A Green-Lean-Six Sigma Model for Environmental Performance in Manufacturing Organizations: A Study of a Developed and Developing Nation

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Abstract

Manufacturing organizations continue to face environmental challenges including greenhouse gas (GHG) emissions, large-scale energy consumption, and solid and liquid waste generation contributing to climate change. While emerging environmental concerns are serious challenges for discrete and process industries in both developed and developing countries, the impact of these issues is more significant for the process industry due to their high energy requirements, GHG emissions, and lack of application of operational strategies.

Green-lean-six sigma (GLSS) is recognized as a promising operational and environmental improvement strategy for minimizing waste and conserving resources in manufacturing organizations. However, scant attention has been paid to examining this strategy in addressing the environmental concerns, and in particular, investigating its application between developed and developing nations. The aim of this study is to examine the drivers, enablers, environmental outcomes, and critical success factors (CSFs) of a GLSS strategy in a developed country (New Zealand) and developing country (Pakistan) context in the manufacturing industry. This study draws on the natural resource-based view, institutional theory-based view, and intellectual capital-based view to understand the execution of this strategy and develops a GLSS model for improving the environmental performance in manufacturing organizations.

A qualitative research methodology is adopted with semi-structured interviews using the case study approach. In the first phase, a preliminary study is undertaken with lean six sigma and environmental consultants from New Zealand (NZ) and Pakistan (PK). In the second phase, the main study is conducted with senior corporate managers of two large-sized flexible packaging manufacturing companies in both NZ and PK who have implemented the green, lean, and six sigma strategies.

This study highlights various internal operational and organizational drivers and external regulatory, market-driven, and society-oriented forces that prompt manufacturing companies to adopt a GLSS strategy. Numerous GLSS enablers for achieving environmental outcomes including waste and emission reduction, resource conservation and recycling, and environmental safety and compliance are revealed. Further, CSFs for the implementation of a GLSS approach comprising the strategic, operational, human resource, and external stakeholder-related elements are presented. By utilizing the results of the preliminary and the main study, a holistic GLSS model is developed for achieving environmental performance in manufacturing organizations, with significant theoretical and practical implications.

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List of Publications

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5. Farrukh, A., Mathrani, S., & Taskin, N. (2020). Investigating the theoretical constructs of a green lean six sigma approach towards environmental sustainability: a systematic literature review and future directions. *Sustainability, 12*(19). doi:10.3390/su12198247. (Scimago Q1; Journal Impact Factor 2021 (Clarivate Analytics) = 3.889, CiteScore (2022) = 5.0)

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List of Abbreviations

Abbreviation	Full form	Abbreviation	Full form
3R	Reducing, reusing, recycling	FMS	Flexible manufacturing system
5S	Seiri, seiton, seiso, seiketsu, shitsuke	FP	Flexible packaging
AMS	Agile manufacturing system	FSC	Forest stewardship council
ANOVA	Analysis of variance	FSCC	Food Safety System Certification
ASSET	Advanced sustainability stewardship evaluation tool	Gage R&R	Gage repeatability and reproducibility
ASQ	American Society for Quality	GDP	Gross domestic product
BOPP	Biaxially oriented polypropylene	GHG	Greenhouse gases
BPR	Business process re-engineering	GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
BRC	British retail consortium	GLSS	Green-lean-six sigma
CA	Cause-effect analysis	GQFD	Green quality function deployment
CBA	Cost-benefit analysis	G-VSM	Green value stream mapping
CE	Circular economy	GW	Gemba walk
CM	Cellular manufacturing	HACCP	Hazard analysis critical control points
CO	Carbon monoxide	HAPs	Hazardous air pollutants
CO_2	Carbon dioxide	HDPE	High-density polyethylene
COD	Chemical oxygen demand	HIRARC	Hazard identification, risk assessment, and risk control
CPS	Cyber physical system	HFO	Heavy fuel oil
CSFs	Critical success factors	IASSC	The International Association for Six Sigma Certification
CSR	Corporate social responsibility	lb	Pounds
DFE	Design for environment	ICBV	Intellectual capital-based view
DFSS	Design for six sigma	IMS	Integrated management system
DOE	Design of experiment	IoT	Internet of things
ECRS	Eliminate-combine-rearrange-simplify	IPCC	Intergovernmental panel on climate control
EMS	Environmental management system	ITBV	Institutional theory-based view
EnMS	Energy management system	JICA	Japan International Cooperation Agency
EPA	Environmental protection agency	JIT	Just-in-time
ERP	Enterprise resource planning	KPIs	Key performance indicators
E-VSM	Environmental value stream mapping	Kt	Kilotons
E-WOF	Environmental warrant of fitness	LCA	Life cycle analysis
FMEA	Failure mode effect analysis	LDPE	Low-density polyethylene

LED	Light emitting diode	RFID	Radio frequency identification
LSS	Lean six sigma	RMA	Resource Management Act
MFCA	Material flow cost analysis	RMS	Reconfigurable manufacturing system
MSA	Measurement system analysis	R&D	Research and development
Mt	Megatons	RTO	Regenerative thermal oxidizer
NCRs	Non-conformity reports	SAC	Sustainable Apparel Coalition
NEQS	National Environmental Quality Standards	SAP	System Analysis and Program Development
NGO	Non-governmental organizations	SCADA	Supervisory control and data acquisition
NO_x	Nitrogen oxide	SIE	Sundar industrial estate
NRBV	Natural resource-based view	SIPOC	Supplier-input-process-output-control
NZ	New Zealand	SMED	Single minute exchange of die
NZPSC	NZ Product Stewardship Council	SO_x	Sulfur oxide
OEE	Overall equipment effectiveness	SOPs	Standard operating procedures
OHSAS	Occupational health and safety assessment series	SPC	Statistical process control
OPP	Oriented polypropylene	TPM	Total productive maintenance
PCA	Process capability analysis	TQM	Total quality management
PDCA	Plan-do-check-act	UN	United Nations
PE	Polyethene	UNIDO	United Nations Industrial Development Organization
PEQS	Punjab Environmental Quality Standard	VFDs	Variable frequency devices
PET	Polyethylene terephthalate	VM	Visual management
PIEMDC	Punjab industrial estates and development management company	VOCs	Volatile organic compounds
PK	Pakistan	VSM	Value stream mapping
PP	Polypropylene	WS	Work standardization
QC	Quality control	WWF	World Wildlife Fund
QFD	Quality function deployment	ZDHC	Zero discharge of hazardous chemicals
QMS	Quality management system	ZLD	Zero liquid discharge
REMC	Resource-efficient management of chemicals		

Chapter 1

Introduction

1.1 Introduction

Climate change and global warming are increasingly associated with human activities which have created critical environmental issues for mankind (IPCC, 2021). The most common types of environmental footprint are carbon, ecological, and water footprints arising from manufacturing plants (Galli et al., 2012; Shaikh et al., 2017). Greenhouse gas (GHG) emissions including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are the major concerns of climate change (Kennelly et al., 2019). For example, CO_2 emissions have an effect in the form of GHG leading to scarcity of energy and natural resources as well as the creation of harmful materials and waste discharges (Thanki et al., 2016). In order to enhance environmental sustainability, there is a need to take action for reducing GHG emissions and preserving natural resources (Dhingra et al., 2014).

Manufacturing organizations are facing challenges in the form of environmental impacts, increasing environmental legislation, and resource scarcity (Teles et al., 2015). These issues have made manufacturing firms conscious of environmental performance and the efficient utilization of resources. Negative environmental impacts of industrial operations have attracted much scrutiny from international bodies, non-governmental organizations (NGOs), governments, consumers, and the public (Farrukh et al., 2022a). Environmental issues are highlighted as the generation of hazardous air pollutants (HAPs), volatile organic compounds (VOCs), and other organic and inorganic wastes (Fercoq et al., 2016). For example, tyre manufacturing is a complicated process, which has many non-value-added activities and process wastes that result in significant environmental issues. Different environmental wastes from tyre manufacturing processes are VOCs, HAP emissions, wastewater, chemical additive spills, leaks, transient emissions, and scrap tyre wastes (Gupta et al., 2018). Similarly, the construction industry and its processes are another major source of greenhouse gases, which are primarily carbon emissions generated by the increasing demand for urbanization (Choi, 2019; Guo et al., 2017). This industry uses around one-third of the world’s energy, 40% of worldwide raw materials, and generates almost 30% of global carbon emissions (Choi, 2019). On the other hand, the most common operational wastes are inventory, over-production, over-processing, excessive motion, transportation, waiting time, defects, and underutilized human resources (Albliwi et al., 2015).

Manufacturing firms – perceived as a key source of environmental degradation – are expected to positively contribute towards global environmental issues such as climate change and resource depletion by incorporating environmental practices within their business strategies (Baah et al., 2021; Eweje, 2020; Terlaak et al., 2018). In the current business environment, these organizations are embracing environmental management programmes to obtain competitive advantage and improve stakeholder value (Nguyen et al., 2021). However, environmental management is a complex endeavour with multifaceted challenges, which manufacturing organizations continue to encounter in aspects such as development of governance systems (Kirschke & Newig, 2017; Wagner, 2020), advancement of knowledge and awareness of environmental issues (Ikram et al., 2019), creation of technology infrastructure and skilled employees, as well as design and implementation of environmental approaches (Moktadir et al., 2018). By implementing continuous improvement strategies and environmental practices, manufacturing organizations can enhance their environmental performance and competitiveness (Gouda & Saranga, 2020; Nguyen et al., 2021).

Environmental performance has been defined as the impact of an organization's operational activities and products on the natural environment (Klassen & Whybark, 1999). It has also been viewed as an organization's commitment to maintain, protect, and preserve the natural environment (Lober, 1996). To address the issues of environmental safety and waste minimization, the concept of green-lean-six sigma (GLSS) has been proposed to minimize environmental degradation by reducing operational and environmental waste while improving the process and system capability (Banawi & Bilec, 2014; Garza-Reyes, 2015a). In this concept, 'green' focuses on environmental performance and resource conservation by using different environmental practices whereas 'lean' targets the removal of wastes and non-value-added activities with the help of various tools and techniques. Along with lean and green strategies towards waste reduction, six sigma also minimizes the defects through a continuous improvement methodology (Farrukh et al., 2020; Kumar et al., 2016).

The GLSS approach is a combination of three independent but interlinked concepts – green, lean, and six sigma – that aims to overcome the limitations of each one. Green manufacturing is described as a philosophy to determine, measure, evaluate, and control environmental wastes by addressing the problems associated with products and processes (Garza-Reyes, 2015a). The objectives of green manufacturing are to conserve resources by efficient and effective utilization of energy, material and water, and minimize the use of toxic chemicals through green practices and techniques (Thanki & Thakkar, 2018). Lean manufacturing has been a widely accepted strategy to handle the issue of waste minimization. It eliminates non-value-added activities and improves an organization's operational performance in terms of productivity, adaptability, effectiveness, and growth (Thanki et al., 2016).

Lean manufacturing mainly reduces waste in aspects such as overproduction, inventory, transportation, overprocessing, defects, waiting, excessive motion, and underutilized human skills. A plethora of studies also emphasize the positive impact of lean manufacturing on environmental performance by saving resources including energy (Chugani et al., 2017; Dieste et al., 2019). However, lean and green are different in terms of their concepts, waste classification, and methodologies (Dües et al., 2013). For instance, increasing productivity is one of the key objectives of the lean concept through cost minimization, waste elimination, and resource conservation. However, improving environmental performance is a goal of the green concept through elimination of toxic materials, use of design for environment (DFE) concepts, and eco-friendly materials, products, and processes (Dhingra et al., 2014). One aspect which is shared by the two approaches is the concept of waste reduction (Garza-Reyes, 2015b). Nevertheless, improved environmental performance has not been achieved even after the integration of the two approaches (Banawi & Bilec, 2014). A problem associated with both lean and green philosophies is that they are not capable of measuring process variation because of a lack of mathematical and statistical tools in performance monitoring which eventually affects decision-making (Assarlind et al., 2013; Garza-Reyes, 2015a). Therefore, researchers have suggested incorporating six sigma alongside lean and green strategies to not only overcome lean and green strategies' limitations but also utilize six sigma practices to enhance environmental performance (Banawi & Bilec, 2014; Garza-Reyes, 2015a). These three approaches are adaptable, interrelated, share commonalities, and fill each other's gaps (Banawi & Bilec, 2014). Additionally, the basis of all three concepts is the same: continuous improvement of processes and waste management (Kumar et al., 2016; Mishra, 2018). Due to these characteristics, green, lean, and six sigma strategies, as a unified approach (i.e., GLSS), can address the aims of waste minimization and resource conservation. Accordingly, the primary motivation of this study is to better understand and address the increasing environmental problems in the manufacturing sector and the linkage of these issues with the GLSS approach.

1.2 Justification for selecting the combination of green, lean, and six sigma strategies

In any organization, people who are cautious about environmental improvement focus on all types of waste elimination. Numerous organizations struggle with how to wipe out waste, i.e., what strategy should be adopted to accomplish it. Therefore, a reasonable critical thinking approach is required with facts, figures, and statistical reasoning (Singh & Rathi, 2018).

There are various manufacturing strategies available such as lean manufacturing, six sigma, total quality management (TQM), and business process re-engineering (BPR), and their use in organizations worldwide is evident from the literature (Chiarini, 2011; Tickle et al., 2014). Other manufacturing paradigms include agile manufacturing systems (AMS), green manufacturing, reconfigurable manufacturing systems (RMS), and flexible manufacturing systems (FMS) (Bi et al., 2008; Kumar et al., 2016). The purpose of these manufacturing strategies is to enhance organizational performance and gain competitive advantage by analyzing, measuring, controlling, and improving processes (Tickle et al., 2014). These strategies have their own characteristics, benefits, and limitations; therefore, they are followed by organizations according to their specific criteria (Bi et al., 2008). The primary objective of TQM is to increase customer satisfaction by providing quality products with a customer focus (Sreedharan et al., 2018). Lean manufacturing targets waste reduction and value addition (Sreedharan et al., 2018). Six sigma minimizes waste by reducing defects and controlling process variation (Singh & Rathi, 2018). Process improvement by redesigning and re-engineering business processes is the objective of BPR (Tickle et al., 2014). FMS, RMS, and AMS are primarily focused on manufacturing flexibility and responsiveness (Bi et al., 2008; Esmaeilian et al., 2016; Mahmood et al., 2017). Green manufacturing focuses on managing environmental impacts by reducing waste, saving resources, and improving environmental safety (Sangwan & Mittal, 2015).

It can be seen from the above that operational performance is targeted by all manufacturing paradigms, whereas green manufacturing, lean manufacturing, and six sigma target waste minimization and generally have positive environmental impacts. Additionally, six sigma is the only strategy which includes several measurement and statistical tools, unlike the other approaches. Based on this discussion, it can be inferred that a combined approach toward environmental performance can help manufacturing organizations improve their environmental outcomes. All other strategies (as per the above discussion), though focusing on operational aspects, do not affect environmental performance.

Further, GLSS is increasingly getting traction in the emerging environmental sustainability discourse and managerial practice. Several studies have investigated green, lean, and six sigma strategies individually and in various combinations to address the environmental management issues of manufacturing organizations such as green-lean, lean-six sigma, and green-lean-six sigma (Erdil et al., 2018; Farrukh et al., 2022b; Fercoq et al., 2016; Gholami et al., 2021; Shokri & Li, 2020). A green-lean approach has been recognized as an efficient way to manage environmental waste based on the shared objective of waste minimization (Fercoq et al., 2016). However, a green-lean implementation has a few limitations which hinder organizations' desired environmental performance outcomes. The green-lean strategy fails to consider the control process variation issue and lacks a structured problem-solving approach to waste reduction (Garza-Reyes, 2015a; Sagnak & Kazancoglu, 2016).

Similarly, the integration of lean-six sigma is regarded as a promising strategy for waste minimization with common characteristics of customer satisfaction and continuous improvement (Parmar & Desai, 2019). However, this strategy does not address the life cycle aspects from a green perspective nor fully implement the environmental improvement initiatives, both of which pose challenges to effectively achieving environmental goals (Banawi & Bilec, 2014; Zhang, 1999). Therefore, researchers have emphasized a GLSS approach as an environmental management strategy to overcome the drawbacks of green-lean and lean-six sigma combinations (Garza-Reyes, 2015a; Gholami et al., 2021). Such a combined strategy can improve the environmental performance by identifying environmental impacts and removing waste, with shared characteristics of waste reduction, value addition, and customer satisfaction (Farrukh et al., 2020; Gaikwad & Sunnapwar, 2020a). Therefore, this study aims to examine the GLSS strategy in reducing the environmental impacts of manufacturing organizations.

1.3 Background of the study

Manufacturing operations enhance the economic development of a country by providing a variety of products and services. However, organizations must use resources in such a way that not only focuses on environmental concerns but also considers the potential for resource-saving in their manufacturing processes (Muñoz-Villamizar et al., 2018). It is estimated that the manufacturing sector uses about half of the world's energy and other resources such as steel, aluminium, copper, nickel, zinc, wood, etc. (Ross, 1992; Sangwan & Mittal, 2015). Manufacturing firms of all sizes have environmental effects in the form of GHG emissions, wastewater, and hazardous materials while consuming a large quantity of natural resources (Mittal & Sangwan, 2014). According to the IPCC report (2021), because of human activities, there are 42 billion tonnes of carbon dioxide emissions in the air per year and there is a need to reduce the global emissions to 45% by 2030 as compared to 2010 levels.

Manufacturing organizations in both developed and developing countries are facing many environmental issues resulting from their business operations such as the energy crisis, industrial waste, carbon emissions, health and safety issues, and insufficient natural resources (Teles et al., 2015). These challenges are significant for developing countries owing to their large population, less concern about pollution, and lack of governance (Du Plessis, 2007). Additionally, organizations in these countries pay more attention to economic issues rather than environmental objectives (Mangla et al., 2018; Teles et al., 2015) owing to weak enforcement of environmental regulations, high cost of environmental programmes, and lack of environmental knowledge (Rao, 2004). However, despite the rigorous policies and environmentally sustainable practices, manufacturing organizations in developed countries also continue to face pressing environmental issues such as air emissions, resource scarcity, and water pollution (Cracolici et al., 2010).

Both discrete and process industries in the manufacturing sector use large amounts of energy and resources, both renewable and non-renewable (Duflou et al., 2012). Discrete manufacturing processes are characterized as producing individual units which can be measured (Duflou et al., 2012). Environmental impacts associated with discrete manufacturing comprise CO_2 emissions through electricity and fossil fuels (Duflou et al., 2012). For example, the automotive industry must cope with environmental issues in the form of energy consumption and air emissions (Cooper et al., 2017). The characteristics of the process industry include the use of specialized and expensive machines in a highly automated environment and high demand variability (Panwar et al., 2015). The process industry is highly energy intensive and has huge environmental impacts (Duflou et al., 2012). For example, the leather industry releases large quantities of VOCs, toxic chemicals, wastewater, and solid wastes (Dixit et al., 2015). Similarly, chemical processing companies also have a major environmental impact as the processes are highly energy and resource-intensive (oil, gas, and minerals). Furthermore, this industry works with harmful, combustible, and hazardous materials and has adverse environmental effects such as GHG, releases of toxic effluents, and air emissions (Liew et al., 2014). Thus, the environmental effects and resource depletion issues are also significant for the process industry (Duflou et al., 2012). However, only a few research studies have used operations and environmental management strategies to address the environmental issues in the process industry (Powell et al., 2017).

Among the different manufacturing sectors in the process industry (such as paper and pulp, dairy, rubber, and cement), the flexible packaging (FP) industry is recognized as a significant contributor to environmental waste due to the use of packaging materials such as plastic, solvents, and adhesives. The packaging industry consumes 37% of the total plastic and its demand is continuously increasing (Brems et al., 2012; Golghate & Pawar, 2012). Both developed and developing countries are facing environmental issues originating from the FP manufacturing industry (Pongpimol et al., 2020; Tencati et al., 2016). Some of the key environmental issues associated with FP materials include toxic chemical production, resource depletion, and solid waste generation due to a lack of recycling and sustainable packaging materials availability. The presence of macro, micro, and nano plastics leads to air pollution and soil infertility affecting plants, animals, and humans (Ahamed et al., 2021). In 2015, around 4.1 megatons (Mt) of macro plastics entered the environment from the mismanaged municipal solid waste in developing countries (Ryberg et al., 2019).

The FP manufacturing industry is a key contributor to other environmental issues such as acidification, climate change, marine pollution, eutrophication, ozone depletion, and freshwater toxicity (Ahamed et al., 2021). A large quantity of plastic ranging from 55–158, 155–413, and 29–78 kilotons (Kt), is entering the Caspian Sea, Persian Gulf, and the Gulf of Oman respectively from the surrounding lands and is projected to increase by 15, 29, and 38% by 2030 (Ghayebzadeh et al., 2020a). Additionally, blockages in the drainage system, ingestion by animals, landfills, lack of waste treatment, and soil depletion are other environmental problems of FP materials (Golghate & Pawar, 2012). In the United States (US), plastic packaging waste accounts for 41% of total municipal waste, of which only 8% is recycled, 76% is sent to landfill, 14% is combusted, and 2% is leaked into the natural environment (Ghayebzadeh et al., 2020b; Heller et al., 2020). Although the FP materials have the potential for recyclability, only a small quantity (14%) is recycled worldwide (Hahladakis & Iacovidou, 2018) due to several challenges faced by this industry such as material structure, lack of technological advancements, and material recovery, collection, and sorting issues (Ahamed et al., 2021; Pongpimol et al., 2020).

Organizations in both developed and developing countries are increasingly considering different manufacturing paradigms such as green, lean, and six sigma to mitigate “wicked ecological problems” (Hörisch et al., 2015; Swarnakar et al., 2020). The effectiveness of manufacturing strategies varies from country to country as culture, policy, region, economic conditions, and perceptions play an important role in their execution (Gandhi et al., 2018). A regional evaluation of these practices among different countries and presentation of results is lacking in the literature, which calls for research into this area (Tseng et al., 2019). Various authors have highlighted this gap and emphasized the need for such assessment to explore the GLSS strategy in developed and developing countries which can provide a holistic understanding of this approach (e.g., Belhadi et al., 2020; Caiado et al., 2018; Cherrafi et al., 2016). Furthermore, research studies in the GLSS domain have been conducted in various discrete manufacturing industries including automotive, electronics, and cookware (Ruben et al., 2017; Mishra et al., 2019; Parmar & Desai, 2020; Tiwari et al, 2020). Nevertheless, the investigation of GLSS as an approach in the continuous process industry in the manufacturing sector is lacking in the literature (Costa et al., 2018; Parmar & Desai, 2019; Powell et al., 2017).

Although the GLSS strategy is recognized as a strong approach to improving environmental performance, there are limited frameworks available in the literature (Kaswan & Rathi, 2020b). Further, a few frameworks have not been empirically tested from an industrial perspective (Farrukh et al., 2020). For example, a GLSS model has been developed based on experts' opinions; however, it requires additional validation in industrial sectors (Kaswan & Rathi, 2019). Moreover, there are limited research studies in the literature presenting the aspects of a GLSS strategy including drivers, enablers, environmental outcomes, and critical success factors (CSFs) as a consolidated approach (Cherrafi et al., 2016; Farrukh et al., 2020; Gaikwad & Sunnapwar, 2020a). Though several studies used quantitative research methodology (Gaikwad & Sunnapwar 2020b; Kaswan & Rathi 2019; Kumar et al., 2016), few studies have adopted the qualitative design using in-depth semi-structured interviews for exploring the GLSS strategy toward the environmental performance of manufacturing firms (Caiado et al., 2019; Sony & Naik 2019).

An organizational theory plays an important role in explaining and demonstrating an organization's behaviour, structure and design and is recognized as a "management insight" (Sarkis et al., 2011, p. 2). According to McAdam and Hazlett (2010), the use of a theoretical lens plays an important role in creating knowledge. The use of an organizational theory for the natural environment (Etzion, 2007) is gaining popularity and is recognized as a significant aspect in understanding the organization's environmental performance (Sarkis et al., 2011). However, to date, very few studies have utilized organizational theories such as the natural resource-based view (NRBV) to examine the GLSS strategy (e.g., Caldera et al., 2019; Farrukh et al., 2021a).

The above research gaps illustrate the justification for this study which was conducted in New Zealand (NZ) as a developed country and Pakistan (PK) as a developing country to explore the adoption of a GLSS strategy for improving the environmental performance of manufacturing organizations. The FP manufacturing industry was selected to conduct this research due to its detrimental environmental impacts and a lack of GLSS investigation in this industry. In addition, three organizational theories – NRBV, ITBV (institutional theory-based view), and intellectual capital-based view (ICBV) – were used to investigate the GLSS strategy.

1.4 Aim and Purpose of this study, research questions, and research design

1.4.1 Aim and Purpose of this study

The purpose of this study is to examine the drivers, enablers, environmental outcomes, and critical success factors of a GLSS strategy in a developed and developing country context and develop a GLSS model for improving the environmental performance of manufacturing organizations in the process industry.

1.4.2 Research questions

Based on the above research gaps and objectives, the following research questions are addressed in this study:

RQ1: What are the drivers of a green-lean-six sigma strategy in manufacturing firms for achieving environmental performance? How do these drivers compel manufacturing firms to adopt a GLSS strategy in a developed and developing country?

RQ2: What are the enablers and environmental outcomes of a green-lean-six sigma strategy in manufacturing firms for achieving environmental performance? How do manufacturing firms use these enablers to achieve environmental outcomes in a developed and developing country?

RQ3: What are the critical success factors for implementing a green-lean-six sigma strategy for achieving environmental performance? How do these CSFs help manufacturing firms to execute a GLSS strategy in a developed and developing country?

1.4.3 Research design

This study used a qualitative research design to answer the above research questions in two phases – a preliminary study (phase 1) and the main study (phase 2). In phase 1, eight semi-structured interviews were conducted with lean six sigma (LSS) and environmental consultants from NZ and PK to gain an in-depth understanding of the GLSS strategy based on these experts' opinions. In phase 2, twenty semi-structured interviews were conducted with senior corporate managers in two large FP companies in NZ and PK that have implemented the green, lean, and six sigma strategies for at least 3 years. Further, organizations' case studies, sustainability reports, and archival records were also assessed in addition to the primary source of data collection. Three organizational theories – NRBV, ITBV, and ICBV– were applied to investigate the GLSS strategy. Thematic analysis was used to collate and summarize the viewpoints of the preliminary and main study participants to generate fresh in-depth insights (Braun & Clarke, 2006; King, 2004). A within-case analysis was first conducted followed by a cross-case analysis, to identify various patterns in the data (Yin, 2014). The results of both the preliminary and main studies are discussed and analyzed to examine the drivers, enablers, environmental outcomes, and CSFs of the GLSS strategy and develop a GLSS model for achieving environmental performance in manufacturing organizations.

1.5 Significance of the study

Manufacturing organizations are practising various strategies such as green manufacturing, lean manufacturing, and six sigma to overcome environmental issues and increase their green company image (Foo et al., 2021; Klochkov et al., 2019; Parmar & Desai, 2019; Mishra, 2018). Several scholars have emphasized the need for development of a model integrating the above-mentioned strategies for optimal environmental performance, as individually these strategies may not achieve the desired environmental outcomes (Cherrafi et al., 2016; Farrukh et al., 2020; Garza-Reyes, 2015a; Kaswan & Rathi, 2020a). Against this background, a GLSS strategy is recognized as a promising approach to addressing the environmental issues of the manufacturing sector (Ershadi et al., 2021; Farrukh et al., 2021a; Gaikwad & Sunnapwar, 2020a; Gholami et al., 2021). However, there is a dearth of empirical research utilizing the qualitative research methodology to explore the GLSS strategy from a developed and developing country perspective. In addition, there are limited studies investigating this strategy in the process industry (Costa et al., 2018; Parmar & Desai, 2019; Powell et al., 2017). Therefore, this study aims to bridge these gaps through an empirical evaluation conducted in NZ and PK to examine the drivers, enablers, environmental outcomes, and CSFs of a GLSS strategy for improving the environmental performance of manufacturing organizations. This study makes significant contributions which are presented below.

