to encourage networking and collaborations among the construction SMEs, there is a need to establish a professional institute for lean construction, organise lean awareness programmes, create and disseminate inter/intra industry lean knowledge by the external environment. Therefore, networking will be highly depended on the enabling environment, which eventually depends on both government and construction industry. Therefore, this research emphasised that, the government need to identify the need of networking and collaboration by providing an opportunity for the construction industry professionals to get together with other industries as well. Thus, the government can introduce national policies/legislations to improve networking with others.

Nevertheless, **'*lack of action learning'*** is the last root cause for NVAA for construction SMEs. Ankomah et al. (2017) proposed action learning as a lean tool to minimise NVAA, which require less monetary investment to implement and can be fully implemented by construction SMEs. Therefore, similar to other root causes, the construction SMEs need encourage action learning by lean learning and start lean by doing by the individual employees. Consequently, the organisation can encourage R&D, networking, maintains a lean culture, lean training, learning by doing and start lean with pilot projects to strengthen the action learning. However, action learning of individuals needs to be supported by the construction SMEs and they need to be monitored by the organisation to identify further improvements. The intensity of action learning will depend on the ability of the organisation and the availability of lean supportive environment. Hence, as discussed in organise lean awareness programmes, create and disseminate inter/intra industry lean knowledge will further mark the liveliness of action learning among construction SMEs.

Accordingly, all identified root causes from EIR-1 can be minimised through practicing the individual level, organisational level and environmental level capacity building strategies identified from EIR-2. Therefore, the framework developed in this study will guide the SMEs to understand the strategies to build lean enabling human capacities and therefore, to accelerate the successful lean implementation among SMEs in Sri Lanka. Interdependencies of lean enabling strategies can be evident among individuals, organisations and external environment related to construction SMEs. Currently, these three interdependencies are not progressive at the same speed due to practical constraints. It is not consistent across the levels. However, it is recommended to progress all three levels at the same speed to achieve the optimum benefits of lean implementation.

6.10 Chapter Summary

The chapter presented the findings of EIR-2 and the solution provided for the construction SMEs in Sri Lanka. The number of semi-structured interviews limited to 24 experts allowing ample data saturation during the data analysis. The chapter initiated by identification of barriers and drivers which are paramount to analyse the existing capacities of the organisation. Henceforth, the chapter presented 12 individual level, 31 organisational level and 26 environmental level drivers for lean implementation for Sri Lankan construction SMEs. Similarly, EIR-2 highlighted 18 individual level, 28 organisational level and 66 environmental level barriers for lean implementation in construction SMEs.

Chapter then discussed the lean enabling capacities. Thus, lean enabling capacities for individual were summarised into seven as communication skills for enabling lean, lean thinking, lean leadership, positive attitudes towards lean, lean knowledge, team working skills and lean ethics. In a similar note lean capacities for organisational level were summarised in to 5 as lean workforce, organisational strategic plan towards lean, organisational lean culture & reward system, physical resources, and R&D. Moreover, environmental lean capacities were categorised into four as institutional support, national policies, lean knowledge dissemination and industry vision.

Consequently, the chapter presented the capacity building strategies to enable the identified lean capacities. Thus, the strategies were presented under the same categorisation as individual level (6), organisational level (11) and environmental level (4) strategies. Therefore, lean knowledge dissemination, lean learning, start lean by doing and lean skills development are considered as noteworthy individual level strategies which responsible of building many lean enabling capacities. Most of the organisational strategies are inter-connected and thus inter-dependent. Yet, maintain a lean culture, networking, lean training and improve organisational processes are in the foremost of building lean enabling capacity building strategies. Nevertheless, all four environmental strategies (establish a professional institute for lean construction, organise lean awareness programmes, create and disseminate inter/intra industry lean knowledge, and introduce national policies and legislation to support lean implementation) are equally noted for building lean enabling capacities.

Finally, the identified lean enabling capacities were mapped with lean enabling capacity building strategies and develop the final framework for construction SMEs. The framework emphasised the interdependencies among individuals, organisation and the enabling environment for successful lean implementation. The framework further highlighted the need of having a holistic understanding on lean enabling capacities and strategies for successful lean implementation.

The chapter further extended on how the EIR-1 findings are informed in the developed framework. The identified root causes of NVAA during EIR-1 were lack of finance, insufficient training, cultural inertia, lack of capacities of individuals, lack of networking and collaborations, and lack of action learning. Thus, the chapter discussed how these root causes can be addressed and minimised through the suggested lean enabling capacity building strategies given in the framework.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter discusses the deriving of conclusions and recommendations from the research findings elaborated in previous chapters. It also elaborates the summary of the research process adopted in deriving the research outcomes. This research aimed to develop a framework for lean enabling capacity building for construction SMEs. To achieve this research aim, certain objectives were established. Thus, the conclusion describes the accomplishment of each objective together with the research findings as explained in the following context. Subsequently, the contribution to knowledge is identified and extended to offer recommendations to the industry. Finally, limitations of the research and further research areas are discussed in the chapter.

7.2 Conclusions

The aim of the research was to develop a lean enabling capacity building framework for construction SMEs. Thus, five objectives were formulated for the attainment of the aim of the research as presented in Section 1.3. The research process was adopted to realise the aim and objectives and thereby answer the main research question of the study. This research shared ontological, idealist assumptions in the interpretive paradigm, including data collection, analysis and validation of findings. Lean enabling capacity building in construction SMEs facilitate the ontological assumption of reality as a social construction. Therefore, subjective qualitative means of knowledge creation were expected with detail descriptions, following the axiological assumptions of more valuable input from the researcher on the research process. This led to the epistemology of understanding, how the social reality about lean enabling capacity building in construction SMEs was created.

The methodology began with a preliminary literature review to identify the research gap and subsequently, reviewed the existing literature on construction SMEs, lean and capacity building concepts to achieve the first objective of the study (refer Chapters 2 and 3). The data collection of the research comprised two rounds as EIR-1 and EIR-2. EIR-1 included data collection from five construction SMEs (Grade C2-C6), selected through quota sampling. EIR-1 resulted in a SWOT analysis for construction SMEs and 5-Whys analysis to identify NVAA and their root causes. Further, EIR-1 revealed the level of lean implementation in construction SMEs in Sri Lanka. Research strategy is case study and 'lean implemented construction SMEs' was the unit of analysis. Data triangulation was achieved through 18 semi-structured interviews, three focus group interviews, non-participatory observations (eleven progress review meetings and eight site visits) and documentary reviews in the cases. Cross-case analysis was carried out using code-based content analysis during the data analysis.

A comprehensive literature review and data gathered from EIR-1 were then used to guide EIR-2. Having an adequate awareness to lean construction is vital in deciding the sample of the study. However, experts having experience and exposure to lean are not common in the Sri Lankan construction industry. Thus, only 24 interviews were selected through purposive sampling for EIR-2. Semi-structured interviews were carried out to determine barriers and drivers for lean implementation in construction SMEs, lean enabling capacities and capacity building strategies at individual, organisational and environmental levels to facilitate lean in construction SMEs in Sri Lanka. Code-based content analysis was done for data analysis. The analysed data were then used to develop the lean enabling capacity building framework and the developed framework was validated by three subject matter experts through interviews.

The main conclusions of the research in relation to each objective are discussed in the next sub-sections.

7.2.1 Review on lean enabling capacity building for construction SMEs

The literature review was extended into: (a) construction SMEs, their importance and issues faced by them, (b) lean philosophy and its application to construction SMEs, (c) capacity building in the context of construction SMEs and (d) capacity building for lean construction. A common characteristic of most of the economies is the significance of a sizeable and rapidly expanding SME sector and thus, the importance of SMEs cannot be downgraded as they play a vital role in the construction industry. Nevertheless, construction SMEs have grown to be an important force in promoting the development of the construction industry. Due to the heterogeneity of SME definitions, the literature highlighted that, there is no universally accepted definition for SME, as it seems to vary from country to country and also from industry to industry. Therefore, most of the countries/industries used quantitative parameters (capital investment on plant and machinery, number of workers and turnover of business) individually or in combination to define SMEs.

The absence of Sri Lankan SME definition for the construction industry was addressed in this research through developing a working definition during the literature review. Accordingly, 'the contractors whose annual turnover is in between 16 to 750 Mn are considered as construction SMEs in Sri Lanka'. This working definition indicated that the organisations in grades C2, C3, C4, C5 and C6 can be identified as SMEs in the construction industry (refer Table 2.3). Thus, construction organisations are categorised in grade C1 or above considered as large construction organisations and organisations in C7 and below were considered as micro construction organisations.

The construction industry is reckoned as being one of the riskiest business areas and thus, several challenges were rightfully noted as issues for construction SMEs to retain their market position (refer Table 2.4). Economic development and SME development are completely interrelated and thus, identification of strategies to overcome the above challenges is imperative. Literature highlighted the need for construction SMEs to be adapted to changing environment and aim to develop and implement new construction processes yielding higher value at lower costs.

Nevertheless, Koskela et al. (2014) emphasised that the conventional systems used in the industry pursue the '*task'* of project completion, however, neglect minimisation of NVAA and maximisation of value. Many organisations are seeking to maximise value addition through embedding lean; as one of the most prominent improvement approaches within the construction industry. Thus, construction SMEs can also be benefited by converting to lean, provided the process is adjusted accordingly. The demand from the supply chain to implement lean can act as the 'crisis' that makes clear the need for lean adoption among construction SMEs.

The TPS model is the initiator to mark for lean principles. The most commonly adopted lean production principles in the literature are five principles specified by Womack and Jones (1996) and Toyota Way 4P principles defined by Liker and Morgan (2006). Lean Iceberg Model and Shingo Model were also successfully implemented by the lean practitioners. The literature further confirmed that even though many researchers discussed lean construction principles in numerous ways (refer Table 2.10), Koskela's (1992) principles is the frequently adopted lean construction principles.

The literature review confirmed eight types of NVAA under lean as overproduction, inventory, motion, waiting, transportation, over-processing, defect and under-utilised human skills (refer Table 2.6) which need to be overcome for successful lean implementation. Traditional control systems focus their attention in conversion activities and ignore flow activities making most of the NVAA become invisible. Therefore, most SMEs take no notice of these NVAA and hence, identification of NVAA as well as their root causes is paramount in the journey towards successful lean implementation. However, setting out to eliminate NVAA from a project or an organisation in isolation from the value purpose of the project or organisation is potentially wasteful.

The implementation of lean in any organisation is a long, on-going and complex process with countless barriers for implementation. Therefore, necessary lean capacities need to identify to optimize the benefits of lean implementation for construction SMEs. This research developed a working definition for lean capacity as the ‘ability of individual, organisational and environmental capacities to enable lean to optimise the value of construction SMEs’. The literature in the lean domain confirmed that there was lack of capacities for lean implementation within the construction SME sector and a need of building capacities to overcome the barriers for lean implementation. Thus, working definition for lean enabling capacity building developed for the research is ‘developing the ability of individual, organisational and environmental capacities to enable lean to optimise the value of construction SMEs’. As one of the main aims of lean construction is reducing waste by maximising value, the capacity building approach must focus on maximising value of a construction project through the right balance between three pillars of the capacity of an organisation namely, individual, organisational and environmental level capacities.

The conceptual framework developed to graphically represent the journey towards implementing lean for construction SMEs based on four main stages to facilitate the empirical investigation, is presented in Figure 3.6. Three main aspects of the study namely, (a) construction SMEs, (b) lean construction, and (c) lean capacity building were combined through a conceptual framework that could facilitate the empirical investigation in any national territory without alterations for lean enabling capacity building for construction SMEs.

7.2.2 Situational analysis of lean implementation in Sri Lankan construction SMEs

Situational analysis of Sri Lankan construction SMEs was achieved in three stages as follows: (1) SWOT analysis for construction SMEs, (2) NVAA in construction SMEs and their root causes and (3) level of lean implementation in construction SMEs in Sri Lanka. The developed SWOT analysis revealed 12 strengths, 12 opportunities, 24 weaknesses and 20 threats relating to construction SMEs in Sri Lanka. Consequently, construction SMEs can get the advantage of small number of workers, flexible cash flows, low interest rates for projects, availability of training programmes for SMEs and increasing public awareness about SMEs. Similarly, construction SMEs need to pay attention to cost controlling techniques, design failures, time overrun, lack of strategic leadership, lack of skilled workers and monopoly created by large organisations.

Koskela (1992) defined the first principle for lean implementation in construction and identified NVAA in the construction projects. It is imperative to analyse the construction SMEs prior to identifying the NVAA of the construction SMEs. SWOT analysis for construction SMEs was prepared to move the path towards the identification of NVAA and root causes. During EIR-1, data were collected with reference to NVAA and their root causes in construction SMEs in the Sri Lankan context. Thus, the researcher developed a 5-Whys analysis based on EIR-1 findings (refer Figure 5.4).

As construction SMEs have their own characteristics, by doing the 5-Whys analysis, construction SMEs will be able to identify the NVAA applicable for their organisation and the root causes for their NVAA. Although Wijesiri and Senaratne (2008) accepted some of the NVAA for the Sri Lankan construction industry, their finding was limited to only ten NVAA and particularly for large construction organisations. Thus, the researcher filled the gap of absence of a suitable analysis to refer to in the literature to reveal the NVAA for construction SMEs. The root causes identification for NVAA is beneficial not only for construction SMEs but also for the large construction organisations to improve the processes. The causes for NVAA in construction SMEs were deep-rooted, and can be attributed to lack of finance, insufficient training, cultural inertia, lack of individual capacities, lack of networking and collaboration, and lack of action learning.

The findings further noted that, most of the SMEs take no notice of NVAA. Therefore, SMEs miss the opportunity to reduce the cost of the project through minimising controllable causes. The main uncontrollable cause identified during the study was the cultural inertia when comparing to other lean implemented countries. People resist to changing their attitudes towards construction due to cultural inertia. However, the researcher has further proven that effective application of the developed framework to the construction SMEs will minimise the impact of cultural inertia and other identified root causes.

The next stage was to identify the lean tools and techniques implemented by the construction SMEs. The researcher was able to identify around 90 lean tools and techniques from the literature. During EIR-1, SMEs were asked to analyse their level of implementation of the 90 lean tools. Table 5.6 on level of understanding of lean tools and techniques by construction and Table 5.7 on level of implementation of lean tools and techniques by construction SMEs were produced by analysing the collected data.

Even though some construction SMEs showed a good understanding of certain lean tools, lack of efforts has been taken for implementation. Accordingly, basic lean tools such as 5S, value engineering, team working, training, daily meetings and check sheets were fairly well understood by them. The findings further confirmed that some of the techniques followed by them are in an ad-hoc manner without realisation of the benefits that can be gained through the implementation. Therefore, impromptu implementation leads to create many other NVAA among the construction SMEs. Conversely, findings emphasised that majority of construction SMEs unaware of lean tools and techniques available in the industry.

The analysis evidently noted that, very few numbers of professionals have their own ways of identifying the NVAA by using customised methods where the use of WhatsApp for visual management within the site itself was well acknowledged by the researcher. The time spent to customise a tool for minimising NVAA was limited to project documentations of the majority of construction SMEs.

7.2.3 Drivers and barriers for lean implementation in construction SMEs

The emphasis of lean thinking on eliminating NVAA and maximising value could be seen as yet another burden on the construction SMEs. Thus, if the workforce perceives that lean construction would cause further inconvenience to them, they may not accept lean, particularly in the long-run. Hence, to ascertain the appropriateness of implementing the lean construction phenomenon in Sri Lankan construction SMEs, a necessity arose to investigate the drivers and barriers for lean implementation within the construction SME community during EIR-2.

All the respondents had unanimously agreed that there are drivers available in the construction industry, which support the lean implementation and further highlighted the importance of strengthening these drivers to accelerate the implementation process through minimising barriers. There are some notable direct and indirect advantages that can be gained from successful lean implementation. Correspondingly, these benefits will drive the lean implementation within the construction SMEs. In a similar note, the problems faced by construction SMEs insisted to overcome the problems through lean implementation. Even though a plethora of research on lean implementation drivers and barriers are available globally, the unavailability of context-specific drivers and barriers for lean in the construction industry in Sri Lanka has hindered lean implementation.

The literature findings on the lean implementation drivers were categorised into three levels of capacities during EIR-2. Therefore, the research fulfils the gap through the identification of 12 individual level drivers (ID1 to ID12), 31 organisational level drivers (OD1-OD31) and 23 environmental level drivers (ED1-ED23) for lean implementation pertaining to construction SMEs in Sri Lanka.

The noteworthy individual level drivers are freedom for employees (ID1) and the experience of the workforce (ID2) due to the inherent characteristics such as flexibility and a smaller number of workers in the construction SMEs. Another highlighted individual driver is the need of workers with the necessary skills and capabilities (ID3) as the majority of construction SMEs believed that lean implementation will increase the capabilities of the employees. Flexible organisation structure (OD1), need of reducing risk to the company (OD2), need of increasing manpower productivity (OD3) and improve the process control (OD4), unbalanced workload on different workstations (OD5), need of standard operating procedure (OD6), and desire to employ best practices (OD7), are the noteworthy organisational drivers identified during EIR-2. Reduce high cost of labour (ED1), need of skilled workers (ED2), reduce problems with low quality materials/parts by suppliers (ED4), need to increase market share (ED5) and need for survival from internal constraints (ED6) demarcated as noted environmental level drivers for construction SMEs.

The literature findings of the lean implementation barriers were categorised into three levels of capacities during EIR-2. Eighteen (18) individual level barriers (IB1-IB18), 28 organisational level barriers (OB1 to OB28) and 16 environmental level barriers (EB1 to EB16) for lean implementation were revealed in relation to construction SMEs in Sri Lanka. High workload (IB1), work pressure (IB2), lack of lean awareness among workers (IB3), inadequate training (IB4), knowledge-level constraints (IB5) and workers' resistance to change (IB6) were stated by the experts as noted individual level lean implementation barriers. Most of the organisational lean implementation barriers identified in the literature were confirmed during EIR-2. High investment cost (OB1), unwillingness of companies to invest extra funds for training (OB2), lack of formal training for employees (OB3), lack of top management involvement (commitment and support) (OB4) and top management resistance (OB5) are the organisational barriers need extensive attention from construction SMEs.

The respondents clearly stated that there are problems with the supply chain in Sri Lankan construction industry. Thus, lack of consultants and trainers in the field (EB1), high cost of lean training (EB2), unstable market for construction (EB3) and lack of cooperation from suppliers (EB4), as noteworthy environmental level barriers for lean implementation which in turns affected to both construction SME organisations as well as individuals. However, SMEs that managed the barriers effectively had a higher probability of lean implementation success.

7.2.4 Determine lean enabling capacities for construction SMEs

In determining lean enabling capacities, the same categorisation is continued as individual, organisational and environmental level lean enabling capacities as a holistic understanding of lean enabling capacities is paramount for successful lean implementation. The findings revealed seven individual level lean enabling capacities namely communication skills for enabling lean, lean thinking, lean leadership, positive attitudes towards lean, lean knowledge, team working skills and lean ethics which are equally contributed to successful lean implementation. Lean enabling organisational level capacities were summarised into five, as; lean workforce, organisational strategic plan towards lean, organisational lean culture & reward system, physical resources, and R&D by affirming the many literature findings. As per Kululanga (2012) and Tezel et al. (2017), the external environment plays a substantial role to support both organisational level and individual level lean enabling capacities. Correspondingly, the empirical findings indicated that environmental level lean enabling capacities will affect the capacities of the other two levels. However, lean does not receive the essential attention and support from the government in Sri Lanka similar to many countries as reflected in the literature. However, the findings explicated, four environmental level lean enabling capacities namely: institutional support, national policies, lean knowledge dissemination and industry vision, which need high consideration by the enabling environment for pledging lean implementation among construction SMEs. Identification of the lean capacities encouraged the construction SMEs to identify the lean enabling capacity building strategies for lean implementation.

7.2.5 Propose lean enabling capacity building strategies for construction SMEs

The strategies were presented under the same categorisation as individual level (6), organisational level (11) and environmental level (4), which was the basis to develop the framework for construction SMEs. Supportively, the research identified lean learning, start lean by doing, lean skills development and lean knowledge dissemination, lean skills development and use of existing capacities as individual level lean enabling capacity building strategies. Thus, individual learning will affect both organisations as well as the environment to improve the lean construction. The individuals can contribute to CPD programmes as resource persons and train the construction workforce as lean trainers. Therefore, lean knowledge dissemination, lean learning, start lean by doing and lean skills development are considered as noteworthy individual strategies responsible for building many lean enabling capacities.

Most of the organisational level lean enabling capacity building strategies are interconnected and inter-dependent. The research explicated them as, improve organisational processes, monitor progress and take necessary actions, learning by doing, maintain a lean culture, networking, appropriate investments to implement lean, suitable recruitment to drive lean, encourage R&D, start lean with the pilot project, lean training and use existing capacities. These strategies are well informed in the literature for pledging lean in construction SMEs. However, maintain a lean culture, networking, lean training and improve organisational processes are in the foremost of building lean enabling capacities.

Even though the external environment can assist the SMEs to build the required lean enabling human capacities, there was a gap in context-specific environmental level strategies for enabling lean. This was proven by the less attention given to lean principles (refer Section 2.8) and lean construction principles (refer Section 2.10.3) in literature. The findings of the research filled the knowledge gap through the identification of four environmental level lean enabling capacity building strategies such as: establish a professional institute for lean construction, organise lean awareness programmes, create and disseminate inter/intra industry lean knowledge, and introduce national policies and legislation to support lean implementation. Nevertheless, all four environmental strategies are equally noted for building lean enabling capacities.

7.3 Contribution to the Knowledge

The knowledge facilitated through this study mainly adds to the body of knowledge in the areas of lean construction, capacity building and construction SMEs. The theoretical contribution and methodological contribution are discussed below. The contribution to practice is discussed under the recommendations.

7.3.1 Theoretical contribution

This research developed a working definition for construction SMEs in Sri Lanka (refer Section 2.4.1). Hence, for this study, "the contractors whose annual turnover is in between 16 to 750 Mn are considered as construction SMEs in Sri Lanka". According to the working definition, construction organisations in grades C2, C3, C4, C5 and C6 can be considered as SMEs in the Sri Lankan construction industry.

Therefore, the absence of a SME definition for the construction industry in Sri Lanka was overcome in this research by developing a definition during the literature review employing theoretical contribution to the heterogeneous definitions available in the global literature. However, the developed definition is limited only to annual turnover of the organisation. Therefore, a more comprehensive national level definition is required considering the number, qualifications and skills of employees, availability of plant, equipment and technology, and construction specialisation for Sri Lankan construction SMEs.

A working definition developed for lean capacity is ‘the ability of individual, organisational and environmental capacities to enable lean to optimise the value of construction SMEs’. This research developed a working definition for lean enabling capacity building as ‘developing the ability of individual, organisational and environmental capacities to enable lean to optimise the value of construction SMEs’. In summary, this research developed two definitions for construction SMEs to identify the lean enabling capacities and lean enabling capacity building by employing theoretical contributions.

Overall, the MRQ of ‘how to build lean enabling capacities by construction SMEs?’ was answered through the development of the framework. The proposed framework mapped the individual level, organisational level and environmental level lean enabling capacities to the individual level, organisational level and environmental level lean enabling capacity building strategies. It can be used as a guide to determine lean enabling capacities and strategies building lean enabling capacities for construction SMEs as presented in Figure 6.13. Accordingly, each capacity and capacity-building strategy is interconnected and depends on each other. Thus, it is vital to have a holistic understanding of lean enabling capacities and strategies for successful lean implementation.

The identified root causes for NVAA during the 5-Whys analysis can be overcome through the strategies proposed in the developed framework as discussed in Section 6.9. As confirmed in the lean literature, lean implementation will not largely need extra money as resemblance to Ankomah et al. (2020), Tezel et al. (2017, 2020) and

Avelar et al. (2019). Therefore, all root causes can be minimised by individual level, organisational level and environmental level lean enabling capacity building strategies without incurring a large cost by construction SMEs to minimise NVAA and consequently efficacious lean implementation.