First, from a theoretical perspective, this study utilizes the knowledge and expertise of the LSS and environmental consultants and the senior corporate managers which provide useful insights into the GLSS domain. In addition, this study uses three organizational theories including the NRBV, ITBV, and ICBV to understand the GLSS drivers, enablers, environmental outcomes, and CSFs for advancing academic knowledge since the extant GLSS literature has overlooked this important aspect. Further, a qualitative research methodology is followed to investigate the

GLSS strategy to gain an in-depth understanding as prior studies have mostly used the quantitative research approach in this subject domain. Moreover, a regional evaluation from a developed and developing country provides valuable insights into the motivations behind adopting the GLSS strategy, the application of GLSS tools and their environmental outcomes, and the CSFs for implementing the GLSS strategy which are missing in prior studies. Finally, a significant theoretical contribution of this research work is the development of a novel model integrating the organizational theories and the GLSS strategy for improving the environmental performance of manufacturing organizations.

Second, the study has significant implications for LSS and environmental consultants in guiding manufacturing firms to execute a GLSS strategy for addressing environmental issues while maintaining their operational performance. Based on the findings of this study, the consultants can advise the practitioners in executing a mix of GLSS practices including environmental management systems (e.g., ISO 14001), energy management systems (e.g., ISO 50001), statistical process control (SPC), designs of experiment (DOE), and life cycle analysis (LCA) for environmental management. In addition, the consultants can also benefit from the study results in facilitating policymakers in designing adequate environmental policies using their knowledge and expertise in implementing GLSS tools in different manufacturing organizations. In this way, consultants can play a significant role in improving the coordination between manufacturers and policymakers regarding environmental protection.

Third, this study addresses the environmental issues of the manufacturing sector, specifically the process industry, using a multiple case study approach in large FP organizations in NZ and PK. The findings can help practitioners in this industry to minimize their environmental burden such as reducing plastic waste, VOC and GHG emissions, and energy consumption, minimizing the use of toxic materials, and improving workplace safety conditions. The study findings can assist the practitioners in selecting appropriate GLSS practices in production operations for eliminating waste and pollution, saving resources, and conserving the environment, which can enhance their organizations' strategic capabilities of pollution prevention, product stewardship, and sustainable development. Additionally, the practitioners can benefit from the study findings in identifying and analyzing the drivers of the GLSS strategy from NRBV and ITBV perspectives which can assist them in decision-making regarding GLSS execution. Moreover, the role of CSFs in GLSS implementation for achieving environmental performance can strengthen the organizations' relationship with the intangible resources comprising green structural, green human, and green relational capital.

Finally, the study findings can assist policymakers in formulating policies and legislation including subsidies, landfill levies, and taxes. Policymakers can help manufacturing organizations in the implementation of GLSS practices for achieving environmental performance through financial assistance. Further, the policymakers can use the study findings in improving collaboration and coordination between academic researchers, consultants, manufacturers, and stakeholders for addressing the issues of environmental degradation and natural resource depletion.

1.6 Roadmap of the study

Figure 1.1 depicts the conceptual framework of this study. It provides a roadmap to briefly describe and clarify the background of the research problem, problem statement, purpose of the study, research questions, theoretical context, research methodology, analysis and reporting of the findings, and the conclusions and implications.

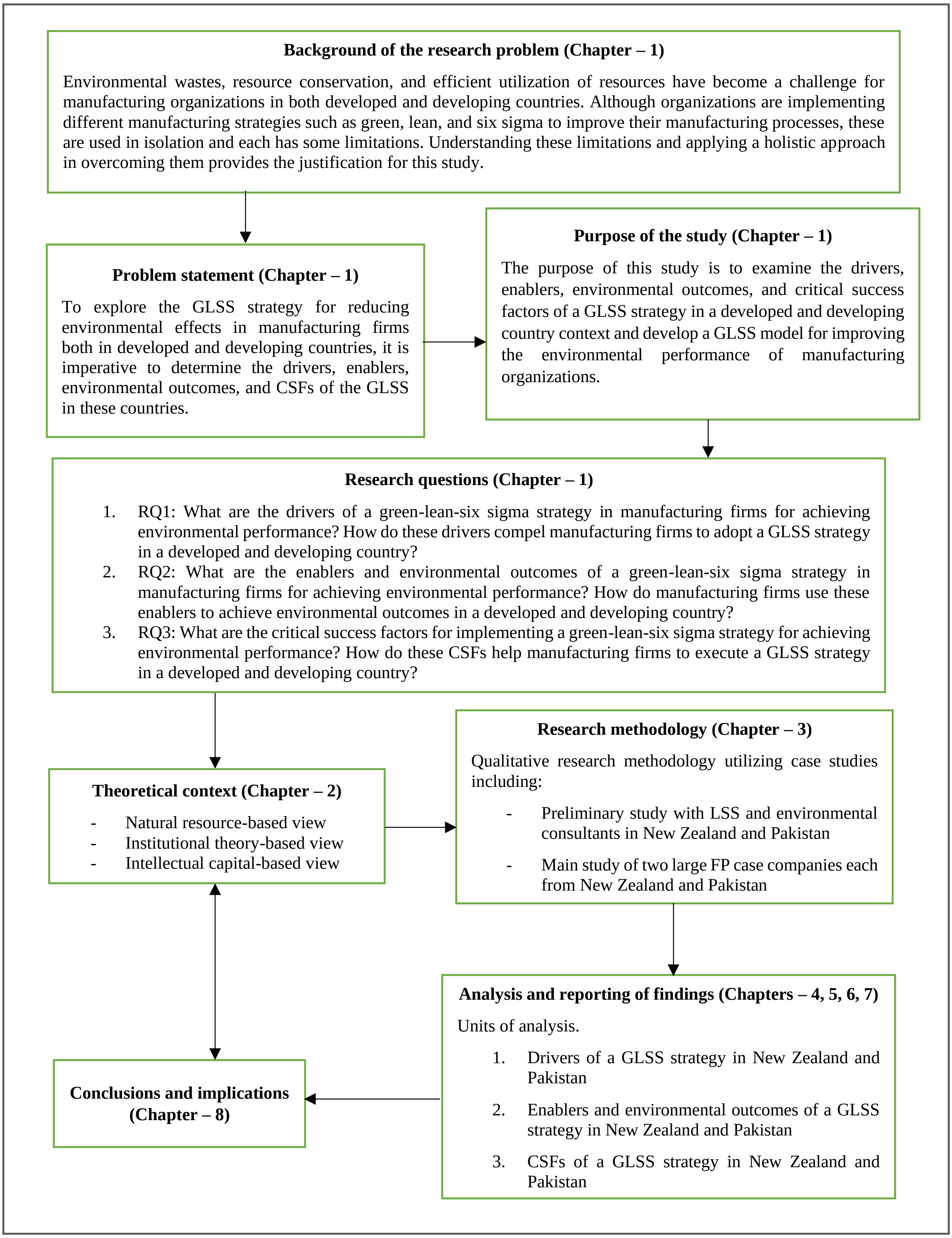

Figure 1.1: Roadmap of the study

1.7 Overview of the thesis

The structure of this thesis includes eight chapters. These are as follows:

Chapter 1 presents the overview, background of the study, justification for selecting the combination of green, lean, and six sigma strategies, aim and purpose of the study, research questions, research design, significance of the study, and a roadmap of the study.

Chapter 2 presents a comprehensive review of the extant literature on the GLSS strategy, existing frameworks, drivers, enablers, environmental outcomes, and CSFs. The related organizational theories are discussed. Finally, a theoretical model linking the NRBV, ITBV, and ICBV with the GLSS strategy for improving the environmental performance of manufacturing organizations is developed.

Chapter 3 discusses the research methodology including the research paradigm, research method and approach, and research strategy used in this study. The data collection methods and the analytical technique are explained followed by a discussion on the quality tests in the qualitative research design. Finally, the ethical considerations and a methodological map of this research study are presented.

Chapter 4 includes the findings of phase 1, the preliminary study conducted in New Zealand and Pakistan. This chapter presents the findings on the drivers, enablers, environmental outcomes, and CSFs of the GLSS strategy from the consultants' perspectives in both countries. These findings provide fresh insights into the GLSS domain based on the consultants' knowledge and expertise in implementing the GLSS strategy in a variety of manufacturing organizations in both countries.

Chapter 5 and Chapter 6 present the findings of phase 2, the main study in which multiple case studies are conducted in the FP manufacturing companies in New Zealand and Pakistan. These chapters discuss the managerial perspectives on implementing a GLSS strategy for improving environmental performance, examining the drivers, enablers, environmental outcomes, and CSFs. The findings of the main study enhance the understanding of GLSS execution in the FP manufacturing industry based on the practitioners' knowledge and expertise from working in the FP companies in NZ and PK.

Chapter 7 discusses the findings of the preliminary study (chapter 4) based on the expertise of LSS and environmental consultants and the main study (chapter 5: NZ case studies and chapter 6: PK case studies) using the knowledge and experiences of corporate managers. Drawing on the NRBV, ITBV, and ICBV, the emerging themes from the empirical investigation are discussed and compared with the literature. The similarities and differences in the drivers, enablers, environmental outcomes, and CSFs of the GLSS strategy in both countries are examined and discussed. Finally, a GLSS model collating the findings of the preliminary and main study and integrated with the NRBV, ITBV, and ICBV is presented.

Chapter 8 concludes with the key findings of this study followed by the theoretical, practical, and policy-related implications. The limitations and future research directions are also discussed.

Chapter 2

Literature Review

2.1 Introduction

This chapter presents a literature review on the environmental performance of organizations in the context of manufacturing in developed and developing countries, their environmental impacts, and environmental issues of the FP manufacturing industry. The literature relevant to green-lean-six sigma is reviewed. The limitations and scope of the existing studies in the GLSS domain are discussed. In addition, the GLSS strategy is assessed in terms of drivers, enablers, environmental outcomes, and critical success factors. This chapter also includes a discussion on organizational theories such as NRBV, ITBV, and ICBV, which are used in this study to understand the GLSS strategy. Further, the theoretical integration of the selected theories with the GLSS strategy is presented. Based on the extensive literature review and theoretical integration, a theoretical model comprising the drivers, enablers, environmental outcomes, and critical success factors of implementing a GLSS strategy for achieving environmental performance is developed.

2.2 Environmental performance

Environmental performance of an organization refers to the overall effect of reducing waste, energy and natural resource consumption, and GHG emissions to minimize health risks, increasing environmental safety and compliance with regulatory requirements (Erdil et al., 2018; Schmitt et al., 2021; Wang et al., 2015). Lober (1996) defined environmental performance as an organization’s commitment to maintain the quality of air, water, and soil, and protect and preserve the natural environment. Similarly, Epstein (1996) identified pollution reduction, resource and energy conservation, waste reduction, potential risks identification, and publicity of environmentally friendly products as the environmental performance aspects of an organization. In a similar vein, Judge and Douglas (1998, p. 245) defined environmental performance as “a firm's effectiveness in meeting and exceeding society's expectations with respect to concerns for the natural environment”. According to Klassen and Whybark (1999), environmental performance is defined as the impact of an organization’s operational activities and products on the natural environment.

2.3 Environmental issues in developing and developed countries

Manufacturing organizations in both developed and developing countries are facing various environmental issues resulting from their business operations such as energy crisis, industrial waste, carbon emissions, health and safety issues, and insufficient natural resources (Teles et al., 2015). Literature reveals that there are several empirical studies regarding the environmental concerns focused on developed countries including, Canada, Australia, United States of America (USA), United Kingdom (UK), and other European countries (Aulia et al., 2018). Furthermore, European countries such as France, Spain, and Portugal also focus on environmental practices as a result of pressure from customers and communities. The evaluation of environmental performance is also important for developed countries as manufacturing operations and technological advancements result in serious environmental consequences such as air emissions, energy consumption, and water pollution (Cracolici et al., 2010). Additionally, the use of environmental practices such as 3R (reducing, reusing, and recycling), DFE, and eco-labelling are frequently observed in developed countries for improving environmental performance (Aulia et al., 2018). Moreover, these countries are more concerned with addressing the emerging environmental regulations (Corbett & Cutler, 2000).

Although both developed and developing countries are trying to achieve environmental targets, developing countries need to put more effort into this since environmental impacts, waste management, and resource depletion are significant issues in these countries (Mangla et al., 2018). In developing countries, energy consumption is three times more as compared to developed countries. Similarly, carbon emissions are four times more and water pollution six times more than in developed countries (Luken & Van, 2008). Developing countries are struggling to cope with environmental problems. However, various reasons are contributing to their environmental performance. For example, the environmental goals of manufacturing organizations are not appropriately aligned with their business strategies. Moreover, the struggle is more oriented towards a reactive approach rather than a proactive one in controlling environmental effects (Rao, 2004). Some other important aspects include the difference in priority of environmental issues, weak enforcement of environmental laws and regulations, high cost of environmental programs, and lack of environmental knowledge (Rao, 2004). In addition, a majority of the world population resides in these countries and these countries are growing rapidly as compared to the developed countries (Rauch et al., 2016). According to an estimate, 90% of the world population will be residing in developing countries by 2050 (Mangla et al., 2018). With an increase in population, developing countries are facing different problems in the form of poverty, lack of education, lack of governance, and unskilled human resources (Du Plessis, 2007).

Further, leading manufacturing organizations are interested in investing in these countries because of high market growth (average annual growth rate approximately 7%) (Rauch et al., 2016). Multinational companies consider developing countries as flourishing and cost-effective markets for expanding their facilities and trading their products. Toyota has its manufacturing plants in Thailand, which is regarded as Toyota's third largest manufacturing base. Similarly, Japanese manufacturing companies invested $1.8 billion in Vietnam, in 2011, due to low labour costs and high market growth (Rauch et al., 2016). Although there is a potential for both international and national manufacturing companies to invest in developing countries, this poses a significant challenge in the form of environmental issues such as resource conservation, global warming, and climate change (Rauch et al., 2016). Nevertheless, the research in the environmental performance domain is limited in developing countries (Cherrafi et al., 2016), thus, requiring further exploration.

2.4 Environmental impacts of manufacturing industries

Manufacturing organizations whether discrete or process have environmental impacts. The final product in the discrete manufacturing process comprises distinct items such as computers, furniture, and automobiles. The characteristics of this industry are make-to-order, variety of equipment, complex and uncertain tasks, low automated machines, multiple parts, and skilled workers (Liu & Miao, 2006). The organizations in this industry have environmental impacts in the form of air emissions, wastewater, and effluents. The environmental issues associated with the waste from electronic and electrical equipment are releases of heavy metals and organic pollutants into the environment. For instance, hazardous materials in computers such as phosphor in cathode ray tubes, batteries, capacitors, plastics comprising flammable bromine, and parts having mercury can have serious environmental consequences (Nnorom & Osibanjo, 2008). Chiarini (2014) has highlighted environmental hazards such as solvents, chemicals, garbage, energy consumption, oil leakage, exhausted oils, and releases of fumes and dust during the motorcycle component manufacturing processes. Similarly, the furniture manufacturing industry has environmental impacts in the form of ozone depletion, acidification, global warming, and photochemical oxidation (Iritani et al., 2015).

Process industry is classified as having different manufacturing processes such as mixing, separating, forming, and chemical reaction. The output is in the form of continuous products such as pulps, gases, liquids, powders, and slurries (Panwar et al., 2015). Manufacturing organizations in the process industry such as petroleum refining, metal processing, mineral processing, chemical production, and plastics and paper manufacturing industries have significant environmental impacts and these industries are highly energy intensive (Duflou et al., 2012). Along with the serious environmental effects, manufacturing firms within the process industry consume a large amount of energy and resources. Moreover, the lack of visibility, far-reaching errors, and long-time duration are critical challenges in the process industry as compared to discrete (Powell et al., 2017). Due to these characteristics, the implementation of operational strategies such as lean manufacturing is difficult and challenging in the process industry as opposed to a discrete industry where the units of products are separable (Panwar et al., 2017).

In addition, the process industry is also facing significant environmental problems. For instance, the cement industry generates CO_2 emissions in large quantities, which are calculated around 1.8 Gt (gigatons) in 2006 which is approximately 7% of the total human caused carbon emissions worldwide (Gao et al., 2015). In the cement manufacturing process, around 90% of carbon emissions are generated in the process of clinker production (Ishak & Hashim, 2015). Similarly, rubber industry uses a huge amount of energy, water, and other resources in its different processes. The rubber material milling process, extrusion process, and rolling process utilize significant amounts of electricity and generate large amounts of carbon emissions (Huisingh et al., 2015). In this regard, a study in three rubber band production plants reported estimated quantities of CO_2 emissions as 1.16, 1.53, and 1.23 tons respectively (Dayaratne & Gunawardana, 2015). In addition, textile industry has significant environmental impacts including high consumption of fossil fuels, ozone depletion, and greenhouse gases (Alay et al., 2016). Another high energy consuming industry is paper and pulp which is also one of the major sources of air emissions generating 40 Mt (megatons) of carbon emissions per year in Europe (Huisingh et al., 2015). The petrochemical industry is another example in which hazardous substances that are flammable, toxic, and explosive in nature are used. A study reported 50% human injuries and 20% human fatalities in a petrochemical plant (Nivolianitou et al., 2006). While the process industry has significant environmental impacts, there is a lack of empirical research on the implementation of operational and environmental strategies (Seth et al., 2016; Sharma et al., 2015; Panwar et al., 2017), hence more investigation is required in this industry.

2.5 Overview of the flexible packaging manufacturing industry

Flexible packaging is an emerging sector in the manufacturing industry that provides efficient ways of processing various materials including plastic, paper, and aluminium foil that fulfil the requirements of packaging different products (Bayus et al., 2016; Kliopova-Galickaja & Kliaugaite, 2018). The packaging criteria comprise shelf-life, cost, safety, and flexibility throughout its life cycle (Ahamed et al., 2021). Due to its characteristics of lightweight, low cost of production and transportation, and increasing shelf-life, FP has gained a major market share as compared to rigid packaging (e.g., bottles, jars, and soda cans) (Garofalo et al., 2018).

Amongst the different materials, plastic is much used (about 76.8%) in the manufacture of FP as compared to paper (11.4%) and aluminium (9.8%) (Izdebska, 2016). A variety of plastic substrates used include LDPE (low-density polyethylene), BOPP (biaxially oriented polypropylene), OPP (oriented polypropylene), PET (polyethylene terephthalate), and HDPE (high-density polyethylene). FP may comprise either a single-layer film that uses only one film or a multi-layer structure in which two or more films are laminated with the use of adhesives. However, the use of a single-layer film does not fulfil the requirements of protection and shelf-life of consumer goods. On the other hand, different polymer layers are laminated in FP to improve the package functionality with lamination of 2 to 17 layer films using these structures, known as a multi-layer film structure (Ugduler et al., 2021; Wagner, 2016). The multi-layer films provide satisfactory results and protect the product from moisture, light, and oxygen (Veksha et al., 2020). Further, the low cost of production, ease of transportation, and increased product life are the benefits of this structure (Pongpimol et al., 2020). The structure used in multi-layer films can be a variety of materials including polymeric (thermoplastics) and non-polymeric (paper or aluminium foils) (Horodytska et al., 2018). Multi-layer films currently comprise 17% of global film production (Horodytska et al., 2018; Tartakowski, 2010). These films are mainly used in electrical appliances, food packaging (such as meat, vegetables, and cheese), fabrics, and snack foods (such as pasta, biscuits, and chips) (Pongpimol et al., 2020; Siracusa et al., 2014).

The manufacturing processes of FP generally include extrusion, printing, lamination, and slitting (Nugroho & Nugroho, 2020). In the extrusion process, the resins are melted and transformed into film layers (Morris, 2017). The printing process, also known as flexography printing, applies various colours of inks to the films (Nugroho & Nugroho, 2020). In the lamination process, adhesives, glue, and hardener are applied to bond various substrates such as plastic film, aluminium foil, and paper (He et al., 2021). Finally, the slitting process involves cutting large rolls into several smaller finished rolls according to customers' requirements (Nugroho & Nugroho, 2020).

2.5.1 Environmental issues of the flexible packaging manufacturing industry

The increasing environmental burden of the FP from its manufacturing, use, and disposal has become a challenge for governments and organizations in both developed and developing countries across the world (Kozake et al., 2021; Kumar et al., 2019). The issues are due to the use of unsustainable packaging materials such as plastics and hazardous chemicals such as solvents and adhesives in this industry (Kliopova-Galickaja & Kliaugaite, 2018; Raheem, 2013).

The review of literature highlighted that the FP industry is facing significant environmental issues arising from manufacturing operations including resin production, extrusion, printing, and lamination. The printing process in the FP is considered one of the main sources of VOCs release (He et al., 2021). The most common VOCs generated during the flexible printing process are alcohols, xylenes, aliphatic, and ketones which are commonly found in printing inks and cleaning solvents (Aydemir & Ayhan Özsoy, 2020). These get evaporated in the air during the ink drying process and cleaning of machine parts including rubber rollers, metal cylinders, and printing plates which are difficult to control. These hazardous air pollutants have substantial environmental and social impacts such as air emissions, flammability, and worker health and safety issues (Kliopova-Galickaja & Kliaugaite, 2018). Along with the printing process, the lamination process of bonding multi-layer films also generates significant amounts of VOCs through a solvent-based lamination technique (He et al., 2021; Kliopova-Galickaja & Kliaugaite, 2018). Furthermore, exposure to these solvents may have a short-term and long-term impact on human health such as breathing problems (e.g., asthma) (Aydemir & Ayhan Özsoy, 2020).

Release of air pollutants is one of the environmental issues linked with the FP manufacturing processes as resin production generates discharges of CO_2, nitrogen oxide (NO_x), airborne particulates, sulphur dioxide, and aromatic hydrocarbons (Siracusa et al., 2014). In general, resin production and extrusion processes have significant environmental issues in the form of resource depletion, global warming, and human toxicity (respiratory issues due to particulate emissions) (Siracusa et al., 2014)). Further, greenhouse gases (such as CO_2, NO_x, and carbon monoxide (CO)) are emitted during the combustion process resulting from water-heating boilers used in the flexography printing process (Kliopova-Galickaja & Kliaugaite, 2018).

Manufacturing of FP has another environmental issue in the form of natural resource depletion. For example, petroleum-based chemicals which are a non-renewable source, are used in the production of plastic pellets such as polyethylene (PE) and polypropylene (PP) (Curtzwiler et al., 2019). Research studies have also examined the loss of plastic pellets during shipping, manufacturing, and handling, which are sources of resource depletion. In this context, a study reported plastic pellet losses of 105 to 1054 tonnes during the manufacturing process in the UK (Cole & Sherrington, 2016; Ryberg et al., 2019). Similarly, a case study in a US plastic packaging company noted loss of 248,500 pounds (lb) of plastic pellets which dropped onto the production floor while loading into the equipment during a film manufacturing process (extrusion) (Cole & Sherrington, 2016). The FP processes also generate liquid waste resulting from the use of inks, adhesives, lubricants, and solvents (Mehra et al., 2017). The toxic liquid waste is produced during the printing process which is gathered in tanks and handed over to the waste management organizations (Kliopova-Galickaja & Kliaugaite, 2018).

FP has an energy footprint in the form of energy consumption (e.g., electrical energy) where a mix of energy resources such as natural gas, coal, and petroleum is used in the manufacturing processes and generating a combination of electrical and thermal energy losses (Cruz-Romero, 2008; Kliopova-Galickaja & Kliaugaite, 2018). For instance, the extrusion process primarily consumes extensive electrical energy that generates electrical and thermal energy losses (Reichel & Krause, 2016; Siracusa et al., 2014). Furthermore, there are heat energy losses in the printing process when energy is produced for the drying chamber through water-heating boilers to dry the inks (Kliopova-Galickaja & Kliaugaite, 2018). Since FP deals with a variety of materials and includes long run times, the excessive setup time in the printing process (Mehra et al., 2017) also leads to electrical and thermal energy losses during this idle time (Farrukh et al., 2022c).

FP plays an important role in food products and one of the key concerns is the size of the package. Bayus et al. (2016) examined the material consumption of family-sized packages versus individual-sized packages. The study concluded that a family-sized package consumes less material (about half per serving), which results in material conservation, energy savings, and low carbon emissions. However, a large-sized packaging may lead to food waste at the consumers' end, which is another environmental challenge (Bayus et al., 2016; Pauer et al., 2019). From this perspective, a study highlighted that 20-25% of household food waste is associated with packaging characteristics (Bayus et al., 2016). The food waste negatively affects the recyclability of FP waste due to the contaminated content (Pauer et al., 2019).

Due to the use of multi-layer film structures and decomposition challenges; FP waste is considered an uneconomic material for collection and recycling (Ahamed et al., 2020). Since there is a lack of technological advancements for separating multi-layer films such as food packaging comprising a combination of PE and PP structures, a large quantity of post-industrial and post-consumer waste is being sent to landfills (Curtzwiler et al., 2019). Thus, FP waste is one of the largest contributors to solid waste which accounts for nearly 30-35% of the municipal solid waste in developed countries (Ahamed et al., 2020; Tencati et al., 2016). In the US itself (in 2015), 238 million metric tons of plastic waste from containers and packages are sent to landfills comprising 30% of the municipal solid waste (Curtzwiler et al., 2019). In Europe, nearly 59% of plastic waste was found to be linked with FP materials (Schmidtchen et al., 2021). Similarly, the daily plastic waste per capita (grams(g)/person/day) generated in NZ is approximately 159g per person, which is much higher compared to larger populous countries such as Australia with 117g per person or Norway with only 26g per person (De Bhowmick et al., 2021).

Literature has revealed that soil pollution is another environmental issue resulting from FP post-consumer waste. A lack of collection and mismanaged municipal solid waste disposal of plastic packaging from industrial and urban areas are the reasons for soil pollution (Ahamed et al., 2021). The presence of plastic leads to infertility in the soil. Moreover, the presence of nanoparticles of plastics in the crops and plants (Li et al., 2019; Su et al., 2019) poses risks to human health by impacting the human food chain through agricultural produce. The quantities of micro and nano plastic are also found in the urban dust which could be inhaled by animals and humans leading to health hazards (Ahamed et al., 2021). Due to recycling issues with the FP waste, an increase in the illegal burning of this waste in developing countries has been observed which leads to air pollution and an increase in respiratory illness (Pongpimol et al., 2020). In addition, an open-loop method – incineration – used for managing FP waste by converting the high carbon content in plastics into CO_2 for energy production, also generates substantial amounts of GHG emissions (96 Mt) (Ahamed et al., 2021).

Another significant environmental issue of FP waste of post-consumer use is marine pollution which is entering into the oceans at increasing rates and threatening sea life (Barron & Sparks, 2020). The increase of plastic waste in developing countries including Pakistan, Bangladesh, and Vietnam has led to marine littering with negative impacts on human health, tourism, fishing industry, and marine health (Bishop et al., 2020; Pawar et al., 2016). It is estimated that approximately 8 million tonnes of plastic waste get leaked into the world's oceans equivalent to disposing one garbage truck into the ocean every minute (MacArthur, 2017), and is expected to double by 2030 (Fadeeva & Van Berkel, 2021). The recovery of these plastics from seas and rivers and management of the recovered plastic waste are significant challenges (Ferraioli et al., 2021). The most alarming impacts of marine pollution are the ingestion and suffocation through plastic debris by hundreds of marine wildlife such as turtles, whales, seabirds, and fishes limiting their ability to swim and increasing internal injuries and infections (Ahamed et al., 2021; Ryan et al., 2016). These packaging materials are fragmented into micro-plastics and nano plastics posing a life-threatening risk to marine wildlife. Furthermore, these plastics are also disrupting ecosystems due to the spread of marine bacteria and organisms (Ahamed et al., 2021). The increasing micro-plastic pollution is significantly impacting the marine environment in NZ with around 8% plastic found in NZ waste streams, which is higher than Norway (2.6%), Canada (3%), Denmark (1.6%), and Australia (7.6%) (De Bhowmick *et al.*, 2021). Table 2.1 presents an overview of the environmental issues of FP manufacturing industry from literature.

Table 2.1: An overview of environmental issues of flexible packaging manufacturing industry

Authors	**VOCs emissions**	**Energy footprint**	**GHG emissions**	**Health hazards**	**Resource depletion**	**Liquid waste**	**Solid waste**	**Landfill**	**Marine pollution**	**Soil pollution**	**Food waste**
Büsser and Jungbluth (2009)		X	X								X
Lopez et al. (2015)							X				
Bayus et al. (2016)					X						X
Horodytska et al. (2018)							X	X			
(Kliopova-Galickaja and Kliaugaite (2018)	X	X	X	X	X	X					
Koshti et al. (2018)								X	X	X	
Borman et al. (2019)								X	X		
Ahamed et al. (2020)					X				X	X	
Anchawale et al. (2020a)		X									
Anchawale et al. (2020b)	X										
Barron and Sparks (2020)									X		
Ahamed et al. (2021)					X		X	X	X	X	
Bening et al. (2021)								X			X
Ferraioli et al. (2021)									X		
He et al. (2021)	X	X	X								
Kozake et al. (2021)	X		X	X							
Schmidtchen et al. (2021)		X			X				X		

2.6 Green-lean-six sigma strategy

Green-lean-six sigma is an approach towards minimizing environmental degradation by reducing operational and environmental waste while improving the process and system capability (Banawi & Bilec, 2014; Garza-Reyes, 2015a). This approach is a combination of green manufacturing, lean manufacturing, and six sigma strategies, which are discussed next.

2.6.1 Green manufacturing

The concept of the green paradigm was initiated in 1990 as an approach to reducing the negative environmental impact of products and processes along with achieving the financial performance of an organization (Garza-Reyes, 2015a; Leme et al., 2018). Green manufacturing has been characterized in several ways such as it is clean manufacturing, environmentally conscious manufacturing, and environmentally responsible manufacturing, while environmental safety is the essence of all green concepts (Sangwan & Mittal, 2015). Green paradigm is well described as a philosophy to determine, measure, evaluate, and control environmental wastes by addressing the problems associated with products and processes (Garza-Reyes, 2015a). It is gaining importance in the manufacturing industry as it facilitates organizations to minimize their environmental impacts. It has positive outcomes in the form of conforming to regulatory requirements, meeting customers' demands for environmentally friendly products, and achieving environmental certification (Prasad et al., 2016). Green manufacturing includes various environmental initiatives in the form of green marketing, green packaging, green purchasing, green innovation, and green design (Kazancoglu et al., 2018). Thus, is also considered as part of a green supply chain (Singh et al., 2021). The core purpose of green manufacturing is to minimize environmental impacts such as hazardous wastes, air emissions, health and safety risks for people and the environment, and energy and resource conservation (Leme et al., 2018; Schmitt et al., 2021).

Organizations are undertaking various environmental initiatives as part of green manufacturing such as implementing cleaner production, life cycle management, and eco-efficiency (Leme et al., 2018; Pampanelli et al., 2014). In addition, organizations are now shifting their attention from the traditional manufacturing concepts to the circular economy (CE) concept (Kazancoglu et al., 2018). A traditional manufacturing system focuses on the linear economy aspects – take, make, and dispose – starting from extracting the raw material, then processing, and finally managing the waste and disposal activities. Conversely, CE is described as a closed loop system aiming to utilize raw material and resources in an effective manner. The objectives of CE are protecting environment, conserving resources, and bringing back resources into the manufacturing system after completing their life cycles (Gaustad et al., 2018). Green manufacturing is also regarded as a facilitator of CE along with environmental improvement and has emerged as a "strategic weapon" for organizations (Kazancoglu et al., 2018, p.1282). A good example of circularity in this perspective is use of 3R practices that assist to reutilize resources in manufacturing systems (Gaustad et al., 2018). Similarly, DFE also takes recovery and remanufacturing into consideration along with 3R practices (Ghazilla et al., 2015).

2.6.2 Lean manufacturing

Lean manufacturing, a systematic method of production, originated from the Toyota Production System and gained recognition after the book "The Machine That Changed the World" was published in 1990. The lean philosophy works on "to do more with less" and minimizes waste in almost every area of an organization (Prasad et al., 2016, p. 410). The lean paradigm can be described as a group of tools for reducing waste, adding value, and continuously improving the processes (Panwar et al., 2017). It is famous for its five principles which are define value, map value stream, make products flow, introduce pull, and improve continuously. Define value means giving importance to customers' requirements. Value stream analysis is about recognizing activities that are required to produce an item and reducing non-value-added tasks. Flow requires the effective management of products and services through all the value generating processes in the value stream without stops and delays. Pull proposes that organizations should deliver products or services when the customer requests, and continuous improvement is about consistency, reliability, and stability of the processes to bring perfection (Isack et al., 2018).

A plethora of studies emphasized the positive effect of lean manufacturing on environmental performance by saving resources and energy (Chugani et al., 2017; Dieste et al., 2019; Garza-Reyes et al., 2018). Lean paradigm offers a variety of tools that can be utilized to reduce the environmental impacts of manufacturing organizations (Alhuraish et al., 2017). These methods not only help organizations in achieving operational performance and competitive advantage but also in accomplishing environmental targets (Garza-Reyes et al., 2018). In this regard, different examples of the lean tools are: total productive maintenance (TPM), kaizen, 5S (seiri, seiton, seiso, seiketsu, shitsuke), value stream mapping (VSM), single minute exchange of die (SMED), cellular manufacturing (CM), just-in-time (JIT), visual management, and work standardization (WS) (Farias et al., 2019; Garza-Reyes et al., 2018; Ramos et al., 2018).

2.6.3 Six sigma

Six sigma strategy was first introduced by Motorola in 1987 in the manufacturing sector. The concept is based on the statistical process control (SPC) technique, to reduce process defects up to 3.4 parts per million opportunities, in which the term sigma describes variation. Six sigma not only helps in removing manufacturing defects in the production processes but also brings improvements throughout the organization (Singh & Rathi, 2018). The core objectives of six sigma are to control process variation and defect reduction (Andersson et al., 2006; Pacheco et al., 2015). Six sigma provides a systematic and structured approach of problem solving through DMAIC (Hilton & Sohal, 2012). While reducing environmental waste is not a primary objective of the six sigma, it is capable of achieving environmental performance such as reduction of air emissions, energy consumption, and wastewater through process improvement (Chugani et al., 2017; Powell et al., 2017; Sagnak & Kazancoglu, 2016). Therefore, the environmental impacts of six sigma are viewed as a "by-product" (Chugani et al., 2017, p.10). By reducing defects and through the utilization of its various tools, six sigma positively affects the objective of resource conservation, air pollution, and waste minimization (Chugani et al., 2017). The environmental aspects related to defects can be observed in the following Figure 2.1.

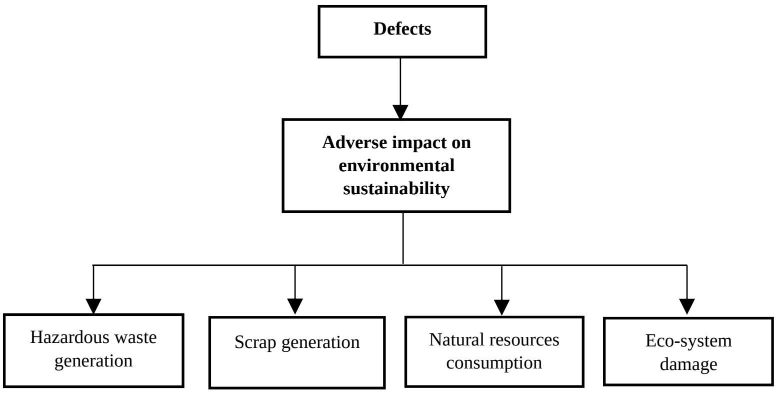

Figure 2.1: Adverse impact of defects on environmental performance, adapted from Goyal et al., (2019)

In addition, the different attributes of the green, lean, and six sigma approaches are presented in Table 2.2.

Table 2.2: A comparison of attributes of green, lean, and six sigma approaches, sourced from Kumar et al. (2016)

[redacted]

2.6.4 Limitations of individual lean, green, and six sigma strategies

Although all the three green, lean and six sigma strategies have strengths towards improving environmental performance, each of them has some limitations individually. While a green strategy includes the application of a decision support system and expert system (Garza-Reyes, 2015a), the techniques lack an effective problem-solving approach (Chan et al., 2010). Therefore, green is incapable of addressing variability issues in the process which can lead to environmental waste (Kaswan & Rathi, 2019). Further, green manufacturing has limitations regarding the strategic concerns of an organization and decision-making towards investment opportunities, for example, how to implement green practices in a manner that achieves organizational goals towards environmental performance and profitability (Nunes & Bennett, 2010). On the other hand, although lean has a positive and strong effect on the environmental impact (Chugani et al., 2017), research studies have emphasized that lean cannot fully remove the root causes of operational and environmental wastes as it lacks a systematic and scientific approach in controlling manufacturing processes (Assarlind et al., 2013; Garza-Reyes, 2015a). Furthermore, lean, individually, cannot overcome problems of defect detection and reduction in the process to address environmental concerns (Kaswan & Rathi, 2019). Similarly, six sigma alone cannot achieve optimal environmental performance since it cannot address operational inefficiencies such as lean wastes or life cycle impact assessment related to products (Zhang, 1999).

2.6.5 A combination of green-lean and lean-six sigma strategies

A review of the literature highlights various researchers who have applied green, lean, and six sigma strategies in different combinations such as green-lean (Farias et al., 2019) and lean-six sigma (De Freitas et al., 2017). The following sections present details on these combinations.

2.6.5.1 Green-lean strategy

The green-lean strategy seems to have emerged in 1996 (Farias et al., 2019; Florida, 1996). The relationship between lean and green is determined by their mutual objective of waste minimization (Garza-Reyes, 2015a). For instance, unnecessary inventory of materials, which is one of the lean wastes leading to an immoderate use of lighting, cooling, and heating (for this inventory), has an impact in the form of excessive energy consumption (green waste) (Garza-Reyes et al., 2018). Therefore, researchers have advocated that lean and green have synergies as lean addresses the minimization of wastes within the processes which has a positive green impact on environmental performance and resource conservation (Ng et al., 2015; Sagnak & Kazancoglu, 2016).

The difference between lean and green wastes is that the first is about non-value-added activities and the second is about unnecessary usage of water, energy, and natural resources (Duarte & Cruz-Machado, 2013). However, US Environmental Protection Agency (EPA) (2007) presented a relationship between lean wastes and green “mudas” after analysis in some American firms which showed the simultaneous occurrence of the environmental wastes along with the lean wastes. Furthermore, the non-value-added activities could be regarded as a segment of wastage of power and natural resources. Unnecessary movements of raw materials, work-in-process, and finished products are regarded as wastes from both lean and green perspectives in terms of power consumption, gaseous emissions, and ineffective use of resources (Carvalho et al., 2011). This synergistic relationship between lean and green not only enables environmental benefits but also reduces costs through waste minimization (Shokri & Li, 2020).

2.6.5.2 Lean-six sigma strategy

The lean-six sigma strategy was initiated in the late 1990s and early 2000s (Byrne et al., 2007; Cherrafi et al., 2016), as a result of an integration of lean and six sigma, which is well acknowledged in literature (Parmar & Desai, 2019)**.** It is defined as an operational improvement strategy to increase customer satisfaction and improve quality, cost, and speed of production (Cherrafi et al., 2016; Snee, 2010). Since waste also includes rework and scrap which are often produced as a result of process variability; therefore, lean and six sigma are also connected

(Klochkov et al., 2019). Several organizations are developing a concurrent lean six sigma approach, which integrates lean with six sigma as they contribute to the common objectives of waste minimization, continuous improvement, and customer satisfaction (Maleyeff et al., 2012; Salah et al., 2010).

2.6.5.3 Limitations of green-lean and lean-six sigma strategies

Due to the inherent limitations of the lean, green, and six sigma strategies, combinations of these strategies such as green-lean and lean-six sigma also experience limitations. In the case of green-lean, although this combination has the ability to identify wastes and environmental impacts, they usually do not present a structured problem-solving approach to waste reduction (Han et al., 2008) nor are they able to control process variation (Sagnak & Kazancoglu, 2016). Despite green and lean being closely related, they do not address the root causes of a problem, which is critical from a waste minimization aspect (Garza-Reyes, 2015a). Therefore, studies have focused on combining six sigma with lean and green to resolve the above limitations of these strategies and enhance environmental performance (Banawi & Bilec, 2014; Sagnak & Kazancoglu, 2016). On the other hand, although, LSS can enhance environmental performance, environmental waste reduction is not the primary objective of LSS. This combination also lacks the ability to address life cycle impacts and deploy environmental improvement programs whereas a green strategy can overcome this limitation by utilizing tools such as LCA and environmental management system (EMS) (Banawi & Bilec, 2014; Zhang, 1999).

2.6.6 Green-lean-six sigma strategy – An approach towards improving environmental performance

The above discussion on the individual green, lean, and six sigma strategies and their combinations highlights that the environmental performance can be improved if all three green, lean, and six sigma strategies are combined to support each other as each of these has limitations. Although the practices associated with the green, lean, and six sigma strategies have positive environmental impacts, their combined effect is more significant as compared to the individual strategies (Green et al., 2019). From this perspective, Banawi and Bilec (2014) emphasized a GLSS approach to minimize environmental damage by reducing both operational and environmental waste while improving the process and system capability. The following Figure 2.2 presents the evolution of the green-lean-six sigma strategy.

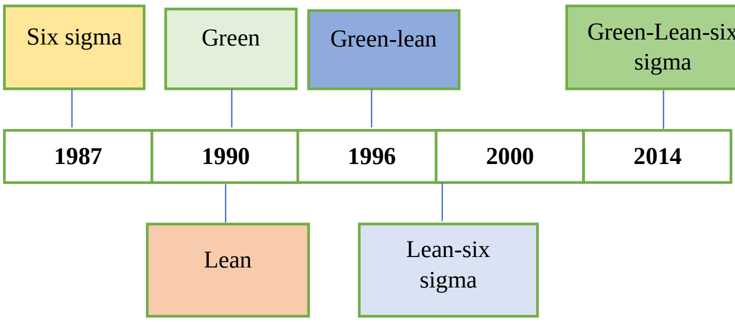

Figure 2.2: Evolution of the green-lean-six sigma strategy (Source: Author's construct)

GLSS is increasingly getting traction in emerging environmental performance discourse and managerial practice. In the current literature, these three strategies are found to have synergies in reducing waste and satisfying customers, which if combined, could be used as a significant approach for achieving environmental objectives (Kaswan & Rathi, 2020b). Waste has a different meaning within the green, lean, and six sigma strategies. In green manufacturing, waste is defined as environmental wastes and the green practices aim to remove these to fulfil customers' requirements of an environmentally safe product. Lean refers to the elimination of non-value-added activities to satisfy customers and attempts to minimize various lean wastes (Garza-Reyes, 2015a). On the other hand, six sigma enhances customer satisfaction by reducing defects (waste) which can result in a high-quality product. Although waste has different meanings in these strategies, the effect of waste is similar from a 'resource consumption' point of view, which is the ultimate impact of all these three strategies (Farrukh et al., 2020). Along with waste reduction and customer satisfaction, all three – green, lean, and six sigma – also create value such as a green strategy includes the concept of green value addition (GVA) which adds value for an organization, stakeholders, and eventually the environment (Ndubisi & Nair, 2009). Organizations implement a lean strategy to create value for customers by minimizing lead time, reducing waste, and improving the process flow (Sony & Naik, 2019). Moreover, value addition in lean manufacturing also includes providing value in products and services that reflect the environmental requirements of customers and initiatives taken by the organization (Sony & Naik, 2019). Similarly, six sigma generates value in the products and services through stable and reliable processes by reducing variation (Kazancoglu et al., 2018). According to the above discussion, a GLSS strategy can improve environmental performance by identifying environmental impacts and removing waste, with common characteristics of waste reduction, value addition, and customer satisfaction (Farrukh et al., 2020; Gaikwad & Sunnapwar, 2020a). The relationship between these three strategies and their mutual objectives are evident in Figure 2.3.

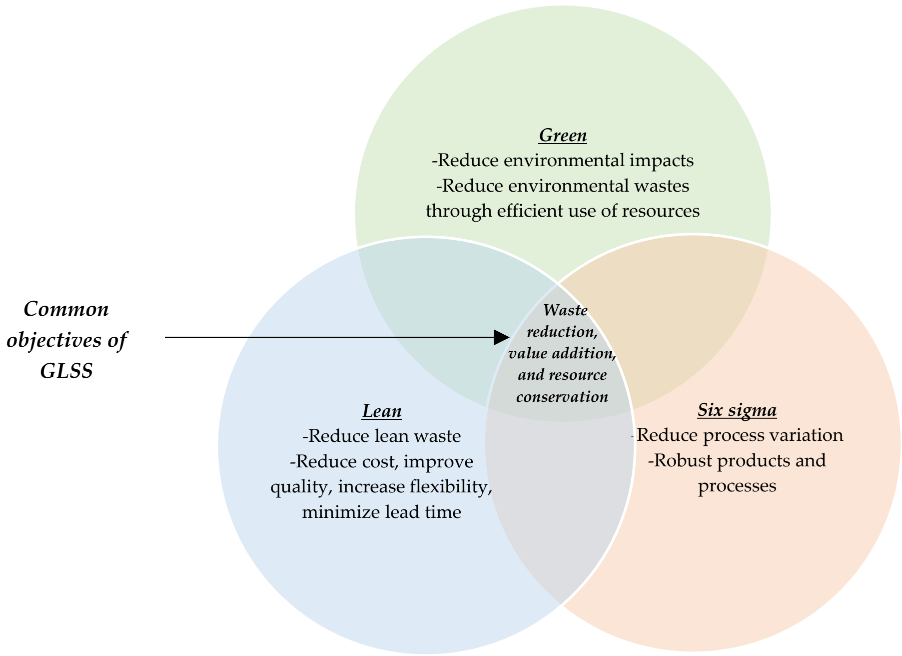

Figure 2.3: Relationship between green, lean, and six sigma strategies and common objectives of GLSS (Source: Farrukh et al., 2020)

2.7 Existing models and frameworks of GLSS

A review of literature has highlighted an increasing trend in the GLSS research that is justified by the rising concerns in organizations to achieve environmental performance. There are GLSS frameworks available in the literature including several frameworks that have not been empirically tested from an industrial or real-life perspective (Gaikwad & Sunnapwar, 2020a; Garza-Reyes, 2015a; Ruben et al., 2017). Table 2.3 presents the GLSS frameworks available in literature along with their contexts and limitations.

Table 2.3: Existing frameworks of green-lean-six sigma

Author	**Description**	**Limitation**
Banawi and Bilec (2014)	Developed a framework for the construction industry by integrating green, lean, and six sigma practices for improving the process and reducing environmental waste.	The framework requires additional verification as it is originally developed for the construction industry and entails considerable implementation time.
Cherrafi et al. (2016)	A framework has been developed by integrating green, lean, and six sigma strategies based on a 5 stage and 16 step process and validated through a research project in 4 companies.	The proposed framework may not be suitable for improving processes such as painting, chemical treatment, and metal finishing due to their complex and sensitive nature.
Kumar et al. (2016)	A hierarchical model comprising 21 barriers has been developed by utilizing the interpretive structural modelling (ISM) technique in the green-lean-six sigma product development process for the automotive industry of India.	The model has been based on experts' opinions, therefore, requires additional validation in industrial sectors.
Sagnak and Kazancoglu (2016)	The authors have proposed to integrate six sigma with green lean to overcome their limitation of lack of controlling process variation by utilizing measurement system analysis and gage control methodology. The model has been tested in a case study of a natural gas-powered boiler.	The execution of the framework has not been presented, and the study was confined to the pollution reduction project.

Aldairi et al. (2017)	The authors have proposed a framework on a knowledge-based lean six sigma maintenance system for eco-sustainable buildings.	The model requires empirical validation in industrial sectors.
Ruben et al. (2018)	The authors have identified 20 barriers regarding LSS implementation with environmental considerations and developed an ISM-based model.	The ISM model has been developed based on experts' opinions. Additional validation through industrial application and case studies is needed.
Caiado et al. (2018)	The authors have developed a GLSS framework for service organizations based on SLR.	The framework was developed for the service industry and requires a practical application and statistical validation.
Mishra (2018)	The authors have proposed a GLSS implementation framework based on the critical success factors.	The GLSS implementation framework has not been validated through industrial application. Further, the relationship between CSFs needs to be explored using other modelling techniques.
Sreedharan et al. (2018)	The authors have developed a GLSS model of the green supply chain for the public sector. The framework comprises 3 stages with a set of 17 activities.	The proposed framework has not been tested in the industrial sector and was developed only for public sector organizations. Moreover, the framework has not addressed the green-lean wastes.
Kaswan and Rathi (2019b)	The authors have developed a GLSS enablers model through interpretive structural modelling.	The model has been developed based on experts' opinions, therefore, requires additional validation in industrial sectors.
Mishra et al. (2019)	The authors have developed a sustainable value stream mapping framework through simulation modelling by ARENA to evaluate the bonnet manufacturing process from lean and green perspectives. They have compared the current VSM and future VSM of the process which resulted in dramatic operational and environmental improvements.	A limitation of the study was that a single case study has been conducted to validate the model and mainly lean tools are addressed in the study.
Gaikwad and Sunnapwar (2020a)	The authors have conducted an SLR and presented a framework for Indian manufacturing industries.	The framework requires empirical validation in industrial sectors.
Shokri and Li (2020)	The authors have proposed a hybrid approach of green LSS projects and developed a mathematical model to facilitate decision-making under LSS projects by which the final outputs can also be environmentally friendly. The volume of production and final price of products for consumers are characterized as "mediating factors" to balance the LSS projects' operational outputs and environmental performance.	Empirical data and case studies are needed for validation by utilizing the analytical model. Moreover, the factors such as price, volume, and energy should also be considered as indicators in the "sustain" stage of the DMAIC cycle.

2.8 Green-lean-six sigma drivers

GLSS drivers include several internal and external drivers that propel an organization to adopt green-lean-six sigma enablers (Gaikwad & Sunnapwar, 2020a). A review of literature has highlighted a lack of studies investigating the reasons behind the implementation of a GLSS strategy, though a few researchers have emphasized both internal and external GLSS drivers for motivating organizations to initiate environmentally responsible practices (Cherrafi et al., 2017; Gaikwad & Sunnapwar, 2020a). Literature reveals that the internal drivers are described as either organizational or operational drivers (Nair et al., 2021; Walker et al., 2008). The external drivers, on the other hand, are defined as drivers set by external agencies such as governments, trade unions, United Nations (UN), European Union (EU), and clients/customers that encourage companies to adopt operational and environmental practices (Darko et al., 2017; Zhang et al., 2019). Essentially, the internal and external drivers can be a prerequisite to each other (Kumar et al., 2019).

Among the internal drivers, an increasing cost of raw materials and resource depletion issues are the operational drivers that can encourage organizations to streamline their processes to meet environmental performance objectives (Diaz-Elsayed et al., 2013; Gaikwad & Sunnapwar, 2020a). Costa et al. (2018) have determined operational drivers in the food industry such as cost reduction, waste reduction, process variation reduction, lead time reduction, defect reduction, and value addition. Garza-Reyes (2015a) and Powell et al. (2017) have emphasized waste reduction and process efficiency as the major operational reasons for GLSS adoption. In a similar vein, Cherrafi et al. (2017) have emphasized profitability and process improvement as operational drivers for GLSS adoption. A recent study in a cookware manufacturing company has determined the reduction of hazardous waste, machine setup time, defective products, and unsafe incidents as the internal drivers (Tiwari et al., 2020). Similarly, the availability of skilled workers, training of employees, and following standard operating procedures (SOPs) are emphasized as key organizational drivers in manufacturing organizations (Sarwar et al., 2019). Caldera et al. (2018) have identified two organizational drivers, namely process streamlining and a company's quest for environmental performance. Additionally, improving financial performance and promoting a continuous improvement culture (Chaplin & O'Rourke, 2018; Parmar & Desai, 2019) are the organizational drivers prompting organizations to execute GLSS practices.

External drivers are generally categorized as shareholders' concerns, customers' requirements, competitive environment, environmental regulations, stakeholders' influence, and social pressure (Cherrafi et al., 2017; Darko et al., 2017; Oelze et al., 2016; Sajjad et al., 2020). Several research studies have recognized customer pressure as an influential factor in adopting environmental management practices (Famiyeh et al., 2018; Mittal & Sangwan, 2015). Government regulations including current and future legislations pressurize organizations to adopt environmental practices (Gandhi et al., 2018; Sajjad et al., 2015; Zhang et al., 2019). Additionally, competitors influence an organization's manufacturing strategy as they set manufacturing standards and promote the adoption of environmental practices showcasing their strong capabilities of green innovation (Walker et al., 2008). Social pressure also drives firms to consider environmental initiatives (Fargani et al., 2016; Mittal & Sangwan, 2014) driven by the public, NGOs, and the media (Liu et al., 2021; Oelze et al., 2016). Tiwari et al. (2020) have determined external drivers as customer satisfaction, environmental regulation compliance, and employee satisfaction. One study conducted in a food company identified "an automatic escalation of the landfill tax" as the key external driver in a landfill reduction project (Chaplin & O'Rourke, 2018, p.13). Similarly, another study in Chinese manufacturing organizations identified the key drivers as corporate social responsibility, improving company image, and fulfilling customers' requirements for environmentally friendly products (Garza-Reyes et al., 2018). Caldera et al. (2018) have identified several drivers, namely customers' requirements, community expectations, competitors' strategies, and environmental legislative demands. Table 2.4 presents internal and external GLSS drivers derived from literature.

Table 2.4: Green-lean-six sigma drivers

GLSS drivers	Categories	Sub-categories	References
Internal drivers	Operational drivers	Cost reduction	(Diaz-Elsayed et al., 2013; Gaikwad & Sunnapwar, 2020a)
		Process control	(Garza-Reyes, 2015a; Powell et al., 2017)
		Waste reduction	(Costa et al., 2018; Tiwari et al., 2020)
	Organizational drivers	Continuous improvement	(Chaplin & O'Rourke, 2018; Parmar & Desai, 2019)
		Environmental responsibility	(Caldera et al., 2018)
External drivers	Regulatory drivers	Environmental regulations	(Gandhi et al., 2018; Sajjad et al. 2015; Zhang et al., 2019)
	Society-oriented drivers	Public pressure	(Liu et al., 2021; Oelze et al., 2016)
	Market-oriented drivers	Customer pressure	(Famiyeh et al., 2018; Mittal & Sangwan, 2015)
		Company image	(Caldera et al., 2018; Garza-Reyes et al., 2018)
		Competitor pressure	(Caldera et al., 2018)

2.9 Green-lean-six sigma enablers and environmental outcomes

GLSS enablers include a mix of green, lean, and six sigma tools and practices that help in minimizing environmental waste and maximizing resource conservation (Kaswan & Rathi, 2020a). Several studies have highlighted the use of GLSS enablers for reducing air emissions, minimizing hazardous waste, conserving water, energy, and other resources, and increasing environmental safety (Al-Sheyadi et al., 2019; Cherrafi et al., 2016; Sagnak & Kazancoglu, 2016). Banawi and Bilec (2014) found the use of VSM, LCA, cause-effect analysis (CA), and Pareto diagram in three steps namely: define and measure, (2) analyze and improve, and (3) control to address air emissions and toxic wastes in the US construction industry. The study emphasized that material waste from the construction industry has a significant environmental impact in the form of greenhouse gases and toxic wastes.

Cherrafi et al. (2016) analyzed the effects of GLSS enablers on environmental performance in a study performed in Morocco investigating four industrial sectors: agri-food, textile, tannery, and hotel. The authors highlighted the use of 5S (seiri, seiton, seiso, seiketsu, shitsuke), single SMED, kaizen, VSM, just-in-time (JIT), cellular manufacturing (CM), TPM, visual management (VM), WS, gemba walk (GW), 5whys, SPC, Pareto diagram, CA, and supplier-input-process-output-control (SIPOC). These enablers were used to address environmental issues such as energy, water, and material conservation, waste reduction, risk assessment, workplace safety, and cost reduction. Similarly, another study used a DMAIC framework in an open cast mine industry by following five principles of the lean thinking cycle for reducing graphite and pollution levels (Sony & Naik, 2019). The GLSS enablers in this study were VSM, multi-voting system, takt time, lean mudas, WS, discrete event simulation, Pareto diagram, CA, 5whys, bottleneck analysis, and SPC. In another study, Mishra et al. (2019) researched a bonnet manufacturing organization in India to evaluate the manufacturing process through simulation modelling. The authors compared the current and future state VSM of the process that resulted in dramatic environmental improvements such as reducing carbon footprint, energy consumption, air acidification, and water eutrophication. Various enablers in this study were VSM, failure mode effect analysis (FMEA), 5S, poke yoke, CA, JIT, kaizen, overall equipment effectiveness (OEE), and 3R. Table 2.5 presents an overview of the GLSS enablers identified in the literature review.