Rather than depending on existing lean construction and capacity building models, this proposed framework will guide construction SMEs to understand the importance of lean enabling capacity building and identify the capacity building strategies to enable lean under three levels of capacities in an organisation. It is another theoretical contribution to address the lack of an implementable framework for construction SMEs. Therefore, it can be said with confidence that the aim and objectives of this study have been successfully achieved. Contribution to knowledge has been made by developing an innovative, easy to apply, robust methodology to enable industry practitioners to optimise their processes and achieve higher productivity.

7.3.2 Methodological contribution

There was a gap in the existing knowledge as to what methodology to be used in data collection from construction SMEs due to the heterogeneity of the definitions and diverse characteristics of SMEs. This research contributed addressing this knowledge gap, validating a methodology designed using case study as the research strategy. Semi-structured interviews, focus groups meeting, non-participatory observations through visiting sites and attending progress review meetings and document review were proposed as suitable data collection techniques.

Moreover, the research proposed the use of 5-Whys analysis as a strategy of inquiry. Data collection and data analysis is in-built in 5-Whys analysis. Therefore, it ensures a structured and comprehensive approach for troubleshooting, quality improvement, and problem solving. Moreover, as the construction industry practicing lean in an ad-hoc manner, the study emphasised questioning about lean from respondents through 'indirect questioning' as the use of the word 'lean' could diminish the values of responses.

7.4 Recommendations

This section discusses the contribution to practice from this research study. This research contributes to unveiling for the first time, a multi-layered lean enabling capacity building framework to minimise the challenges to lean implementation in construction SMEs in Sri Lanka. Some recommendations can be made to the Sri Lankan construction industry based on the research findings.

The outcome of this research could be used for decision making for individuals of the organisation, organisation it-self and enabling environment for successful lean implementation. As noted in the literature, many lean implemented projects at construction SMEs fail due to the misunderstanding of lean. Similarly, Chandrakanthan (2018) highlighted that in Sri Lankan context, the technical investments made in the name of lean thinking where no groundwork has been done ultimately leads to failures in lean implementation. Therefore, the framework developed in this study will guide the construction SMEs to understand the strategies to build lean enabling human capacities and therefore, to accelerate the successful lean implementation among SMEs in Sri Lanka. Therefore, the findings facilitate in guiding lean implementation, and such guidance will be helpful to remove misunderstandings on lean construction among members and organisations to avoid any unnecessary suffocations. When the individuals are aware of individual strategies, most of the contradictory differentiations, which consume the positive energies, can be overcome.

The individuals are recommended to contribute to CPD programmes as resource persons, and train the construction workforce as lean trainers. Therefore, lean knowledge dissemination, lean learning, start lean by doing and lean skills development are considered as prioritising individual strategies which are responsible for building many lean enabling capacities. Moreover, it is important for project stakeholders, more importantly, construction SMEs to be aware of organisational strategies to be followed up to pledge lean construction. Thus, it is recommended to create a lean culture that encourages lean implementation within the organisation and ultimately within the supply chain. Similarly, networking, lean training and improving organisational processes need to be prioritised with the organisation and continuously monitored for further improvements. In general, construction SMEs should be more customer-centric and pay extra attention to understanding and developing their employees. Therefore, there is a need to be more carefully interpreted the ideas, thoughts and experiences of the employees. Thus, organisational commitment to lean needs to be sustained through informing all stakeholders about the benefits lean offers to the project as well as the organisation. By considering the whole life cycle of the projects, construction SMEs need to clearly define the values of the project with the agreement of all the parties involved in the whole life cycle.

As indicated by many researchers, the availability of implementable strategies at enabling environment is imperative to successful lean implementation as both individuals and organisations are largely shaped by the external environment. The findings explicated the need to develop a best practice guideline for lean implementation, develop a code of conduct for lean professionals, produce lean trainers and introduce a belt system for lean learning through establishing a professional institute for lean construction. Moreover, it is recommended to organise lean awareness programmes, create and disseminate inter/intra industry lean knowledge through organising annual lean conferences and exhibitions to facilitate lean awareness among the construction industry. Further, the establishment of financial endowments for lean research and encourage academic-industry partnerships in lean research will further strengthen to look forward the new frontiers in lean construction. Therefore, Knowledge Transfer Partnerships (KTP) are required for the government, academia and researchers to work together. Similarly, the government needs to introduce national policies and legislation to support lean implementation.

Environmental level strategies will be beneficial for policymakers particularly for Construction Industry Development Authority and relevant Ministries to accelerate lean not only in construction SMEs but also the construction industry as a whole. This aspect can be further incorporated in the secondary, tertiary and vocational education syllabuses to increase the lean awareness among students and accordingly to enhance the lean trainers/consultants in the construction industry.

It is recommended that a more inclusive and up-to-date definition for Construction SMEs be developed by considering both quantitative and qualitative criteria such as number, qualifications and skills of employees, availability of plant, equipment and technology, and construction specialisation. This will help the government in focusing targeted improvements for construction SMEs. The findings of this study will be beneficial to the construction industry in Sri Lanka as well as the construction industries of the developing countries similar to the Sri Lankan construction industry, which have shared the same socio-economic, demographic or cultural traits.

7.5 Limitations of the Research

Studies related to construction SMEs are being context-specific, it is worth highlighting the general context of construction SMEs tested through this research. The findings were limited to the building contractors rather than studying specialised contractors and consultants fall under the construction SME category. There is lack of national information on number, qualifications and skills of employees, availability of plant, equipment and technology, and construction specialisation to develop a more comprehensive definition for construction SMEs in Sri Lanka. Therefore, the developed working definition is limited to annual turnover of the organisations. It was further confined to small and medium contractors from Grade C2 to C6 as per the working definition developed for the study. Nevertheless, there is a lack of published information with regards to micro sized construction organisations in the Sri Lankan context. Thus, the research is narrowed down to study the construction SMEs only. Further, this research carries the axiological assumptions of value input from the researcher within the research process too. Thus, the research lacks the objectivity of the researcher.

This research bears the limitations inherent to the research methodology being adopted. Due to the use of case study as the research strategy in EIR-1 and confined to five construction SMEs selected through quota sampling, this research provided an output best fit for theoretical generalisation, rather than statistical generalisation as described by Yin (2009). The findings of this research should be used as a framework to understand the lean enabling capacity building for construction SMEs, rather than using it as generalised statements to describe the construction SMEs. There can be a danger of deriving general conclusions from a case study; generalisations cannot easily be made on this basis. Case studies are useful for testing theory and hypotheses in areas where little/no work has been carried out previously and thus enabling the gaining of a holistic view of the process under study.

Given the large volume of data typically involved in a case study, there is a danger of losing focus in the final interpretation and the building of a theory that tries to capture everything. Similarly, during EIR-1, the whole truth may not be revealed by the individual owing to fears of top management and the exposure of the company's identity. Thus, this limitation was overcome using different data collection techniques. During EIR-2, there was a possibility of the interviewee bias and the ability to interpret a particular set of events in a realistic manner. Speaking to as many people as possible across the company was adopted to reduce the biasness of the interviewee. The scope of this study is limited to SMEs in the construction industry. However, in the future, it can be extended to other industries. This will determine its wider applicability to other production and service environments.

7.6 Further Research

Based on the findings of this research, a plethora of further research has emerged as follows.

- Covering a wider range of construction SMEs, the developed framework can be further validated in the Sri Lankan context through a longitudinal study.
- A longitudinal study could be carried out to understand the NVAA among construction SMEs in Sri Lanka
- An empirical study to evaluate the value definitions in lean from the Sri Lankan construction industry perspective through a more context-oriented research.

- The research identified more than 90 lean tools and techniques in the global phenomena which can be implemented in the construction industry. Each identified lean tool can be tested to its applicability in Sri Lankan construction industry. The outcome of such research could contribute to enhancing the lean awareness among Sri Lankan construction industry.
- Action research to analyse the lean enabling capacity building by SMEs in Sri Lankan construction industry
- Identified lean enabling capacities and lean enabling capacity building strategies can be tested in actual construction SMEs and can be extended to large construction organisations.
- Enabling lean in construction industry (of which construction SMEs are part of) require the whole life consideration of value. However, due to lack of capacities to discuss about the value addition in design phase, operational stage and demolition stage in the Sri Lankan context, data collection of this research is limited to construction phase only. Yet, lean is not limited to construction phase. Waste can be generated throughout the whole life cycle and, whole life consideration of value is paramount for successful lean implementation. Therefore, research on whole life consideration of waste elimination and value addition is essential for the Sri Lankan construction industry.
- The demand from the supply chain to implement lean is evident in the need for lean adoption. However, this initial implementation is only a starting point and strong efforts will need to be made to embed the project-based lessons learnt throughout the organisation for successful lean implementation. Thus, more collaborative research such as Knowledge Transfer Partnerships (KTP) is recommended for Sri Lankan construction industry for successful lean implementation.

The above further research areas will pave the path to accelerate the lean implementation in the construction industry, so that the lean construction benefits can be communicated to the community, in a much broader manner.

7.7 Concluding Remarks

Lean construction will meet changing needs and provide alternatives that will lead to new standards in construction worldwide. The close interactions among individuals, organisations and the enabling environment are essential for successful lean implementation. Hence, this research developed a lean enabling capacity building framework for construction SMEs by integrating and interrelating individuals, organisations and the enabling environment related to them. The outcomes of this research study will be beneficial to construction SMEs, academics, researchers, and government institutions in developing countries sharing similar socio-economic, demographic or cultural traits to Sri Lanka.

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RESEARCH DISSEMINATION

Journal Papers

- Ranadewa, K.A.T.O., Sandanayake, Y.G. and Siriwardena M.L., Enabling lean through human capacity building: an investigation of small and medium contractors, *Built Environment Project and Asset Management*, Accepted and Published online for EarlyCite: 30 March 2021, DOI:https://doi.org/10.1108/BEPAM-03-2020-0045, (Indexed in Scopus and Emerging Sources Citation Index).

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- Ranadewa, K.A.T.O., Sandanayake, Y.G., & Siriwardena, M.L. (2019). Lean enabling human capacity building of small and medium contractors in Sri Lanka, *In* Proceedings of the 8th World Construction Symposium 2019 (CIOB), (pp 01-13). Colombo, Sri Lanka.
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Awards

- EMERALD Research Award: Built Environment Project and Asset Management Best Paper Award for the paper titled "Lean Enabling Human Capacity Building of Small and Medium Contractors in Sri Lanka", presented at the Eighth World Construction Symposium 2019, at Colombo, Sri Lanka, in July 2019.

Participation as Resource Personnel

- Resource personnel for International Cost Engineering Council for Rising Professionals (ICEC-RP) Virtual Session 5.0. on ‘Enabling lean in construction industry’ organised by Pacific Association of Quantity Surveyors (PAQS) on 12 September 2020.
- Guest Lecture on Lean construction for Quantity Surveying students at General Sir John Kotelawela Defence University on 08 September 2017 at Ratmalana.
- Guest Lecture on Lean construction for Quantity Surveying students at College of Quantity Surveying Sri Lanka on 20 March 2018.
- Resource person for Postgraduate workshop organised by Ceylon Institute of Builders on 2019, at Berjaya hotel, Mt. Lavinia.

APPENDICES

Appendix 1

Lean tools and techniques glossary

Tool/ Technique	Description	References
Eight wastes identification	Identification of wastes of transportation, motion, waiting, inventory, defects, over processing, over production and under-utilised human skills	[2], [5], [8], [9], [12], [13], [17], [18], [20], [21]
Value Identification	The notion of value should never be ignored and essentially is the capability provided to the customer at the right time at an appropriate price, as defined in each case by the customer	[1], [7], [8], [13], [16], [17], [18], [20], [21], [22]
Continuous improvement/kaizen	The continual pursuit of improvements in quality, cost, delivery and design.	[1], [2], [3], [4], [15], [20], [21]
Continuous Flow	Constantly provide or process and produce through a progressive system of uninterrupted steps in the process	[2], [3], [4], [20], [21]
Cellular manufacturing	It is vital to group closely all the facilities required to make a product (or related group of products), in order to reduce transport, waiting and process time	[1], [6], [10], [21]
U-shape line	The U-line arranges machines around a U-shaped line in the order in which production operations are performed. Operators work inside the U-line.	[1], [6], [10], [16], [21]
Just in Time (JIT)	This is a technique aimed primarily at minimizing flow times within a production as well as response times from suppliers and to end users. In any case, JIT is a way of thinking, working and managing to eliminate wastes in processes.	[2], [3], [4], [5], [10], [12], [16], [20], [21], [22]
Kanban (Pull planning)	Means “billboard or signboard”. It is an information control process which regulates the movements or flow of resources so that parts and supplies are ordered and released as they are needed.	[1], [3], [4], [5], [10], [16], [21]
Single piece flow	Where products proceed, one complete product at a time through various operations in design, order taking and production, without interruptions, backflows or scrap	[1], [9], [16], [21]
5S	To reduce the clutter and inefficiency of any typical production and office environment (Sort, Set, Shine, Standardise, Sustain)	[1], [3], [4], [5], [6], [20], [21], [22]
Visual management	To reduce the clutter and inefficiency of any typical production and office environment. Any communication device used in the work environment that tells us at a glance how work should be done and whether it is deviating from the standard	[1], [3], [4], [5], [7], [12], [13], [17], [20], [21], [22]
A3 problem solving	A3 problem-solving sheet provides a standard template that a team can use to ensure a structured approach is applied when resolving the root cause of a problem and proposing remedial or counter-measures.	[6], [10], [11], [13], [21]
Fishbone analysis/ ‘cause and effect’ or Ishikawa	visual or diagrammatic brainstorming process to identify factors most likely to contribute to the problem	[6], [21]
5Whys & 2hows	a systematic questioning process used to identify the root cause of a problem	[6], [8], [9], [14], [21], [22]
PDCA cycle	A structured four-step approach to process improvement (Plan–do–check-act)	[4], [6], [10], [20], [21]
DMAIC	A structured five-step approach to process improvement	[14], [21]

Tool/ Technique	Description	References
	(Define-Measure-Analyse-Improve-Control	
LAMDA	A structured five-step approach to process improvement (Look-Ask-Model-Discuss-Act)	[21]
Lean Six Sigma	Sets of tools and techniques for improving quality through identification and removal of defects and reduction of variability in processes.	[3], [4], [5], [21]
Process mapping	This is a detailed mapping of the order fulfilment process	[1], [10], [11], [17], [21]
Construction Process Analysis	Effectively describe process flow and enable a quick determination of areas where problems exist in the process. The charts comprise of six symbols; Operation, Storage, Transportation, Volume Inspection, Delay, and Quality Inspection. The process diagram records every progression or step of a construction operation.	[4], [5], [11], [14], [19]
Single minute exchange of dies (SMED)	In order to reduce the lead-time and improve flows it is necessary to eliminate delays in change-over times on machines	[1], [7], [11], [21]
Last Planner System	Last Planner with Planned Percentage Complete (PPC) Management tools were used for daily/ weekly monitoring of compliance to programme	[2], [4], [5], [12]
Value Stream Mapping	A technique for visually analyzing, documenting and improving the flow of a process in a way that highlights improvement opportunities.	[4], [5], [10], [20], [21]
Root Cause Analysis (RCA)	This is a problem-solving technique that focuses on discovering and resolving the real problem instead of quick fix application that only solve problem symptoms	[10], [17], [20], [21]
Takt Time calculation	TAKT time is the available production time divided by the units a customer demands	[21]
FIFO inventory management	This is an approach for handling work request in order of flow from first to the last.	[4], [5]
Concurrent Engineering	This methodology involves the various tasks parallelly executed multi-disciplinary teams with the aim of optimizing engineering cycles of products for efficiency, quality, and functionality	[2], [4], [5], [21]
Step change/ kaikaku	There is a need to make radical improvements of an activity to eliminate waste	[1], [21]
Supplier development	Need to actively develop links with suppliers and working closely with them for mutual benefits	[1], [10]
Supplier base reduction	Further attempting to reduce the number of suppliers an organisation engages with	[1], [10]
Supplier involvement in product design	Getting suppliers information to design the product according to the requirements of the suppliers	[10]
Customer involvement in product design	Getting customers information to design the product according to the requirements of the end users	[5], [6], [21]
Simplicity	Avoiding the complicated tasks and achieving the tasks in a simple way	[8], [20], [22]
Total Quality Management (TQM)	A system of management based on the principle that every member of staff must be committed to maintaining high standards of work in every aspect of a company's operations.	[13], [17], [20], [21]
Total productive maintenance (TPM)	This is aimed at improving the reliability, consistency and capacity of machines through maintenance regimes	[1], [3], [4], [21]

Tool/ Technique	Description	References
Preventive Maintenance	This is regular maintenance performed on equipment to reduce the probability of its failure. It is usually performed while the equipment is working to avoid unexpected breakdown	[3], [4], [10], [14]
Work standardization	Manufacturing documented procedures that capture best practices. This "living" documentation that is easy to change.	[3], [4], [20], [21]
3P (Production Preparation Process)	3P is a Rapid Event for developing a new product or business product Line.	[10], [21]
JIDOKA/ Automation	The purpose of Jidoka is to design machines to partially automate the manufacturing process and operations in order to separate people from machines so that operators carry out other task(s) while the machines are running	[3], [4], [9], [16], [21]
Heijunka – Production levelling	This is an evenly spreading of production for customer orders by looking at the average demand and combining them into a production schedule that takes into consideration the volume and mix.	[3], [4], [9], [11], [21]
Synchronize/Line Balancing	This involves levelling of workload across all processes in a value stream to remove excess capacity and bottlenecks.	[3], [4], [9], [18], [21]
Work Structuring	The development of process design and operation in alignment with the supply chain, allocation of resources, product design, and assembly design efforts with the objective of making work process more reliable & quick.	[4], [5], [12], [15], [18]
Multi-Process Handling	This involves assigning operators tasks in multiple processes in an oriented layout of a product flow	[3], [4]
Power NAP - Japanese	A power nap is a short sleep that terminates before deep sleep; it is intended to quickly revitalize the subject.	[21]
Poka Yoke	This is a mechanism design to detect and prevent errors in processes with the aim of achieving zero defects.	[3], [4], [10], [16], [21], [22]
Setup time reduction	This is a changeover technique use to speedily change tools and fixtures in order for multiple products to be run on the same machine	[3], [4]
First Run Studies	Trial execution of a process with a specific end goal to decide the best means, strategies, sequencing, among others to perform it. In construction, this is used for redesigning critical assignments as a part of continuous improvement effort, by redesigning and streamlining the distinctive functions involved.	[4], [5], [13], [17], [20], [21], [22]
Time and Motion Study	A procedure for evaluating industrial or other operational efficiency on the basis of the taken or needed time for an operation or production.	[3], [4]
Bottleneck Analysis	This is the identification of the part of the process that put a limitation on the overall productivity in order to improve the performance of that part.	[4], [5], [10]
Gemba walk	Used to identify waste through observation of operations, how work processes are conducted, and noting areas where improvements are needed	[3], [4], [7], [8], [20], [21]
Genchi Genbutsu	Go and See where the work carried out	[7], [8], [21]
Andon	A system to notify management, maintenance, and other workers of a quality or process problem. The alert can be activated manually by a worker using a pullcord or button or may be activated automatically by the	[7], [21]

Tool/ Technique	Description	References
	production equipment itself.	
Spaghetti Chart	Visual representation using a continuous flow line tracing the path of an item or activity through a process.	[21]
Target value design	Refers to the application of Target Costing (TC) to the delivery of projects in the Architecture-Engineering-Construction (AEC) industry. This design method radically differs from what has become the traditional way of designing and making production	[1], [4], [5]
Global 8D	Global 8D hosted software is a world-class solution that allows individuals and teams across an enterprise and supply chain to create, request, review, and report on problem solving efforts	[21]
ChakuChaku	Chaku Chaku is a way to operate a semi-automated manufacturing line.	[6], [21]
HoshinKanri/Policy deployment	A 7-step process used in strategic planning in which strategic goals are communicated throughout the company and then put into action	[1], [6], [7], [10], [21]
Jishuken	Form of problem solving using gemba kaizen combined with a kaizen blitz, but it involves more than solving a problem.	[21]
Team Work	Encourage team working within the organisation to improve the tasks allocated	[1], [5], [8], [14], [15], [20], [21]
Cross functional teams	A group of people with different functional expertise working toward a common goal. It may include people from finance, marketing, operations, and human resources departments. Typically, it includes employees from all levels of an organisation	[4], [10], [15], [21]
Training	Provide training in the organisation to reduce the non-value adding activities	[1], [2], [5], [7], [9], [11], [12], [13], [15], [17], [20]
Workforce commitment	Use of motivational theories to get the optimum commitment from the employees	[1], [2], [17], [19]
Daily schedule adherence	Develop daily schedules for each and every employee of the organisation with the tasks allocated for them during the day and the management will monitor the adherence of the schedule with organisation's KPIs.	[13], [16], [17], [18]
Continuous flow	Moving products through a production system without separating them into lots	[1], [4], [5], [7], [8], [12], [17], [20], [21]
Time Based Competition	A broad-based competitive strategy which emphasizes time as the major factor for achieving and maintaining a sustainable competitive advantage	[13]
Integrated project Delivery (IPD)	Integrated project delivery (IPD), is a collaborative alliance of people, systems, business structures and practices into a process that harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximise efficiency through all phases of design, fabrication, and construction.	[2], [12], [17], [18]
Building Information modelling (BIM)	An intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage projects	[1], [2], [16]

Tool/ Technique	Description	References
Balance Score card System	A performance measurement tool to balance between the use of financial and non-financial measures to achieve strategic alignment.	[19]
Reverse-phase scheduling (RPS)	A pull technique is used to develop a schedule that works backwards from the completion date by team planning; it is also called RPS. They also state that phase scheduling is the link between work structuring and production control, and the purpose of the phase schedule is to produce a plan for the integration and coordination of various specialists' operations.	[1], [2], [12], [13], [17], [20]
Choosing by Advantage (CBA)	Two or more construction methods, materials, building design, or construction systems from which one must be chosen	[13], [16], [17], [18]
Check Sheet	Known as Defect Concentration Diagram: structured form prepared for collecting and analysing data. It is a generic tool adapted for a variety of purposes including observation and a collection of data on the frequency of patterns of problems, events, defects, causes, etc	[4], [5], [14], [21]
Pareto Analysis	This is a bar graph that is used for analysing data about the frequency of the causes or problems in processes. It visually depicts which situation are more important	[4], [5], [14]
Check Points and Control Points	These are mechanisms used to regulate and determine the levels of improvement in the activities of managers occupying different levels of positions	[3], [4], [5],
Failure Mode and Effects Analysis (FMEA)	This is a step by step approach for identifying potential failures in product or service, design, and manufacturing, etc. The failures are further ranked to determine the seriousness of their consequences in order to take actions to eliminate them, starting with the highest ranked ones.	[4], [5], [14], [16], [21]
Fail Safe for Quality	This relies on the generation of ideas which alert for potential defects. Same as Poka-Yoke, but it can be extended to safety. However, the concentration in safety is on potential hazards rather than potential defects, and is identified with the risk assessment technique.	[4], [13]
Daily meetings	This a technique used for communicating and for everyday meeting process of the project team in order to accomplish workers involvement.	[1], [4], [7], [8], [13], [18], [20], [22]
SMART Goals	Develop goals that are Specific, Measurable, Attainable, Relevant, and Time-Specific.	[4], [10]
Quality Function Development (QFD)	Use of customer's voice, different organisation functions and units for final engineering specification of a product	[3], [4]
Statistical Process Control	A quality control tool that monitors and control process in order to ensure that system output variables operate to its full potential through periodic measurement.	[3], [4]
Nemawashi	Informal process of quietly laying the foundation for some proposed change or project, by talking to the people concerned, gathering support and feedback.	[1], [9], [16], [21]
[1] Bhasin & Burcher, (2006), [2] Aziz and Hafez (2013), [3] Alireza and Sorooshian (2014), [4] Ansah, Sorooshian, Mustafa & Duvvuru (2016), [5] Rahman et al. (2013), [6] Connor & Swain (2015), [7] Liker (2004), [8] Tommelein (2015), [9] Tsao et al. (2004), [10] Leanproduction.Com (2015), [11] Lee et al. (1999), [12] Howell, & Ballard (1998), [13] Salem et al. (2005), [14] ASQ (2015), [15] Brunet and New (2003), [16] Hutchins (2016), [17] Mossman (2017), [18] Arroyo, Tommelein & Ballard (2015), [19] Hudson, Smart & Bourne (2001), [20] Koskela (1992), [21] Stadnicka & Antosz (2013), [22] Muhammad et al. (2013)		

Appendix 2

Interview guideline (EIR-1)

Date

Dear Sir/Madam

Data Collection

I am Tharusha Ranadewa, doctoral student in Department of Building Economics, University of Moratuwa, conducting a research under the supervision of Dr. Y.G. Sandanayake and Dr. Mohan Siriwardena on lean enabling capacity building in construction SMEs. This research will develop a lean enabling capacity building framework for construction SMEs. The intended framework will guide construction SMEs to understand the importance of lean enabling capacity building and identify the capacity building measures to enable lean. It will further provide solutions for the challenges faced by construction SMEs through capacity building in the lean enabling environments.