Table 2.5: An overview of green-lean-six sigma enablers

GLSS enablers	Description	References
Life cycle analysis	Measures environmental impacts of products or processes such as air emissions, toxic wastes, effluents, and solid wastes over their whole life.	(Banawi & Bilec, 2014; Caiado et al.,2019; Ruben et al., 2017; Tasdemir & Gazo, 2019)
Environmental management system	Develops guidelines with a holistic approach towards managing environmental issues arising from manufacturing processes.	(Antony et al., 2018; Habidin & Yusof, 2012; Gaikwad & Sunnapwar, 2020a)
3R	Efficient utilization of resources including water, energy, and material during manufacturing operations.	(Antony et al., 2018; Caiado et al., 2019; Chugani et al., 2017; Gaikwad & Sunnapwar, 2020a)
Design for environment	Considers all environmental aspects of a product (from cradle-to-cradle) including end-of-life in the design process to minimize environmental wastes.	(Gaikwad & Sunnapwar 2020a; Garza-Reyes, 2015a; Ruben et al., 2017)
Kaizen	Helps towards continuous improvement by involving everyone in the organization.	(Cherrafi et al., 2016; Mishra et al., 2019; Tiwari et al., 2020)
Value stream mapping	A systematic procedure of mapping the manufacturing operations of a product to show any discrepancies within the processes.	(Bhat et al., 2020; Gholami et al., 2020; Ratnayake & Chaudry, 2017; Tasdemir & Gazo, 2019)
5S	A house-keeping practice for improving the work environment that helps in the identification of wastes including effluent discharges and chemical spills.	(Fatemi & Franchetti, 2016; Klochkov et al., 2019; Ruben et al., 2017; Tiwari et al., 2020)
Work standardization	A set of standard operating procedures comprising guidelines and methods for operations such as process activities, sequence, and control.	(Bhat et al. 2020, Cherrafi et al. 2016; Powell et al., 2017; Tasdemir & Gazo, 2019)
5 Whys	A brainstorming tool to discover the root causes of a problem by asking why five times to an issue.	(Ruben et al., 2017; Sony & Naik, 2019; Tasdemir & Gazo, 2019; Tiwari et al., 2020)
Failure mode effect analysis	A tool for identifying potential failures and their effects during the design of a product and process.	(Aldairi et al., 2017; Cherrafi et al., 2016; Mishra et al., 2019; Tiwari et al., 2020)
SIPOC	Provides an overall picture of the process by defining the characteristics of a supplier, input, process, output, and control.	(Aldairi et al., 2017; Bhat et al., 2020; Tasdemir & Gazo, 2019; Wang et al., 2019)
Cause-effect analysis	Highlights possible and potential causes against a problem and classifies solutions into useful categories.	(Cherrafi et al., 2016; Fatemi & Franchetti, 2016; Powell et al., 2017; Sony & Naik, 2019)
Process capability analysis	Used as a measure of performance to analyze the ability of a process to meet customer specifications of a product.	(Bhat et al., 2020; Tasdemir & Gazo, 2019; Wang et al., 2019)
Pareto diagram	Analyzes results of a problem in the form of a histogram according to the frequency of occurrence identifying major issues using 80-20 rule.	(Cherrafi et al., 2016; Ruben et al., 2017; Sony & Naik, 2019; Tasdemir & Gazo, 2019; Tiwari et al., 2020)
SPC	Helps in measuring, controlling, and minimizing variation in the manufacturing processes.	(Aldairi et al., 2017; Gholami et al., 2020; Powell et al., 2017; Sony & Naik, 2019)
DMAIC	A disciplined and structured approach to problem solving.	(Antony et al., 2018; Bhat et al., 2020; Erdil et al., 2018; Gholami et al., 2020; Marrucci et al., 2020; Wang et al., 2019)

A few research studies have categorized the above GLSS enablers related to environmental performance/outcomes' criteria such as waste and emission reduction, resource conservation, and environmental safety and compliance (Chugani et al., 2017; Farias et al., 2019; Farrukh et al., 2021a). Waste and emission reduction emphasizes the process waste including reworks, defects, rejects, overproduction and environmental waste focusing on wastewater, energy consumption, solid waste, GHG emissions, VOC emissions, and airborne particulate (Chugani et al., 2017; Farias et al., 2019; Galeazzo et al., 2014; Ng et al., 2015). Various studies have revealed the use of GLSS enablers such as 5S, 5whys, CA, process capability analysis (PCA) cost-benefit analysis (CBA), DFE, DMAIC, DOE, EMS, FMEA, GW, kaizen, LCA, Pareto diagram, poke-yoke, project charter, SPC, TPM, time motion study, VM, and VSM to minimize the waste and emission reduction (Ahmed et al., 2021; Besseris, 2011; Gholami et al., 2020; Marrucci et al., 2020; Tiwari et al., 2020; Powell et al., 2017; Sony & Naik, 2019). Similarly, resource conservation emphasizes less use of energy, water, raw materials, hazardous chemicals, and more resource recycling (Chugani et al., 2017; Farias et al., 2019; Farrukh et al., 2021a). Research studies have highlighted use of various GLSS enablers to conserve resources such as 3R, 5S, 5Whys, CA, DOE, DFE, DMAIC, EMS, FMEA, GW, kaizen, LCA, PDCA (plan-do-check act), Pareto diagram, process mapping, SIPOC, SPC, VM, and WS (Ruben et al., 2017; Chaplin & O'Rourke, 2018; Kendrick et al., 2017; Marrucci et al., 2020). In addition, environmental safety and compliance emphasizes decrease in environmental fines and penalties, sound environmental decision-making, future orientation, and employees' and workplace safety (Farrukh et al., 2021a). Various GLSS enablers have been used in these contexts such as 5S, 5whys, CA, CBA, CM, DMAIC, EMS process mapping, FMEA, kaizen, LCA, PDCA, Pareto diagram, poke-yoke, SIPOC, SPC, TPM, VM, VSM, and WS (Cherrafi et al., 2016; Kazancoglu et al., 2018; Tasdemir & Gazo, 2019; Tiwari et al., 2020). Table 2.6 presents the GLSS enablers and environmental outcomes based on literature.

Table 2.6: Green-lean-six sigma enablers and environmental outcomes

GLSS enablers	Environmental outcomes categories	Sub-categories	References
5S, 5whys, CA, CM, CBA, DFE, DMAIC, DOE, EMS, FMEA, GW, kaizen, LCA, Pareto diagram, poke-yoke, project charter, PCA, process mapping, SIPOC, SPC, TPM, time motion study, VM, VSM, WS	Waste and emission reduction	• Air emission and carbon footprint reduction • Process waste reduction	(Besseris 2011; Gholami et al., 2020; Marrucci et al., 2020; Powell et al., 2017; Sony & Naik, 2019; Tiwari et al., 2020)
3R, 5S, 5Whys, CA, CM, CBA, DOE, DFE, DMAIC, EMS, FMEA, GW, kaizen, LCA, PCA, Pareto diagram, process mapping, project charter, poke-yoke, SIPOC, SPC, time motion study, VM, WS	Resource conservation and recycling	• Less use of energy, water, and raw material • Increase in recycling • Less use of hazardous materials	(Chaplin and O'Rourke, 2018; Kendrick et al., 2017; Marrucci et al., 2020; Ruben et al., 2017)
5S, 5whys, CA, CBA, CM, DOE, DMAIC, EMS process mapping, FMEA, GW, kaizen, LCA, PCA, Pareto diagram, poke-yoke, project charter, SIPOC, SPC, TPM, VM, VSM, WS	Environmental safety and compliance	• Decrease in environmental fines and penalties • Sound environmental decision-making • Future orientation • Improve employee and workplace safety	(Cherrafi et al., 2016; Kazancoglu et al., 2018; Tasdemir & Gazo, 2019; Tiwari et al., 2020)

2.10 Critical success factors for implementing green-lean-six sigma to achieve environmental outcomes

While the GLSS strategy can reduce both the operational and environmental wastes and improve environmental performance, the implementation of GLSS enablers could face some challenges such as lack of strategic focus, lack of external cooperation, and lack of human resource management (Kumar et al., 2016; Sreedharan & Raju, 2018; Hussain et al., 2019). Therefore, there is a need to overcome these challenges by determining factors responsible for the success of this strategy (Mishra, 2018). A review of literature has revealed various critical factors for the successful execution of GLSS enablers such as leadership support, resource allocation, adequate government policies, customer and supplier relations, and technological infrastructure (Caiado et al., 2019; Cherrafi et al., 2017; Kaswan & Rathi, 2019; Powell et al., 2017). In addition, these CSFs have been divided into categories of strategic, operational, human resource, and external stakeholder-related factors (Costa et al., 2018; Parmar & Desai, 2020; Singh et al., 2021).

Strategic factors include leadership commitment and involvement, resource allocation, organizational infrastructure, culture and communication, reward and incentives, and linking GLSS to business strategy (Parmar & Desai, 2020; Raval et al., 2018; Singh et al., 2021). The leadership style, support, and motivation from top management ensure effective implementation and culture of environmental practices (Dubey et al., 2015; Caldera et al., 2019). The role of executives is significant in an organization towards environmental improvement initiatives. The commitment should be depicted from the physical and enthusiastic involvement by high level management (Costa et al., 2019). Moreover, clear communication of organizational vision, encouragement of empowerment, and trust from the top management enhance employee motivation and morale (Costa et al., 2019; Larteb et al., 2015). In addition, rewards and incentives for employees are recognized as a crucial factor for GLSS implementation as linking rewards with GLSS execution can attract and motivate employees to take interest in environmental initiatives (Gandhi et al., 2018; Yadav & Desai, 2017).

Various researchers have highlighted resource allocation as a CSF of GLSS strategy according to which the management must allocate sufficient resources such as financial resources, environmental and LSS consultants, and materials to achieve the environmental goals (Anass et al., 2016; Pandey et al., 2018; Yadav & Desai, 2017). Green manufacturing activities require heavy investments; therefore, the availability of financial resources is crucial for its implementation (Caldera et al., 2019). Financial resources are equally important for the execution of lean practices (Yadav & Desai 2017). Lean implementation also requires the services of lean experts, which incur a cost to an organization. Similarly, large investments are also needed when organizations change their traditional manufacturing layout to cellular manufacturing to improve the workflow (Dora et al., 2015). The same is the case with the six sigma approach as six sigma projects are expensive and time consuming (Kumar et al., 2016). Further, these projects require strong analytical and project management skills to successfully implement their techniques. Therefore, financial support is essential to manage six sigma practices and the training of employees (Arcidiacono et al., 2016).

Operational factors include performance measurement system, role of innovation and technology, and project management approach (Costa et al., 2018; Kaswan & Rathi, 2019; Raval et al., 2018). Performance measures of a strategy indicate the previous and existing situation of an organization. These metrics assist management in strategic decision-making by highlighting the areas for improvement (Hon, 2005). An appropriate environmental performance measurement system is necessary for assessing resource utilization and environmental wastes (Masri & Jaaron, 2017).

The role of innovation and information technology (IT) enables an organization to effectively implement a GLSS strategy. Technological advancements play a considerable role such as in renewable energy, recycling, and waste management systems (Orji, 2019). With the emergence of Industry 4.0 infrastructure, information technology facilitates green manufacturing in new ways, for example, environmental data is utilized to develop green policies in manufacturing firms. Similarly, with the assistance of cyber physical system (CPS) and Internet of things

(IoT), energy managers can monitor and analyze the performance of their associated operations and environmental measures. Further, radio frequency identification (RFID) tag facilitates suppliers to evaluate their performance in terms of lead times, quality, and environmental conformance to requirements (Jabbour et al., 2018). A research study emphasized the benefit of using RFID technology in logistics to reduce pollution by minimizing excessive transportation (Dhingra et al., 2014).

While lean practices are easily applied in manufacturing organizations, the IT structure can handle a variety of data and respond to changing market conditions. Nevertheless, innovation and IT is considered as a significant factor for enhancing the effectiveness of lean practices and assisting in achieving leanness in an organization (Sartal et al., 2017). Customer participation gets enhanced and is more interactive by using 3D printing and virtual engineering for the design of a product (Kamble et al., 2018). In addition, manufacturing organizations create a large amount of data through processes carried out by various machines, sensors, and other electrical equipment. This data is useful for firms in improving operations, effective resource utilization and environmental performance. Using DOE in six sigma projects can generate valuable data through IoT and interconnected devices which can be utilized for improvements and effective decision-making for environmental performance. In this regard, big data analytics play an important role in solving problems addressed by six sigma projects by utilizing different techniques such as text mining, machine learning, and artificial neural networks (Dogan & Gurcan, 2018). As six sigma utilizes statistical methods which are descriptive and exploratory, integrating data analytics in six sigma projects for environmental performance can help six sigma experts and professionals in analyzing possible green outcomes (Gupta et al., 2019).

Appropriate project selection and prioritization is another operational CSF for the successful execution of GLSS enablers. Organizations should select such projects which can improve the environmental performance along with operational ones. Further, GLSS projects should be aligned with the overall objective and aims of an organization and should address the stakeholders’ concerns. In addition, cross-functional project teams should be developed with competent employees (Anass et al., 2016; Mishra, 2018; Pandey et al., 2018; Singh et al., 2021).

Human resource factors are linked with an organization’s employees which include employee training and education, employee involvement and empowerment, and teamwork (Parmar & Desai, 2020; Singh et al., 2021). Employees are a valuable resource for an organization and their participation in organizational activities is crucial for its success (Alhuraish et al., 2017). Their involvement in organizational improvement should be a part of their natural behaviors (Costa et al., 2019). It is necessary that all the employees from top to bottom levels must be involved in the implementation of GLSS enablers. For example, lean practices are oriented towards the daily habits of employees such as 5S (Alhuraish et al., 2017). According to Pampanelli et al. (2014), kaizen is an essential practice of lean manufacturing for continuous improvement. This practice works on two principles: (1) creating an environment to address the organizational problems and (2) involving everyone in the organization. Several studies have identified kaizen as a major lean practice to improve environmental performance (Chiarini, 2014; Farias et al., 2019; Garza-Reyes et al., 2018).

Employee training and knowledge are crucial for gaining environmental results and effective resource utilization (Cherrafi et al., 2016; Parmar & Desai, 2020). Training includes workshops, seminars, and different programs to foster green knowledge in employees. The purpose of these programs is to create awareness regarding various aspects of environmental performance such as energy and resource conservation, waste treatment, and engraining green habits in individuals. Moreover, organizations should initiate environmental improvement projects to involve their employees in environmental activities. The concept of job rotation assists in this task and improves employees' environmental skills (Masri & Jaaron, 2017).

External stakeholders also play a vital role in the successful execution of GLSS implementation which includes customers, suppliers, and government (Cherrafi et al., 2016; Ershadi et al., 2021; Pampanelli et al., 2014). Customer relations would depend on the importance given to customers' awareness of the product characteristics which are customer requirements, customer participation, and customer suggestions for further improvement (Garza-Reyes et al. 2018). Long term relationships with customers are dependent on the ways an organization responds to customers' expectations, queries, and complaints to satisfy them (Iranmanesh et al., 2019). As customers are getting conscious of environmental issues, they are willing to pay more for environmentally friendly products (Pekovic et al., 2016). Therefore, an organization's environmental initiatives are mainly concerned with its customers' requirements and suggestions (Grekova et al., 2016). Similarly, relations with customers have a significant impact on their returning of products, recycling, and treatment of waste disposal as this depends on the customers' participation (Lai et al., 2015). The organizations share their environmental information with their customers in the form of eco-labelling and environmental certifications so that they can be engaged in environmental activities (Lai et al., 2015). Moreover, communicating this information has a positive impact in the form of a prompt response to customers, better services, and cost reduction. A famous outfit company, Zara, promoted its environmental success of energy conservation (i.e., minimizing 20% energy usage at its outlets) to customers and stakeholders through their advertisements. As a result, it not only enhanced the company image towards green activities and increased market share but also created awareness in customers to participate in the environmental activities (Lai et al., 2015).

Supplier collaboration plays a significant role in improving an organization's environmental performance. Strong supplier relationships can be established by communicating and understanding the consequences of environmental aspects (Dubey et al., 2015). Suppliers should not only be conscious about the environmental impacts of their processes but must be careful regarding the environmental needs of the manufacturers. An organization should involve its suppliers in the planning and design stages of products and processes to minimize the environmental impacts. For example, 3R focuses on the standardization and modularity in the product characteristics to achieve its objective of reducing, recycling, and reusing materials, thereby making it crucial to involve suppliers in the product design stage (Lai et al., 2015). Similarly, a strong relationship with suppliers is also necessary for the successful implementation of lean practices such as JIT deliveries which are dependent on an effective supplier relationship (Garza-Reyes et al., 2018). Several researchers have emphasized the importance of supplier relations for the successful execution of six sigma projects (Alhuraish et al., 2017; Dubey et al., 2015). Effective implementation of six sigma projects depends on the minimal variations in supplier's processes to provide quality raw materials to manufacturing firms (Julien & Holmshaw, 2012). Further, the success of the six sigma strategy requires the suppliers' involvement at the design stage of the DFSS (design for six sigma) technique to reduce the errors and defects in product design (Kwak & Anbari, 2006).

Government support and policies also play a critical role in the implementation of GLSS. In this regard, government needs to introduce effective environmental legislations, ensure their implementation, and provide adequate infrastructure for waste management and financial support to manufacturing firms for adopting environmental initiatives (Kong et al., 2016; Hussain et al., 2019). For example, the technical support and financial assistance provided by the local Chinese government to electric vehicle (green product) manufacturers is an attempt towards encouraging environmental initiatives (Yang et al., 2015). Similarly, governments in developed countries such as North America, the United Kingdom, Australia, New Zealand, and several European countries have either banned single-use of plastic or introduced levies on plastic bag consumption (Camilleri, 2020; Wurm et al., 2020; Xanthos & Walker, 2017). The following Table 2.7 presents the critical success factors of a GLSS strategy based on literature.

Table 2.7: Critical success factors of a GLSS strategy

Critical success factors of GLSS	Sub-categories	References
Strategic factors	• Leadership commitment	(Cherrafi et al., 2016; Ershadi et al., 2021; Pampanelli et al., 2014)
	• Resource allocation	(Mishra, 2018)
	• Communication	(Caiado et al. 2018; Erdil et al., 2018; Niñerola et al., 2020; Powell et al., 2017)
	• Reward system	(Gandhi et al., 2018; Ruben et al., 2017; Ruben et al., 2018; Yadav & Desai, 2017)
	• Linking GLSS to business strategy	(Kaswan & Rathi, 2019; Yadav & Desai, 2017)
Operational factors	• Performance measurement	(Kaswan & Rathi 2019; Ruben et al. 2017)
	• Project management	(Mishra, 2018; Ruben et al., 2017)
	• Innovation and technology infrastructure	(Caiado et al., 2019)
Human resource factors	• Employee training and education	(Caiado et al. 2018; Cherrafi et al., 2016; Furukawa et al. 2017; Ruben et al. 2017)
	• Teamwork	(Kaswan & Rathi, 2019)
	• Employee involvement and empowerment	(Caiado et al., 2019; Caiado et al., 2018; Cherrafi et al., 2016; Marrucci et al., 2020; Pampanelli et al., 2014)
External stakeholder-related factors	• Customer and supplier relations	(Cherrafi et al., 2016; Ershadi et al., 2021; Pampanelli et al., 2014)
	• Government support and policies	(Cherrafi et al., 2016; Kong et al., 2016; Parmar & Desai, 2020)

To summarize, there is a lack of research investigating the above GLSS aspects including drivers, enablers, environmental outcomes, and CSFs in a holistic fashion and developing a model comprising these aspects. Additionally, prior studies mainly examined these aspects of a GLSS strategy using a quantitative research methodology such as a survey approach ignoring the significance of a qualitative research design that could provide in-depth information on the GLSS strategy. Further, the theoretical alignment of the GLSS drivers, enablers, environmental outcomes, and CSFs with the organizational theories is largely missing in the literature. A review of literature also reveals that within the manufacturing sector, several studies examined the GLSS approach in the discrete manufacturing industry (Mishra et al., 2019; Ruben et al., 2017; Wang et al., 2019), however, an investigation of a GLSS approach in the continuous process industry is lacking (Parmar & Desai 2019; Powell et al., 2017), especially in the FP manufacturing industry which is highly detrimental to the environment.

2.11 Theoretical model development

The application of organizational theory to the natural environment (Etzion, 2007) is gaining popularity and is considered significant in understanding an organization's environmental performance (Sarkis et al., 2011). While the theoretical alignment has a central role in knowledge creation (McAdam & Hazlett, 2010), extant GLSS literature has overlooked this important aspect for advancing academic knowledge. Against this background, the NRBV, ITBV, and ICBV have been utilized to better understand the GLSS approach for achieving environmental performance. The next sections present the justification for selecting the NRBV, ITBV, and ICBV, explain these organizational theories, and their link with the GLSS strategy.

2.11.1 Justification for selecting NRBV, ITBV, and ICBV theories

This study uses multiple organizational theories (NRBV, ITBV, and ICBV) to investigate the GLSS approach to achieving environmental performance (Shaharudin et al., 2019; Yusoff et al., 2019). The rationale behind using these theories is that this study examines a combination of three strategies – green, lean, and six sigma which is a complex research phenomenon. Further, the study aims to explore different aspects of a GLSS approach including drivers, enablers, environmental outcomes, and CSFs which are difficult to examine using a single theoretical lens. Since this study presents findings on the GLSS strategy from NZ and PK; therefore, the use of ITBV is justified to understand the institutional forces and mechanisms for the GLSS adoption in manufacturing organizations in developed and developing countries as the external pressures (such as regulatory frameworks and social norms) for environmental performance may vary across countries (Sarkis et al., 2011; Ye et al., 2021).

In addition, the organizations are adopting the GLSS strategy to address the increasing environmental issues and gain a competitive advantage in terms of lowering cost, green product designs, and long-term environmental commitment by implementing different GLSS enablers (Cherrafi et al., 2017; Kaswan & Rathi 2020a). Moreover, this study is conducted in the FP manufacturing organizations which are highly energy-intensive and largely rely on the use of natural resources such as petroleum-based raw materials (Ahamed et al., 2021; Curtzwiler et al., 20119). From these perspectives, the GLSS strategy can comprehend the pollution prevention, product stewardship, and sustainable development strategic capabilities of an organization which justifies the use of NRBV theory in this study. While the key resources in NRBV including continuous improvement, shared vision, and stakeholder integration can link with the CSFs such as the role of internal and external stakeholders, performance measurement, innovation and technology, and leadership commitment (Hart et al., 2010), it may not address other significant factors identified in the GLSS literature such as reward and recognition, project management, and linking GLSS to business strategy. Thereby, covering all the possible dimensions of the CSFs of a GLSS strategy rationalizes the use of ICBV in this study addressing the green structural, green human, and green relational capital in an organization for environmental performance (Astuti & Datrini, 2021; Mansoor et al., 2021; Yong et al., 2019; Yusoff et al., 2019). Table 2.8 presents the justification of the selected organizational theories for this study.

Table 2.8: Justifications for selecting organizational theories

	Organizational theories		
	Institutional theory-based view	***Natural resource-based view***	***Intellectual capital-based view***
Objective	ITBV investigates the role of external pressures in implementing an organizational strategy/action by identifying the coercive, normative, and mimetic isomorphic drivers (DiMaggio & Powell, 1983).	NRBV is an extension of the resource-based view that defines the relationship between an organization and the natural environment. NRBV includes three strategic capabilities including pollution prevention, product stewardship, and sustainable development (Hart et al., 2010).	ICBV stems from the RBV that specifically considers three organizational capitals – structural, human, and relational which are related to an organization's competitive advantage (Astuti & Datrini, 2021; Yong et al., 2019).
Application in environmental performance-related studies	This theory is widely used in several empirical research studies for examining the external forces in different manufacturing industries such as automobile, textile, leather, and pharmaceutical (e.g., Kalyar et al., 2019; Saeed et al., 2018).	This theory is used in empirical research studies on environmental performance in different industries such as automobile and healthcare equipment manufacturing (e.g., Cristina De Stefano et al., 2016; Gabriel et al., 2018).	This theory is emerging in environmental performance-related studies and has been used in a few empirical studies conducted in manufacturing industries such as electronics (e.g., Chen, 2007).
Research methods	Both qualitative and quantitative methods are used including interviews and surveys.	Both qualitative and quantitative methods are used including interviews and surveys.	Quantitative methods are mostly used including surveys.
Relevance with this study	It is used to explore the external drivers of the GLSS strategy in manufacturing firms in a developed and developing country context.	It assisted in examining the internal drivers of a GLSS strategy and identifying the GLSS enablers and practices for achieving the environmental performance of manufacturing organizations in a developed and developing country context.	It enabled the investigation of the CSFs of a GLSS strategy in a comprehensive manner for improving the environmental performance of manufacturing firms in a developed and developing country context.

2.11.2 Natural resource-based view

The NRBV argues that an organization could gain competitive advantage through three strategic capabilities of pollution prevention, product stewardship, and sustainable development (Barney, 1991; Cristina De Stefano et al., 2016; King & Lenox, 2002). Each of these strategies has different environmental forces, building upon different key resources. The key driving force for pollution prevention includes the reduction of waste and emissions by reducing inputs and simplifying processes (Gabriel et al., 2018; Hart et al., 2010). Pollution prevention strategy seeks to reduce waste and emissions from the manufacturing processes rather than cleaning up at the end of pipe resulting in lowering the cost. Removal of pollutants and waste from the production operations can result in minimizing cost by reducing the number (and quantity) of inputs required, simplifying the processes, and reducing the compliance cost (Gabriel et al., 2018; Hart et al., 2010).

Product stewardship strategy extends the scope of pollution prevention by reducing the life cycle impacts and costs related to products and processes which can be achieved by incorporating the 'voice of the environment' (Hart et al., 2010, p.1466) in the design of products (Gabriel et al., 2018). It can result into minimal use of environmentally hazardous materials and environmentally friendly design of products and processes to reduce lifecycle costs (Cristina De Stefano et al., 2016).

Along with the pollution prevention and product stewardship strategies, sustainable development includes environmentally-oriented practices for reducing the negative environmental impacts and using resource-efficient methods for indefinitely sustaining resources for future use (Baumgartner & Rauter, 2017; Cristina De Stefano et al., 2016). It also helps an organization in managing risks associated with the products and processes, in reducing environmental wastes, improving workplace safety, and focusing on long-term environmental sustainability (Tiwari et al., 2020).

With respect to linking green-lean-six sigma drivers with the NRBV, the underlying mechanisms of waste reduction, resource conservation, and continuous improvement aligned with pollution prevention, product stewardship, and sustainable development policies cause an organization to implement GLSS enablers. The operational and environmental waste reduction (e.g., defects reduction, energy reduction, and wastewater reduction) are the reasons for an organization to adopt a GLSS strategy (Darnall et al., 2008) linked with pollution prevention. This study uses the NRBV theory to investigate the internal GLSS drivers such as cost reduction, waste reduction, and resource conservation since these drivers are directly linked to the three strategic capabilities of NRBV. For example, waste reduction is a driver of GLSS (Darnall et al., 2008) linked to the pollution prevention capability of NRBV. Further, operational and environmental cost reduction as a GLSS driver (Gandhi et al., 2018; Parmar & Desai, 2019) is linked with product stewardship due to life cycle cost considerations. Similarly, continuous improvement of products and processes – as an organizational driver (Garza-Reyes et al., 2018; Mishra, 2018) is associated with sustainable development.

A GLSS approach can create competencies in substantially reducing environmental outcomes from synergies of the joint strategy and improving an organization's eco-friendly image in the market and increasing the stakeholder's value and competitive advantage (Gaikwad & Sunnapwar, 2020b; Farrukh et al., 2020; Garza-Reyes, 2015a; Lokkerbol et al., 2012). It is envisaged that a GLSS approach is capable to comprehend the NRBV capabilities of pollution prevention, product stewardship, and sustainable development strategies through enablers such as EMS, LCA, DOE, VSM, 3R, 5S, SPC, and DMAIC (Chugani et al., 2017; Nadeem et al., 2019). EMS ensures that environmental considerations are incorporated in an organization's corporate strategies and processes, aiming to strengthen the NRBV capabilities of an organization. It provides a holistic approach towards managing environmental aspects and improves the overall environmental performance of an organization (Nguyen & Hens, 2015). Similarly, researchers have integrated the environmental measures such as CO_2 emissions, water, and energy use in a traditional VSM and defined it as environmental value stream mapping (E-VSM) and green value stream mapping (G-VSM) (Chiarini, 2014; Ng et al., 2015). VSM helps an organization for the effective implementation of pollution prevention and product stewardship strategies. Similarly, SPC controls process variation resulting in reducing product defects and saving resources in relation to the product stewardship aspects (Jakhar, 2017). The SIPOC diagram is used to determine air emissions, solid waste, and effluent discharges associated with the manufacturing processes (Cherrafi et al., 2016) enhancing the pollution prevention capability of an organization.

2.11.3 Institutional theory-based view

The ITBV evaluates various factors such as environmental regulations, cultural aspects, and social values that influence organizations while seeking legitimacy (Baumol et al., 2007; Caldera et al., 2019). ITBV includes three isomorphisms – coercive, mimetic, and normative to demonstrate an organization's motivations behind the adoption of a strategy (DiMaggio & Powell, 1983). Coercive isomorphisms include pressure from regulatory authorities, customers, and suppliers that force an organization to execute a certain strategy (Adebanjo et al., 2017; Ebrahimi & Koh, 2021; Hofer et al., 2011). Mimetic isomorphisms include the role of competitors that compel an organization to adopt a strategy to follow the footsteps of successful organizations in a similar industry (Aerts et al., 2006; Caldera et al., 2019; DiMaggio & Powell, 1983; Sarkis et al., 2011). Normative isomorphisms include social pressure such as NGO, social media, and public concerns that compel an organization to meet social expectations and obligations which contribute to organizational survival and success (Gupta et al., 2017; Ebrahimi & Koh, 2021; Oliver, 1997). The ITBV has been suggested as a suitable theoretical lens to understand the reasons for environmental management practices adopted by organizations in developed and developing countries as the institutional pressures for environmental performance from external agencies may vary across countries (Sarkis et al., 2011; Ye et al., 2021).

With respect to links between external GLSS drivers and the institutional theory, pressure from government agencies to initiate environmental practices is a coercive driver (Laosirihongthong et al., 2013; Rivera, 2004). Further, customers' requirements for eco-friendly products at a minimum price can be a coercive isomorphic driver (Thun & Müller, 2010). In this scenario, the customer influences an organization to adopt lean and six sigma either through contract specifications in a formal way or informally by highlighting the benefits of an LSS implementation (Braunscheidel et al., 2011). Organizations also adopt GLSS to imitate the practices of successful companies in the industry due to mimetic pressure. An example is Interface, the leading carpet manufacturer in the USA, which has received significant attention. In 2006, it was the first company to implement a commercial recycle and reuse system (Rajala et al., 2016; Trapp & Kanbach, 2021) that influenced other companies in the carpet industry to follow in Interface's footsteps. Similarly, the success of the lean strategy in Japanese manufacturing organizations has influenced other companies and industries across the world to implement it to achieve business excellence (Dhiravidamani et al., 2017; Jasti & Kodali, 2016; Sahoo et al., 2008). Likewise, many companies have followed in the footsteps of General Electric and Motorola who were the early adopters of the six sigma strategy. Normative isomorphic drivers include social requirements from local communities, media, and NGOs (Ball & Craig, 2010; Gandhi et al., 2018; Sarkis et al., 2011) that cause organizations to execute GLSS practices. For instance, Greenpeace, Friends of Earth, and World Wildlife Fund (WWF) are international NGOs promoting green practices (Lauesen, 2013). Similarly, professional societies encourage organizations to adopt lean and six sigma, such as the American Society for Quality (ASQ) and The International Association for Six Sigma Certification (IASSC) (Braunscheidel et al., 2011). Accordingly, it can be argued that the NRBV incorporates the internal drivers and institutional theory encompasses the external drivers.

2.11.4 Intellectual capital-based view

While ICBV is primarily used in knowledge management research, it is increasingly considered in green human resource management, business sustainability, and environmental performance research domains (Asiaei et al., 2022; Chaudhry et al., 2016; Chen, 2007; Yong et al., 2019; Yusoff et al., 2019). The ICBV focuses on a combination of an organization's intangible assets including human, structural, and relational capital to create value and competitive advantage (Costa et al., 2017). Due to its application in the environmental performance-related studies (Mansoor et al., 2021; Yong et al., 2019; Yusliza et al., 2020), the intellectual capabilities of the ICBV are recognized as green intellectual capital including green human, green relational, and green structural capital (Chen, 2007; Mansoor et al., 2021; Yong et al., 2019; Yusoff et al., 2019). Green human capital encompasses employees' skills, knowledge, competencies, attitude, commitments, experience, and creativity that can help organizations create an impact on environmental performance and achieve competitive advantage (Asiaei et al., 2022; Chen, 2007; Yusoff et al., 2019). Similarly, green structural capital refers to an organization's information technology infrastructure, reward systems, organizational culture, and leadership commitment to environmental protection (Asiaei et al., 2022; Chen 2007). This structure includes research and development activities, internal policies, and environmental practices such as low carbon management practices (Yusoff et al., 2019). In addition, green relational capital includes the organization's relationships with suppliers, customers, institutions, and other stakeholders related to environmental management in achieving market competitiveness (Asiaei et al., 2022; Chen, 2007).

The success of a GLSS strategy is premised on various factors associated with an organization's structure, information and technology infrastructure, and employees' and external stakeholders' involvement (Kaswan & Rathi, 2019). The green human capital of ICBV emphasizes that employees' skills, knowledge, competencies, attitude, commitments, and creativities (Chen, 2007; Yusoff et al., 2019) can help organizations in executing the GLSS strategy for achieving environmental performance. Similarly, green structural capital refers to the organization's information technology infrastructure, reward systems, culture, and leadership commitment regarding sustainable consumption and production of the resources. In addition, green relational capital includes the organization's relationships with suppliers, customers, institutions, and other stakeholders (Chen, 2007), which can play a significant role in the GLSS implementation for improving environmental performance.

Based on the above discussion, Figure 2.4 presents a theoretical model of a GLSS strategy for achieving environmental performance linking to the NRBV, ITBV, and ICBV.

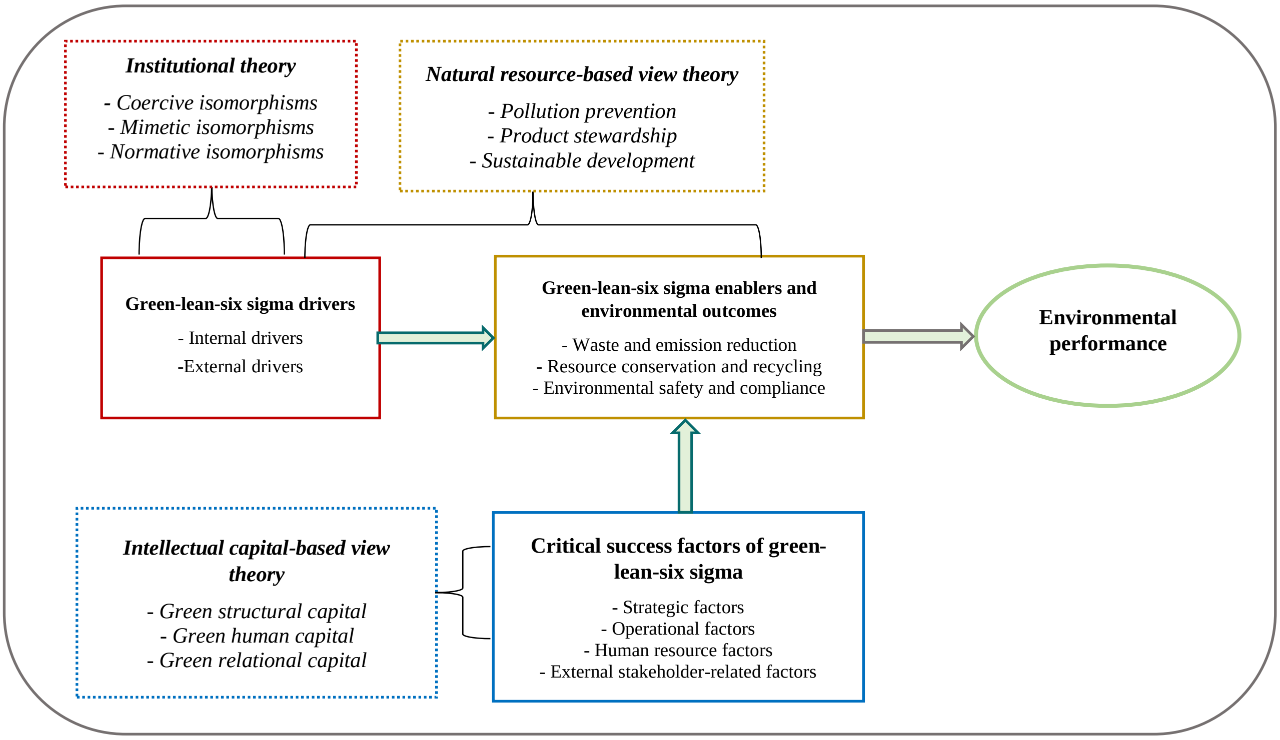

Figure 2.4: Theoretical model of green-lean-six sigma strategy linking with NRBV, ITBV, and ICBV

2.12 Summary

This chapter presented a review of the extant literature on the environmental performance, environmental issues in developing and developed countries, and the environmental impact of the manufacturing industry including discrete and process industries followed by a review of the FP industry and the environmental issues associated with this industry. The GLSS strategy, existing GLSS frameworks, drivers, enablers, environmental outcomes, and CSFs were reviewed followed by a discussion on organizational theories of the NRBV, ITBV, and ICBV. Finally, a theoretical model of the GLSS strategy for improving the environmental performance embedded with the NRBV, ITBV, and ICBV was developed.

Chapter 3

Research Methodology

3.1 Introduction

The primary purpose of this research entails the investigation of the drivers, enablers, environmental outcomes, and CSFs of the GLSS strategy for reducing the environmental effects of manufacturing organizations in a developed and developing country context and developing a holistic GLSS model. This research aims to answer the following research questions:

RQ1: What are the drivers of a green-lean-six sigma strategy in manufacturing firms for achieving environmental performance? How do these drivers compel manufacturing firms to adopt a GLSS strategy in a developed and developing country?

RQ2: What are the enablers and environmental outcomes of a green-lean-six sigma strategy in manufacturing firms for achieving environmental performance? How do manufacturing firms use these enablers to achieve environmental outcomes in a developed and developing country?

RQ3: What are the critical success factors for implementing a green-lean-six sigma strategy for achieving environmental performance? How do these CSFs help manufacturing firms to execute a GLSS strategy in a developed and developing country?

The suitable methodology for this research is qualitative due to the exploratory nature of the study that aims to examine the complex research phenomenon of a GLSS approach which manufacturing organizations in both a developed and developing country are implementing for improving their environmental performance (Yin, 2011). Accordingly, the research design involves a preliminary study (phase 1) and main study (phase 2) in which multiple case studies were conducted in NZ and PK. The preliminary study constitutes semi-structured interviews conducted with LSS and environmental consultants who have vast implementation experience of these strategies in different manufacturing organizations. The main study comprises semi-structured interviews with senior managers practicing the green, lean, and six sigma strategies in two large FP manufacturing companies in these regions.

This chapter first demonstrates the selection of an appropriate research paradigm for this study. Then the research method and approach are discussed followed by the research strategy, data collection, and data analysis technique. Finally, research quality issues and the ethical considerations for this study are explicated and a methodological map of the study is presented.

3.2 Research paradigm

The research purpose of this study focuses on exploring uncertainties in organizational environmental performance aspects through the application of a GLSS strategy which is based on realism (Guba & Lincoln, 1994). The term 'reality' for this research refers to the drivers, enablers, environmental outcomes, and CSFs of a GLSS strategy for improving the environmental performance of manufacturing organizations that might differ in terms of companies and countries. In this research, realities are uncertain and need more exploration and interpretation, which could be achieved through participants' knowledge and expertise (Ryan, 2006). Further, the realities would evolve based on the varying opinions of the participants (Creswell & Miller, 2000). This study involves human participants to explore and describe the GLSS constructs from an environmental perspective of manufacturing firms using a theoretical model (Creswell, 2003; Creswell & Poth, 2016). It is aligned with the phenomenological methodology which emphasizes the description, understanding, and clarification of the human experience of a phenomenon (Sousa, 2014). According to Creswell (2012, p. 76), "a phenomenological study describes the common meaning for several individuals of their lived experiences of a concept or phenomenon".

Since this research aims to capture new insights on the drivers, enablers, environmental outcomes, and CSFs of a GLSS strategy for achieving environmental performance to enrich theory, an in-depth analysis of the stated problem is considered relevant to provide new findings. This can be achieved by using a qualitative methodology through the conduct of multiple case studies (Jabbour et al., 2020; Pagell & Wu, 2009). Conversely, a quantitative methodology can limit the in-depth exploration of the research phenomenon which would be based on a deductive approach rather than an inductive stance (Johnson & Onwuegbuzie, 2004).

Based on the above requirements of this study, this research uses a post-positivist paradigm as it investigates the reality based on the multiple perspectives of participants (Creswell & Poth, 2016). Post-positivism refers to the value of enthusiasm and desires in research assuming the potential of viewing the entire picture of a reality (Ryan, 2006). It provides the researcher with the opportunity of learning rather than testing as it connects the researcher and the humans who participate in the research, enabling the researcher to learn from the participants. According to this paradigm, precise and logical qualitative research methods of investigation were applied

(Creswell & Poth, 2016). This paradigm views research as a process of developing and refining knowledge (Creswell, 2003) and explores a reality using theories and models (Paya, 2018).

This research involved creating a deep understanding of the GLSS strategy to address the environmental impacts in two different countries, indicating the qualitative and exploratory requirements of the study. Accordingly, the ontology of this research is critical realism (Paya, 2018) to explore the environmental impacts of manufacturing organizations and how these organizations can implement a GLSS strategy to achieve environmental performance. The epistemology of this research is modified dualist (Paya, 2018) as the drivers, enablers, environmental outcomes, and CSFs of a GLSS strategy may evolve based on the perceptions of the research participants (Cresswell & Poth, 2016). Since post-positivism is a blend of theory and practice (Henderson, 2011), NRBV, ITBV, and ICBV provide the theoretical underpinning through the development of a model (Figure 2.4) to understand the practical insights from the experience and knowledge of experts and professionals in this study. The selected research strategy details are presented in section 3.4.

3.3 Research method and approach

The knowledge claims for this study are based on the post-positivism paradigm requiring empirical studies and in-depth analysis to evaluate the theoretical model. The purpose of this study is to investigate the drivers, enablers, environmental outcomes, and CSFs of a GLSS strategy in manufacturing firms for improving environmental performance. A holistic GLSS approach is complex and broadly structured both internal and external to the manufacturing organizations with the evaluation of environmental performance aspects being a challenging issue (Cinelli et al., 2014). Therefore, a qualitative research methodology has been applied using comprehensive inductive approaches to investigate the experience of experts and practitioners in the context of the specific research settings (Creswell & Miller, 2000; Patton, 1990).

Qualitative research methodology is characterized by exploration, theory building, and induction. In this approach, a researcher is a primary source for data collection (Johnson & Onwuegbuzie, 2004). Qualitative researchers view reality as "socially constructed" where behaviours are built upon social concepts (Antwi & Kasim, 2015, p.221). Qualitative research concentrates on recognizing the participants' viewpoints and beliefs. It facilitates a researcher to "get close to their objects of study" to better understand the subjective aspects of the research study (Antwi & Kasim, 2015, p.221) through in-depth analysis of the research phenomenon, handling complicated situations and providing the benefits of cross-case analysis (Johnson & Onwuegbuzie, 2004).

In qualitative research, the researcher aims to comprehend the perspectives of the participants which is also characterized as "empathetic understanding" (Antwi & Kasim, 2015, p.221). An inductive reasoning approach is used which facilitates the researcher in gaining an in-depth understanding of the research phenomenon and analytical generalization of the empirical results. Accordingly, this research utilized a qualitative research approach to understand the specific study phenomenon (GLSS strategy in this study) from the participants (consultants and practitioners) in two different countries. Valuable outcomes emerged as a result of direct interaction with the participants from these countries through an in-depth analysis. By doing so, thoughtful insights were generated on the issues related to the environmental performance of the manufacturing firms in these countries, not only by utilizing the varied experience of the consultants, but also the expertise of the professionals working in the FP manufacturing industry.

3.4 Research strategy

The research questions of this study justify the use of case study methods. According to Yin (2011), a case study strategy is suitable for questions such as "what is happening or has happened?" and "how or why did something happen?" (Yin, 2011, p.5). Case studies provide an in-depth knowledge of the study phenomenon and facilitate a researcher to encompass a wide range of comparative and complicated situations (Yin, 2011). It is defined as "an empirical inquiry about a contemporary phenomenon (e.g., a case), set within its real-world context – especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2011, p. 4).

This study used a preliminary (phase 1) and main study (phase 2) as part of the research strategy. The preliminary study was conducted with the LSS and environmental consultants in both regional domains to capture specialist knowledgeable insights. After the preliminary study, the main study was conducted in FP manufacturing organizations in NZ and PK to gather in-depth information from the corporate managers to understand the application of GLSS strategy in this industry. Since this study investigates the GLSS strategy to address the environmental issues of manufacturing organizations based on the experts' and practitioners' knowledge and information, the data was collected from the participants at one specific point in time instead of over a long period (longitudinal) (Saunders et al., 2007). Accordingly, the time horizon of this study is cross-sectional with the time under study being the recent past.

Yin (2011) has defined three steps in designing a case study: case definition, selection of case, and utilization of theory. The first step (case definition) includes defining the case which could be a person, incident, social phenomenon, or organization. In this research, the GLSS strategy for the environmental performance of manufacturing organizations is defined as a case since the research questions include the GLSS strategy as a research phenomenon to be studied in the manufacturing sector addressing environmental issues. In the second step involving the selection of cases, the researcher selected a total of four cases (two large FP companies each from NZ and PK) in the FP industry within the manufacturing sector of a developed and a developing nation. It helped in achieving literal replication as according to Yin (2003), a few cases (2 or 3) in multiple case-design can assist in predicting similar patterns (i.e., literal replication). The third step refers to the application of theory in case study design which facilitates the analytical generalization process by establishing data analysis methods (Yin, 2011). Accordingly, this study has utilized the NRBV, ITBV, and ICBV as the theoretical grounding for this research.

In addition, the essential elements for a case research design include clear research questions, a priori specification of constructs, and units of analysis (Eisenhardt, 1989; Yin, 2011). The research questions were defined in Chapter 1, section 1.4.2. According to Eisenhardt (1989, p. 536), “a priori specification of constructs can also help to shape the initial design of theory-building research" and assist researchers in critically examining the constructs of a theoretical model building on the literature review. The constructs of the model in this research are defined as internal and external drivers (under the GLSS drivers), waste and emission reduction, resource conservation and recycling, environmental safety and compliance (under the GLSS enablers), and strategic factors, operational factors, human resource factors, and external stakeholder-related factors (under the GLSS critical success factors). These constructs are explicitly analyzed in the interview protocol and facilitate enriching theory through empirical findings emerging from the preliminary and main studies. In this study, a theoretical model (Figure 2.4) of the GLSS strategy for achieving environmental performance in Chapter 2 was developed based on the extensive literature review linked with the organizational theories. Table 3.1 presents the specification of constructs.

Table 3.1: Constructs of GLSS model for achieving environmental performance

Levels	GLSS model	Constructs
Level 1	Green-lean-six sigma drivers	- Internal drivers - External drivers
Level 2	Green-lean-six sigma enablers and environmental outcomes	- Waste and emission reduction - Resource conservation and recycling - Environmental safety and compliance
Level 3	Green-lean-six sigma CSFs	- Strategic factors - Operational factors - Human resource factors - External stakeholder-related factors

The unit of analysis is a research terminology commonly used in case study research. According to Yin (1994, p. 83), there can be "unitary or multiple units of analysis" in a single or multiple case study design. Accordingly, this study includes three embedded (multiple) units of analysis; (1) drivers of a GLSS approach, (2) GLSS enablers and environmental outcomes, (3) and CSFs for the GLSS strategy which will lead to answering the research questions of the study as shown in Figure 3.1. The evaluation of data from the preliminary and main studies is based on the above units of analysis.

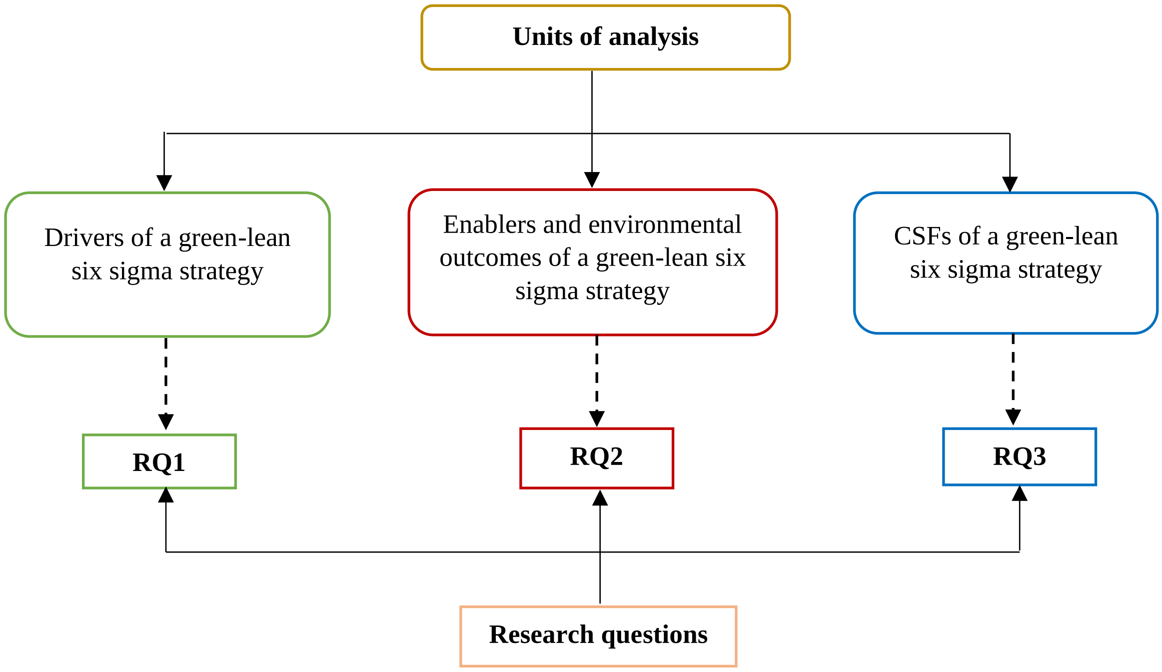

Figure 3.1: Units of analysis leading to the research questions

Both the preliminary (phase 1) and main studies (phase 2) are described in the following sections.

3.4.1 Preliminary study (phase 1)

A preliminary study assists the researcher in understanding the research phenomenon and refining the instruments for data collection for the main study (Arain et al., 2010; Lancaster, 2015). The preliminary study for this research work is significant as insights from developed (NZ) and developing (PK) countries in a holistic manner regarding the GLSS strategy for assessing environmental performance is lacking in the literature. Therefore, semi-structured interviews were conducted with the LSS and environmental experts from NZ and PK. The preliminary study used these consultants as they are multi-talented, have knowledge and experience of these strategies, and have handled a variety of projects in various manufacturing organizations. The opinions of these consultants are valuable in conceptualizing the GLSS strategy because they have vast implementation experience of green, lean, and six sigma strategies in different manufacturing organizations, which is aligned with the main scientific inquiry of this study (Lopez & Willis, 2004; Pietkiewicz & Smith, 2014). In addition, the preliminary study assisted the main study to detect any possible limitations or shortcomings in the research instrument and analyze whether the components of the main study can all work together (Dikko, 2016; Lancaster 2015) by (1) highlighting any ambiguities, (2) assessing the time taken for completing an interview, (3) deciding whether each question prompts a satisfactory response, (4) interpreting the responses according to the model, and (5) identifying any missing question(s) required to address the components of the research.

3.4.2 Main study (phase 2)

The main study was conducted in two FP manufacturing companies in NZ and PK using a multiple case study design. Although a single case study can produce rich information, multiple cases provide sufficient grounds for theory building in a research study (Eisenhardt & Graebner 2007; Yin 2009). Multiple case study design helps in understanding the similarities and differences across the cases to provide deeper insights into the research phenomenon. Further, it increases the robustness of the study findings by replicating the patterns emerging from the data (Yin, 2014). Accordingly, a multiple case study research design was utilized to examine the GLSS strategy in FP organizations for improving environmental performance (Kumar & Rodrigues, 2020). The semi-structured interviews were conducted with the senior corporate managers in these companies as they have experience in executing GLSS practices in their companies.

3.4.3 Sampling strategy for the preliminary and main study

Selecting a sample has considerable significance in conjunction with the data collection and data analysis processes in a qualitative research design since it plays an important role in addressing the validity aspect of qualitative research (Curtis et al., 2000). In qualitative research, “nothing is more important than making a proper selection of cases" (Stake et al., 1994, p. 243). The sampling procedures for qualitative research do not require case selection based on statistical methods such as random probability sampling. Instead, a purposive sampling method is followed in the selection of cases as the qualitative research design focuses on analytic generalization rather than statistical generalization. The samples are generally small in qualitative research, they are examined intensively and generate a large amount of information (Curtis et al., 2000). In addition, the rationale of the cases also depends on the theoretical implications and ethical concerns, which assist in the inclusion and exclusion of certain cases (Curtis et al., 2000).

According to Miles and Huberman (1994), the sampling strategy for qualitative research design is evaluated in terms of the following attributes: (a) the sampling strategy is required to be pertinent to the research questions and theoretical framework, (b) the samples should be selected with the objective of generating rich information and enhancing the analytic generalization of the research findings, (c) the samples should produce reliable information and explanation regarding a research phenomenon to be studied, (d) the sampling strategy should include the ethical considerations and assess the benefits and risks associated with the case selection, and (e) the sampling plan should be feasible including the requirements of time, money and resources, accessibility to the cases, and compatibility of the researcher (such as communication skills and ability to collect data under various circumstances).

Based on the above discussion, a purposive sampling method was used to select the participants for the preliminary study, case companies, and participants for the main study to gain an in-depth understanding of the study aspects (Bryman & Bell, 2007; O'reilly & Parker, 2013; Patton, 1990; Sony et al., 2020). For the preliminary study, four participants including LSS and environmental experts working in small consultancy firms involved in LSS and green implementations were selected from both countries. The experts were contacted after reviewing their profiles on LinkedIn and were requested to participate in this research study. The inclusion criteria for the experts were: (a) they work as LSS and environmental consultants, and (b) have at least two years of implementation experience in manufacturing firms of NZ and PK.

For the main study, two cases were selected from both NZ and PK to collect high quality information. The case companies with at least 3 years of implementation experience of GLSS practices were considered to be mature in this domain (Moosa & Sajid, 2010; Sony et al., 2020). The companies were selected based on the following four criteria: (a) the companies should be working in the FP segment of the packaging industry, (b) the companies should be large manufacturing organizations, (c) the companies should have implemented GLSS practices for at least 3 years, and (d) the companies must have their manufacturing plants in NZ and PK. In addition, human resource (HR) department was contacted to suggest the the participants from operational departments in these companies with at least 2 years' experience in implementing GLSS practices. A careful selection of participants with knowledge and experience in GLSS implementation achieves rigour and addresses validity in the case study approach (Kumar & Rodrigues, 2020; Yin, 2014). Accordingly, the HR department suggested the senior corporate managers (e.g., production manager, purchase manager, quality assurance manager, environmental health and safety manager, supply chain manager, and research and development manager) who are knowledgeable and involved in the implementation of green, lean, and six sigma strategies in the case research companies.

3.4.4 Data collection preparation, skills, and case study protocol

Yin (2003) has emphasized the prerequisites of data collection in qualitative research which include desired skills of the researcher, training and preparation for conducting a case study, and development of a case study protocol. The discussion regarding the case study protocol is given in section 3.5. The next sections describe the skills of the researcher and training and preparation for the study.

3.4.4.1 Skills of the researcher

Yin (2003) highlighted that the researcher's knowledge, ego, skills, and emotions play an important role during the data collection process, especially in the case study research methodology as the data collection procedures are not standardized. Thus, a well-trained researcher can help to ensure robust data collection and high quality results. According to Yin (2003), a well-trained researcher should have the following skills.