The purpose of this interview is to get answers for following research questions.

- RQ2a : What are the NVAA of construction SMEs and their root causes?
- RQ2b : What is the level of understanding and implementation of lean tools and techniques by construction SMEs in Sri Lankan construction industry?

It will be appreciated if you would kindly allow me an appointment to conduct the interviews. I assure that the information collected will be purely used for the research purpose, and the confidentiality of the details will be strictly maintained. If you have any questions about this study, or you would like additional information to assist you in reaching a decision about participation, please contact
Supervisor - Dr. Y. G. Sandanayake (ysandanayake@uom.lk)
Supervisor - Dr. Mohan Siriwardena (mohan.siriwardena@googlemail.com)
Researcher- Mrs. Tharusha Ranadewa (0772266488, tharusharanadewa@yahoo.com)

Thank you for your time and contribution.

Yours faithfully

Tharusha Ranadewa
PhD Research Student
Department of Building Economics
University of Moratuwa

Lean Enabling Capacity Building for Construction Small and Medium Enterprises (SMEs) in Sri Lanka

1. General Information

1.1 Overview of the Organisation

1.1.1 What is the grade of your organisation?

1.1.2 What is the organisation's field of specialisation?

1.1.3 Number of employees in your organisation

10-20		150-200	
20-50		200-300	
50-100		>300	
100-150			

1.1.4 What is the annual turnover of your company?

1.1.5 Number of projects in hand

1.1.6 On average, how many projects does the company handles at any given time?

1.1.7 How long have you been in the industry?

1.1.8 Briefly explain the historical development of your organisation.

1.1.9 What are the resources of your company?

Individual	Organisational	External

1.2 Respondent's details

1.2.1 Designation :

1.2.2 Experience :

1.2.3 Educational Qualifications:

1.2.4 Professional Qualifications:

1.2.5 Sources of data collection:

PART -1

2. Lean implementation in construction SMEs

2.1 Have you heard of lean?

2.2 What do you mean by lean?

2.3 Should construction companies be lean?

If 'Yes', why should companies be lean? Specify your reasons.

If "No", why shouldn't companies be lean? Specify your reasons

2.4 Do you think that lean can increase the productivity of your organisation? Specify your reasons.

2.5 What are the performance / productivity measures you used in your organisation?

2.6 How do you use those measures to interpret performance in your organisation?

3. NVAA of construction SMEs

3.1 Why there are '***transportation***' wastes in construction SMEs.

Below items are to facilitate the interviewer during the interview based on literature

Type of transportation waste	W1	W2	W3	W4	W5
Moving work-in-process from place to place					
Delivering equipment, incomplete orders					
Moving to and from storage.					

3.2 Why there are '***inventory***' wastes in construction SMEs.

Below items are to facilitate the interviewer during the interview based on literature

Type of inventory iwaste	W1	W2	W3	W4	W5
Excess raw material, WIP or finished goods causing longer lead times, obsolescence					
Damaged goods, transportation/ storage costs and delays.					
Large site stores of materials					
Poor stock management					
Too much material compromising workspace.					

3.3 Why there are '***motion***' wastes in construction SMEs.

Below items are to facilitate the interviewer during the interview based on literature

Type of motion waste	W1	W2	W3	W4	W5
Unnecessary movement of people and equipment that does not add value, including walking between different work places etc					
Walking between workplace and welfare facilities, manual paperwork processing					
Movement of materials and drawing information					

3.4 Why there are '***waiting***' wastes in construction SMEs.

Below items are to facilitate the interviewer during the interview based on literature

Type of waiting waste	W1	W2	W3	W4	W5
Workers unable to do value-creating work, and capacity bottlenecks					
Waiting time between processes or for capacity to take the next step					
Documents awaiting updating or processing					
Equipment downtime					

3.5 Why there are ***'over-production'*** wastes in construction SMEs.

Below items are to facilitate the interviewer during the interview based on literature

Type of over-production waste	W1	W2	W3	W4	W5
Producing items earlier than needed					
Producing items beyond specification					
Producing more than is needed					
Larger than necessary excavations, orders placed for same materials with different suppliers					
Generating waste through overstaffing, storage and transportation costs					
Overstaffing					
Can be physical or information that is produced.					

3.6 Why there are '***defects***' wastes in construction SMEs.

Below items are to facilitate the interviewer during the interview based on literature

Type of defects waste	W1	W2	W3	W4	W5
Production of defective work/corrections, not meeting specifications first time					
Inspections to reduce/remove defects					
Wrong information on drawings					
Production of replacements – rework.					
Estimation errors					
Design failures/ Changes					
Documentation errors in the procurement					
Time overrun and missed deadlines					

3.7 Why there are ‘***over-processing***’ wastes in construction SMEs.

Below items are to facilitate the interviewer during the interview based on literature

Type of over-processing waste	W1	W2	W3	W4	W5
Taking unnecessary steps					
Multiple plant movements					
Inefficient processing, especially due to poor design or work planning causing something unnecessary					
Providing quality products beyond specifications					
Work done to ‘fill the gaps’ rather than appear to be waiting					

3.8 Why there are ‘***under-utilised human skills’*** in construction SMEs.

Below items are to facilitate the interviewer during the interview based on literature

Type of under-utilised human skills	W1	W2	W3	W4	W5
Losing time and ideas, skills improvements and learning opportunities					
Learning from one site not being used well on another					
People working one or two levels down from their true capability					
Mismanaged health and safety					

3.9 What are the actions that your organisation undertaken to overcome the above problems?

4. SWOT analysis for construction SMEs

4.1 What are the strengthes of construction SMEs in Sri Lanka?

4.2 What are the Opportunites available for construction SMEs in Sri Lanka?

4.3 What are the Weeknesses of construction SMEs in Sri Lanka?

4.4 What are the threats for construction SMEs in Sri Lanka?

PART -2

5. Lean Tools and Techniques Implementation

5.1 Please specify your level of understanding of the following tools and techniques?

5.2 Have you implement the stated tool in your Organisation? If so to what extent have you implement them in your organisation?

5.3 Please provide the reasons for not implementing the given tools in your organisation.

(Please refer table of definitions given at the last page (glossary) for more details)

Lean tool	5.1 Level of Understanding	5.2 Level of Implementation	5.3 Remarks
8 waste identification			
Value identification			
Continuous improvement/kaizen			
Cellular manufacturing			
U-shape line			
Just in Time (JIT)			
Kanban			
Single piece flow			
5S			
Visual management			
A3 problem solving			
Fishbone analysis/ ‘cause and effect’ or Ishikawa			
5W & 2H			
Plan–do–check-act (PDCA) (Improvement cycle)			
Lean six sigma Define-Measure-Analyse-Improve-Control (DMAIC)			
Look-Ask-Model-Discuss-Act (LAMDA cycle)			
Process mapping			
Single minute exchange of dies (SMED)			
Last planner with Planned Percentage Complete (PPC)			
Value Stream Mapping			
Root Cause Analysis (RCA)			

Lean tool	5.1 Level of Understanding	5.2 Level of Implementation	5.3 Remarks
Takt Time calculation			
FIFO inventory management			
Concurrent Engineering			
Step change/ kaikaku/ Reengineering			
Supplier development			
Supplier base reduction			
Supplier involvement in product design			
Customer involvement in product design			
Simplicity			
Total Quality Management (TQM)			
Total productive maintenance (TPM)			
Work standardization			
3P (Production Preparation Process)			
JIDOKA			
Heijunka – Production levelling			
Power NAP – Japanese			
Poka Yoke			
Setup time reduction			
Gemba walk			
Genchi Genbutsu			
Andon			
OEE			
Rules of release			
Spaghetti Chart			
Target value design			
Milk man cours			
Global 8D			
ChakuChaku			
HoshinKanri/Policy deployment			
Jishuken			
Team Work			
Cross functional teams			
Training			
Workforce commitment			
Daily schedule adherence			

Lean tool	5.1 Level of Understanding	5.2 Level of Implementation	5.3 Remarks
Long term contract			
“Error proof” equipment			
Small lot size			
Continuous flow			
Time Based Competition			
Integrated project Delivery			
Building Information modelling (BIM)			
Worker Participation			
Suggestion box			
Feedback box			
Whats app / any other app			
Improvement KATA and coaching KATA.			
Any other			

5.4 Are there any tools and techniques other than the above listed and currently implemented in your organisation to reduce the NVAA in your organisation and for value addition. If so, please describe them in detail.

5.5 Why did you start to implement some of the lean techniques?

5.6 Did you study and compare yourself with other companies before the start of the implementation of these techniques?

5.7 If yes what are the areas to be considered before implementation of these techniques?

5.8 If No, what areas do you think that need to take in to accounts before implementation of these techniques?

5.9 How are you going to assess the success of those techniques applied to your organisation?

5.10 Have you experienced any failures during the implementation of any lean tool in your organisation?

GLOSSARY

Tool/ Technique	Description
Eight wastes identification	Identification of wastes of transportation, motion, waiting, inventory, defects, over processing, over production and under-utilised human skills
Value Identification	The notion of value should never be ignored and essentially is the capability provided to the customer at the right time at an appropriate price, as defined in each case by the customer
Continuous improvement/kaizen	The continual pursuit of improvements in quality, cost, delivery and design.
Continuous Flow	This means to constantly provide or process and produce through a progressive system of uninterrupted steps in the process
Cellular manufacturing	It is vital to group closely all the facilities required to make a product (or related group of products), in order to reduce transport, waiting and process time
U-shape line	The U-line arranges machines around a U-shaped line in the order in which production operations are performed. Operators work inside the U-line.
Just in Time (JIT)	This is a technique aimed primarily at minimizing flow times within a production as well as response times from suppliers and to end users. In any case, JIT is a way of thinking, working and managing to eliminate wastes in processes.
Kanban (Pull planning)	Means “billboard or signboard”. It is an information control process which regulates the movements or flow of resources so that parts and supplies are ordered and released as they are needed.
Single piece flow	Where products proceed, one complete product at a time through various operations in design, order taking and production, without interruptions, backflows or scrap
5S	To reduce the clutter and inefficiency of any typical production and office environment (Sort, Set, Shine, Standardise, Sustain)
Visual management	To reduce the clutter and inefficiency of any typical production and office environment. Any communication device used in the work environment that tells us at a glance how work should be done and whether it is deviating from the standard
A3 problem solving	A3 problem-solving sheet provides a standard template that a team can use to ensure a structured approach is applied when resolving the root cause of a problem and proposing remedial or counter-measures.
Fishbone analysis/ ‘cause and effect’ or Ishikawa	visual or diagrammatic brainstorming process to identify factors most likely to contribute to the problem
5W & 2H	a systematic questioning process used to identify the root cause of a problem
Plan–do–check-act (PDCA cycle)	A structured four-step approach to process improvement
Define-Measure-Analyse-Improve-Control (DMAIC)	A structured five-step approach to process improvement Define-Measure-Analyse-Improve-Control
Look-Ask-Model-Discuss-Act (LAMDA)	A structured five-step approach to process improvement
Lean Six Sigma	Sets of tools and techniques for improving quality through identification and removal of defects and reduction of variability in processes.
Process mapping	This is a detailed mapping of the order fulfilment process
Construction Process Analysis	This actualizes process charts and top-view flow charts common among process analysis methods. These diagrams and charts depend on standardized symbols and effectively describe process flow and enable a quick determination of areas where problems exist in the process. The charts comprise of six symbols; Operation, Storage, Transportation, Volume Inspection, Delay, and Quality Inspection. The process diagram records every progression or step of a construction operation. Furthermore, it records flow within units, sections, and departments
Single minute exchange of dies (SMED)	In order to reduce the lead-time and improve flows it is necessary to eliminate delays in change-over times on machines
Last Planner System	Last Planner with Planned Percentage Complete (PPC) Management tools were used for daily/ weekly monitoring of compliance to programme
Value Stream Mapping	A technique for visually analyzing, documenting and improving the flow of a

Tool/ Technique	Description
	process in a way that highlights improvement opportunities.
Root Cause Analysis (RCA)	This is a problem-solving technique that focuses on discovering and resolving the real problem instead of quick fix application that only solve problem symptoms
Takt Time calculation	TAKT time is the available production time divided by the units a customer demands
FIFO inventory management	This is an approach for handling work request in order of flow from first to the last.
Concurrent Engineering	This methodology involves the various tasks parallelly executed multi-disciplinary teams with the aim of optimizing engineering cycles of products for efficiency, quality, and functionality
Step change/ kaikaku	There is a need to make radical improvements of an activity to eliminate waste
Supplier development	The organisation needs to actively develop links with suppliers and working closely with them for mutual benefits
Supplier base reduction	Further attempting to reduce the number of suppliers an organisation engages with
Supplier involvement in product design	Getting suppliers information to design the product according to the requirements of the suppliers
Customer involvement in product design	Getting customers information to design the product according to the requirements of the end users
Simplicity	Avoiding the complicated tasks and achieving the tasks in a simple way
Total Quality Management (TQM)	A system of management based on the principle that every member of staff must be committed to maintaining high standards of work in every aspect of a company's operations.
Total productive maintenance (TPM)	This is aimed at improving the reliability, consistency and capacity of machines through maintenance regimes
Preventive Maintenance	This is regular maintenance performed on equipment to reduce the probability of its failure. It is usually performed while the equipment is working to avoid unexpected breakdown
Work standardization	Manufacturing documented procedures that capture best practices. This “living” documentation that is easy to change.
3P (Production Preparation Process)	3P is a Rapid Event for developing a new product or business product Line.
JIDOKA/ Automation	The purpose of Jidoka is to design machines to partially automate the manufacturing process and operations in order to separate people from machines so that operators carry out other task(s) while the machines are running
Heijunka – Production levelling	This is an evenly spreading of production for customer orders by looking at the average demand and combining them into a production schedule that takes into consideration the volume and mix.
Synchronize/Line Balancing	This involves levelling of workload across all processes in a value stream to remove excess capacity and bottlenecks.
Work Structuring	This is used for the development of process design and operation in alignment with the supply chain structure, allocation of resources, product design, and assembly design efforts with the objective of making work process more reliable and quick while delivering quality to the client.
Multi-Process Handling	This involves assigning operators tasks in multiple processes in an oriented layout of a product flow
Power NAP - Japanese	A power nap is a short sleep that terminates before deep sleep; it is intended to quickly revitalize the subject.
Poka Yoke	This is a mechanism design to detect and prevent errors in processes with the aim of achieving zero defects.
Setup time reduction	This is a changeover technique use to speedily change tools and fixtures in order for multiple products to be run on the same machine
First Run Studies	Trial execution of a process with a specific end goal to decide the best means, strategies, sequencing, among others to perform it. In construction, this is used for redesigning critical assignments. This is part of continuous improvement effort, and incorporate efficiency studies and review work techniques by redesigning and streamlining the distinctive functions involved. The techniques involve the use of photographs, video files or graphics to demonstrate the process
Time and Motion Study	A procedure for evaluating industrial or other operational efficiency on the basis

Tool/ Technique	Description
	of the taken or needed time for an operation or production.
Bottleneck Analysis	This is the identification of the part of the process that put a limitation on the overall productivity in order to improve the performance of that part.
Gemba walk	used to identify waste through observation of operations, how work processes are conducted, and noting areas where improvements are needed
Genchi Genbutsu	Go and See where the work carried out
Andon	A system to notify management, maintenance, and other workers of a quality or process problem. The alert can be activated manually by a worker using a pullcord or button or may be activated automatically by the production equipment itself. The system may include a means to stop production so the issue can be corrected.
Spaghetti Chart	Visual representation using a continuous flow line tracing the path of an item or activity through a process.
Target value design	Refers to the application of Target Costing (TC) to the delivery of projects in the Architecture-Engineering-Construction (AEC) industry. This design method radically differs from what has become the traditional way of designing and making produc
Global 8D	Global 8D hosted software is a world-class solution that allows individuals and teams across an enterprise and supply chain to create, request, review, and report on problem solving efforts using the proven Global 8D methodology
ChakuChaku	Chaku Chaku is a way to operate a semi-automated manufacturing line.
HoshinKanri/Policy deployment	A 7-step process used in strategic planning in which strategic goals are communicated throughout the company and then put into action
Jishuken	Form of problem solving using gemba kaizen combined with a kaizen blitz, but it involves more than solving a problem.
Team Work	Encourage team working within the organisation to improve the tasks allocated
Cross functional teams	a group of people with different functional expertise working toward a common goal. It may include people from finance, marketing, operations, and human resources departments. Typically, it includes employees from all levels of an organisation
Training	Provide training in the organisation to reduce the non-value adding activities
Workforce commitment	Use of motivational theories to get the optimum commitment from the employees
Daily schedule adherence	Develop daily schedules for each and every employee of the organisation with the tasks allocated for them during the day and the management will monitor the adherence of the schedule with organisation’s KPIs.
Continuous flow	Moving products through a production system without separating them into lots
Time Based Competition	A broad-based competitive strategy which emphasizes time as the major factor for achieving and maintaining a sustainable competitive advantage
Integrated project Delivery (IPD)	Integrated project delivery (IPD), is a collaborative alliance of people, systems, business structures and practices into a process that harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximise efficiency through all phases of design, fabrication, and construction.
Building Information modelling (BIM)	An intelligent 3D model-based process that gives architecture, engineering, and construction (AEC) professionals the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure. Your industry.
Balance Score card System	A performance measurement tool to balance between the use of financial and non-financial measures to achieve strategic alignment.
Reverse-phase scheduling	A pull technique is used to develop a schedule that works backwards from the completion date by team planning; it is also called Reverse Phase Scheduling (RPS). They also state that phase scheduling is the link between work structuring and production control, and the purpose of the phase schedule is to produce a plan for the integration and coordination of various specialists’ operations.
Choosing by Advantage (CBA)	Two or more construction methods, materials, building design, or construction systems from which one must be chosen
Check Sheet	Known as Defect Concentration Diagram: structured form prepared for collecting and analysing data. It is a generic tool adapted for a variety of purposes including observation and a collection of data on the frequency of patterns of problems, events, defects, causes, etc

Tool/ Technique	Description
Pareto Analysis	This is a bar graph that is used for analysing data about the frequency of the causes or problems in processes. It visually depicts which situation are more important
Check Points and Control Points	These are mechanisms used to regulate and determine the levels of improvement in the activities of managers occupying different levels of positions
Failure Mode and Effects Analysis (FMEA)	This is a step by step approach for identifying potential failures in product or service, design, and manufacturing, etc. The failures are further ranked to determine the seriousness of their consequences in order to take actions to eliminate them, starting with the highest ranked ones.
Fail Safe for Quality	This relies on the generation of ideas which alert for potential defects. This is almost the same as Poka-Yoke techniques but it can be extended to safety. However, the concentration in safety is on potential hazards rather than potential defects, and it is identified with the risk assessment technique. It requires action plan that avoids bad outcomes
Daily meetings	This a technique used for communicating and for everyday meeting process of the project team in order to accomplish workers involvement.
SMART Goals	Goals that are Specific, Measurable, Attainable, Relevant, and Time-Specific.
Quality Function Development (QFD)	This refers the use of customer's voice and different organisation functions and units for final engineering specification of a product
Statistical Process Control	This is a quality control tool that monitors and control process in order to ensure that system output variables operate to its full potential through periodic measurement.
Nemawashi	Informal process of quietly laying the foundation for some proposed change or project, by talking to the people concerned, gathering support and feedback, and so forth. It

Appendix 3

Progress review observation guideline

PROGRESS REVIEW MEETING OBSERVATION GUIDELINE

Project:	
Progress Review Meeting Number:	
Date:	
Place of Meeting:	
Organising Party of the Meeting:	

1. Project details	
a) Scope	
b) Duration	
c) Contract Sum	
d) Procurement method	
e) Client	
f) Consultant	
g) Contractor	

2. Progress details	
a) Finished project scope up-to-date	
b) Finished project time up to date	
c) Finished project cost up to date	

3. Members present at the meeting (Designations only)	
a) Client's party	
b) Contractor's party	
c) Consultant's party	

4. Main issues discussed in the meeting

5. Proposed solutions for discussed issues

6. Identified wastes during the meeting
Transportation   Inventory   Motion   Waiting   Over-production   Over-processing   Defects   Under-utilised human skills

7. Used lean techniques during the meeting

8. Other general Observations

1) What is the language the meeting is being conducted and general communication is done?

2) Any major strategies discussed in the meeting to achieve objectives?

3) From where these strategies coming from? Is the strategies completely based on formal reasoning and logic, or is it partly a product of the beliefs and bias of someone in the project team?

4) How do the members discover that they are not meeting goals and targets?

5) Any performance evaluation system noted by the observer related to the project team in terms of cost, time quality?

6) What kind of variations discussed in the meeting?

7) Does the project team discuss about innovations at the meeting?

8) How much are the team members encouraged to agree or disagree in front of the meeting chair and other team members while proceeding meeting?

9) Does every team member contribute to the meeting? If not, who are the members not participate much with the discussions?

10) Does the project manager or the meeting chair discuss about the performance of the parties (consultant/contractor) directly?

11) Does the meeting start on time and end on time?

12) Only the regular set of team members attending the meeting or any special people are brought into the meeting?

13) Does the client influence a lot on decision making during the meeting? If yes, in what way? Does any team member refuse any proposal by the client?

14) Any incident discussed amounting to a reward and the behaviour of the members in the team at the meeting?

15) Any incident amounting to a punishment and the behaviour of the members in the team?

16) Any future agendas to be discussed in the next meeting?