(1) Relevant questions: Asking relevant questions depends on thorough familiarization with the research phenomenon to be studied in the case study prior to the interview and asking probing further questions if required. In this study, a thorough literature review was conducted and interview questions were carefully designed to address the critical aspects of the GLSS strategy for environmental performance.

(2) Effective listening/empathetic listening: This includes careful observation of participants' expressions, accurate interpretation, assimilation of information without any bias, and clarification of any vague information. To address this, the interviews were recorded and notes were taken. Further, follow-up questions were asked to clarify the information received from the participants.

(3) Flexibility and adaptability: This means the researcher can adapt to unexpected changes that occur during the research procedures and plans. In this study, the researcher rescheduled a few interviews with the consultants and corporate managers in NZ and PK due to the unexpected COVID situation and frequent lockdowns in both countries.

(4) Control of bias: This emphasizes the researcher's control of personal reflection during the data collection and interpretation. In this study, it was achieved through regular meetings and discussions with the supervisors/colleagues.

(5) Adequate knowledge of the issues: This requires the researcher to understand the primary purpose of the case study and the research phenomenon to be examined which can be achieved through a theoretical understanding of the research phenomenon and its practical application in the relevant areas. In this study, the researcher conducted a comprehensive literature review on the GLSS strategy for achieving environmental performance. In addition, the researcher's prior project experience in manufacturing organizations, particularly in the FP manufacturing industry, and formal and informal discussions with the corporate managers enabled the collection of relevant data for this research study.

3.4.4.2 Training and preparation for the case study

Since training and preparation for the study is a significant aspect of case study research (Yin, 2003), the researcher attended seminars, workshops, a boot camp, and a doctoral consortium that guided in case study investigation including developing a case study design, research strategy, and case study methods.

The researcher also presented the detailed research proposal at the NZISDC Doctoral Consortium, held at the University of Waikato, Hamilton (2019), attended a PhD thesis symposium at the 7th IEEE i-COSTE, the international conference on sustainable technology and engineering, Brisbane, Queensland, Australia (2021), and participated in the 2-Minute Research Elevator Pitch, IEEE-Women in Engineering, NZ North Affinity group (2022) to gather valuable insights from the experts. In addition, the researcher presented the research work at different international conferences during the research process (e.g., Farrukh et al., 2019a; Farrukh et al. 2019b; Farrukh et al., 2021b) which helped in improving the research design.

3.4.5 Research instrument for data collection

The various methods for data collection in qualitative research include direct observations, interviews, audio visuals, documents, participant observations, and organization records

(Creswell et al., 2016; Yin, 2011). Among all these methods, interviews are recognized as the primary source of data collection and provide the most comprehensive information from case study respondents on a specific matter (Turner III, 2010; Yin, 2014). Interviews are considered a useful instrument for data collection in qualitative research for an in-depth exploration of a research phenomenon as compared to surveys in quantitative research. There are different types of interview designs to gather the data in a qualitative research approach (Creswell & Poth, 2017): structured interviews, semi-structured interviews, and unstructured interviews (Qu & Dumay, 2011). Semi-structured interviews are popular because they can enable complex responses systematically by utilizing themes, providing flexibility, and revealing the hidden social aspects (Qu & Dumay, 2011). On the other hand, structured interviews are conducted with a set of predetermined questions that allow the researcher minimum deviation from the pre-established list of questions. That is why this kind of interview is also described as “rigid” (Qu & Dumay, 2011, p.244). Unstructured interviews are referred to as open-ended, in which the researcher does not inevitably have all the questions in advance; rather the questions depend on the participant's response (Turner III, 2010). A problem associated with unstructured interviews is the lack of stability and reliability due to the discrepancy in questions and the possibility of digression from the topic (Creswell & Poth, 2017).

In this research, semi-structured interviews were conducted as a primary source of data collection with the participants of both preliminary and main studies to gain in-depth insights into the GLSS strategy. Further, the participants were also asked follow-up questions to obtain more information. An interview guide was developed and used in this study including interview questions to ensure the empirical exploration of the GLSS strategy focusing on the drivers, enablers, environmental outcomes, and CSFs. The interview guide was used to facilitate the research in systematically conducting the interviews, focusing on the research area, and managing the interview time (DiCicco-Bloom & Crabtree, 2006; Gummesson, 2000). An information sheet and interview questions (Appendix B and C) were developed for this research as part of the case study protocol. The information sheet and consent form (Appendix D) was sent to the participants of both the preliminary and main study before the interviews.

Eight interviews were conducted in the preliminary study (phase 1) and twenty interviews in the main study (phase 2). The average duration of each interview was 90 minutes. The interviews for the preliminary study were conducted between February and June 2020 and for the main study between January and May 2021. Initially, face-to-face interviews were planned for both the preliminary and main study; however, due to the COVID-19 situation in NZ and

PK, all the interviews were conducted via Zoom and Skype. To ensure the credibility of data, a digital voice recorder was used in the interview process with the permission of the respondents. All the interviews were transcribed using the software Otter.ai which provides speech-to-text transcriptions. In addition to the primary source of data collection, organizations' sustainability reports, brochures, websites, and published case studies were also assessed to strengthen the study findings (Creswell et al., 2016; Yin, 2003). Figure 3.1 depicts the research onion (Saunders et al., 2012) for this study including the research paradigm, research approach and method, research strategy and time horizon, and data collection method as discussed in the above sections.

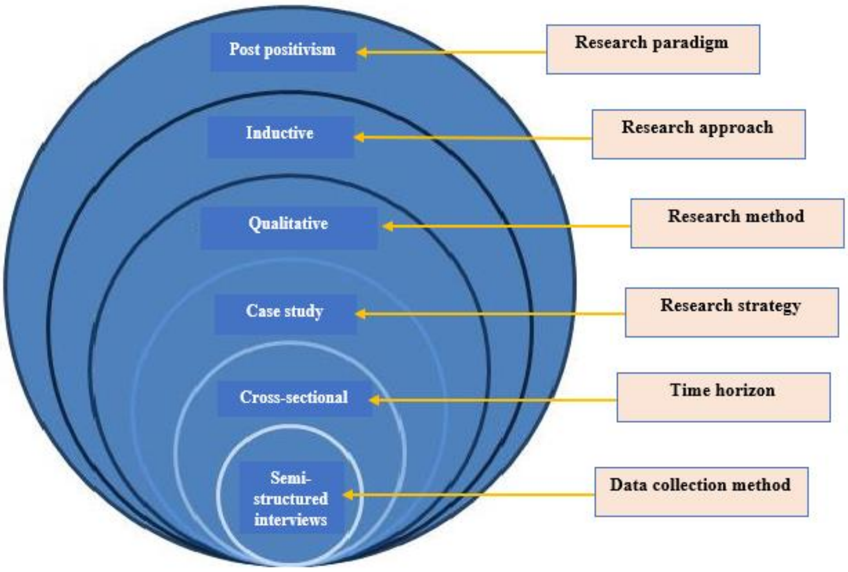

Figure 3.2: Research onion, adapted from Saunders et al. (2012)

3.4.6 Data analysis and reporting of case studies

3.4.6.1 Data analysis

The overall purpose of the data analysis is to develop an understanding of the research phenomenon by evaluating and systematically arranging the data. According to Eisenhardt (1989, p. 539), data analysis is "both the most difficult and the least codified part of the process". In qualitative research, a large amount of textual data is produced. Therefore, the data is inductively examined to create groups and theoretical explanations. After examining the data, the analytical categories are created based on the inductive approach (Pope et al., 2000). Since the qualitative research strategy is complex and diverse, thematic analysis is considered as a suitable method of analysis for qualitative data (Braun & Clarke, 2006). A within-case analysis was conducted (Chapter 5 and Chapter 6) to identify the patterns emerging from the NZ and PK case studies followed by a cross-case analysis to identify the similarities and differences in both regions (Yin, 2014). An overall case analysis is presented based on both within-case and cross-case analysis to evaluate the research phenomenon in each of the cases and review replication (Yin, 2003) which led to the development of a GLSS model for achieving environmental performance of manufacturing organizations.

According to Braun and Clark, (2006, p. 82), “a theme captures something important about the data concerning the research question and represents some level of patterned response or meaning within the data set”. In this study, the thematic analysis has been conducted based on the stages recommended by Braun and Clark (2006). The interview data were transcribed and reviewed several times to extract the concepts, meanings, and patterns emerging from the data which helped in understanding the link between GLSS strategy and environmental performance (Braun & Clarke, 2006; King, 2004). A manual coding process was followed to analyze the GLSS drivers, enablers, environmental outcomes, and CSFs. This process resulted in generating various codes including codes already defined in the prior studies such as cost reduction (see Chapter 4) and some new codes not covered in the literature such as the role of development organizations (see Chapter 4) under the GLSS drivers dimension. These codes were organized into main themes and sub-themes which were reviewed and refined to ensure their validity emerged from the entire data set.

After reviewing the themes, different names were assigned to them. As a result of thematic analysis, several first-order codes were developed and categorized into second-order themes under the key dimensions of drivers, enablers, environmental outcomes, and CSFs of a GLSS strategy for achieving environmental performance (Reay et al., 2017). For example, under the CSFs for implementing a GLSS strategy to achieve environmental performance, various first-order codes (CSFs) were collated in four second-order themes – strategic factors, operational factors, human resource factors, and external stakeholder-related factors (based on the priori specification of constructs) – leading to the unit of analysis under study (CSFs of a GLSS strategy).

Overall, the interview data highlighted the understanding and recognition of the GLSS drivers, enablers, environmental outcomes, and CSFs in both regional domains. Additionally, the analysis of both the primary and secondary data facilitated determining the correlations between the empirical findings and theories used in this study (Kumar & Rodrigues, 2020).

3.4.6.2 Reporting of case studies

This study uses the narrative descriptions and tabular presentation to report the empirical findings emerging from the preliminary and main study as "reporting case study results is one of the most challenging aspects of doing case studies" (Yin, 2009, p. 141). In addition, three steps are emphasized for the composition of the case study reports which include the identification of the report audience, designing the structural composition, and compiling a portion of the case study early.

From this study's perspective, the case study reporting first identified the potential audience which included academic scholars, LSS and environmental experts, corporate managers, and policymakers in both a developed and developing country. Second, the structural composition of the case study reporting was developed through the initial design of the case research. Finally, the case study write-up as the third step started along with the data collection process which helped in bringing clarity to the empirical findings, analysis, resolving any issues, tracking the research activities, and timely completion of the research study.

3.5 Quality of the research design

The quality of research depends on the validity and reliability of the research outcomes. From this perspective, scholars have recommended four tests – construct validity, internal validity, external validity, and reliability – to determine the quality of a research design (Teegavarapu et al., 2009; Tellis, 1997; Yin, 2003). Validity of research is a significant aspect of assessing the research quality, which includes the accuracy and credibility of research findings (Creswell, 2012). Yin (2003) identified construct validity, internal validity, and external validity as the three categories of validity in qualitative research. Construct validity is achieved by acquiring data from multiple sources, establishing a logical chain of evidence, and verifying the transcriptions from the study participants (Teegavarapu et al., 2009; Yin, 2003).

Triangulation is recognized as an approach for achieving construct validity of research findings by utilizing two or more sources of data (Golafshani, 2003). There are different types of triangulations such as data triangulation, investigator triangulation, methodological triangulation, and theoretical triangulation (Carter et al., 2014; Thurmond, 2001). In data triangulation, data is obtained from multiple sources such as people, groups, and communities. Investigator triangulation refers to the data generated by two or more researchers who are working on the same study. Methodological triangulation implies the use of various methods of data collection. Lastly, theoretical triangulation indicates the utilization of more than one theory or hypothesis to investigate a phenomenon (Carter et al., 2014). The purpose of triangulation is to come up with generalized results. In this study, data triangulation, methodological triangulation, and theoretical triangulation were performed. From a data triangulation perspective, data is obtained from multiple sources including the consultants (preliminary study) and the practitioners (main study). Further, data generated from interviews, notes taken during the interviews, and organization documents (such as sustainability reports) are also assessed for methodological triangulation. Theoretical triangulation was performed with the use of organizational theories – NRBV, ITBV, and ICBV to understand the GLSS strategy in manufacturing organizations for improving environmental performance.

A logical chain of evidence enhances the research quality by addressing the construct validity (Yin, 2003). From this perspective, a case study database is maintained including the interview data and the organizations' documents which can be retrieved in case an external reviewer requires the evidence of the research data. In addition, to ensure construct validity, the interview transcripts and notes developed during the interviews were emailed to the participants so they could confirm their accuracy.

Internal validity refers to determining the causal relationships of variables in a study. Since the exploratory nature of the case study does not evaluate the causal relationships of variables, pattern matching, explanation building, and a logic model are suggested for assessing the internal validity of case study research (Teegavarapu et al., 2009; Yin, 2011). Pattern matching is applicable for any case study design whether it is a single case or more (Almutairi et al., 2014). Further, pattern matching achieves internal validity by comparing the resulting pattern (evidence-based) with the predicted one. For this research study, pattern matching was utilized for the internal validity of the research outcomes. Next, explanation building is defined as developing an initial theoretical proposition about a social phenomenon and comparing it with the results of cases. Then an iterative procedure is followed by revising and comparing the resulting analytical statements with the subsequent case findings (Hsieh, 2004). This technique was applied in this research as the results of the preliminary study and the main study were compared with the initial theoretical model (Figure 2.4) and associated literature followed by a discussion (Chapter 7). Further, the case study results were cross-validated to verify the themes, trends, and patterns. The logic model in this research is the theoretical model of GLSS strategy for achieving the environmental performance of manufacturing organizations including drivers, enablers, environmental outcomes, and critical success factors which are also the units of analysis.

External validity refers to the generalization of the case study results (Yin, 2011). Yin (2011) has emphasized analytical generalization for qualitative research rather than statistical generalization. In case studies, interpretation relies on analytical induction (Starman, 2013; Yin, 2011). The links between different processes and incidents are explored in analytical generalization (Starman, 2013). Additionally, generalizability increases with multiple case studies as a single case study can restrict the generalizability (Bergen & While, 2000). In this research, generalizability is addressed through multiple case studies conducted in two countries with specific criteria for company selection. Further, replication logic is utilized to compare data findings from multiple cases (Yin, 2011). In replication logic, the results of a case study are checked against other cases for generalizing a theory (Bergen & While, 2000). Two forms of replication are literal replication and theoretical replication. The former entails predicting similar results and the latter involves contrasting results with predicted reasons (Bergen & While, 2000; Yin, 2003). The prominent characteristic of replication logic is that the data analysis within cases is conducted before cross-case analysis (Bergen & While, 2000).

Reliability in a case study indicates the consistency and stability of the research outcomes using the same data collection processes involved in conducting a case study which can be repeated to yield similar findings (Amaratunga & Baldry, 2001; Yin, 2003). Further, the reliability can be achieved by utilizing two techniques: (1) case study protocol and (2) case study database (Voss et al., 2002). Research quality criteria are presented in Table 3.3.

Yin (2011) has emphasized developing a case study protocol by demonstrating interview questions and procedures. It is helpful in following the procedures regarding goal setting, pursuing support from research participants, designing data collection tools, and performing case studies. Table 3.2 represents the case study protocol for this research. Further, the case study database was developed by including the interview files, notes taken during the interview, and organizational documents.

Table 3.2: A structure of case study protocol for this study

Components	Description
Organization	Flexible packaging manufacturing companies with at least 3 years' experience in green, lean, and six sigma practices.
Permission	Ethical consideration for conducting the study and thereafter its publication. A letter explaining the purpose of the study was sent to the consultants and case companies (seeking permission) prior to the research.
Purpose	The purpose of this study is to examine the drivers, enablers, environmental outcomes, and critical success factors of a GLSS strategy in a developed and developing country context and develop a GLSS model for improving the environmental performance of manufacturing organizations.
Units of analysis	The drivers, enablers, environmental outcomes, and CSFs of a green-lean-six sigma strategy.
Time limit	6 months for the preliminary study and 6 months for the main study.
Data sources	Interviews with consultants, senior corporate managers, organizational documents, and archival records.
Construct validity	Available recorded data from interviews, organizational documents, and archival records.
Internal validity	Pattern matching, explanation building, and theoretical model.
External validity	Cross-case analysis by replication logic
Key questions	Q1: Please explain which green tools do manufacturing organizations implement. How do these tools affect environmental performance and help in conserving resources? Q2: What do you think about other manufacturing strategies such as lean and six sigma for achieving environmental impacts and resource conservation? If so, what are the tools that help in increasing environmental performance and why these tools are useful for increasing environmental performance? Q3: What are the environmental outcomes expected on implementing green-lean-six sigma practices and why? Q4: While implementing green-lean-six sigma practices in manufacturing organizations, what are the critical success factors according to you for successful implementation of these practices and why?

3.6 Ethical considerations

Ethical considerations include conflicts of interest, respect for participants, data confidentiality, potential harm to participants, and informed consent. As a requirement of Massey University, a low-risk notification was obtained from the Massey University Human Ethics Committee before the commencement of the study. This study was deemed as a low risk through peer review since it does not require any personal and confidential information from the consultants and case study participants. The information regarding the topic of the study, nature of the study, objectives of the study, interview type, length of interviews, and interview questions along with low-risk notification were communicated to the preliminary and main study participants. Participants were informed that they can contact the Massey University Human Ethics Committee if they have any concerns regarding the research work. Written consent from the participants with their signatures was obtained before commencing each interview. In addition, the confidentiality of the companies and anonymity of participants was maintained throughout the research study.

3.7 Methodological map of the study

Figure 3.3 presents the methodological map of the study which starts with the initial framework development including the GLSS drivers, enablers, environmental outcomes, and CSFs linking with organizational theories. Then, phases of the preliminary and main study, data collection, analysis, and findings are presented. Finally, the map concludes with the development a GLSS model for achieving environmental performance in manufacturing organizations by combining the findings of the preliminary and main study.

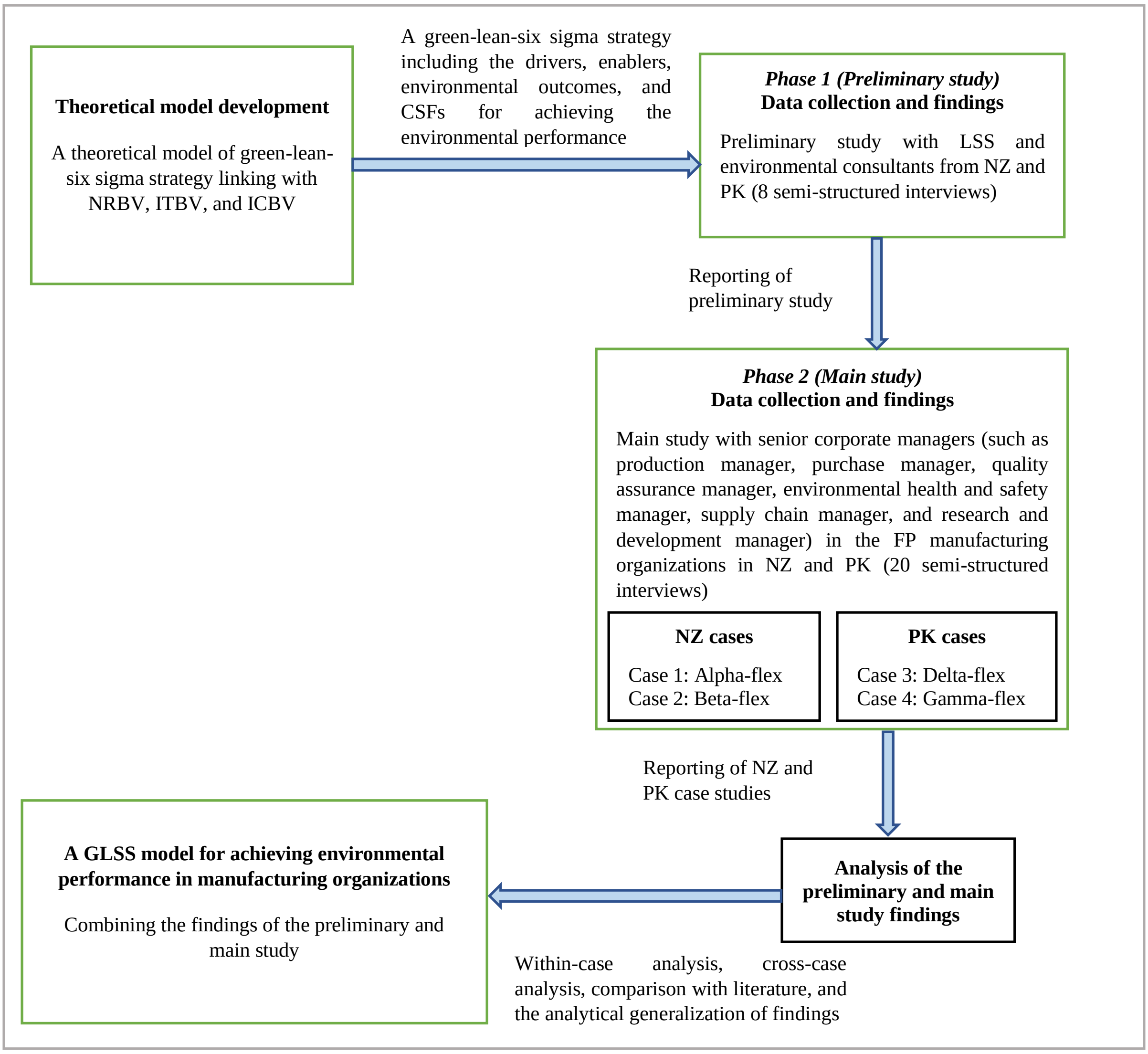

Figure 3.3: Methodological map of the study

3.8 Summary

This chapter discussed the research methodology for this study including the research paradigm, research design, research strategy, data collection, and data analysis. Post-positivism was selected as the research paradigm and the qualitative research approach was selected as a suitable methodology for exploring the GLSS strategy in manufacturing organizations. Semi-structured interviews were selected as a primary source of data collection and thematic analysis as the data analysis technique. In addition, quality tests for the research design and ethical considerations for this study were discussed.

Chapter 4

Preliminary Study

4.1 Introduction

This chapter presents the findings of the preliminary study (phase 1) which is conducted to investigate the views of LSS and environmental consultants on the GLSS strategy from a developed (NZ) and developing (PK) country perspective in enhancing the environmental performance of manufacturing organizations. Since a regional evaluation from a developed and developing nation regarding the GLSS strategy for investigating environmental performance is lacking in the literature, the preliminary study conducted in NZ and PK significantly contributes to the GLSS literature including insightful information provided by these experts. In addition, the preliminary study facilitated the main study by highlighting any shortcomings and ambiguities in the data collection method and research design. The theoretical model developed in Figure 2.4 (Chapter 2) has been used as a guide for an empirical investigation. The key informants from NZ and PK are experts in applying green, lean, and six sigma strategies and have at least two years of implementation experience in different types of manufacturing organizations. The perspectives of these consultants are valuable in understanding a holistic view of GLSS strategy towards achieving environmental goals. The details of the selected informants are given in Table 4.1.

Table 4.1: Details of informants from New Zealand and Pakistan

Country	Consultants' codes	Type of expertise	Years of experience	Job description
New Zealand	N1 LSS	Lean six sigma expert	20	Principal
	N2 LSS	Lean six sigma expert	2	Associate supplier quality engineer
	N1 Enviro	Environmental expert	3	Chief executive officer
	N2 Enviro	Environmental expert	15	Advisor
Pakistan	P1 LSS	Lean six sigma expert	17	Chief executive officer
	P2 LSS	Lean six sigma expert	8	Managing director
	P1 Enviro	Environmental expert	8	Executive director
	P2 Enviro	Environmental expert	14	Chief executive officer
Notes: LSS = lean six sigma, Enviro = environmental				

The chapter is organized as follows. Sections 4.2, 4.3, and 4.4 present the findings on the GLSS drivers, enablers, environmental outcomes, and CSFs from NZ consultants and sections 4.5, 4.6, and 4.7 present the findings from PK consultants.

4.2 Green-lean-six sigma drivers – New Zealand perspective

4.2.1 Internal drivers

The findings highlighted cost reduction as one of the operational reasons for adopting the GLSS strategy in manufacturing organizations. N1 Enviro posited that a *"green strategy helps organizations in reducing their manufacturing and total lifecycle cost".* Similarly, N2 LSS noted the tax benefits as a reason for implementing green strategy, "*basically, one of the main reasons to implement green is because manufacturing organizations try to reduce their cost and bring in tax benefits".* N2 Enviro explained that organizations tend to look at their financials as a reason for adopting lean and six sigma. Manufacturing companies use the lean paradigm for reducing costs in the form of environmental fines and penalties since they are required to pay for discharging effluents and dumping waste.

The findings revealed operational and environmental waste reduction as one of the key operational GLSS drivers by NZ consultants. Minimizing environmental waste such as wastewater, excessive energy consumption, and carbon footprints from manufacturing operations are some of the reasons for companies to adopt green practices as noted by the environmental and LSS consultants. From a lean perspective, the findings suggest that manufacturing firms implement lean initiatives to minimize operational wastes which do not add value for their customers. Waste reduction through error-free production is also cited as one of the major reasons for implementing six sigma in NZ. Similarly, N2 Enviro emphasized, *"having less rework and scrap are the main drivers for the majority of the businesses that we are working with.*

Process control is also recognized as a driving force for GLSS implementation where lean strategy is used for controlling processes in small scale production. N1 LSS highlighted that if three people are working in a process in three different ways, it may end up with some sort of failure. Therefore, the cause of failure is identified, and the process is standardized through lean methods to overcome the problem. N1 LSS stated, "*there are plenty of businesses in NZ that are not involved in mass production, and it is difficult for them to control any variables. Nevertheless, they are still controlling their processes through work standardization".*

Consultants from NZ also emphasized minimizing process variation as a significant reason for implementing six sigma. Manufacturers use this approach when the process generates large amounts of data and statistical tools are required to simulate complex problems with different variables. This was suggested by both LSS consultants. Similarly, N1 LSS and N1 Enviro explained that manufacturing firms in NZ apply six sigma practices to control process variation in highly automated and repeatable processes such as dairy plants and printing presses.

All three – green, lean, and six sigma – are system improvement strategies, therefore "*continuous improvement is a driver of these approaches"* as stressed by N1 LSS who also stated that this was a *"reality of life"*. N1 LSS further noted, *"organizations need to continuously improve their business models due to changing circumstances, customers' preferences, emerging regulations, and competitors' strategies"*. On the other hand, N2 Enviro explained that many organizations do not recognize continuous improvement as a driver for green manufacturing because it requires investment and resources. One LSS and two environmental consultants argued that environmental responsibility has compelled manufacturers in NZ to undertake long-term initiatives and to adopt a green strategy as part of their corporate policy. N1 LSS explained that organizations evaluate different environmental parameters such as *"how many fewer tons of wastes go into landfills, how much less carbon footprint they have created, and whether they have transitioned from one toxic compound to a more neutral compound?"*.

Consultants from NZ also highlighted resource circulation as a significant organizational driver of the GLSS. Most of the manufacturing organizations in NZ now are trying to incorporate the closed-loop cycle in their operations to retrieve recyclable products and the circular economy is being acknowledged as an environmental initiative in NZ as emphasized by N1 Enviro. It is gaining traction due to increasing awareness and the realization of benefits by manufacturers and the government. Therefore, organizations are effectively working on product stewardship aspects and integrating environmentally friendly design in their products and processes. N1 Enviro highlighted that manufacturers plan for various aspects of product stewardship such as what will they do with the products at the end of life. Manufacturing companies are using the lean paradigm to increase their recycling abilities to avoid fines and penalties in the discharge of effluents and waste.

4.2.2 External drivers

Among the external GLSS drivers, regulatory requirements for environmental performance have a significant impact on adopting green practices in NZ as they force manufacturers to reduce their environmental waste such as air pollution and solid waste. According to N2 Enviro, *"there are government policies for environmental performance including carbon footprint and health and safety in NZ"*. N2 Enviro further explained that manufacturing organizations in NZ are required to procure an industrial and trade activities permit from the council regarding their environmental waste such as air emissions and effluent discharges. Similarly, N1 Enviro noted environmental regulations such as carbon taxes as a driver for green manufacturing. N1 Enviro further explained that the Resource Management Act (RMA, 1991) in NZ follows international patterns of assigning liability to manufacturing firms in cases of environmental deterioration. According to the RMA, everyone is responsible for saving the environment and effectively handling the environmental impacts of their associated activities. N1 Enviro commented, *"there are going to be taxes and regulations. For example, in the plastic industry, manufacturers can see the government pressure on plastic. Therefore, they know that they have to do something around their packaging as the cost of compliance is increasing".* N1 Enviro further stressed the regulatory requirements as a possible reason for implementing six sigma as it enables organizations in controlling manufacturing processes to achieve legal obligations (e.g., air emissions and effluent discharges in the dairy industry) through practices such as control charts and DOE.