Appendix 4: Case study reference for strengths of construction SMEs

Strength	Semi-structured interviews participant code	Focus group discussions	Progress review meetings	Site visits	Document review
Less capital requirement	RA-2, RB-1, RB-2, RD-2, RD-3, RE-1			SVA-1	X
Flexible cash flows	RA-1, RB-1, RD-2		PRC-1, PRC-2		
Small number of workers	RA-1, RA-3, RC-2, RC-3, RD-1	FG-E			X
Easy to train people	RA-3, RA-4, RB-2				
Better control of the resources	RA-3, RA-4, RB-1, RD-2				
Quick reactions to problems	RB-1, RD-2		PRA-1, PRC-1, PRC-5, PRC-6	SVB-1, SVC-1, SVC-2, SVC-3	
Entrepreneurial Culture	RA-1, RB-1, RD-2				
Independent workforce	RA-1, RB-3, RC-2, RC-3 , RD-1, RE-1	FG-C, FG-E		SVC-1	
High flexibility and resilience to changes	RB-1, RD-2				
Independent business firm	RD-1				
Easy handling of workers	RA-3, RA-4, RB-2			SVA-1, SVA-2	
Competitive advantage over large companies	RA-1, RD-2, RC-2				

Appendix 5: Case study reference for opportunities for construction SMEs

Opportunities	Semi-structured interviews participant code	Focus group discussions	Progress review meetings	Site visits	Document review
Special loan schemes form government and private bank	RA-2, RD-3, RE-1				X
Low interest rates for projects	RA-1, RD-2				
Tax reductions	RA-1, RA-3, RC-2, RC-3 , RD-1,		PRC-7		X
Availability of funds for research and innovations	RA-1				
Adding value to products (knowledge, services)	RB-1, RD-2				
Available of training programs for SMEs	RA-1, RA-3, RB-1, RD-2	FG-A	PRC-1, PRC-4		
Availability of human resources	RA-1, RB-1, RD-2	FG-C			X
Availability of new process improvement methodologies	RA-1, RB-2, RB-3, RC-2, RE-1				
Special incentives from the government	RB-1				
Supportive legislations	RD-1				
Professional bodies accreditations	RA-3, RA-4, RB-2				
Increasing public awareness about SMEs	RD-2, RC-2				

Appendix 6: Case study reference for weaknesses of construction SMEs

Weaknesses	Semi-structured interviews participant code	Focus group discussions	Progress review meetings	Site visits	Document review
Lack of Capital	RA-1, RA-3, RB-1, RB-2, RB-4, RC-1, RC-3 , RD-1, RD-2, RD-3, RD-4, RE-1				X
Budget overrun	RA-1, RA-3, RB-1, RB-2, RB-4, RC-1, RC-3 , RD-1, RD-2, RD-3, RD-4, RE-1		PRA-1, PRA-2, PRB-1, PRC-1, PRC-2, PRC-5, PRC-6, PRC-7		X
Lack of cost controlling techniques	RA-2, RA-3, RB-1, RC-1, RC-3 , RD-1, RD-2, RD-3, RD-4, RE-1		PRC-1, PRC-2, PRC-5		X
Delaying payment	RA-1, RA-2, RA-3, RA-4, RB-1, RB-2, RB-3, RB-4, RC-1, RC-2, RC-3 , RD-1, RD-2, RD-3, RD-4, RD-5, RE-1, RE-2	FG-A, FG-C, FG-E	PRA-1, PRA-2, PRB-1, PRC-1, PRC-2, PRC-5, PRC-6, PRC-7	SVC-1	X
Lack of value addition	RA-1, RB-2, RB-3, RC-2, RC-3 , RD-1, RE-1				X
Unable to meet the market demand	RA-3, RA-4, RB-2				
Decreasing productivity	RA-2, RA-3, RB-1, RB-2, RC-3 , RD-1, RD-2, RD-3, RD-4, RD-5, RE-1, RE-2		PRC-1, PRC-2, PRC-5	SVC-3	X
High rate of collisions and accidents	RA-1, RD-2, RC-2	FG-A, FG-C			X
Design failure/ changes	RA-1, RA-3, RB-1, RB-2, RC-3 , RD-1, RD-2, RD-3, RD-4, RD-5, RE-1, RE-2		PRC-2, PRC-5		X
Increase of waste in projects	RA-1, RA-2, RA-3, RA-4, RB-1, RB-2, RC-1, RC-2, RC-3 , RD-1, RD-2, RE-1		PRA-1, PRA-2, PRB-1, PRC-1, PRC-2, PRC-5, PRC-6, PRC-8	SVA-1, SVA-2, SVB-1, SVC-1, SVC-2, SVC-3, SVD-1, SVE-1	X
Quality deficiencies in the output	RA-1, RD-2, RC-2	FG-C		SVC-2	X
Difficulties in technology	RD-1, RC-1				

Weaknesses	Semi-structured interviews participant code	Focus group discussions	Progress review meetings	Site visits	Document review
transfer					
Limited use of information technologies	RA-3, RA-4, RB-1, RD-2			SVC-1	
Time overrun & missed deadlines	RA-1, RA-3, RB-1, RB-2, RC-3 , RD-1, RD-2, RD-3, RD-4, RD-5, RE-1, RE-2		PRA-1, PRA-2, PRB-1, PRC-1, PRC-2, PRC-5, PRC-6, PRC-8		X
Internal policies and strategies of the parent organisation	RD-1, RD-2, RD-3				X
Difficulties in meeting regulations and policies of professional bodies	RA-1, RD-2, RC-2				X
Lack of qualified professionals	RA-1, RD-2, RC-2	FG-A			X
Insufficient R&D	RA-1, RB-2, RB-3, RC-2, RC-3 , RD-1, RE-1				
Lack of strategic leadership	RA-1, RB-2, RC-1, RC-3 , RD-1, RE-1				
Lack of motivation in the workforce	RA-1, RA-3, RB-1, RB-2, RC-3 , RD-1, RD-2, RD-3, RD-4, RD-5, RE-1, RE-2		PRC-1, PRC-4	SVC-3	
Limited resources	RA-3, RB-1, RB-2, RC-3 , RD-1, RD-2, RD-4, RD-5, RE-1, RE-2	FG-C, FG-E			
Limited networking	RA-1, RD-2, RC-2		PRC-3		
Instability of the construction processes	RD-1, RE-1				
Lack of H & S awareness	RB-1, RD-2				

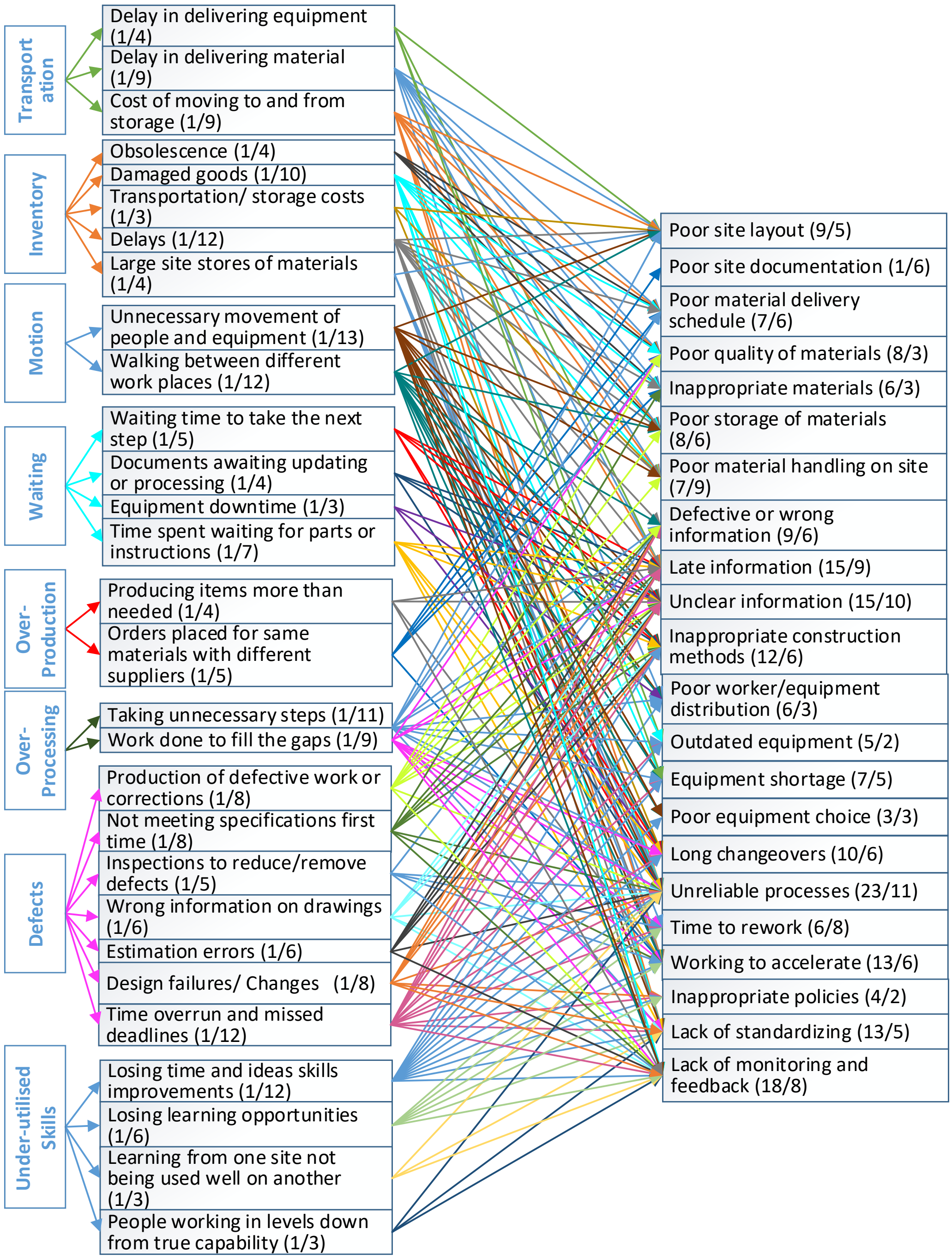
Appendix 7: Case study reference for threats for construction SMEs

Threats	Semi-structured interviews participant code	Focus group discussions	Progress review meetings	Site visits	Document review
Difficulties in access to finance	RA-1, RA-3, RB-1, RB-2, RB-4, RC-1, RC-3 , RD-1, RD-2, RD-3, RD-4, RE-1				
Significant increase of energy cost	RB-1, RB-2, RB-4, RC-1, RC-3 , RD-1, RD-4, RE-1				X
High cost of labour**,** material**s** and equipment	RA-1, RA-2, RA-3, RA-4, RB-1, RB-2, RB-3, RB-4, RC-1, RC-2, RC-3 , RD-1, RD-2, RD-3, RD-4, RD-5, RE-1, RE-2	FG-A, FG-C, FG-E	PRA-1, PRA-2, PRB-1, PRC-1, PRC-2, PRC-5, PRC-6, PRC-8		X
High interest rates	RB-1, RB-2, RB-4, RC-1, RC-3 , RD-1, RD-4, RE-1				X
Equipment and material unavailability	RA-1 , RD-1, RD-2				X
New construction technologies	RA-3, RA-4, RB-2				
Lack of skilled workers	RA-2, RA-3, RB-1, RB-2, RC-3 , RD-1, RD-2, RD-5, RE-1, RE-2	FG-A		SVA-1, SVC-2	
Migration of Sri Lankan construction workers to neighbouring countries	RA-1, RD-2, RC-2		PRB-1, PRC-1		
Poor Quality of material and equipment	RB-1, RB-2, RC-3 , RE-2	FG-A, FG-C	PRC-1, PRC-4	SVA-1, SVC-2	X
The demand of bribe by politician	RA-2, RB-1, RC-3, RE-1				
Continuous change in regulations	RA-1, RD-2, RC-2				
Occupational health/ safety related laws	RD-1, RC-1				
Instability of the political environment	RA-3, RA-4, RB-1, RD-2				
Taxations	RA-1, RB-1, RD-1, RE-1				
Unfavorable procurement methods	RA-1, RD-2, RD-3		PRC-1		
Monopoly created by large construction companies	RA-1, RA-3, RB-1 , RD-1, RD-2, RD-3, RD-4, RD-5, RE-1, RE-2				
Competition within construction SMEs	RA-1, RD-2, RC-2				
Lack of access to international markets	RA-1, RB-2				
Unfavourable weather conditions	RC-1, RD-1, RE-1			SVC-1	
Negative attitudes on SMEs stability	RA-1, RB-2, RC-3, RE-2				

Appendix 8: Causes for NVAA for Why 1

WHY - 2 / WHY - 1		2.01 Poor site layout	2.02 Poor site documentation	2.03 Poor material delivery schedul	2.04 Poor quality of materials	2.05 Inappropriate materials	2.06 Poor storage of materials	2.07 Poor material handling on site	2.08 Defective or wrong informatio	2.09 Late information	2.1 Unclear information	2.11 Inappropriate construction me	2.12 Poor worker/equipment distrib	2.13 Outdated equipment	2.14 Equipment shortage	2.15 Outdated equipments	2.16 Long changeovers	2.17 Unreliable processes	2.18 Time required to rework	2.19 Working to accelerate	2.2 Inappropriate policies	2.21 Lack of standardizing	2.22 Lack of monitoring and feedb.	**Total of Y values - Why 1**
1.01	Dealy in delivering equipment	1								1				1	1									4
1.02	Delay in delivering material	1		1	1	1	1	1		1			1					1						9
1.03	Cost of moving to and from storage	1		1	1		1	1		1								1		1			1	9
1.04	Obsolescence			1	1	1	1																	4
1.05	Damaged goods			1	1	1	1	1						1	1			1				1	1	10
1.06	Transportation/ storage costs	1						1									1							3
1.07	Delays	1		1		1	1	1	1	1	1							1		1		1	1	12
1.08	Large site stores of materials	1																1	1	1				4
1.09	Unnecessary movement of people/ equipment	1					1	1			1	1	1		1	1	1	1		1		1	1	13
1.10	Walking between different work places	1					1		1		1	1	1		1	1	1	1		1			1	12
1.11	Waiting time to take the next step									1	1	1					1	1						5
1.12	Documents awaiting updating or processing									1	1	1						1						4
1.13	Equipment downtime										1		1				1							3
1.14	Time spent waiting for parts or instructions									1	1	1					1	1		1		1		7
1.15	Producing more than needed									1	1									1			1	4
1.16	Orders placed with different suppliers		1	1	1	1														1				5
1.17	Taking unnecessary steps	1		1	1				1	1			1	1	1		1	1				1		11
1.18	Work done to fill the gaps				1					1	1						1	1	1	1		1	1	9
1.19	Production of defective work or corrections				1		1	1	1		1	1						1					1	8
1.20	Not meeting specifications first time					1			1	1	1	1						1		1			1	8
1.21	Inspections to reduce/remove defects								1									1	1	1			1	5
1.22	Wrong information on drawings									1	1	1						1				1	1	6
1.23	Estimation errors								1	1	1	1						1					1	6
1.24	Design failures/ Changes								1	1	1	1						1			1	1	1	8
1.25	Time overrun and missed deadlines								1	1	1	1		1	1		1	1	1		1	1	1	12
1.26	Losing time and ideas skills improvements											1	1	1	1	1	1	1	1	1	1	1	1	12
1.27	Losing learning opportunities																	1	1	1	1	1	1	6
1.28	Learning from one site not being used well																	1				1	1	3
1.29	People working below their true capability																	1				1	1	3
	Total of X values - Why 2	9	1	7	8	6	8	7	9	15	15	12	6	5	7	3	10	23	6	13	4	13	18	

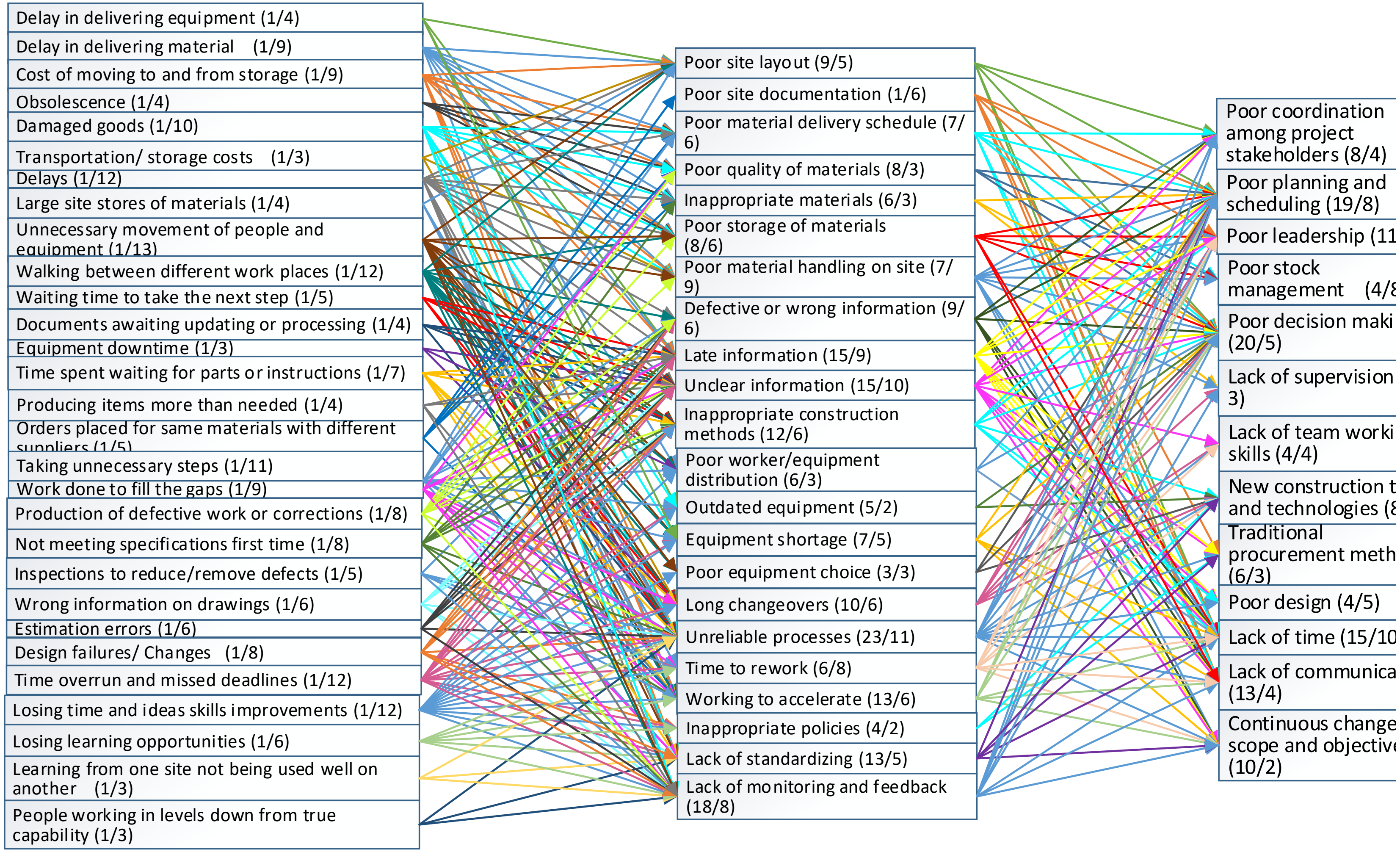
Causes for Why-1



Appendix 9: Causes for NVAA for Why 2

		3.01	3.02	3.03	3.04	3.05	3.06	3.07	3.08	3.09	3.10	3.11	3.12	3.13	
		Poor coordination among project stakeholders	Poor planning and scheduling	Poor leadership	Poor stock management	Poor decision making	Late supervision	Lack of team working skills	New construction tools and technologies	Traditional procurement methods	Poor design	Lack of time	Lack of communication	Continuous change of scope and objectives	**Total of Y values - Why 2**
2.01	Poor site layout	1	1			1						1	1		5
2.02	Poor site documentation		1	1		1				1		1	1		6
2.03	Poor material delivery schedule	1	1		1	1						1	1		6
2.04	Poor quality of materials		1		1	1									3
2.05	Inappropriate materials		1			1	1								3
2.06	Poor storage of materials		1	1	1	1							1		5
2.07	Poor material handling on site	1	1	1	1	1	1					1	1	1	9
2.08	Defective or wrong information	1	1			1						1	1	1	6
2.09	Late information	1	1	1		1				1	1	1	1	1	9
2.10	Unclear information	1	1	1		1		1		1	1	1	1	1	10
2.11	Inappropriate construction methods		1	1		1			1		1	1			6
2.12	Poor worker/equipment distribution		1			1						1			3
2.13	Outdated equipment					1			1						2
2.14	Equipment shortage		1			1						1	1	1	5
2.15	Poor equipment choice		1			1			1						3
2.16	Long changeovers		1	1		1	1	1	1						6
2.17	Unreliable processes	1	1	1		1		1	1	1	1	1	1	1	11
2.18	Time required to rework		1	1		1		1	1			1	1	1	8
2.19	Working to accelerate		1	1		1						1	1	1	6
2.20	Inappropriate policies								1	1					2
2.21	Lack of standardizing								1	1		1		1	4
2.22	Lack of monitoring and feedback	1	1	1		1	1					1	1	1	8
	Total of X values - Why 3	8	19	11	4	20	4	4	8	6	4	15	13	10	

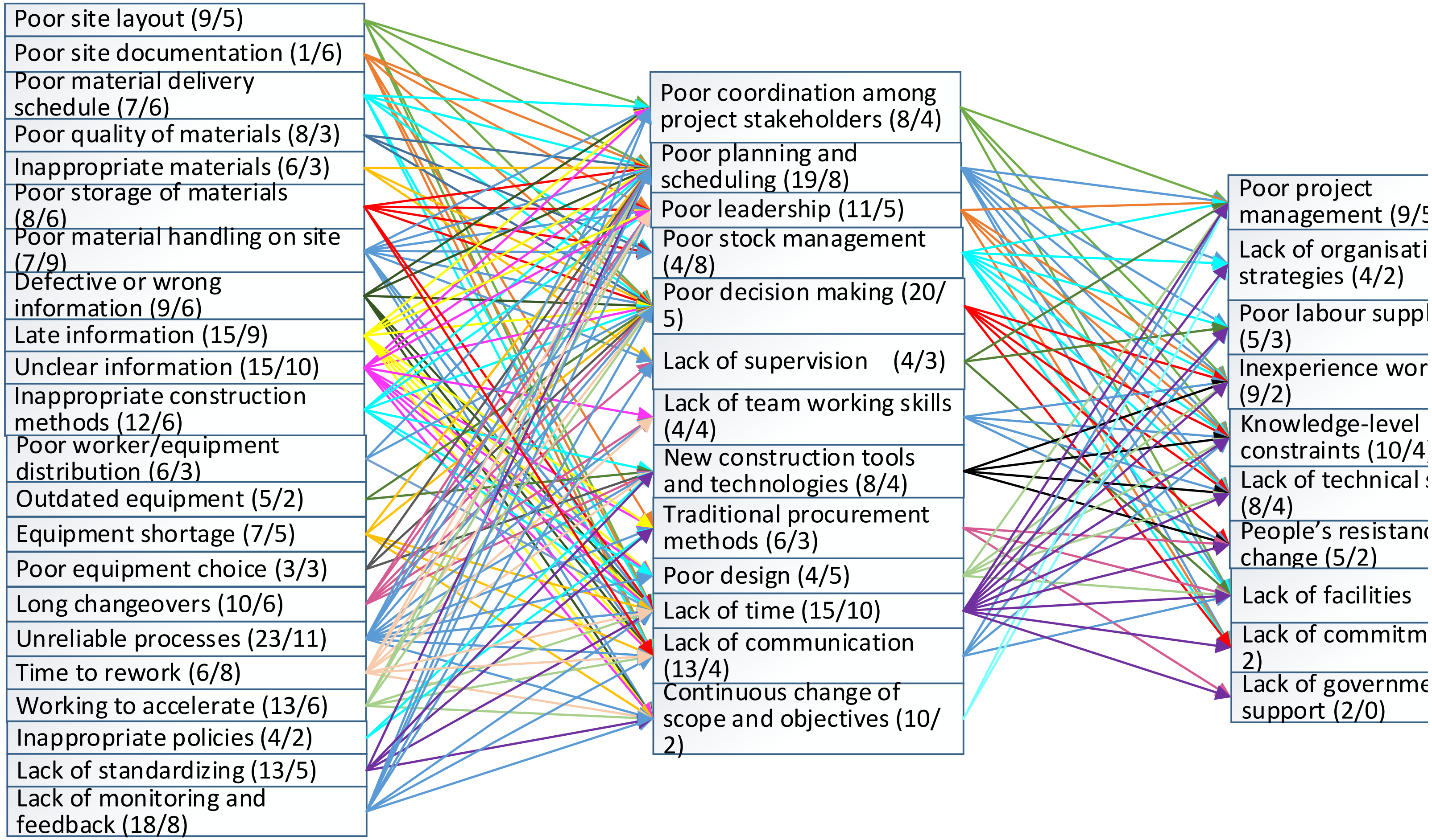
Causes for Why-2



Appendix 10: Causes for NVAA for Why 3

WHY - 4 / WHY - 3		4.01 Poor project Management	4.02 Lack of organisational strategies	4.03 Lack of workers	4.04 Inexperience workers	4.05 Knowledge-level constraints	4.06 Lack of technical skills	4.07 People's resistance to change	4.08 Lack of facilities	4.09 Lack of commitment	4.10 Lack of government support	**Total of Y values - Why 3**
3.01	Poor coordination among project stakeholders	1			1	1			1			4
3.02	Poor planning and scheduling	1	1	1	1	1	1		1	1		8
3.03	Poor leadership	1			1	1	1			1		5
3.04	Poor stock management	1	1	1	1	1	1		1	1		8
3.05	Poor decision making				1	1	1	1		1		5
3.06	Too late supervision	1		1					1			3
3.07	Lack of team working skills				1	1	1	1				4
3.08	New construction tools and technologies				1	1	1	1				4
3.09	Traditional procurement methods							1	1		1	3
3.10	Poor design	1			1	1	1		1			5
3.11	Lack of time	1	1	1	1	1	1	1	1	1	1	10
3.12	Lack of communication	1		1		1			1			4
3.13	Continuous change of scope and objectives	1	1									2
Total of X values - Why 4		9	4	5	9	10	8	5	8	5	2	

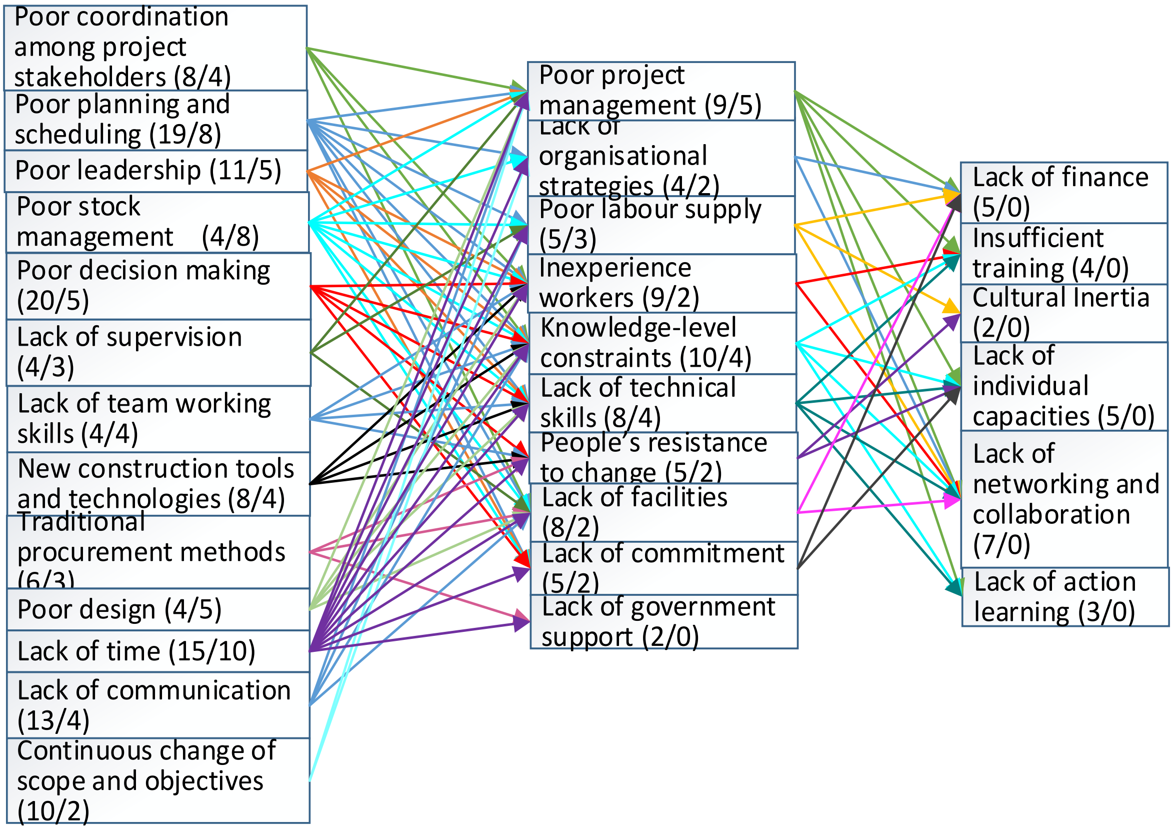
Causes for Why-3



Appendix 11: Causes for NVAA for Why 4 & Why 5

WHY - 4 \ WHY - 5		5.01 Lack of finance	5.02 Insufficient training	5.03 Cultural inerrtia	5.04 Lack of individual capacities	5.05 Lack of networking and collaboration	5.06 Lack of action learning	**Total of Y values - Why 4**
4.01	Poor project management	1	1		1	1	1	5
4.02	Lack of organisational strategies	1				1		2
4.03	Lack of workers	1		1		1		3
4.04	Inexperience workers		1			1		2
4.05	Knowledge-level constraints		1		1	1	1	4
4.06	Lack of technical skills		1		1	1	1	4
4.07	People’s resistance to change			1	1			2
4.08	Lack of facilities	1				1		2
4.09	Lack of commitment	1			1			2
4.10	Lack of government support							0
	Total of X values - Why 5	3	4	1	3	6	3	

Causes for Why- 4 & Why - 5



Appendix 12

Interview guideline (EIR-2)

Date

Dear Sir/Madam

Data Collection

I am Tharusha Ranadewa, doctoral student in Department of Building Economics, University of Moratuwa, conducting a research under the supervision of Dr. Y.G. Sandanayake and Dr. Mohan Siriwardena on lean enabling capacity building in construction SMEs. This research will develop a lean enabling capacity building framework for construction SMEs. The intended framework will guide construction SMEs to understand the importance of lean enabling capacity building and identify the capacity building measures to enable lean. It will further provide solutions for the challenges faced by construction SMEs through capacity building in the lean enabling environments.

The purpose of this interview is to get answers to the following research questions.

- RQ3a : What are the drivers for lean implementation in construction SMEs?
- RQ3b : What are the barriers for lean implementation in construction SMEs?
- RQ4 : What are the capacities required for enabling lean in construction SMEs?
- RQ5 : What are the strategies for enabling lean in construction SMEs?

Your responses to this survey will be held in the strictest confidence. If you have any questions about this study, or you would like additional information to assist you in reaching a decision about participation, please contact
Supervisor - Dr. Y. G. Sandanayake (ysandanayake@uom.lk)
Supervisor - Dr. Mohan Siriwardena (mohan.siriwardena@googlemail.com)
Researcher- Mrs. Tharusha Ranadewa (0772266488, tharusharanadewa@yahoo.com)

Thank you for your time and contribution.

Yours sincerely

Tharusha Ranadewa
PhD Research Student
Department of Building Economics
University of Moratuwa

Lean Enabling Capacity Building for Construction Small and Medium Enterprises (SMEs) in Sri Lanka

1. Respondent's details

1.1. Designation :

1.2. Experience :

1.3. Educational Qualifications:

1.4. Professional Qualifications:

1.5. Sources of data collection:

2. Awareness of Lean

2.1. According to your opinion, what is 'value' in a construction project?

2.2. Have you heard about the concept 'lean construction'?

2.3. What is lean construction?

2.4. How did you learn about lean?

2.5. Have you partipated any lean workshops and CPDs on lean?

Internationa level:

Local:

Organisational level:

2.6. Are you aware about lean principles?

2.7. Are there 'non-value adding activities' in construction projects?

3. Drivers and barriers for lean implementation in construction SMEs

3.1. Drivers for lean implementation in construction SMEs

3.1.1 What are the significant individual level drivers for lean implementation of construction SMEs?

3.1.2 What are the significant organisational level drivers for lean implementation of construction SMEs?

3.1.3 What are the significant environmental level drivers for lean implementation of construction SMEs?

3.2. Barriers for lean implementation in construction SMEs

3.2.1 What are the significant individual level barriers that hinder lean implementation of construction SMEs?

3.2.2 What are the significant organisational level barriers that hinder lean implementation of construction SMEs?

3.2.3 What are the significant environmental level barriers that hinder lean implementation of construction SMEs?

3.3. What are the methods that can be used to minimise the problems associated with lean construction?

3.4. Does the construction SMEs have a strategic goal for lean that everybody knows about?

3.5. Do all workers know what they should do to support these strategic goals?

3.6. Are everybody committed for lean implementation?

4. Lean Capacities for Construction SMEs

4.1. What are the existing capacities of your organisations?

4.2. Should construction companies build capacities?

If "Yes", why should companies build capacities?

If "No", state the reasons.

4.3 Please state the individual level capacities required for lean implementation in a construction SME organisation and state the importance of that capacity for lean implementation.

Ex: Knowledge, skills, values, attitudes, etc.

4.4 Please state the organisational level capacities required for lean implementation in a construction SME organisation and state the importance of that capacity for lean implementation.

Ex: Individuals, facilities, equipment, materials, capital, organisational strategy, strategic planning, organisational structure and management methods, incentives, leadership, etc.

4.5. Please state the environmental level capacities required for lean implementation in a construction SME organisation and state the importance of that capacity for lean implementation.

Ex: Administrative, legal, technological, political, economic, social, etc.

5. Capacity building in construction SMEs

5.1. Have you heard about capacity building concept?

5.2. Do you think that building capacities will help to implement lean techniques in your construction project?

If 'Yes', state what capacities need to build to implement lean technique.

If 'No', state the reasons.

5.3. What are the ways to build individual level capacities in your organisation for successful lean implementation?

5.3.1 How to improve existing capacities?

5.3.2 How to introduce new capacities?

5.3.4 Who is responsible for building individual level lean capacities?

5.4. What are the ways to build organisational level capacities in your organisation for successful lean implementation?

5.4.1 How to improve existing capacities?

5.4.2 How to introduce new capacities?

5.4.3 Who is responsible for building Organisational level lean capacities?

5.5. What are the ways to build individual level capacities in your organisation for successful lean implementation?

5.5.1 How to improve existing capacities?

5.5.2 How to introduce new capacities?

5.5.3 Who is responsible for building environmental level lean capacities?

5.6. Do you have any other facts/ information to state which has been missed during the discussion and might be useful for the research?

Thank you very much for your contribution

Appendix 13

Nvivo analysis for individual level lean enabling capacities

Appendix 13.1: Parent and child nodes for communication skills for enabling lean

Parent Node	Child Nodes	Sources	References
Communication Skills for Enabling Lean	Active listening	15	15
	Effective negotiation skills	14	14
	Non-verbal communication	16	16
	Understanding body language	16	16
	Verbal communication	16	16
	Visual communication	16	16
	Writing skills	17	17

Appendix 13.2: Parent and child nodes for lean thinking

Parent Node	Child Nodes	Sources	References
Lean thinking	Common sense and practical judgement	10	10
	Creative and innovative thinking	11	11
	Critical analysis	10	10
	Open mind-set	8	8
	Logical thinking	10	10
	Research interest	3	3
	Diagnostic and troubleshooting ability	10	10

Appendix 13.3: Parent and child nodes for lean leadership

Parent Node	Child Nodes	Sources	References
Lean Leadership	Accountable for outcome	5	5
	Appreciate people	7	7
	Command attention	3	3
	Conflict management	10	10
	Decision making	11	11
	Delegation and empowerment	5	5
	Drive change management	12	12
	Facilitation	8	8
	Provide constructive feedback	10	10
	Figurehead	5	5
	Team management ability	10	10

	Progress monitoring and motivation	7	7
	Self-control	5	5
	Share the big picture	3	3
	Willingness to support	12	12
	Visionary leadership	8	8
	Networking	5	5

Appendix 13.4: Parent and child nodes for positive attitudes towards lean

Parent Node	Child Nodes	Sources	References
Positive Attitudes towards lean	Being proactive	1	1
	Confident	10	10
	Cooperative	8	8
	Energetic	4	4
	Friendly	16	16
	Genuine and authentic	9	9
	Optimistic	5	5
	Patient	10	10
	Respect others	15	15
	Work-life balance	7	7
	Willingness to learn	16	16

Appendix 13.5: Parent and child nodes for lean knowledge

Parent Node	Child Nodes	Sources	References
Lean knowledge	Learning by doing	10	10
	Awareness on lean principles, tools and techniques	13	13
	Training for implementing lean tools	18	18

Appendix 13.6: Parent and child nodes for team working skills

Parent Node	Child Nodes	Sources	References
Team working skills	Collaborative	11	11
	Work under pressure	11	11
	Deal with difficult personalities and internal politics	3	3
	Understanding the diversity in people	4	4
	Emotional intelligence	2	2
	Liaise with team members	5	5
	Team building	7	7

Appendix 13.7: Parent and child nodes for lean ethics

Parent Node	Child Nodes	Sources	References
Lean Ethics	Punctual and meeting deadlines	8	8
	Reliability	12	12
	Self-regulation	6	6
	Morality	7	7
	Trust	11	11
	Responsibility	14	14
	Integrity	9	9
	Honesty	5	5
	Fairness	7	7

Appendix 14

Nvivo analysis for organisational level lean enabling capacities

Appendix 14.1: Parent and child nodes for lean Workforce

Parent Node	Child Nodes	Sources	References
Lean Workforce	Individuals with lean knowledge and skills	14	14
	Lean leaders	7	7

Appendix 14.2: Parent and child nodes for organisational strategic plan towards lean

Parent Node	Child Nodes	Sources	References
Organisational Strategic Plan towards Lean	Lean knowledge and skills development programmes	6	6
	Financial management plan	17	17
	Internal Business Processes management plan	13	13
	Construction project management plan	17	17
	Risk management plan	6	6
	Business development and growth plan	12	12
	Visionary leadership	12	12
	Plan for value creation through supply chain integration	9	9

Appendix 14.3: Parent and child nodes for organisational lean culture and reward system

Parent Node	Child Nodes	Sources	References
Organisational lean culture and reward system	Well defined organisation structure	9	9
	Reward and recognition system for lean implementers	12	12
	Flexible organisational policies and procedures	10	10
	Learning Organisation	13	13
	No blame culture	3	3

Appendix 14.4: Parent and child nodes for physical resources

Parent Node	Child Nodes	Sources	References
Physical Resources	Working Capital	7	7
	Materials, tools and equipment	7	7
	Inventory management system	12	12
	Logistics and storage facilities	10	10
	Space	7	7

Appendix 14.5: Parent and child nodes for R&D

Parent Node	Child Nodes	Sources	References
R&D	Partnerships and linkages with external parties	7	7
	Organisational support to research initiatives	12	12
	Best practices shared by partner organisations	2	2
	Best practices shared within organisation	10	10

Appendix 15

Nvivo analysis for environmental level lean enabling capacities

Appendix 15.1: Parent and child nodes for institutional support

Parent Node	Child Nodes	Sources	References
Institutional Support	Lean supportive institutional leadership	17	17
	Code of conduct for lean organisations	9	9
	Institute for regulating lean construction	11	11
	Financial endowment for lean implementation	11	11
	Academic industry partnerships in lean research	12	12

Appendix 15.2: Parent and child nodes for national policies

Parent Node	Child Nodes	Sources	References
National Policies	Conducive policies for lean implementation	11	11
	Plan for retaining construction workforce	5	5
	Tax concessions for lean implemented projects	17	17
	Favourable interest rates for lean implemented projects	11	11

Appendix 15.3: Parent and child nodes for lean knowledge dissemination

Parent Node	Child Nodes	Sources	References
Lean Knowledge Dissemination	CPDs on lean implementation	15	15
	Transparency and flow of information	4	4
	Lean knowledge embedded into construction education/training curricula	15	15
	Annual lean conference and exhibition in Sri Lanka	5	5
	Lean experts/trainers	15	15

Appendix 15.4: Parent and child nodes for industry vision

Parent Node	Child Nodes	Sources	References
Industry Vision	Encouragement through equal opportunities for SMEs	4	4
	Lean learning from international partnership projects	6	6

Appendix 16

Screen shot of Nvivo analysis of EIR-2

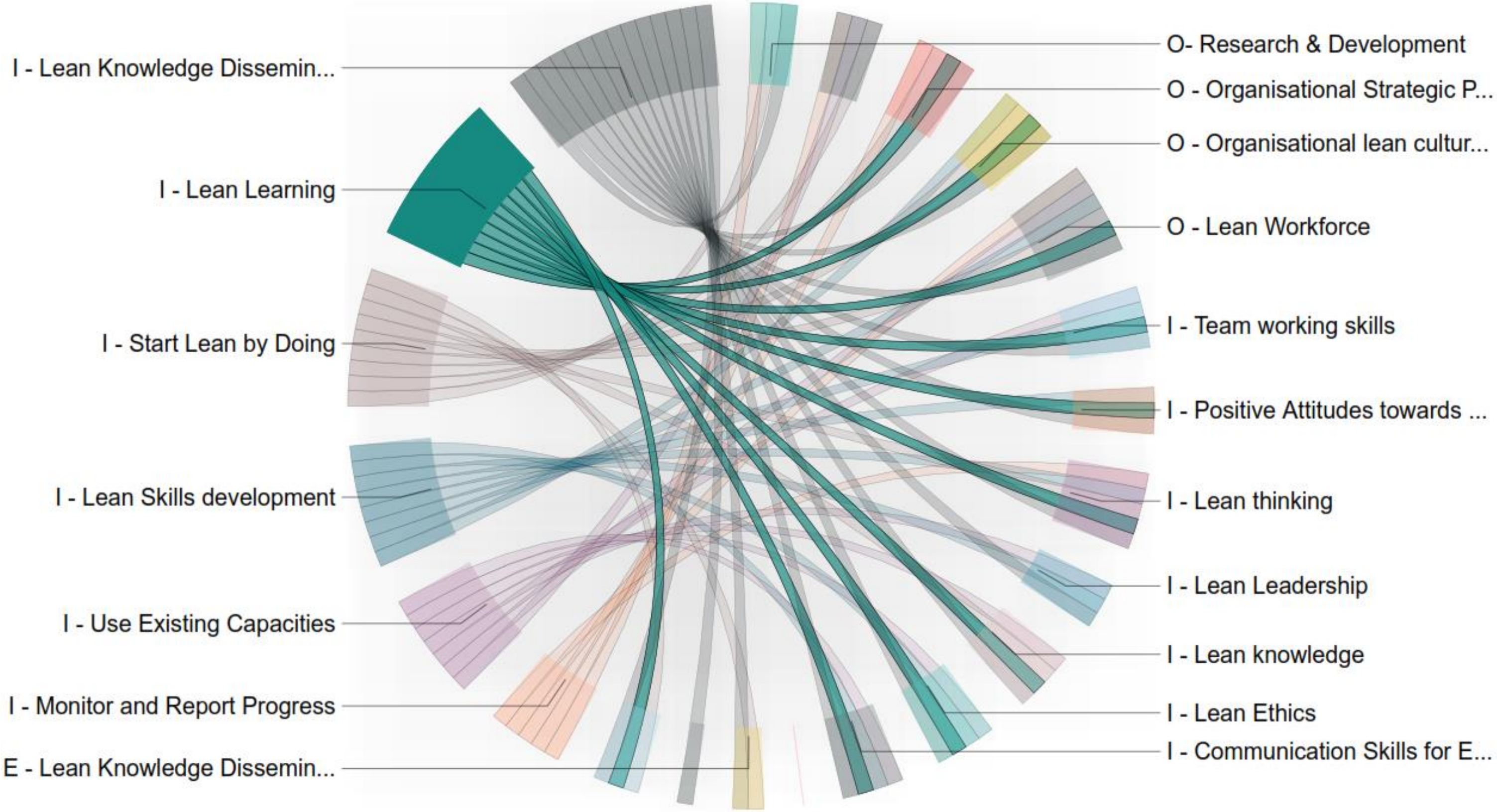
Nodes

Name	Sources	References
Lean Capacities	245	1563
Environmental level lean capacities	82	281
Administrative environment	17	61
Economic environment	11	46
Legal environment	17	38
Political environment	9	13
Social & Cultural environment	13	52
Technological environment	15	71
Individual level lean capacities	91	917
Communication Skills	18	156
Critical Thinking	10	144
Leadership	6	96
Positive Attitude	16	153
Sound Knowledge	18	63
Team working skills	11	103
Work Ethics	12	202
Organisational level lean capacities	72	365
Human Resources	14	21
Intellectual resources	17	96
Organisational structure	12	80
Physical resources	17	95
Research & Development	12	73

Appendix 17: Analysis of individual level lean enabling capacity building strategies

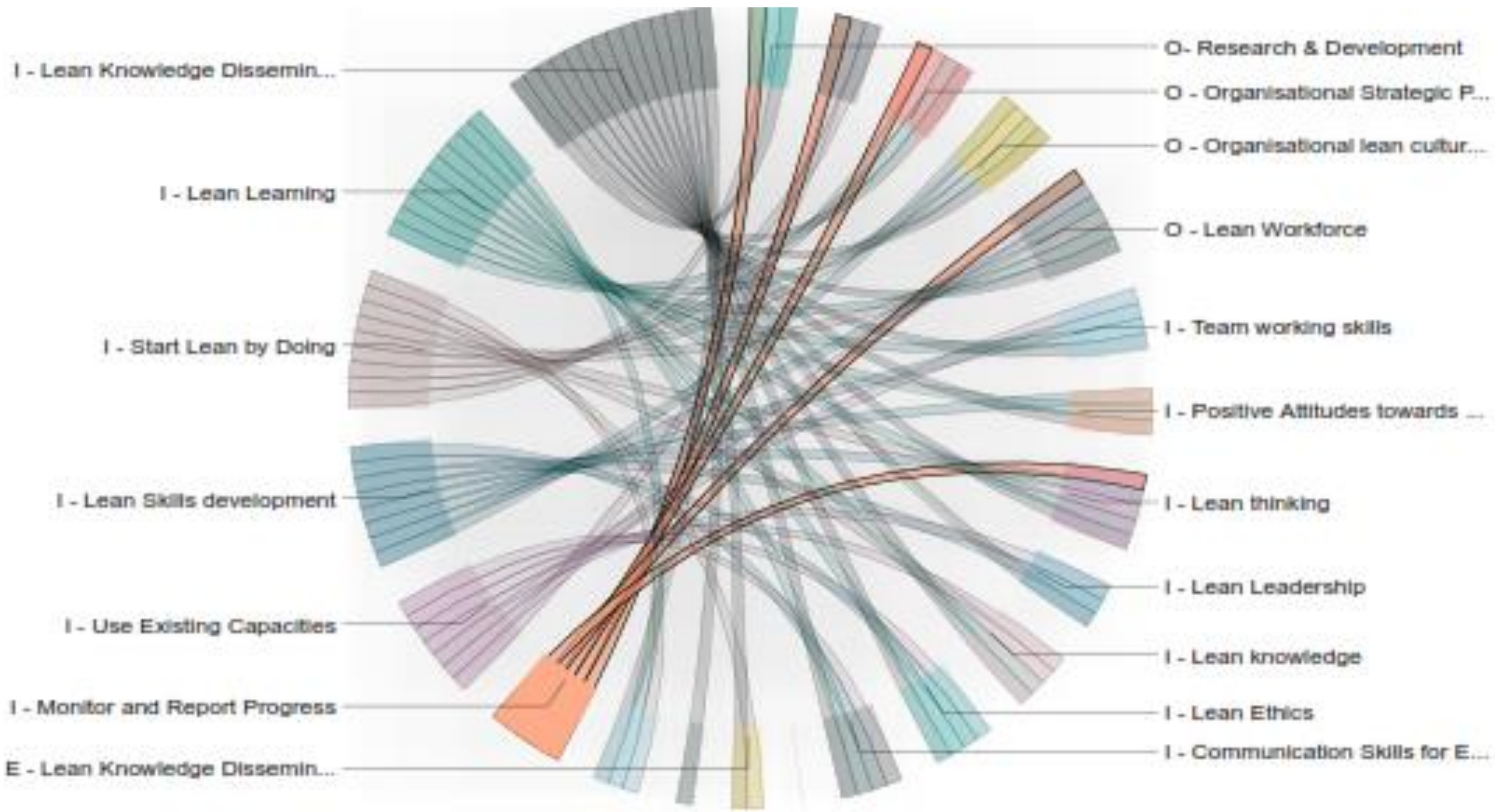
Appendix 17.1: Parent and child nodes for lean learning and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Lean learning	Continuously improving lean knowledge and skills	9	9
	Lifelong lean learning	4	4
	Genuine commitment and interest in Lean learning	4	4