Public pressure is recognized as a society-oriented driver for manufacturing organizations in NZ to initiate green activities. N1 Enviro explained that these organizations consider environmental sustainability strategies since they face substantial public pressure and need to have some environmental practices in place because of that, *"large companies like Silver Fern, Toms and Gallagher have got quite a big public presence and they need to have some sustainability things in place".* For example, Silver Fern has a visible "Sustainable Chain of Care" programme that includes financial, environmental, and social sustainability aspects. Their environmental sustainability practices include recycling initiatives, sustainable procurement, zero biological waste, wastewater treatment plants, and an environmental management system. Along with the public pressure, the local development bodies are also encouraging companies to incorporate green strategies such as the circular economy in their operations. N1 Enviro maintained, *"A group called "Rata" is promoting social sustainability through scientific and ecological literacy programmes and involving the community in environmental decision-making".* The NZ Product Stewardship Council (NZPSC) facilitates government, industry, and community towards evaluation and execution of product stewardship and related regulation. Similarly, Plastics NZ, the industry association for the New Zealand plastics industry, works closely with its members to educate the public about plastic pollution in the environment. They aim to produce plastics in a sustainable manner and promote the recovery, reuse, and recycling of plastics.

All environmental and LSS consultants suggested various market-oriented drivers such as customer pressure for environmentally friendly products is driving manufacturing organizations in NZ to implement GLSS practices. N2 Enviro emphasized that customers are the key stakeholders in any business, and they are keen to know about an organization's environmental credentials, green practices, and environmental performance. Likewise, N2 LSS asserted that consumer preferences are moving towards selecting eco-friendly products, *"many customers in NZ choose their product or service from the companies that are awarded in environmental sustainability, the driver over here is the customer"*. N2 LSS further stated that customers now expect that organizations have implemented some kind of efficiency programme such as lean and six sigma towards supplying quality products at a reasonable price. Additionally, N1 LSS stressed customer value as the driver for GLSS and regarded it as a *"forward thinking and proactive approach"*.

According to N2 LSS, competitiveness is not a significant driving force for organizations in NZ due to a limited number of manufacturing firms in a particular area and having high profitability. However, N1 Enviro stressed that manufacturers in NZ are now becoming conscious of achieving competitiveness by adopting a green strategy, which has now become an emerging driver, *"seen a couple of things, seen that it is going to become a competitive advantage. So, we have got a client who can say that they are carbon neutral all across. Environmental credibility is one thing that I am starting to see emerging"*.

The findings further revealed company image as one of the key drivers for green-lean-six sigma adoption in NZ. According to N1 LSS, dairy farmers continuously implement ecological practices to maintain their green image and avoid negative environmental impacts. Improving their corporate green image allows manufacturing firms in NZ to also address environmental regulatory requirements. Similarly, N2 Enviro emphasized that a positive company image of an organization assures its stakeholders that the organization is working on fulfilling their demands, achieving a branding benefit. However, N2 LSS stated, *"my perception is that the company does not worry much about the environment but the impact that can cause the company if they do not follow the regulations"*. N2 Enviro further explained that businesses can become more *"marketable and valuable"* with lean implementation, especially for small and medium firms, as every operation is visible through process mapping. Thus, the entire operations can be easily understood by new staff or management and chances of errors are reduced. Furthermore, organizations utilize their positive image for commercialization as well. Companies want to improve and maintain their image to gain trust and recognition from customers, which is also strongly associated with six sigma, as explained by N2 Enviro. According to N2 Enviro, six sigma is seen to be quite an achievement as it carries kudos with it, *"six sigma is like ISO 14001 these days and it can be a struggle for some organizations.*

Therefore, six sigma has a significant branding benefit as it promotes and increases a company's image". N2 Enviro further added:

> *six sigma has a little bit more global awareness than lean does or perhaps not global awareness, maybe it is better attainment by manufacturers. So, to be recognized by other manufacturers and clients, it adds trust in that manufacturer. So, that level of added trust of the manufacturer probably is a stronger driver for six sigma than is for lean.*

Table 4.2 presents the GLSS drivers from New Zealand perspective.

Table 4.2: Green-lean-six sigma drivers from New Zealand consultants

GLSS drivers	Categories	Sub-categories	NZ Consultants
Internal drivers	Operational drivers	Cost reduction	N1 LSS, N2 LSS, N1 Enviro, N2 Enviro
		Process control	N1 LSS, N1 Enviro
		Waste reduction	N1 LSS, N2 LSS, N1 Enviro, N2 Enviro
	Organizational drivers	Continuous improvement	N1 LSS, N2 LSS
		Resource circulation	N1 Enviro, N2 Enviro
		Environmental responsibility	N1 LSS, N1 Enviro, N2 Enviro
External drivers	Regulatory driver	Environmental regulations	N1 Enviro, N2 Enviro
	Society-oriented drivers	Public pressure	N2 LSS, N1 Enviro
		Development organizations	N1 LSS, N2 Enviro
	Market-oriented drivers	Customer pressure	N1 LSS. N2 LSS, N2 Enviro
		Company image	N1 LSS, N2 LSS, N1 Enviro, N2 Enviro
		Competitor pressure	N1 LSS, N1 Enviro

4.3 Green-lean-six sigma enablers and environmental outcomes – New Zealand perspective

4.3.1 Waste and emission reduction

The findings revealed that manufacturing firms in NZ are inclined towards various environmental programs and certifications such as eco-labelling, The Natural Step, environmental warrant of fitness (E-WOF), and Enviro-Mark to address their environmental issues as highlighted by N2 Enviro. These programs are meant to implement carbon certifications around products looking at their entire lifecycle rather than just the manufacturing activities in organizations. N2 Enviro stated, *"for example, when wine is being sent to Europe, the European winemakers say you do not want to buy that NZ wine, the carbon footprints hideously trail all the way around the world".*

N2 Enviro further stressed the use of eco-design practices followed by the manufacturing sector in NZ to incorporate life cycle aspects in their product designs. Similarly, N1 LSS noted the use of green tools such as EMS, DFE, and LCA to reduce the air emissions and carbon footprint from manufacturing processes to achieve environmental sustainability. Moreover, a carbon zero statement (eco-labelling) on a product removes the negative ecological impact of its manufacturer increasing their green image. Other green enablers such as carbon calculators are also used by NZ's manufacturing firms as stressed by N2 Enviro.

VSM is considered a strong lean tool for addressing environmental issues by identifying, measuring, and eliminating wastes in the manufacturing processes as noted by two LSS and one environmental consultant. WS is also regarded as an enabler for controlling air emissions in manufacturing firms. For example, if an organization wants to reduce air emissions such as VOCs from a printing process, it can use vegetable-based inks which is an eco-friendly method to minimize VOCs and wastewater. Although these inks are more difficult to print with, organizations are controlling the printing process with the help of standardized work practices to minimize their air emissions. N2 LSS noted that JIT is frequently used by manufacturing firms in NZ to minimize inventory-related problems citing the example of Fisher & Paykel Healthcare that commonly uses JIT in reducing its inventory wastes for a positive impact on their environmental performance.

SPC is an effective six sigma tool for monitoring the environmental aspects commonly applied by NZ manufacturing organizations, as mentioned by N2 LSS. For instance, a dairy plant and a paper mill utilizes control charts to monitor the environmental performance (e.g., air emissions) of a process, and check if it is going out of control limits. Although different kinds of SPC charts can be used in a manufacturing process, the most common ones used to control environmental performance are individual (MR) and x bar ($\overline{X}$) charts.

4.3.2 Resource conservation and recycling

The consultants from NZ noted an increase in recycling and conserving resources as advantages to GLSS enablers. Most of the manufacturing companies in NZ are currently working on the recycling stage of the 3R strategy to improve processes in each of their waste streams so that no recyclables are lost to landfill. According to N2 LSS, *"due to stringent environmental regulations in NZ, manufacturing firms are now continuously treating their waste efficiently and their recycling abilities have improved".* N1 Enviro emphasized that circular economy is being recognized as an emerging practice that is gaining more traction due to increasing awareness and significance of product stewardship aspects by NZ manufacturers resulting in resource savings such as water, material, and energy.

Additionally, N1 LSS emphasized the increase in waste recycling as an outcome of lean and six sigma which is commonly recognized by the NZ livestock industry. For example, using 5S and SPC in a thermal waste recycling plant where inedible by-products of animals are separated and converted into edible by-products such as poultry heads and feathers, fish scales, and horns and hooves are converted into protein hydrolysates which are used in liquid and solid seasoning and concentrated soups and beverages. N2 LSS and N2 Enviro opined that the majority of companies in NZ are inclined towards recycling as compared to reducing waste.

N2 Enviro highlighted the minimum use of toxic materials and chemicals as an environmental outcome of using hazardous substance inventory tools. N2 Enviro further added that energy management system (EnMS) such as ISO 50001 is also offered in NZ and is termed as *"Energy Mac"*, used by only a few organizations. There is not enough market for ISO 50001 in NZ because most of the environmentally sustainable practices are driven by requirements from clients' who are generally unaware of this ISO standard. However, organizations such as councils and district health boards utilize ISO 50001 because they are massive energy users. Although ISO 50001 is not generally used in NZ, energy audits are frequently conducted in organizations to evaluate the energy consumption and carbon footprint as explained by N2 Enviro.

N1 LSS asserted that lean practices such as VSM and lean mudas result in material conservation and energy reduction by removing the non-value-added activities which automatically bring the cost benefit for an organization. Similarly, N2 LSS suggested that lean emphasizes manufacturing of a product according to customers' demand, and by utilizing JIT, avoids any kind of storage, resulting in saving energy and material. In a similar vein, N2 Enviro advocated the use of process mapping for managing energy and mass balances, which is helpful in the environmental analysis of a process resulting in resource conservation.

4.3.3 Environmental safety and compliance

Other significant benefits of GLSS enablers achieved by NZ manufacturing companies are environmental safety, risk management, and compliance to regulatory requirements as stated by N2 Enviro and N2 LSS. According to N2 LSS, manufacturing organizations in NZ use green practices such as EMS and hazardous substance inventory tools because of environmental regulations, to avoid penalties. For example, WorkSafe New Zealand has various hazardous substance inventory tools to understand the risks associated with these materials which are utilized by different manufacturing organizations. Similarly, N2 Enviro highlighted the workplace and employee safety as an outcome of using hazardous substance inventory tools. Additionally, N2 LSS indicated the use of renewable energy sources as a potential energy management practice by contemporary NZ manufacturing firms from a long-term environmental sustainability perspective.

According to N1 Enviro and N2 Enviro, manufacturing firms get environmental compliance benefits through lean (e.g., lean mudas, WS, VSM, and JIT) specifically because they are required to pay for discharging effluents and dumping waste. Similarly, six sigma helps organizations to achieve government regulatory requirements by decreasing environmental fines and penalties N1 LSS noted. For example, Fonterra has repetitive processes in its dairy plants and SPC helps in conforming with the environmental obligations by controlling the processes and environmental performance (e.g., effluent discharges and GHG emissions) within regulatory limits. Similarly, the printing industry also has highly repeatable processes and gains the benefit of regulatory compliance in controlling VOCs by using six sigma enablers such as SPC.

All three green, lean, and six sigma facilitate organizations in effective decision-making towards environmental waste management as these are based on continuous improvement cycles through EMS, PDCA, and DMAIC. According to N2 Enviro:

> *all of these green, lean, and six sigma include the plan, do, check, act cycle. They all are management systems and use a similar cycle. You need sound analytical decision-making for planning, implementing, reviewing, improving, and fixing things. That is in all of them.*

N2 Enviro further emphasized the significance of EMS for improving social impact such as involving the wider community in ecological decision-making, promoting social interaction, and stewardship. Table 4.3 presents the GLSS enablers and environmental outcomes from NZ.

Table 4.3: Green-lean-six sigma enablers and environmental outcomes from New Zealand consultants

GLSS enablers	**Environmental outcomes' categories**	**Sub-categories**	**NZ consultants**
5S, EMS, energy audits, JIT, SPC, VSM, carbon calculators, DFE, ecolabelling, enviro mark, EWOF, LCA, The natural step, WS	Waste and emission reduction	• Air emission and carbon footprint reduction	N1 LSS, N1 Enviro, N2 Enviro
		• Process waste reduction	N1 LSS, N2 LSS, N1 Enviro, N2 Enviro
3R, 5S, energy audits, JIT, lean mudas, SPC, hazardous substance inventory tools, process mapping, VSM	Resource conservation and recycling	• Less use of energy, water, and raw material	N1 LSS, N2 LSS, N1 Enviro, N2 Enviro
		• Increase in recycling	N1 LSS, N2 LSS, N1 Enviro, N2 Enviro
		• Less use of hazardous materials	N2 Enviro
DMAIC, EMS, lean mudas, renewable energy sources, SPC, VSM, hazardous substance inventory tools, JIT, PDCA, WS	Environmental safety and compliance	• Decrease in environmental fines and penalties	N1 LSS, N2 LSS, N1 Enviro, N2 Enviro
		• Sound environmental decision-making	N2 LSS, N2 Enviro
		• Future orientation	N2 LSS
		• Improve employee and workplace safety	N2 LSS, N2 Enviro

4.4 Critical success factors for implementing green-lean-six sigma to achieve environmental outcomes– New Zealand perspective

4.4.1 Strategic factors

The consultants suggested various strategic factors of a GLSS strategy such as leadership commitment, culture and communication, and resource allocation. Leadership commitment and involvement in an organization to understand the performance plays a vital role in implementing GLSS as suggested by N2 Enviro. Moreover, the direction given by top management is required in the success of a GLSS program and there should be a shared understanding of the direction by everyone in the organization as explained by N1 LSS. In addition, communicating the organizational objectives throughout the organization is an important aspect to provide clarity to everyone about what an organization wants to achieve. Therefore, top management should have a proper communication plan for this purpose as expressed by N2 Enviro, *"you need to have an appropriate communication strategy to make people understand what you are aiming for and what it will be like when you implement some processes".* N2 Enviro further added that the employees' connection with the leadership team is a substantial element so they can see where things are heading in the organization and *"do not get any nasty surprises*".

N2 LSS highlighted that convincing senior managers to implement the GLSS strategy is the essential factor and commented:

> *I suggested to my managers to make job rotation on machines but generally, they do not agree with this. However, last week my manager decided to make job rotation for everyone in the organization because employees were absent as they needed to go home due to the COVID situation.*

According to N1 Enviro, change management while making people ready to accept the change is a critical success factor for a GLSS strategy, "*process of change management is not built into the standards"*. The top management should consider how is it going to implement a change over time and share it with the employees. So suddenly, people are no longer frightened or resistant to change, in fact, they would realize that it needs to be done and they will be happy to do it. Moreover, N1 LSS emphasized considering the positive and negative aspects while implementing a change in an organization as a critical success factor. The management should consider whether a specific change is going to make the job harder for the employees or is it irrelevant. N1 LSS noted:

> *The sooner an organization realizes the negative impact of a change, sooner it can work out. If an organization does something ahead of time, then it is more likely to succeed.*

Additionally, the GLSS strategy should be followed continuously in an organization as stressed by N2 LSS and N2 Enviro. According to N2 LSS, *"many companies start training of employees to execute a strategy and 99% of these companies do not continue that improvement program"*. The organizations only conduct functional projects that are completed within a few months and do not continue the program due to a lack of people having a continuous improvement mindset. Then they start from zero again. It is necessary to identify the people having the same mindset of continuous improvement for the success of the GLSS approach. Similarly, N2 Enviro explained that implementation of GLSS strategy is an on-going process in an organization, which should be continuously implemented by the organization's employees, *"it is something they are going to do every week and even for the rest of their working life"*.

N2 Enviro highlighted that the top management needs to have a detailed plan for the implementation of the GLSS strategy through small manageable steps. N1 Enviro further added financial resources, leadership commitment, clear vision, aligning goals with business strategy, and change management as critical success factors of GLSS. Furthermore, the consultants from NZ emphasized the integration of GLSS as a CSF to increase the environmental performance as waste is a common aspect in all three strategies to achieve environmental objectives. A combination of these strategies overcomes the weaknesses of others, noted N2 Enviro. For example, by implementing an EMS, an organization would need to follow work instructions on how to perform its manufacturing processes. However, quality and process control are not the intentions of an environmental program. According to N2 Enviro:

> *it is not difficult to stretch any of these programs to incorporate the other ones. It is not difficult to take an environmental program and include the quality and control aspects of lean and six sigma strategies because you are trying to control the environmental performance. An organization can integrate these strategies by adding environmental aspects in the plan, do, check, act approach and it will become a more efficient program.*

4.4.2 Operational factors

The consultants from NZ highlighted project management as a critical success factor for a GLSS strategy for problem solving and identifying the improvement opportunities in an organization. N2 LSS remarked:

> *when I started using project management best practices in my projects, the results were better. It is easy to conduct projects when you use project management practices. Today, I combine lean, six sigma, and project management in my projects.*

N1 LSS also stressed that a project management approach must be considered in situations when there is a complex environmental problem,

> *a project plan helps the team members to know what is going to happen? who is doing what? and when it is going to happen? Organizations should use various human resource training techniques for different projects when it is necessary.*

According to N2 Enviro, it is not necessary to conduct every GLSS project at once because sometimes financial resources limit the organization to achieve its objectives. In this case, an organization should prioritize its GLSS projects through adequate planning.

The adequate utilization of appropriate tools at the right place and at the right time is another success factor in the effective execution of GLSS approach as explained by N1 LSS. For instance, the organization needs to understand when VSM, DOE, 5S, and LCA should be applied in different stages of solving an environmental problem. Similarly, N2 LSS noted, *"many companies would like to implement six sigma tools in the first place but personally, I do not recommend. First, an organization needs to implement 5S and work standardization"*.

Further, the organization should be clear about the objectives to be achieved by the implementation of a specific tool. According to N1 LSS, if tools are not implemented adequately, then the organization may fail to achieve the desired results. Additionally, N2 LSS cautioned that unnecessary use of tools can divert the focus of an organization from the main purpose of a project which can result in negligence of the main objectives. Sometimes, people like to use complex tools in a GLSS project; however, the problem does not require the utilization of such tools. In many companies, consultants use many quality and statistical tools to solve a simple problem just to show everyone that they know about the tools.

Analytical thinking is also required for implementing the GLSS strategy. Although statistical thinking is significant in solving complex problems, the analytical approach is relevant in understanding the environmental issues and finding solutions as statistical tools may not be required for every problem. According to N2 LSS:

> *statistical thinking is important; however, it is not necessary to use complex tools to solve a problem. I would replace statistical thinking with analytical thinking because effective utilization of data and timing of decision-making is important rather than statistics. Mindset of people in terms of analysis and perception is critical. Analytical thinking is essential to think outside the box, understand different situations, identify different opportunities, and think differently about other people. It is not easy to find people with this kind of mindset.*

In addition, N2 Enviro highlighted statistical thinking as a critical success factor for six sigma, however, it is not required for green strategy as "*green is more a holistic approach and you do not need to know what variability is and what is the difference between mean and median values?".* Similarly, N1 Enviro asserted statistical thinking as an essential aspect of six sigma methodology as compared to lean manufacturing.

It is also imperative to understand and evaluate the on-going processes and the associated performance of an organization before execution of a GLSS strategy as highlighted by N1 Enviro, *"there's no point in doing some product lifecycle analysis and trying to improve your design if you have not got some basic understanding of your current process in place".* Similarly, N2 Enviro stressed the robust understanding of the organizational activities with expected outcomes through process mapping as a critical success factor of GLSS strategy.

Performance measurement system is an essential factor for managing GLSS strategy. It is necessary to develop appropriate key performance indicators (KPIs) while implementing GLSS because an organization cannot realize improvement in its processes until it has KPIs. The selection of adequate KPIs is a critical aspect as an organization needs to identify the improvement areas by measuring performance. Moreover, an organization should also evaluate the baseline values of its processes in terms of KPIs. Although many organizations in NZ have strategic KPIs, they do not divide these into operational and environmental KPIs while measuring their overall organizational performance N2 LSS noted.

4.4.3 Human resource factors

The consultants emphasized various human resource factors for successfully implementing the GLSS strategy such as training of the senior managers and the people who implement GLSS enablers is required. Similarly, N2 Enviro stressed the identification of competent people having skills and ability to execute the GLSS strategy as an important factor, *"organizations are not much concerned about the qualification of people, in fact, somebody who has been running a health and safety program for years can be good at implementing a strategy because of the competency".* Not only skills and competencies of the employees are essential but also the teamwork and collaboration among employees are necessary for the effective utilization of GLSS strategy as noted by N2 LSS. Moreover, employee empowerment is also crucial in the implementation of the GLSS strategy. Although employees are empowered and free to take decisions in manufacturing organizations in NZ, somehow employee satisfaction is low and that is why absenteeism and employee turnover rate is high in NZ. Organizations need to measure their employee satisfaction for the successful execution of GLSS strategy as explained by N2 LSS.

4.4.4 External stakeholder-related factors

From the external stakeholders' perspectives, there are government support and policies for environmental performance, carbon foot printing, and health and safety in NZ. These requirements play a critical role in the execution of green strategy as compared to lean and six sigma as suggested by N1 and N2 Enviro. N1 Enviro emphasized, *"the government policies, regulations, and guidelines drive more of the environmental green strategy than lean or six sigma".* In addition, N2 LSS and N2 Enviro emphasized that financial institutions do not play a critical role in GLSS implementation in NZ because of (1) high profit margins and (2) less competitive environment. Therefore, manufacturing organizations do not prefer to take loans from financial institutions. Table 4.4 presents CSFs of the GLSS strategy suggested by New Zealand consultants.

Table 4.4: Critical success factors for green-lean-six sigma implementation from New Zealand consultants

Critical success factors of GLSS	Sub-categories	NZ Consultants
Strategic factors	• Leadership commitment	N1 LSS, N2 LSS, N2 Enviro
	• Resource allocation	N1 Enviro
	• Communication	N1 LSS, N2 LSS, N2 Enviro
	• Change management	N1 LSS, N2 LSS, N1 Enviro
	• Continuous implementation of GLSS	N2 LSS, N2 Enviro
	• Linking GLSS to business strategy	N2 Enviro
Operational factors	• Performance measurement	N2 LSS, N2 Enviro
	• Project management	N1 LSS, N2 LSS, N2 Enviro
	• Analytical thinking	N2 LSS
	• Adequate utilization of tools	N1 LSS, N2 LSS
	• Statistical thinking	N1 LSS, N1 Enviro, N2 Enviro
Human resource factors	• Employee training and education	N1 LSS, N2 LSS, N2 Enviro
	• Employee involvement and empowerment	N2 LSS
	• Competent employees	N1 LSS, N1 Enviro, N2 Enviro
	• Teamwork	N2 LSS
	• Employee satisfaction	N2 LSS
External stakeholder-related factors	• Government support and policies	N1 Enviro, N2 Enviro

4.5 Green-lean-six sigma drivers - Pakistan perspective

4.5.1 Internal drivers

The consultants from PK highlighted cost reduction as a significant operational driver of GLSS. P1 Enviro regarded cost minimization as one of the key reasons for implementing green strategy for those organizations who understand that reducing environmental footprints such as water, material, and carbon will have a substantial impact on manufacturing cost. However, there is only a small number of such organizations in PK that realize this aspect. One consultant explained that buyer organizations force manufacturers to reduce their operational costs by implementing lean practices which can result in a substantial decrease in per-unit cost. Similarly, P2 LSS asserted cost reduction as a lean driver for both local and export manufacturing firms in PK, especially operating in the apparel sector. These local branded organizations have become quite large and their sales revenues have increased. However, they are still not making money because their cost of production is high. Therefore, these kinds of companies want to use lean processes to reduce their operational costs to become more efficient and compete with international brands. Similarly, P1 LSS emphasized, *"when the volume is huge, even pennies mean a lot. For example, if you are exporting 100 million dollars' worth of products, even a penny of that is huge. The main driver is cost".* P1 Enviro noted that cost is also a substantial driver for six sigma and commented:

> *if a pesticide organization is filling a bag with a surplus of one hundred grams due to process discrepancies, it will increase the cost. Therefore, those manufacturers that understand the concept of cost incurrence associated with the process variation apply six sigma in their organizations.*

Consultants pointed out waste reduction including air emissions and effluent discharges as definite operational reasons for a GLSS strategy. According to P1 Enviro, *"the driver normally would be a reduction in the environmental footprint. So, it could be water, it could be hazardous chemicals, or it could be gaseous emissions"*. Organizations also focus on minimizing various operational wastes in production, transportation, and warehousing by considering lean mudas (wastes or inefficiencies) which have an impact on environmental performance. For example, an organization may use mechanized vehicles for transportation if the travel distances are large. Reducing travel distances with better transportation systems can improve air emissions and energy usage, explained P1 Enviro.

The findings suggest process control as one of the key operational GLSS drivers. Achieving process control through green practices is highlighted as a major reason for implementing the energy management system ISO 50001, which focuses on energy performance through process optimization. It evaluates the energy indicators by assessing energy data to determine the causes of process variation as stressed by P2 Enviro. Reducing process variation is a significant driving force for implementing six sigma. Six sigma enables the organizations to deliver their products with least variation and maintain the product quality throughout the manufacturing processes as per customers' specification limits, P2 LSS emphasized. The consultants include variance analysis as part of the environmental performance indicators in the realization that variation in processes could negatively affect environmental performance. P2 LSS cited the examples of Pakistan Tobacco Company and Philip Morris, who have commonly implemented six sigma to solve critical problems in their processes. Their industrial engineers are trained in using six sigma in manufacturing operations. These companies have also provided statistical training to their employees to handle large amounts of data to solve complex problems and develop data visualization.

Environmental responsibility in manufacturers is regarded as an organizational GLSS driver to implement green initiatives, which was conveyed by one LSS and one environmental consultant. Corporate policies towards environmental sustainability force organizations to implement green practices; however, few organizations have included corporate social responsibility (CSR) in their business models as explained by P2 Enviro. P2 Enviro further maintained, *"companies like Engro have adopted green strategy due to their corporate policies according to which they implement environmentally sustainable practices to save environment and society from the harsh impact of environmental issues"*. The export-oriented manufacturing organizations in PK are conscious of the environmental aspects while implementing lean initiatives as compared to those organizations that only have local customers. P1 Enviro indicated that environmental responsibility is used as a potential reason for six sigma implementations by consultants though manufacturing organizations do not consider it as a driver, but rather a process variation control tool.

The findings further highlighted that manufacturing organizations have started using GLSS practices to increase the recycling levels. P2 LSS noted, *"we are producing large poly bags to pack fabric rolls, which costs Rs. 20 per poly bag. We transport the fabric rolls to dye houses and then bring back those poly bags and reutilize".* P1 LSS explained that sugar manufacturers in PK now recycle the by-products of sugarcane to generate energy. Additionally, manufacturing organizations in Karachi are generally recycling their wastewater and reusing it in processes as compared to manufacturing firms in Lahore. This difference is attributed to the scarcity of freshwater facilities for manufacturing firms in Karachi as compared to Lahore, which forces manufacturers (in Karachi) to recycle wastewater. Further, the export-oriented companies generally address this aspect more stringently as compared to the local ones. Most of the export-oriented companies in PK are adopting a green strategy for wastewater recycling. P1 Enviro further elaborated on the use of lean and six sigma in the waste recycling process, *"organizations are applying six sigma for treatment of wastewater by reducing variation in water quality parameters such as chemical oxygen demand (COD)".*

4.5.2 External drivers

The consultants highlighted several regulatory drivers, society-oriented drivers, and market-oriented drivers for GLSS adoption in Pakistan. International environmental regulations force export-oriented manufacturers in PK to embrace green practices, as clarified by P2 LSS. For example, the European Union has certain environmental regulations, which must be fulfilled by any supplier supplying to Europe. The local government regulations in PK are not strict compared to the international regulatory requirements, which is why minimizing environmental fines and conforming to legal obligations is not a priority for PK firms as per P1 Enviro. Further, the local environmental regulations vary between different regions of PK where organizations may need to comply with obligations due to penalties. P1 Enviro stated, *"there are local laws which have started to get implemented in some areas to some extent and the organizations have to fulfil those otherwise they could face penalties".*

In some industrial areas, government inspectors regularly visit and measure the wastewater load and wastewater quality in manufacturing organizations and may penalize them in cases of non-compliance. Additionally, P2 LSS highlighted that several environmental initiatives have been taken by the new PK government such as installing water treatment plants at different industrial sites of export-oriented organizations. The findings revealed that the PK government is actively implementing environmental programmes to better improve the water footprint of manufacturing firms as compared to other environmental wastes such as air pollution.