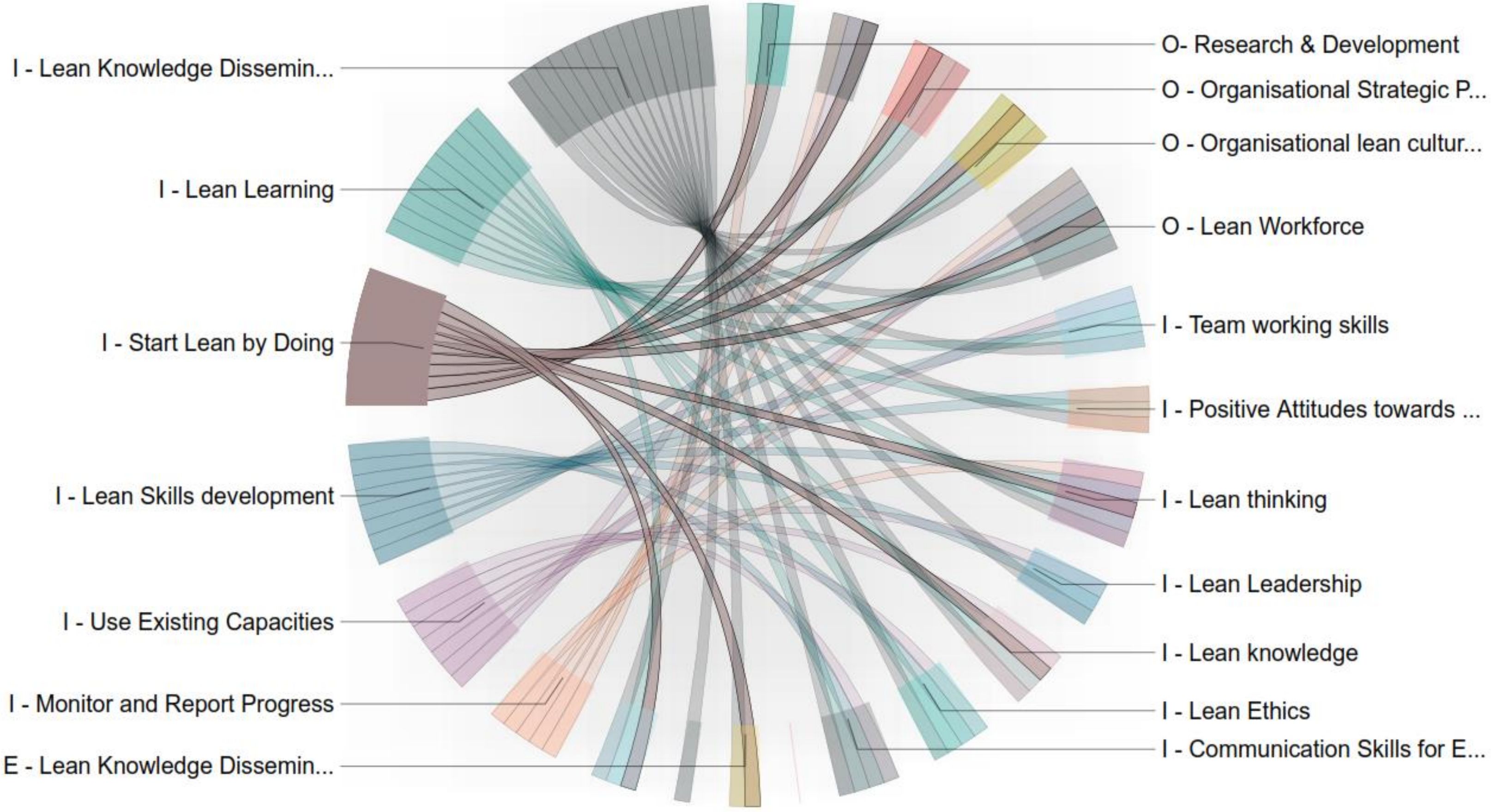
Appendix 17.2: Parent and child nodes for monitor & report progress and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Monitor & report progress	Monitor and report the individual progress	7	7
	Take corrective actions for individual improvement	3	3



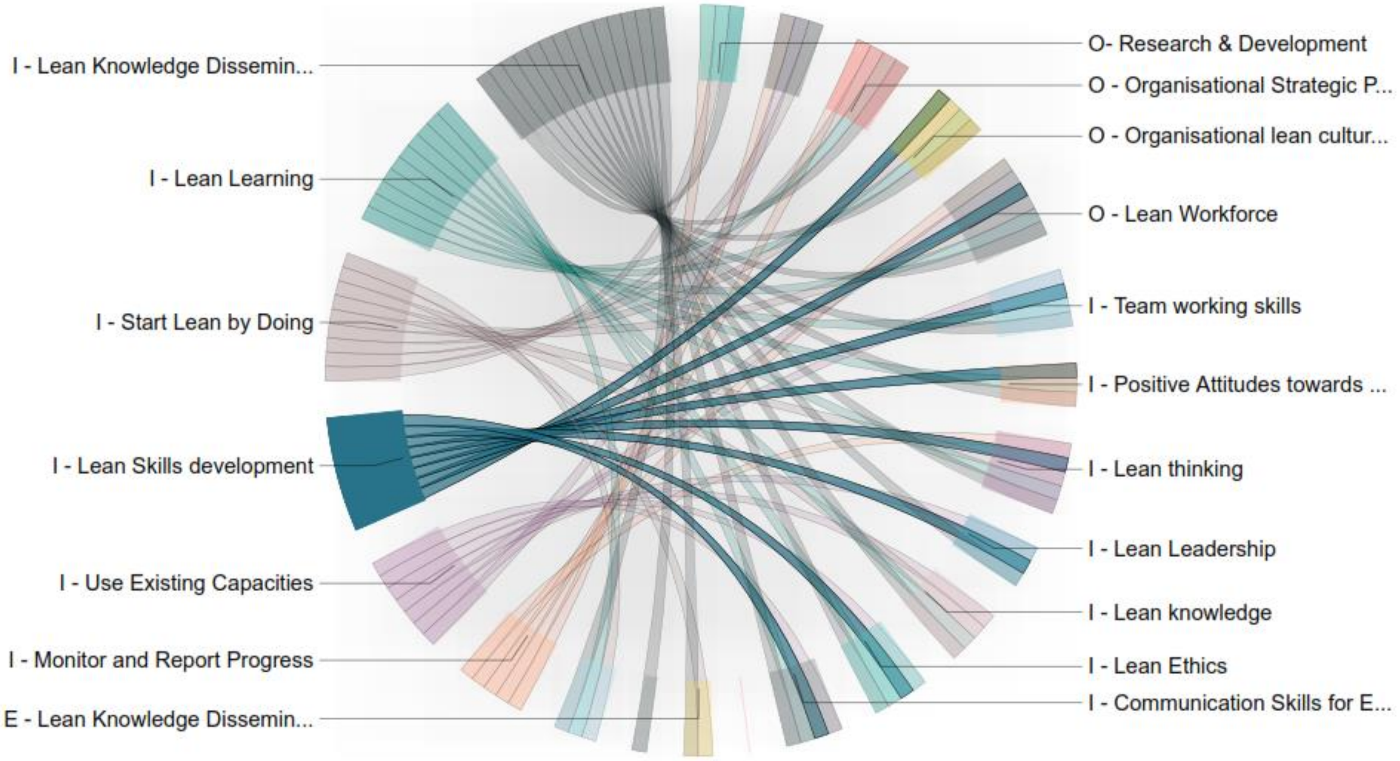
Appendix 17.3: Parent and child nodes for start lean by Doing and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Start lean by Doing	Start lean implementation from pilot projects	5	5
	Start lean implementation with basic tools	15	15



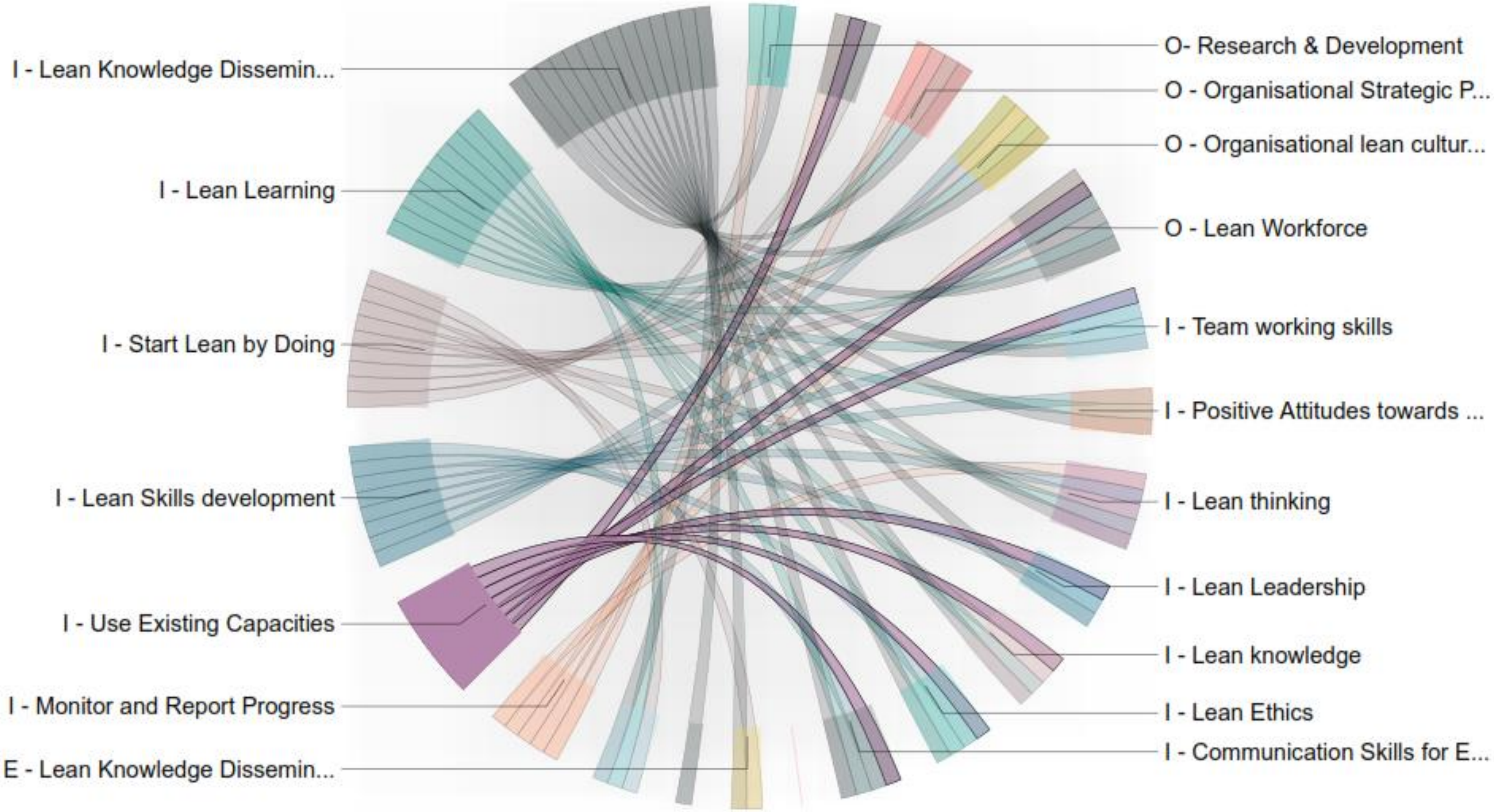
Appendix 17.4: Parent and child nodes for lean skills development and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Lean skills development	Attend CPD programmes on lean skills development	3	3
	Develop challenging mind sets	3	3
	Change the attitudes of individuals towards lean	5	5
	Respect the value system and foster self-esteem	8	8
	Stay engaged under difficult circumstances	8	8



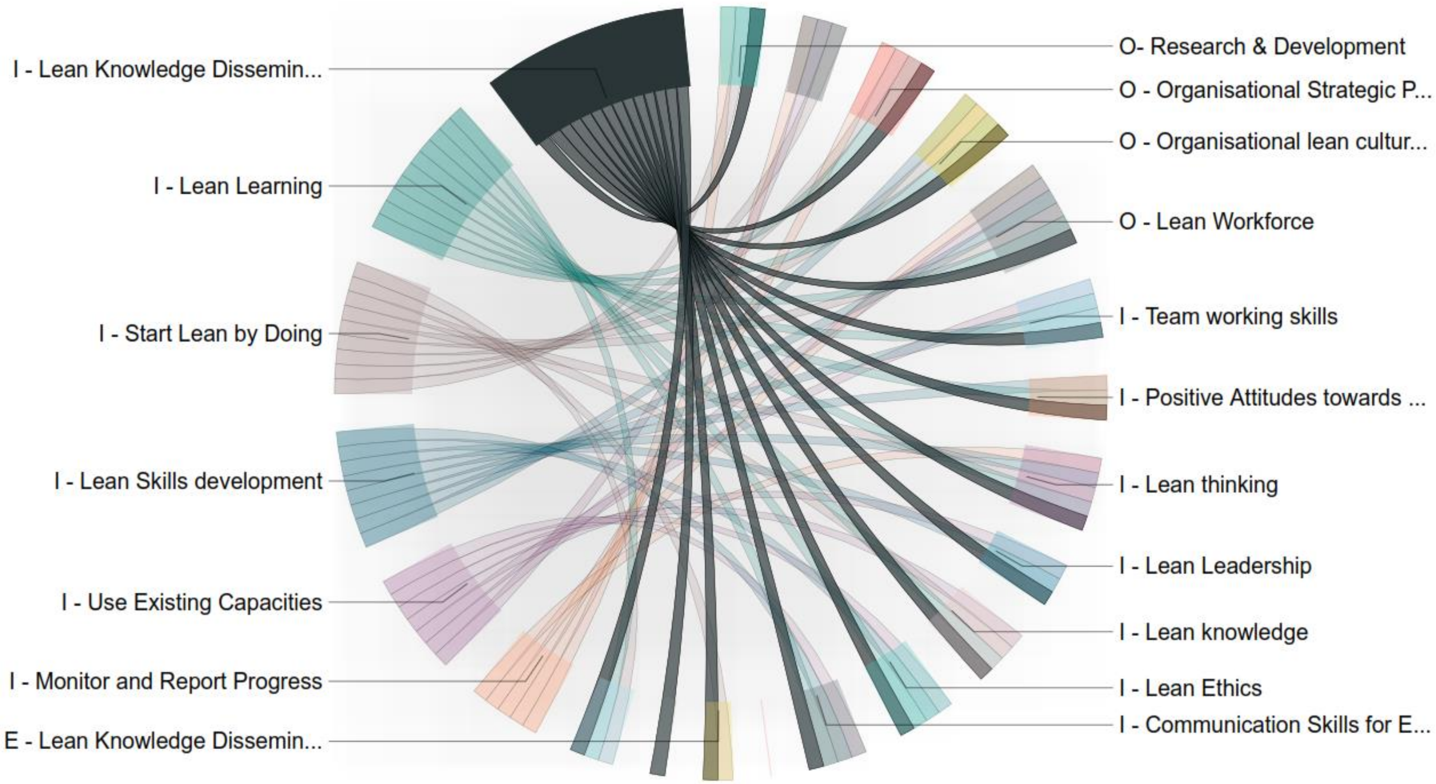
Appendix 17.5: Parent and child nodes for use existing capacities and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Use existing capacities	Making better use of existing capacity	5	5
	Strengthening existing capacity	8	8



Appendix 17.6: Parent and child nodes for lean knowledge dissemination and mapping to lean enabling capacities

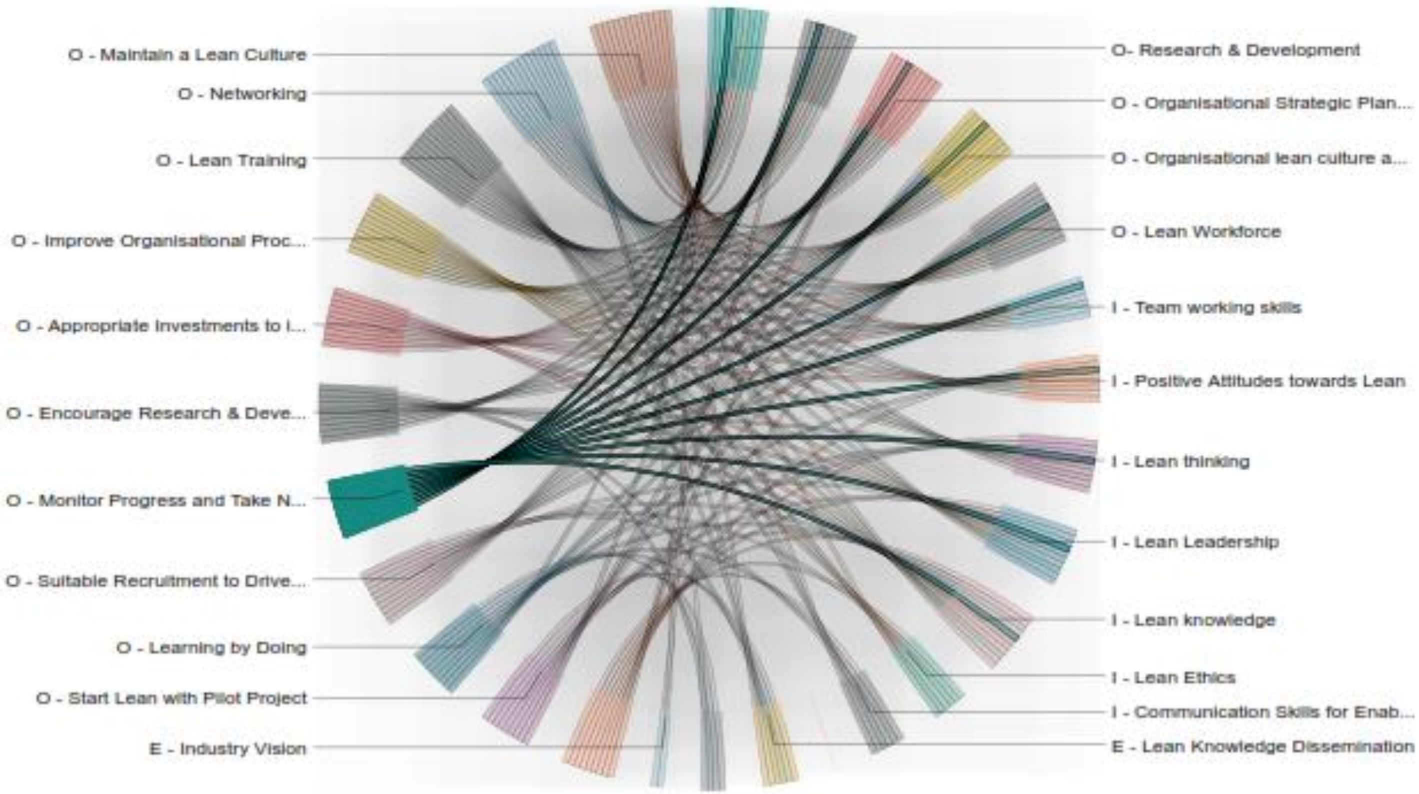
Parent Node	Child Nodes	Sources	References
Lean knowledge dissemination	Participate lean awareness CPD programmes as a resource person	9	9
	Train construction workforce as lean trainers	13	13
	Share lean knowledge and best practices with others	7	7



Appendix 18: Analysis for organisational level lean enabling capacity building strategies

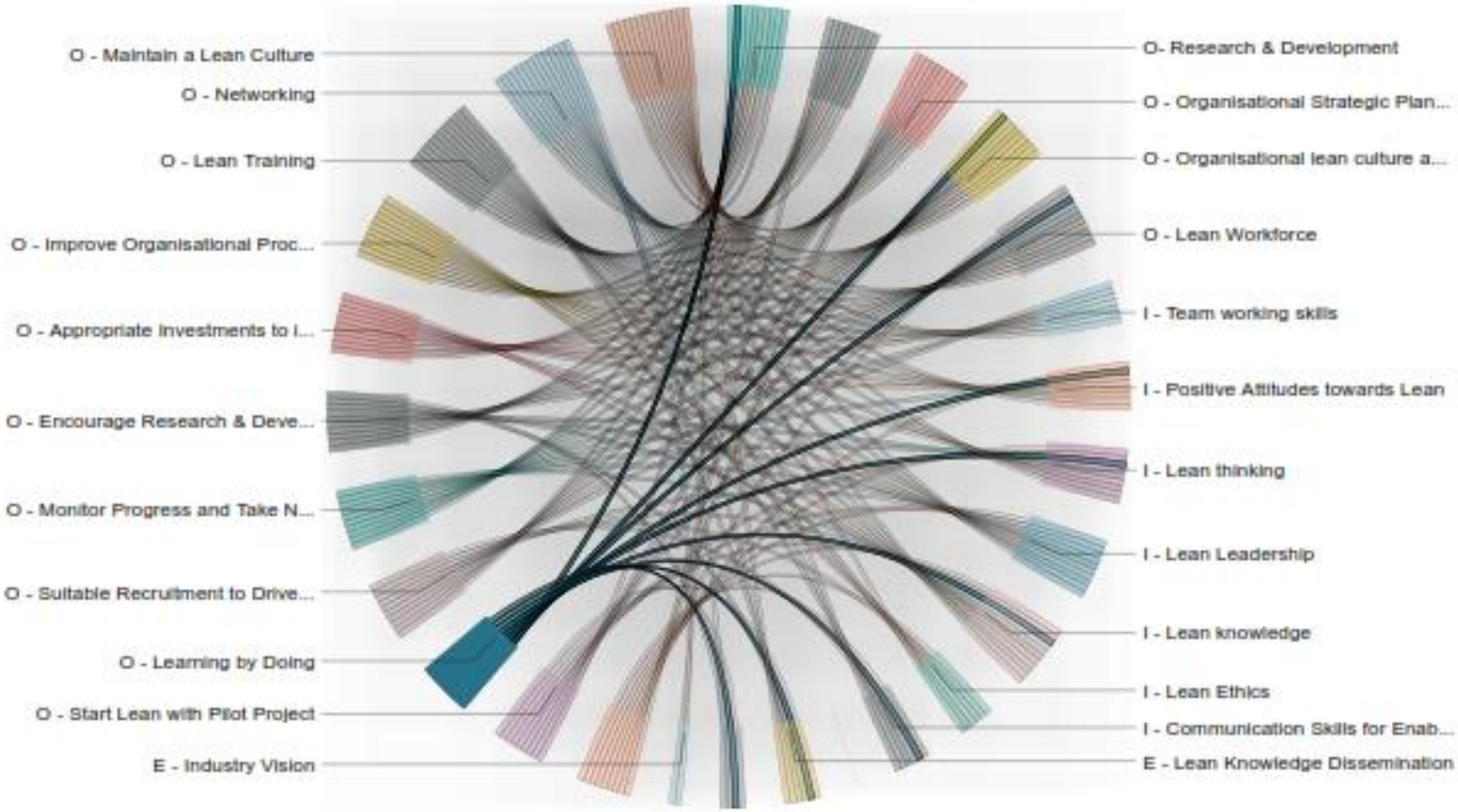
Appendix 18.1: Parent and child nodes for monitor progress and take necessary actions and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Monitor Progress and Take Necessary Actions	Establish KPIs for monitoring the progress of lean implementation	7	7
	Monitor and report the progress of lean implementation	12	12
	Take necessary actions to correct the deviations	3	3



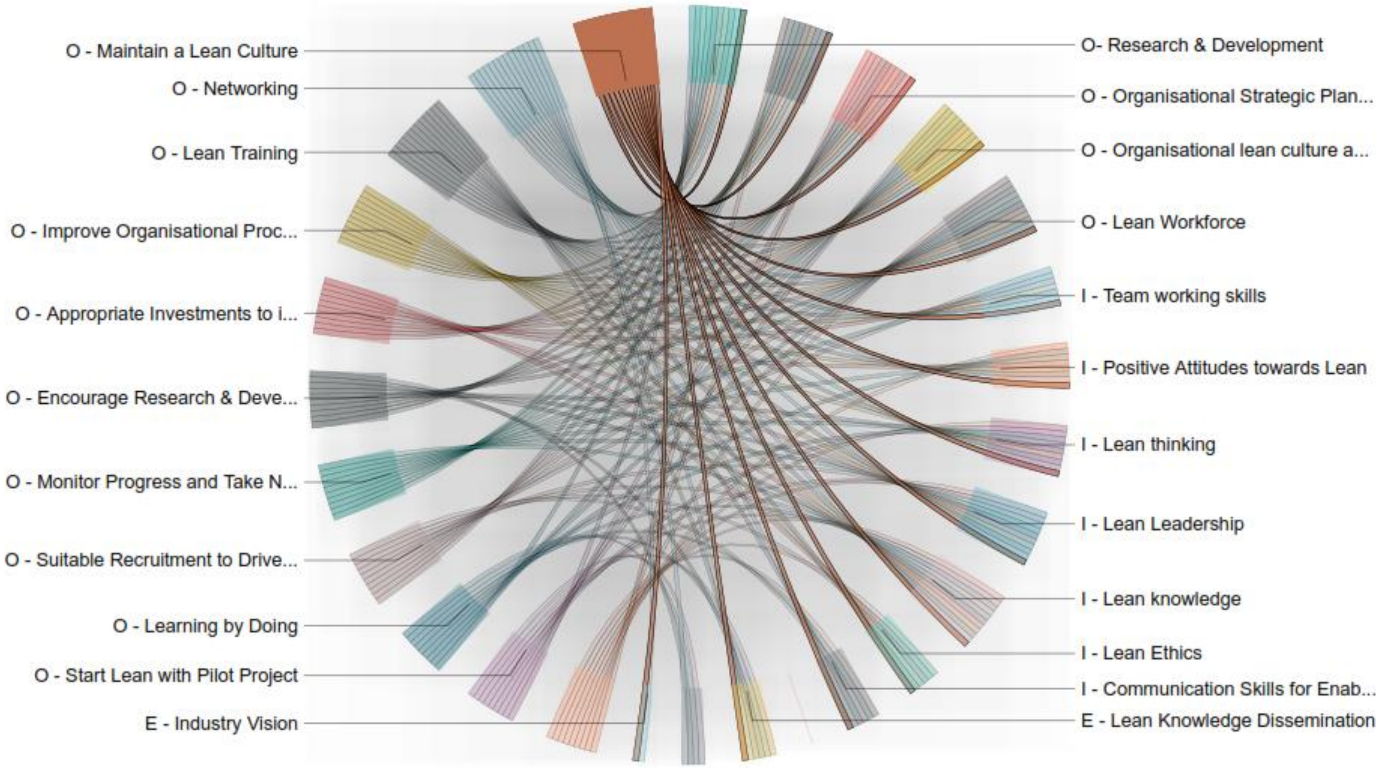
Appendix 18.2: Parent and child nodes for learning by doing and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Learning by Doing	Provide freedom for people to learn by doing	12	12
	Let people learn through errors	7	7



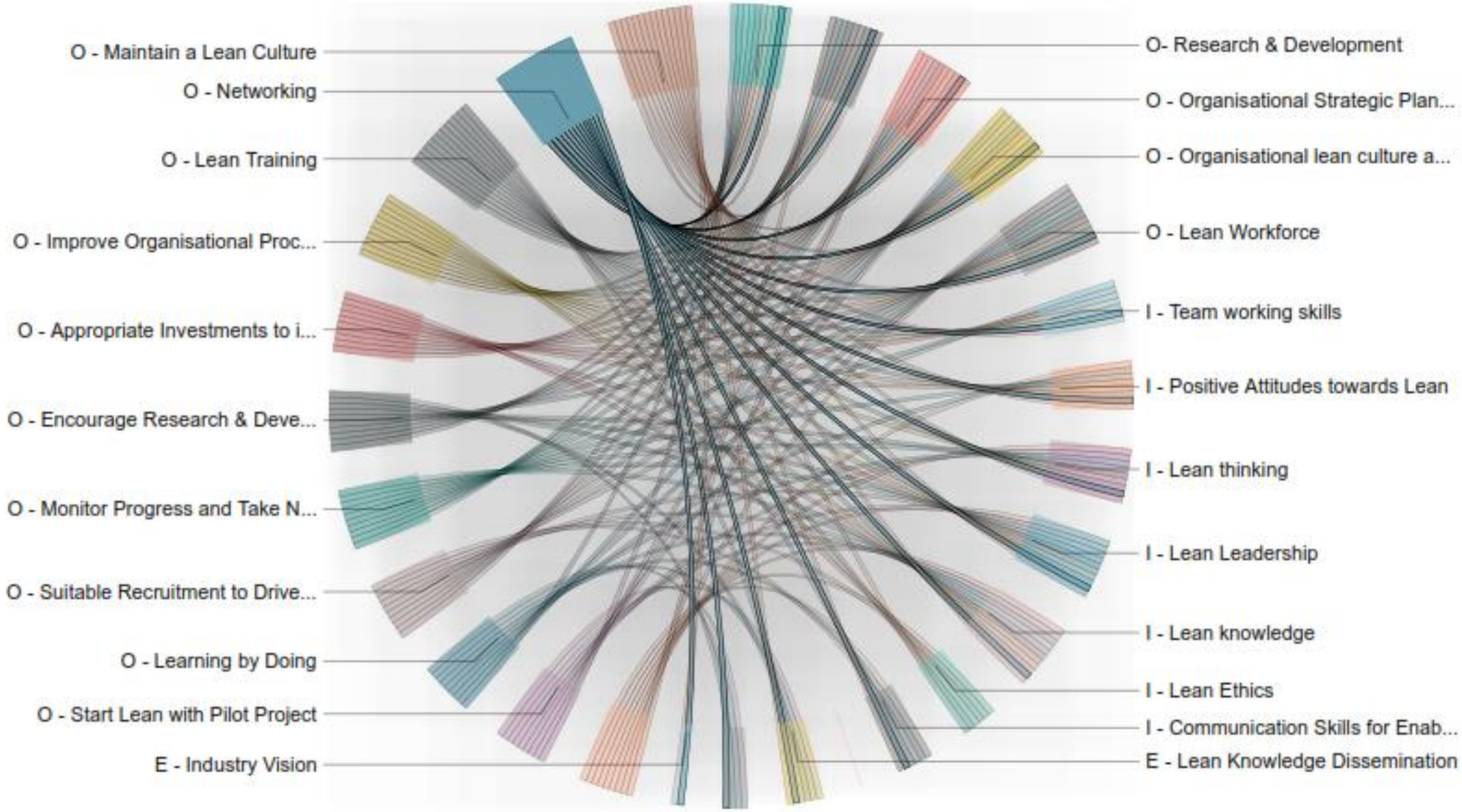
Appendix 18.3: Parent and child nodes for maintain a lean culture and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Maintain a lean culture	Adopt a lean supportive culture	2	2
	Maintain a no blame culture	8	8
	Maintain problem solving culture	8	8
	Reinforce behavioural guidelines to support lean	2	2
	Respect for people	5	5



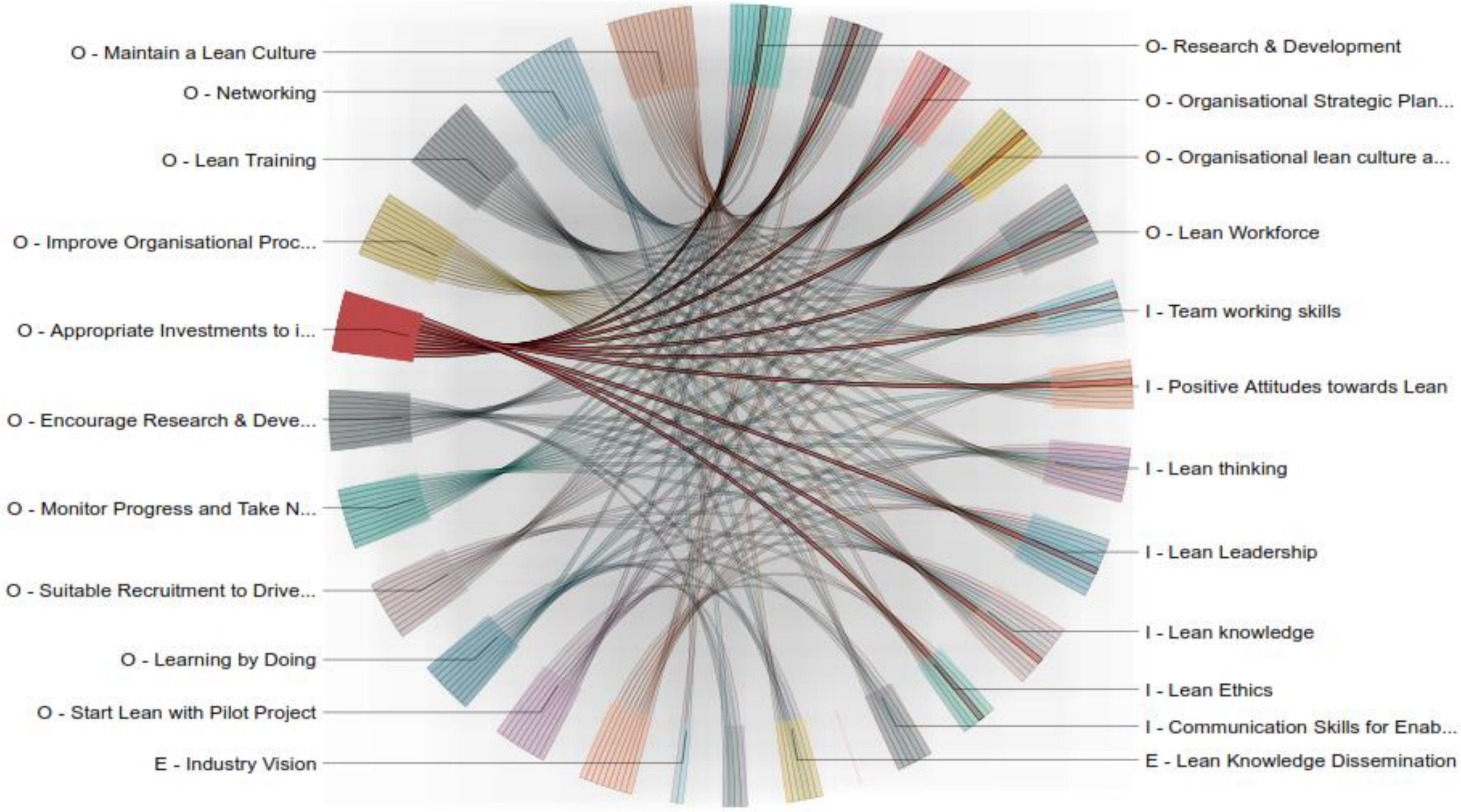
Appendix 18.4: Parent and child nodes for networking and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Networking	Encourage networking	6	6
	Share best practices within the organisation	13	13
	Share best practices of other organisations	13	13
	Pursue partnerships in working with others	8	8



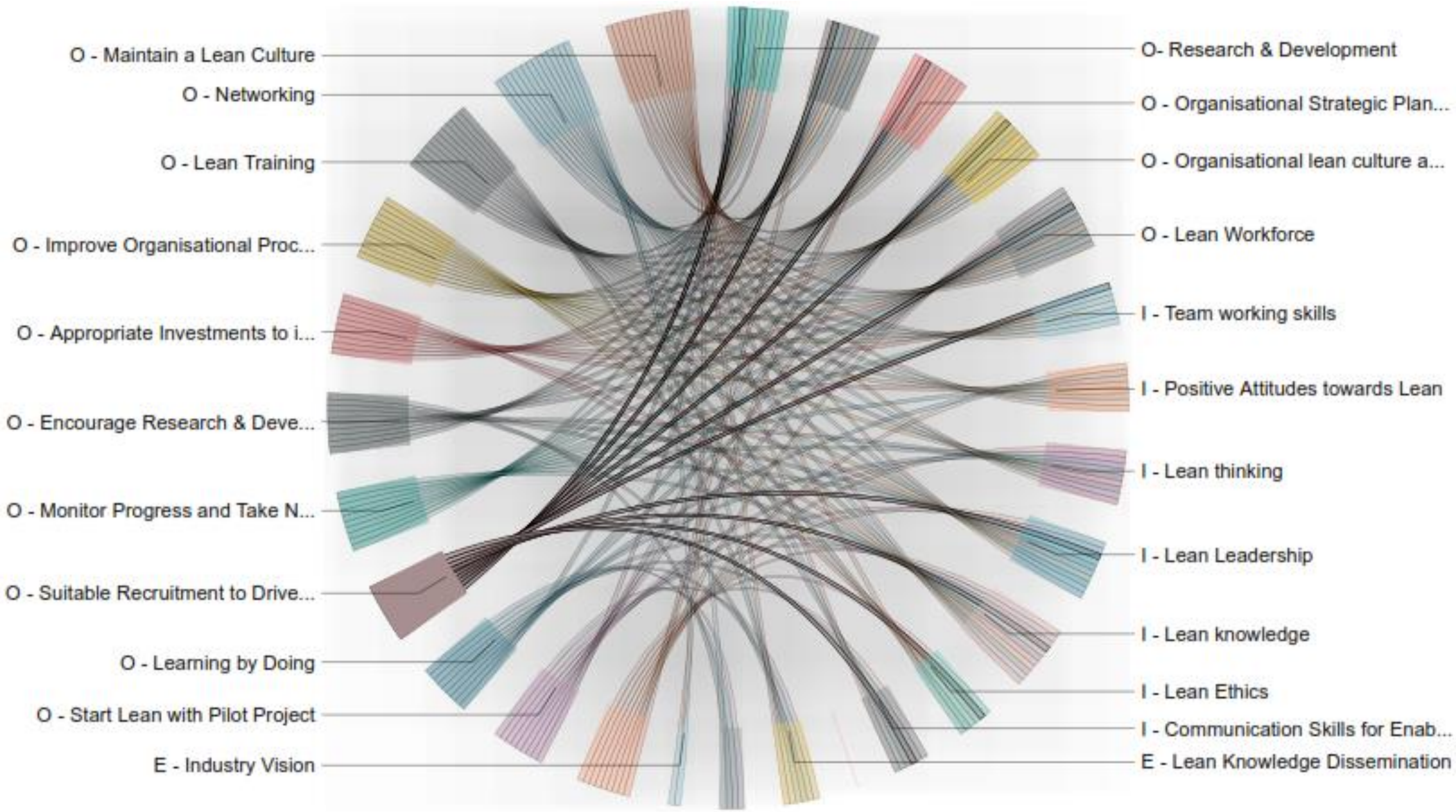
Appendix 18.5: Parent and child nodes for appropriate investments to implement lean and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Appropriate Investments to implement lean	Establish lean encouraged incentive schemes	14	14
	Invest in lean tools that give both short- and long-term benefits	10	10



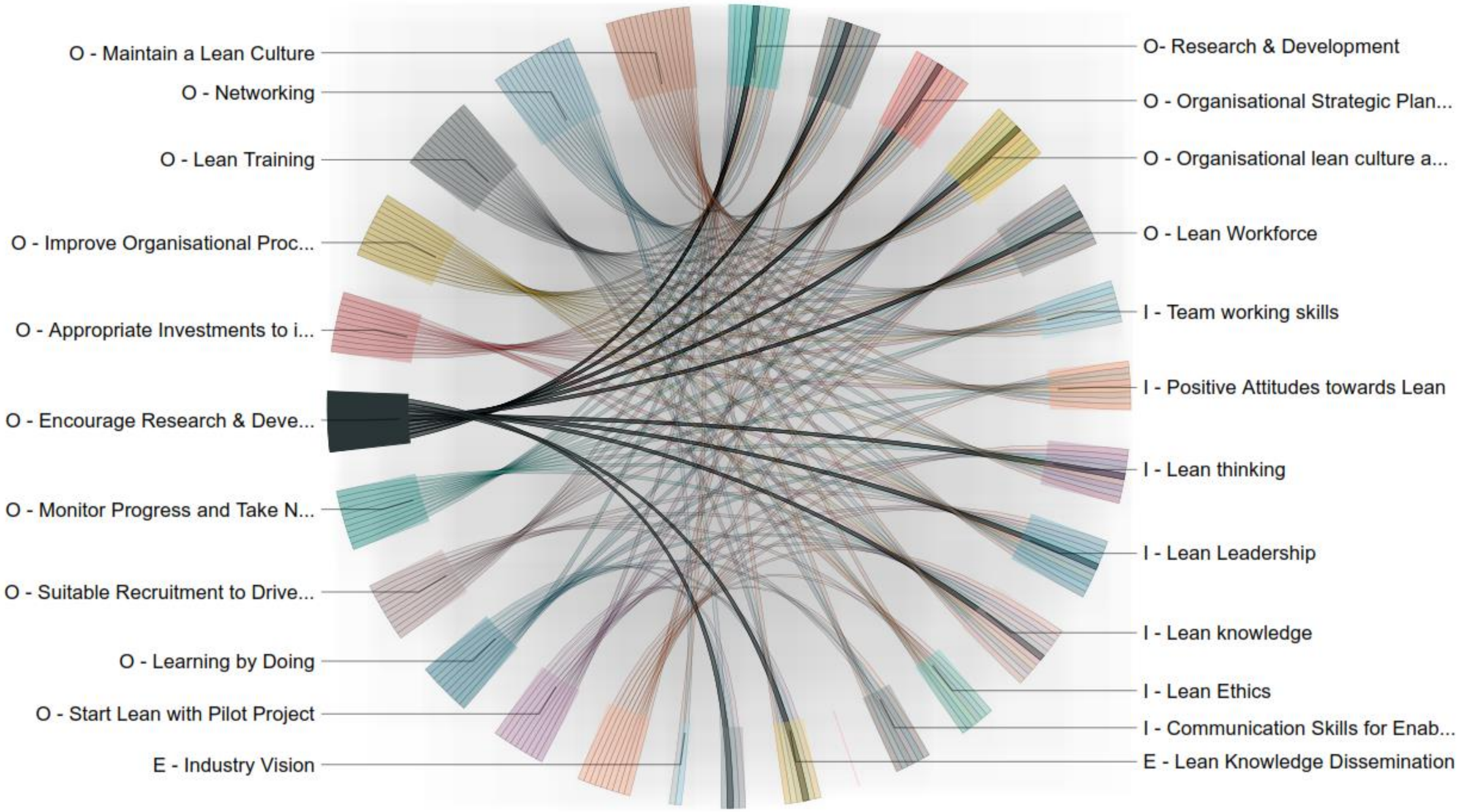
Appendix 18.6: Parent and child nodes for suitable recruitment to drive lean and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Suitable Recruitment to drive lean	Hire a lean expert for organisation	17	17



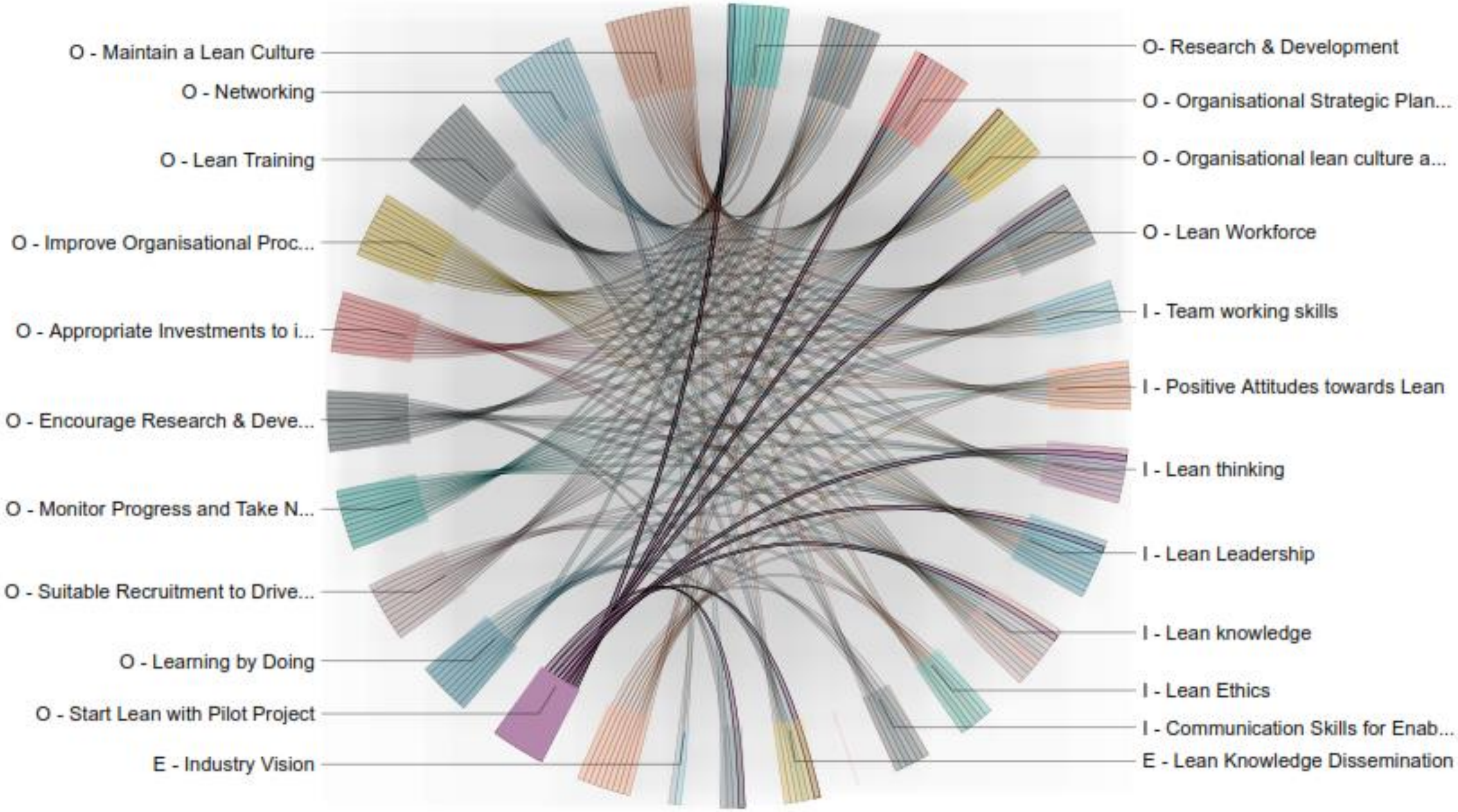
Appendix 18.7: Parent and child nodes for encourage R&D and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Encourage R&D	Encourage lean innovations	2	2
	Pursue partnerships in research initiatives	9	9
	Seek new development for an organisation	9	9



Appendix 18.8: Parent and child nodes for start lean with pilot project and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Start lean with pilot project	Start lean with pilot projects	2	2
	Start lean implementation with basic tools	8	8
	Develop a strategic and operational plan for lean implementation	5	5

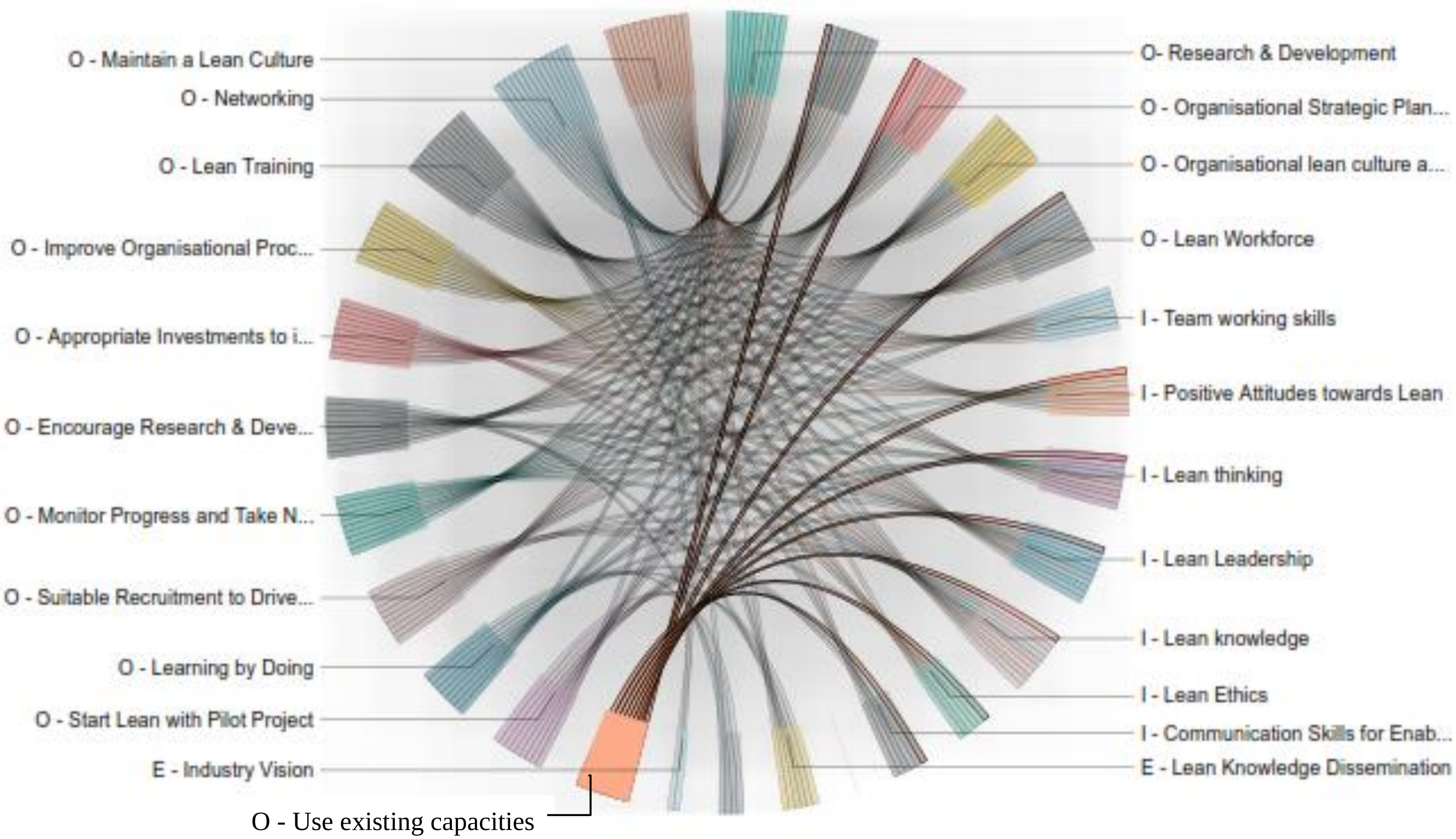


Appendix 18.9: Parent and child nodes for lean training and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Lean Training	Organise CPDs/seminars/workshops/training sessions to develop lean knowledge	13	13
	Obtain services of lean trainer(s)	8	8
	Organise group meetings to share the success stories in lean	13	13

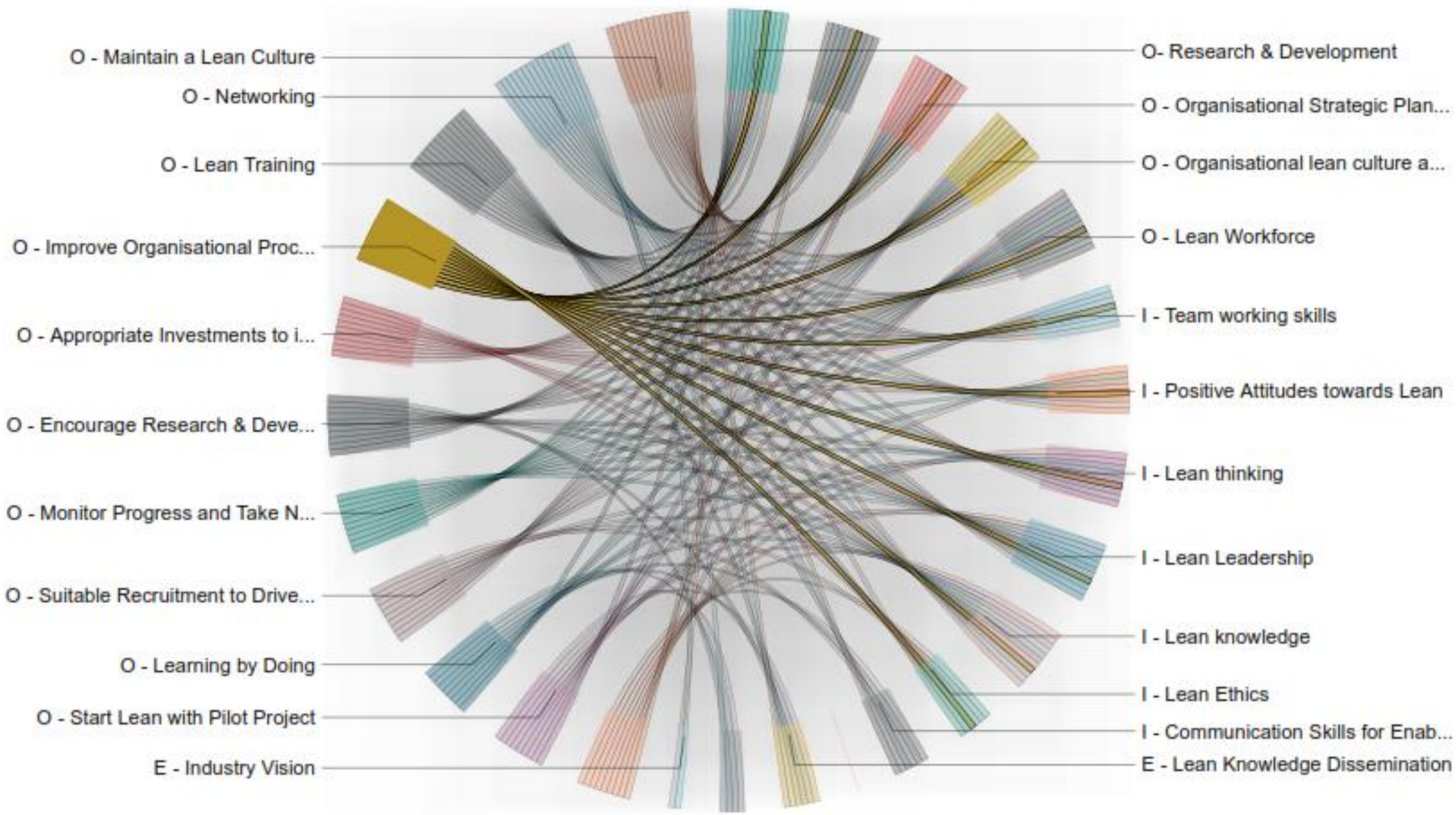
Appendix 18.10: Parent and child nodes for use existing capacities and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Use Existing Capacities	Strengthening the existing capacities	8	8
	Eliminate inappropriate capacities	2	2
	Optimally utilize the existing capacities	8	8



Appendix 18.11: Parent and child nodes for improve organisational processes and mapping to lean enabling capacities

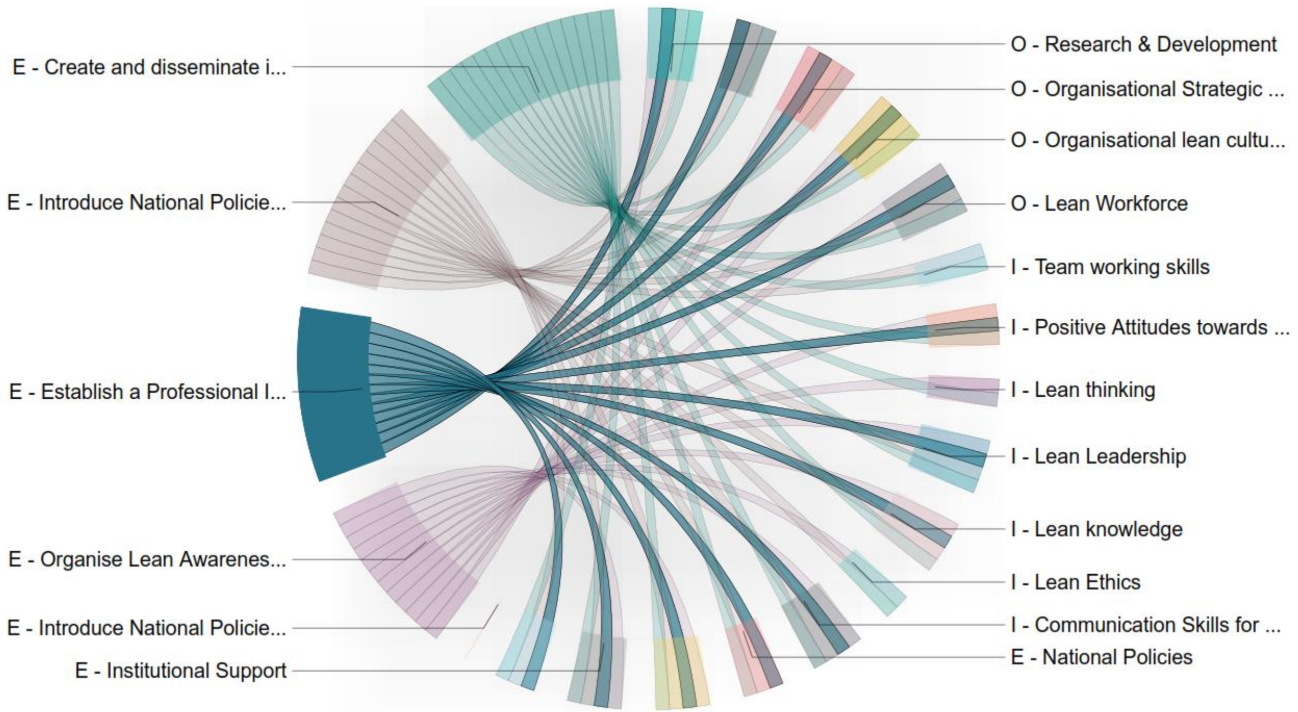
Parent Node	Child Nodes	Sources	References
Improve organisational processes	Redesign organisational processes by eliminating non-value adding activities	9	9
	Allow access to information to relevant parties within the organisation	3	3
	Develop an organisational structure that support lean implementation	8	8
	Integration of activities at various levels to address complex problems	6	6
	Optimise the usage of existing facilities	6	6
	Remain accountable to ultimate beneficiaries	3	3
	Develop a recruitment policy that support employing individuals with lean knowledge and attitude	7	7
	Design conducive policies and procedures for lean implementation	8	8


O - Maintain a Lean Culture
O - Networking
O - Lean Training
O - Improve Organisational Proc...
O - Appropriate Investments to i...
O - Encourage Research & Deve...
O - Monitor Progress and Take N...
O - Suitable Recruitment to Drive...
O - Learning by Doing
O - Start Lean with Pilot Project
E - Industry Vision
O- Research & Development
O - Organisational Strategic Plan...
O - Organisational lean culture a...
O - Lean Workforce
I - Team working skills
I - Positive Attitudes towards Lean
I - Lean thinking
I - Lean Leadership
I - Lean knowledge
I - Lean Ethics
I - Communication Skills for Enab...
E - Lean Knowledge Dissemination

Appendix 19: Analysis for environmental level lean enabling capacity building strategies

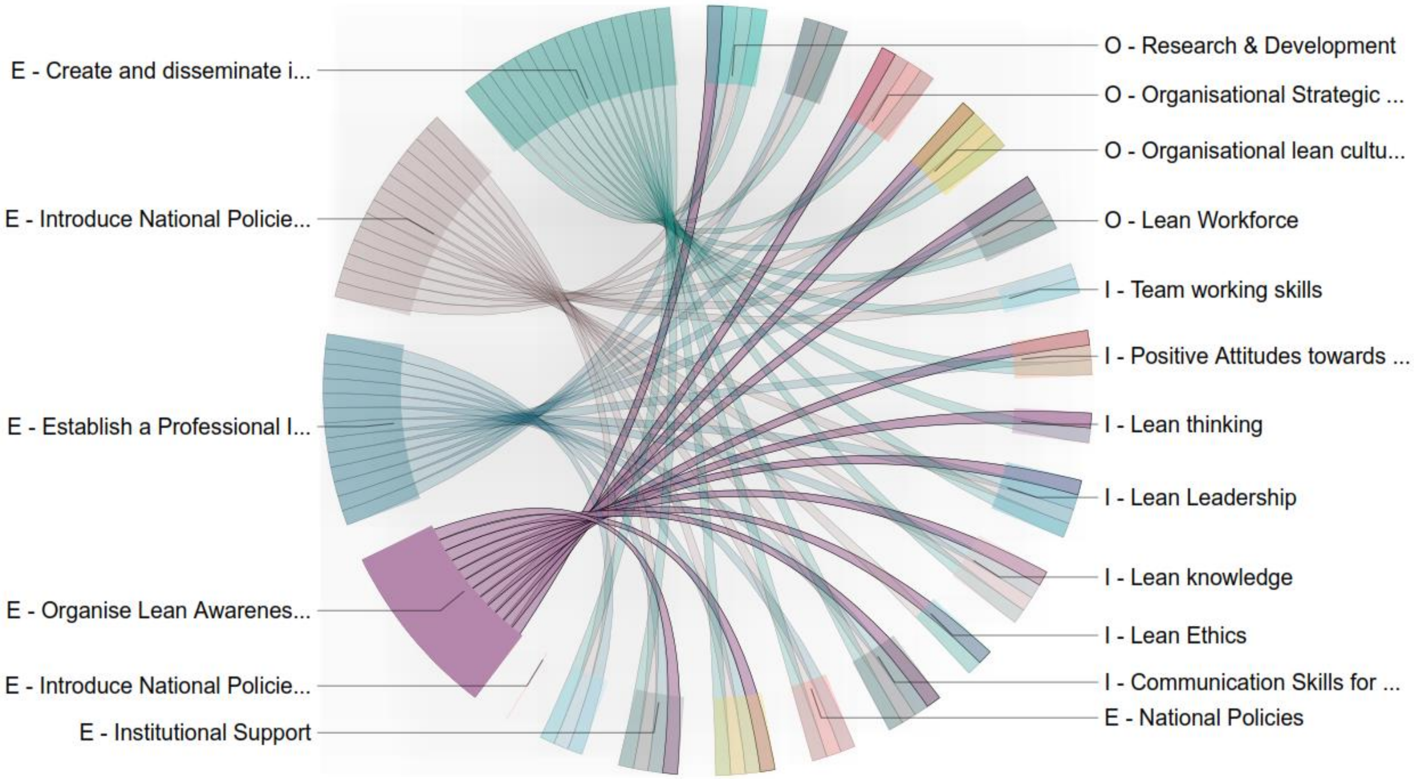
Appendix 19.1: Parent and child nodes for establish a professional institute for lean construction and mapping lean enabling capacities

Parent Node	Child Nodes	Sources	References
Establish a Professional Institute for Lean Construction	Develop a best practice guideline for lean implementation	13	13
	Develop a code of conduct for lean professionals	2	2
	Produce lean trainers	11	11
	Introduce a belt system for lean learning	3	3



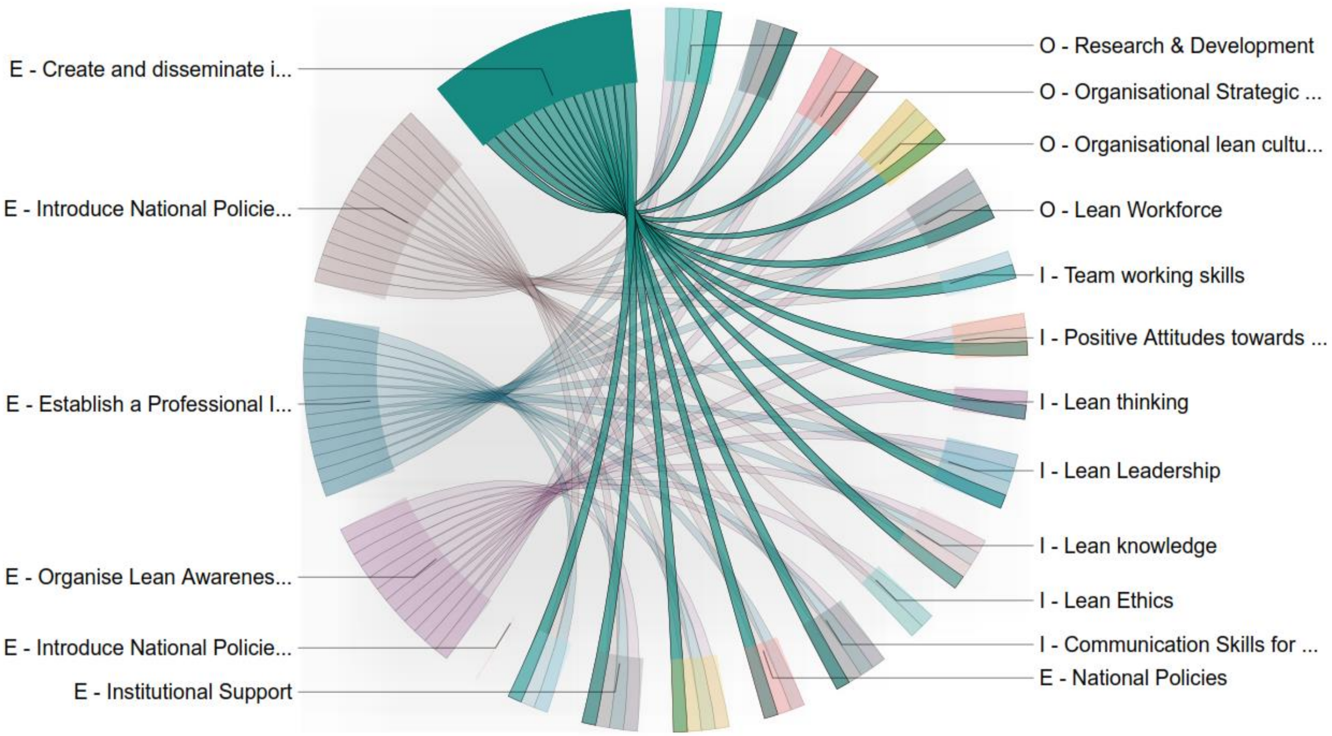
Appendix 19.2: Parent and child nodes for organise lean awareness programmes and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Organise Lean Awareness Programmes	Conduct CPD programmes for lean by professional institutes	11	11
	Organise lean training programmes and workshops by government organisations	11	11
	Embed lean knowledge into construction education/training curricula	6	6



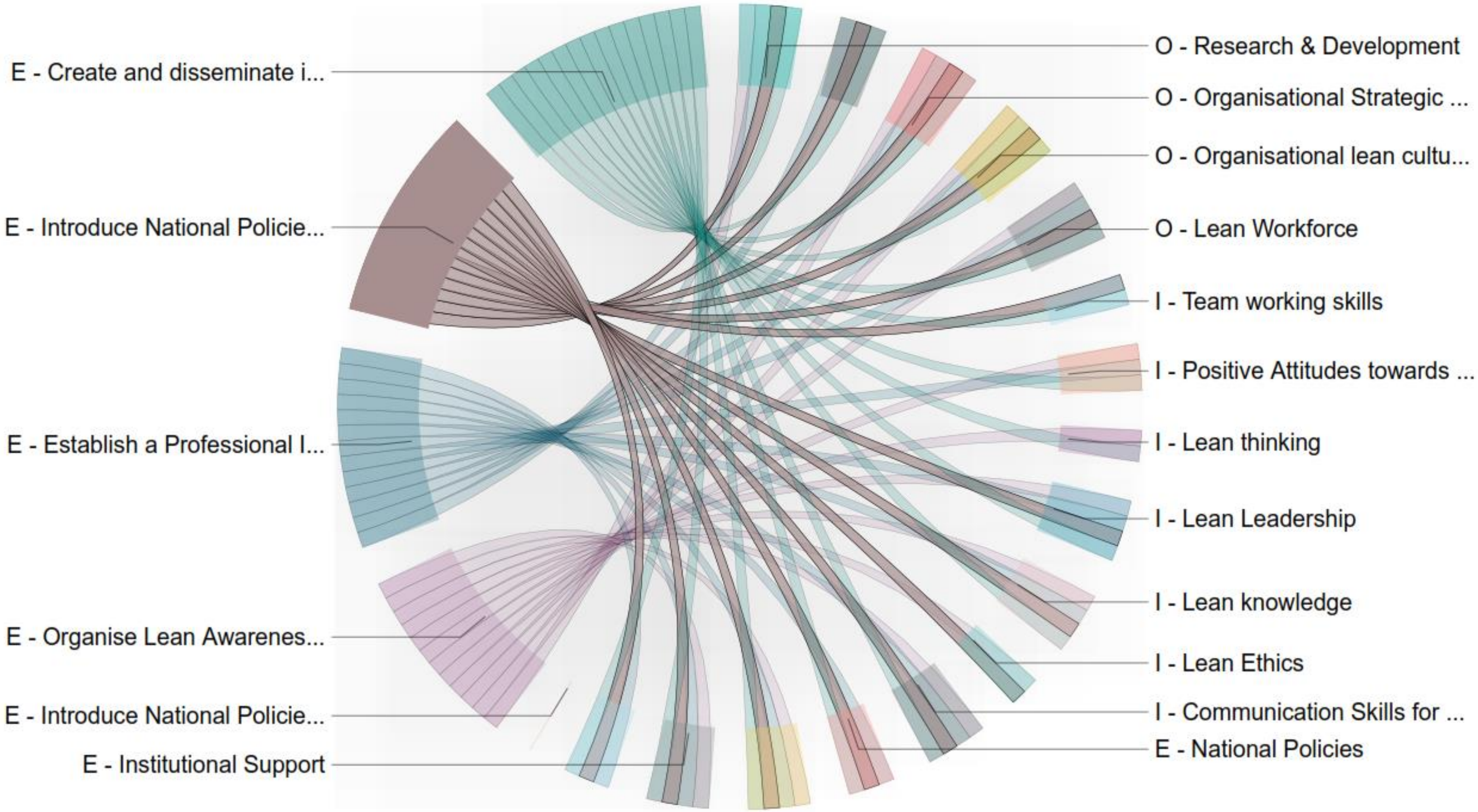
Appendix 19.3: Parent and child nodes for create and disseminate inter/intra industry lean knowledge and mapping to lean capacities

Parent Node	Child Nodes	Sources	References
Create and Disseminate Inter/Intra Industry Lean Knowledge	Organise annual lean conference and exhibition	6	6
	Establish financial endowment for lean research	20	20
	Encourage academic industry partnerships in lean research	8	8
	Encourage lean learning from local and international partnership projects	14	14



Appendix 19.4: Parent and child nodes for introduce national policies and legislation to support lean implementation and mapping to lean enabling capacities

Parent Node	Child Nodes	Sources	References
Introduce National Policies and Legislation to Support lean implementation	Allocate more funds for lean awareness programmes	20	20
	Ensure equal opportunities for SMEs in public funded projects	5	5
	Introduce KPI-driven lean investment plans for construction SMEs	20	20
	Develop appropriate legislation, policies and standards for lean implementation by the government	14	14
	Encourage to implement IPD approach that support lean	8	8
	Introduce favourable loan interest rates for lean implemented projects	20	20
	Provide tax concessions for lean implemented projects	12	12
	Introduce plan for retaining construction workforce	6	6



E - Create and disseminate i...
E - Introduce National Policie...
E - Establish a Professional I...
E - Organise Lean Awarenes...
E - Introduce National Policie...
E - Institutional Support
O - Research & Development
O - Organisational Strategic ...
O - Organisational lean cultu...
O - Lean Workforce
I - Team working skills
I - Positive Attitudes towards ...
I - Lean thinking
I - Lean Leadership
I - Lean knowledge
I - Lean Ethics
I - Communication Skills for ...
E - National Policies