Public pressure is found to be an emerging society-oriented driver for green manufacturing in PK. One environmental consultant (P1 LSS) explained that there are organizations such as "*Fixit*" who are working towards creating environmental awareness in the public. Certain manufacturing organizations are being forced to follow environmental practices in city outskirt areas where public pressure is high as a result of industrial wastes discharged from these organizations belonging to industries such as leather and paper and pulp. P2 LSS emphasized:

> *in PK, it is not right now but in certain areas where organizations are located in those outskirts areas where people are having agricultural issues and the wastewater is coming from the organizations. In those areas, public pressure is coming up from, like, villages.*

The findings also highlight that various international development organizations are forcing manufacturing companies in Pakistan to adopt a GLSS strategy. Different donor organizations and development cooperation organizations are enthusiastically working in PK on various projects in green productivity, chemicals management, and green efficiency, and are trying to convince manufacturers to implement GLSS. For example, the United Nations Industrial Development Organization (UNIDO), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), and Japan International Cooperation Agency (JICA) have various green-lean, lean-six sigma, and green-lean-six sigma projects in different industry sectors of PK such as textile, automotive parts manufacturing, and engineering. P1 Enviro cited:

> *I was working on a project in which six areas of improvement have been included such as energy efficiency, wastewater reduction, quality improvement, chemicals management, process improvement, and resource efficient management system of an organization. All these six areas are combined under the resource efficiency programme initiated by International Finance Corporation in PK.*

Among the market-oriented drivers, customer influence is found to be one of the main drivers of GLSS practices in PK as emphasized by environmental and LSS consultants. However, it is viewed as a major driver for export organizations specifically because they need to comply with their international customers' requirements of having environmental certifications such as

ISO 14001. The buyers from PK exporting companies insist on adherence to international environmental standards in reducing their carbon footprints and water footprints. P1 LSS noted, "*I remember, buyers have prompted Sitara Chemicals for ISO 14000 certification".* The international customers also seek social compliance from manufacturers. P1 LSS cited an example that Nike's suppliers in Pakistan are required to follow the CSR policies of Nike which focus on environmental safety in the manufacturing plants and training programmes for workers to educate them regarding Nike's codes of conduct. CSR audits are conducted by Nike's agent in Pakistan to verify compliance. Customer influence is also recognized as a driver for the lean strategy. For example, if a PK organization is a supplier to a Japanese car manufacturer, then it is necessary for the company to follow lean practices because every year they may be audited by the Japanese firm on their lean implementation. P2 Enviro further explained that customer pressure is a relevant factor in six sigma adoption as well, since customers drive an organization to meet their demands and force an organization to produce quality products with minimum variation.

The consultants further suggest competitor pressure as a driver for compelling PK manufacturing organizations to adopt a GLSS strategy. P2 LSS explained that manufacturers have realized that they will not be able to compete with global companies without implementing GLSS practices. For instance, Interloop – one of the largest hosiery manufacturing companies – is taking up environmental initiatives due to global competition. Additionally, manufacturing firms in Pakistan are implementing GLSS practices for improving their company's image and using it for advertising purposes. P2 LSS noted, *"being Nike's vendors in PK, Style Textile, Interloop, and Silver Star have to compete with other vendors in the world".*

P1 Enviro elucidated that organizations who implement green tools for increasing environmental performance publicize their green projects by breaking them down into mini projects. By doing this, they want to show their customers that they are working on different environmental improvement initiatives such as energy consumption, chemicals management, and air emissions rather than only one green project. Moreover, P2 LSS emphasized corporate green image as a driver for export-oriented organizations as they needed to comply with international regulatory obligations. However, according to P1 LSS, the green image of a company is not a reality but is just a *"façade"* because most multinationals in some ways are destroying the environment with their products (e.g., cigarette manufacturers) and on the other hand they say, *"oh, we are just putting some trees on. We are spending money on planting trees"*.

P2 Enviro emphasized that manufacturing organizations want to maintain a positive company image for their immediate clients instead of the end consumer. For example, if an organization is producing auto parts for Honda and Toyota, it will implement lean and six sigma to build its image for the client companies as the end user is *"least bothered"*. According to P1 Enviro, *"there is a second type of organization who are not yet exporting but they want to market themselves as green companies or environmentally responsible companies and then they go for these kinds of initiatives".* P1 Enviro further commented*:*

> *Interloop is implementing six sigma, and sometimes the company hires very expensive European consultants for conducting six sigma projects. The CEO of this company occasionally talks about six sigma programmes through press and media, thereby, utilizing it for marketing purposes.*

Table 4.5 presents the GLSS drivers from Pakistan's perspective.

Table 4.5: Green-lean-six sigma drivers from Pakistan consultants

GLSS drivers	Categories	Sub-categories	Pk Consultants
Internal drivers	Operational drivers	Cost reduction	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro
		Process control	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro
		Waste reduction	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro
	Organizational drivers	Resource circulation	P1 LSS, P2 LSS, P1 Enviro
		Environmental responsibility	P1 Enviro, P2 Enviro
External drivers	Regulatory driver	Environmental regulations	P2 LSS, P1 Enviro
	Society-oriented drivers	Public pressure	P1 LSS, P2 LSS
		Development organizations	P1 Enviro
	Market-oriented drivers	Customer pressure	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro
		Company image	P2 LSS, P1 Enviro, P2 Enviro
		Competitor pressure	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro

4.6 Green-lean-six sigma enablers and environmental outcomes – Pakistan perspective

4.6.1 Waste and emission reduction

Among the GLSS enablers, EMS is found to be a significant green tool implemented by manufacturing organizations in PK as indicated by all LSS and environmental consultants. EMS requires careful monitoring of the environmental wastes such as air emissions and effluent discharges generated from manufacturing processes with a comparison against the benchmarked requirements resulting in a gap analysis. Similarly, P1 Enviro also explained that there is an environmental program called *"zero discharge of hazardous chemicals (ZDHC)"* – as a roadmap to zero discharges. Every textile, footwear, and leather exporter needs to conform to the requirements of ZDHC to obtain the certification. There is another requirement coming from the European customers; zero liquid discharge (ZLD) designed to remove liquid wastes, which is becoming a global requirement now.

5S is recognized as a significant lean tool by all consultants for improving the workplace having a positive environmental impact on manufacturing organizations in PK. For instance, P2 LSS explained the utilization of 5S by manufacturing companies for segregating and disposing of different types of plastic, paper, and a few hazardous wastes,

> *there are very minute types of metal wastages such as metal dust, cutting fluid, metal cations (copper, cobalt, and chromium), and oil mist in organizations using machine tools such as lathes in different manufacturing sectors including dye houses, apparel, and auto parts. By using 5S, such hazardous wastes can be removed on an ongoing basis.*

Moreover, it reduces the negative impact on the food chain by minimizing the release of these minute wastes in an aquatic environment which can be consumed by fish. Likewise, P1 LSS added *"security"* as an additional feature in the traditional 5S tool since environmental protection is becoming an essential concern for manufacturing organizations. All consultants considered JIT important in reducing inventory waste by managing inventory levels. According to P2 LSS, organizations working with hazardous substances such as dyes and chemicals have adopted JIT to reduce the negative environmental impact by carefully examining their shelf life. Additionally, consultants refuted the negative environmental impact of JIT practices such as increasing air emissions through frequent transport use for replenishments by balanced scheduling. P1 Enviro emphasized the CA in reducing air emissions and stated:

> *If you apply six sigma on the exhaust of a boiler and look at the causes of why sometimes the boiler starts emitting more carbon monoxide rather than carbon dioxide or oxygen and why suddenly the excess air of boiler increases. Then, a cause-effect analysis will reduce the air emissions and lead towards regulatory compliance as well.*

4.6.2 Resource conservation and recycling

Consultants highlighted resource conservation as a major benefit of green strategy through 3R practices. Recycling waste and reutilizing resources by 3R practices are now becoming the norm in PK and commonly followed by organizations especially in generating energy for manufacturing processes as noted by P2 LSS:

> *some organizations are producing their electricity. They have power generation plants and dye houses. Now, they are using water during their dying process and they are also using steam. They bring it back, recycle it, and use it two to three times to cool down their machines rather than using it only once.*

However, wastewater recycling is common in manufacturing firms in PK (e.g., dye houses) as compared to other types of recycling, and almost 80-90% of export-oriented companies are considering this aspect, N2 LSS explained.

Furthermore, P1 Enviro explained the concept of material flow cost analysis (MFCA) that addresses environmental problems in a cost-effective manner with a clear indication of the flow of materials including water and energy, their relevant costs, environmental impacts, material losses, and disposal costs of end-of-life manufacturing processes. P1 Enviro stressed the utilization of MFCA in the focal area of an organization used in combination with Pareto analysis that results in materials savings and cost reduction. Further, two environmental consultants emphasized the higg index as a green tool, which is commonly applied by the leather and textile manufacturing organizations of PK. It comprises a set of tools developed by the Sustainable Apparel Coalition (SAC) as explained by P1 Enviro. P1 Enviro also stressed that higg index could be used in any kind of industrial sector (e.g., auto parts, chemical, and leather manufacturing organizations) as it comprises the general principles of environmental performance improvement including energy management and solid waste management. P1 Enviro further noted resource-efficient management of chemicals (REMC) as a green enabler towards minimum use of hazardous chemicals and improving environmental safety.

P1 Enviro and P2 Enviro emphasized energy reduction by utilizing green practices such as EMS and ISO 50001. ISO 50001 is considered an emerging practice in PK for achieving environmental performance and promoting a green image of organizations. According to P1 Enviro, the number of companies implementing ISO 50001 to get environmental benefits is rising. ISO 50001 requires monitoring, measuring, and evaluating the energy indicators where energy data are collected and analyzed to indicate the causes of variation in the processes. This standard comprises work instructions to minimize the variation in energy consumption that positively affects the environmental performance remarked by P2 Enviro.

The interview findings reveal that the lean paradigm also helps the manufacturing sector to efficiently recycle waste. For instance, P1 LSS and P2 LSS asserted that lean practices (e.g., 5S) enable an organization towards efficient, faster, and sensible waste recycling by identifying and segregating hazardous and non-hazardous wastes. According to P1 Enviro, lean mudas increase production output by reducing cycle time and removing non-value-added activities from manufacturing processes. Consequently, increasing productivity with the same energy requirements results in energy savings and subsequently minimizes air emissions.

Six sigma is also used to improve the waste recycling process as stated by P1 Enviro. For instance, applying SPC to reduce variation in water quality parameters (e.g., COD level) helps a firm in the effective treatment of wastewater. P1 Enviro further suggested energy conservation as a major benefit of deploying six sigma enablers (e.g., DOE) by consultancy firms. For example, energy utilization in a process depends on a variety of variables having an impact on the rate of energy consumption such as temperature, humidity, product type, customer requirements, and manufacturing techniques. Variation in energy consumption can be the result of these variables. An organization needs to consider the impact of various variables by applying statistical tools such as multivariable regression analysis to find out the energy consumption under certain conditions. Among the six sigma enablers, CA is also noted as a significant enabler that can be used in any area of environmental improvement such as conserving resources, reducing waste and air emissions, and improving environmental safety.

4.6.3 Environmental safety and compliance

GLSS enablers not only increase environmental safety outside the organization but also stress environmental safety aspects within an organization by increasing workplace safety practices. This leads to both social and operational positive outcomes as mentioned by P2 Enviro. For example, in a garment manufacturing facility, a huge amount of heat is produced if the machines are uninsulated, which spreads throughout the facility. As a result, the workplace temperature rises, and it becomes difficult for employees to work in that environment. It harms employees' productivity which may also result in poor product quality. Moreover, energy losses from uninsulated machines are considered environmental waste. To overcome this, EnMS requires manufacturing organizations to insulate their machines to reduce the energy loss, which also achieves both social and economic benefits.

Similarly, there are environmental advantages of lean and six sigma enablers (e.g., 5S, lean mudas, DOE, and CA) for chemical manufacturing organizations in the form of increased environmental safety and risk management due to reduction in the use of toxic chemicals and hazardous waste generation as explained by P1 Enviro. P1 Enviro further emphasized that quality circles can be modified into environmental circles in a manufacturing facility which can be deployed for environmental improvements such as resource conservation, waste and effluent reduction, and environmental safety and risk management.

VSM not only facilitates manufacturers in evaluating their environmental performance but also enhances the health, safety, and environmental aspects of an organization through a detailed evaluation. By incorporating and analyzing the physical, psychological, and environmental factors along with the traditional process timelines, organizations are minimizing the burden on employees working at lower levels such as machine operators. It is also recognized as ergonomics value stream mapping (Ergo-VSM). P2 LSS stated:

> *health is becoming a major issue for export-oriented organizations in Pakistan, especially those organizations which have manpower more than 5000 to 10,000 people. These organizations need to comply with the international customer's social requirements along with the environmental ones.*

P1 LSS explained that six sigma can facilitate manufacturing organizations in complying with legal requirements by utilizing tools such as DFSS and QFD, hence reducing environmental fines and penalties. Similarly, P2 LSS highlighted its use for identifying the causes in case of non-compliance with customers' environmental requirements and regulatory obligations. DMAIC and DFSS are six sigma techniques that can be used in accomplishing environmental goals such as saving energy, water and materials, reducing carbon emissions, and improving environmental safety expressed P1 LSS.

According to P2 Enviro, EnMS and EMS help an organization in effective environmental decision-making. An example given was that ISO 14000 series guides an organization in the right direction towards environmental cost-related decisions either through lifecycle cost analysis or material flow cost analysis. Similarly, EnMS supports organizations in environmental decision-making regarding various energy performance indicators such as energy consumption and utilization of alternative and renewable energy sources. Lean practices also enable manufacturing organizations in effective decision-making through its tools as explained by P1 LSS. The famous lean tools such as 5S, eight wastes, kaizen, TPM, and VSM are regarded as surface-level tools since lean also includes analytical tools such as heijunka. P2 LSS highlighted that Pareto diagram helps an organization in a factual approach to decision-making by identifying the major contributing factors in an environmental issue. With the help of statistical tools such as SPC, box plots, and DOE, six sigma enhances environmental decision-making capability by evaluating environmental key performance indicators. So, the probability of *"getting things right"* increases as suggested by P1 LSS. Table 4.6 summarizes the empirical results of GLSS enablers from PK

Table 4.6: Green-lean-six sigma enablers and environmental outcomes from Pakistan consultants

GLSS enablers – PK	Environmental outcomes categories	Sub-categories	Pk Consultants
5S, EMS, energy audits, JIT, SPC, VSM, CA, DFSS, DMAIC, DOE, environmental circles, heijunka, higg index, kaizen, lean mudas, MFCA, Pareto diagram, ZDHC, ZLD	Waste and emission reduction	Air emission and carbon footprint reduction	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro
		Process waste reduction	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro
3R, 5S, energy audits, JIT, lean mudas, SPC, CA, DFSS, DMAIC, DOE, EMS, EnMS, environmental circles, higg index, MFCA, multivariable regression analysis, Pareto diagram, REMC	Resource conservation and recycling	Less use of energy, water, and raw material	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro
		Increase in recycling	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro
		Less use of hazardous materials	P1 Enviro
DMAIC, EMS, lean mudas, renewable energy sources, SPC, VSM, 5S, box plots, CA, DFSS, DOE, environmental circles, heijunka, EnMS, Pareto diagram, QFD, REMC, ZDHC	Environmental safety and compliance	Decrease in environmental fines and penalties	P1 LSS, P2 LSS
		Sound environmental decision-making	P1 LSS, P2 LSS, P2 Enviro
		Future orientation	P2 Enviro
		Improve employee and workplace safety	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro

4.7 Critical success factors for implementing green-lean-six sigma to achieve environmental outcomes – Pakistan perspective

4.7.1 Strategic factors

P2 LSS and P1 Enviro stressed that top management commitment is necessary for taking up initiatives and motivating employees in an organization. Leadership is depicted by top management commitment which should not only be verbal since a vigorous involvement by top management in organizational activities leads to the successful implementation of GLSS strategy. Departmental head of an organization need to participate in improvement initiatives to reduce resistance from employees which can result into better organizational performance. The availability of resources such as time, finance, and competent employees are also vital for the success of a GLSS program as stressed by P1 and P2 Enviro. Therefore, top management should also allocate financial and human resources to execute these strategies. The management should have clear goals and objectives which must be communicated adequately into workable instructions throughout the organization.

P1 Enviro argued change management and skills of the employees to adapt to the changes as critical success factors to execute the GLSS strategy. Although, change management is driven by top management commitment, it depends on how commitment is translated into policies, practices, and work instructions to make it easy for the employees as highlighted by P2 LSS.

The consultants from PK also emphasized the integrated GLSS as a critical factor. P1 LSS noted that Hubco and K-Electric are ISO 14001 certified companies and regularly conduct environmental audits. They have also implemented a six sigma program for their power operations to reduce environmental wastes such as carbon footprints, wastewater effluents, and air emissions. According to P1 Enviro:

> *I applied green (energy audit), lean (5S), and six sigma (Pareto diagram, DOE) enablers together in a pesticide manufacturing company to reduce the cost of pesticide manufacturing area. We divided this project into four mini projects. As an outcome, we reduced process variance, rejection and defects, material spillage, and energy consumption. Hence, improved environmental performance as well as health and safety conditions of workers.*

P1 Enviro contradicted the reward system as a critical success factor for GLSS because *"rewards can only keep employees happy for a certain time and with the passage of time, they get used to it and require more rewards".* Instead, a safe working environment is a *"big reward"* for employees, P1 Enviro explained. The organizational work environment is an important factor that makes people feel better about the security and safety aspects of their jobs. P1 Enviro commented:

> *I think what is important for me to work in an organization is that when I am working in an organization; I am safe and my job is secure. These are the things I am normally looking at. So, if you are able to give your employees a sustainable and safe work environment that is the biggest reward for them.*

4.7.2 Operational factors

Among the operational factors, an appropriate performance measurement system is recognized as an essential element since it facilitates organizations in decision-making after an analytical assessment of various performance factors in the manufacturing process. According to P2 Enviro:

> *there must be some measurement and evaluation techniques, tools, and a criterion on which we should evaluate the results. The factors or different variables should be analyzed so that we can implement the PDCA cycle for the successful implementation of our plans. If we cannot measure it, we cannot improve it.*

Moreover, P1 Enviro mentioned the organizational internal processes of record-keeping as a critical success factor of GLSS strategy for improving environmental performance.

Project management approach is an obvious element in a GLSS approach described by P2 Enviro. For managing a GLSS project, an organization needs to decide, *"(1) project objectives, (2) action plan, (3) assessment criterion to identify the gaps,(4) timelines of the project, and (5) methods of monitoring and evaluation".* In addition, statistical thinking facilitates the organizations in analyzing large amount of data and decision-making which is regarded as a critical success factor of GLSS by P2 LSS. Now, organizations are inclined towards enterprise resource planning systems (ERPs) and they are either establishing their own ERPs or purchasing it (e.g., System Analysis and Program Development (SAP)). These ERPs have facilitated organizations in sound decision-making of statistical data. Further P1 LSS and P1 Enviro emphasized information technology and IoT such as RFID as critical success factors of the GLSS approach. According to P1 Enviro, *"an organization should have some kind of information system and technology to effectively implement these strategies".*

Adequate utilization of tools and techniques helps in accurate analysis of a problem as indicated by P1 Enviro. For example, if an organization receives regular fines from the government due to wastewater discharge, a consultant may convince the organization to improve a specific manufacturing process by implementing certain GLSS enablers to minimize the waste discharge. However, at the end of the project, the actual root cause is found to be in wastewater treatment process instead of the manufacturing process, then it can result into wrong analysis which eventually leads to wrong decisions. Similarly, P1 LSS emphasized that tools should be selected according to the nature of a problem, "*you might be using complex tools for things which do not require complex tools. That is overdosing of tools".* P1 LSS further advised that success is in simplicity. The tools should be utilized in a simple and practical way.

4.7.3 Human resource factors

The consultants from PK highlighted various critical factors related to human resource for the successful execution of GLSS strategy. Employees are a valuable resource in an organization who facilitate the organization in the adequate utilization of other resources (such as machinery and raw material) by using their knowledge and skills as emphasized by P1 Enviro. Thus, employee involvement in organizational activities is crucial for achieving success in GLSS strategy. For example, if an organization buys a new machine which is environmentally friendly, consumes less energy, and produces more; still, it needs employees to familiarize themselves with that machine to operate it. The skills and mental readiness of employees play a vital role in successfully implementing the GLSS strategy as highlighted by P2 LSS. In many organizations, employees do not like a certain machine and do not want to work on it because they consider that machine a threat to themselves. P2 Enviro highlighted training of the appropriate personnel regarding the use of different GLSS enablers such as EnMS, DFE, DOE, 5S, Pareto diagram in the manufacturing operations as a critical success factor of the GLSS strategy for improving environmental performance.

P2 LSS also highlighted employee empowerment as an essential factor of GLSS to authorize people in implementing this strategy. P1 LSS stressed respect for people as a critical success factor for GLSS implementation and highlighted, *"GLSS should be a way of life which requires respect for people".* Additionally, employee awareness regarding the significance of GLSS strategy for achieving environmental performance is a crucial factor so that they can be enthusiastically involved in the green initiatives taken by the organization, P1 LSS argued.

4.7.4 External stakeholder-related factors

Among the external stakeholder-related factors, government policies are considered as a critical success factor for implementing a GLSS strategy; however, there are limited standards for a few environmental indicators which are followed by manufacturing organizations in Pakistan as expressed by P2 Enviro:

> *in Pakistan, the government policies are just focusing on very limited national standards for the effluents such as NEQS (National Environmental Quality Standards). The organizations only bother about three, four or five of the environmental parameters and not more than that.*

The findings reveal that the financial institutions can play a critical role in the implementation of a GLSS strategy; however, there are few companies in Pakistan for whom it is a critical success factor as emphasized by P2 Enviro. For example, in the case of developing renewable energy sources, few organizations take loans from banks. Conversely, P2 LSS refuted the role of financial institutions as a CSF and stated, *"I have never heard anyone going to any financial institution"*. Similarly, P1 LSS emphasized that most of the manufacturers in Pakistan have enough financial resources therefore, they do not take loans from a bank, *"there are manufacturing establishments who have been successful for decades. For example, Sialkot airport is made by industrialists because government did not have enough financial resources".* Moreover, there are religious aspects such as interest rate due to which manufacturers do not use bank loans as a source of capital, P1 LSS noted. Table 4.7 highlights critical success factors of a GLSS strategy by Pakistan experts.

Table 4.7: Critical success factors for green-lean-six sigma implementation from Pakistan consultants

Critical success factors of GLSS	Sub-categories	PK Consultants
Strategic factors	• Leadership commitment	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro
	• Resource allocation	P1 LSS, P1 Enviro, P2 Enviro
	• Communication	N2 Enviro
	• Integrated GLSS	P1 LSS, N1 Enviro
	• Safe working environment	P1 Enviro
	• Change management	P1 LSS, P1 Enviro
Operational factors	• Performance measurement	P1 Enviro, P2 Enviro
	• Project management	P2 Enviro
	• Adequate utilization of tools	P1 LSS, P1 Enviro
	• Innovation and technology infrastructure	P1 LSS, P1 Enviro
	• Statistical thinking	P2 LSS
Human resource factors	• Employee training and education	P2 LSS, P1 Enviro, P2 Enviro
	• Employee involvement and empowerment	P1 LSS, P2 LSS, P1 Enviro, P2 Enviro
	• Teamwork	P1 LSS
	• Employee awareness	P1 LSS
	• Competent employee	P1 Enviro, P2 Enviro
	• Respect for employees	P1 LSS
External stakeholder-related factors	• Financial institution	P2 Enviro
	• Government support and policies	P1 LSS, P2 LSS, P2 Enviro

4.8 Summary

This chapter presented the findings of the phase 1 – preliminary study which is conducted in NZ and PK to understand the GLSS strategy from consultants' viewpoint for improving the environmental performance of the manufacturing firms. In this preliminary study, knowledge and experience of the LSS and environmental consultants facilitated in gaining an in-depth understanding of the reasons for GLSS adoption, enablers used by manufacturing firms for achieving environmental outcomes, and CSFs for a successful execution of the GLSS strategy. The next chapter – 5 presents the empirical findings of the phase 2 – main study conducted in flexible packaging manufacturing companies of NZ.

Chapter 5

Case Studies of New Zealand Flexible Packaging Manufacturing Companies

5.1 Introduction

This chapter presents findings of the phase 2 – main study conducted in two large flexible packaging manufacturing companies in NZ namely Alpha-flex and Beta-flex (pseudonyms) to investigate the views of key respondents on the implementation of the GLSS strategy for achieving environmental performance. This study collected data from practitioners of FP companies on the drivers, enablers, environmental outcomes, and CSFs of a green-lean-six sigma strategy. A theoretical model of a GLSS strategy for achieving environmental performance (Figure 2.4) was utilized to conduct this study. Semi-structured interviews were conducted with senior corporate managers in both companies. Table 5.1 summarizes the details of the companies (Alpha-flex and Beta-flex) and the participants.

Table 5.1: Details of New Zealand case companies Alpha-flex and Beta-flex and interview participants

Company Name	No. of employees	No. of interviews	Participants' codes	Job role	Years of experience
Alpha-flex	> 50	4	PM-N1	Production manager	17
			SCM-N1	Supply chain manager	5
			QA-N1	Quality assurance manager	13
			HSE-N1	Health safety and environmental manager	25
Beta-flex	> 50	5	PM-N2	Production manager	26
			SCM-N2	Supply chain manager	4
			QA-N2	Quality assurance manager	7
			RDM-N2	Research and development manager	6
			HSE-N2	Health safety and environmental manager	3.5

This chapter is organized as follows. Sections 5.2 and 5.3 present the overview of the companies Alpha-flex and Beta-flex and the interview findings on the drivers, enablers, environmental outcomes, and CSFs of a GLSS strategy in these companies.

5.2 Case 1 – Alpha-flex

Alpha-flex is a global company that develops and manufactures FP solutions for beverages, pharmaceutical, medical, home and personal care, and pet care products, and technical applications such as for agricultural and chemical products. The company has operations in more than 40 countries. Its head office is in Zurich, Switzerland and has three manufacturing sites in NZ, two of which are located in Auckland and one in Christchurch. The NZ based sites have certifications for hazard analysis critical control points (HAACP), the British retail consortium (BRC), and ISO 22000.

5.2.1 Green-lean-six sigma drivers

5.2.1.1 Internal drivers

The findings highlight cost reduction as a major GLSS driver for Alpha-flex. PM-N1 and HSE-N1 emphasized cost reduction as a green driver for the company because green practices (e.g., energy management practices) can facilitate environmental cost reduction such as compliance and energy cost. On the other hand, SCM-N1 stressed that implementing green practices increase costs such as using environmentally friendly materials (biodegradable) which require a huge investment. However, due to economies of scale, if the company gets enough demand for these materials, then there could be a cost reduction, *"at the moment, the company is still at the point where producing biodegradable film structures incur heavy cost".* Additionally, cost minimization is emphasized as a key driver of lean and six sigma for FP manufacturing organizations to reduce the costs associated with storage of raw materials and semi-finished products and reworking and recycling of products (by reducing defects).

The participants also highlighted process control as a driver of the GLSS strategy. HSE-N1 posited process controlling as a potential reason for lean implementation through visual management tools to indicate variations in the process flow and the related information. PM-N1 stressed process control as an *"absolute reason"* for six sigma implementation. The participant explained that specific variables in the extrusion process need controlling such as sectional temperature at different zones and speed of the extruder for reducing VOC emissions and energy consumption. If the temperature of any zone is above the specification limits, it can result into polymer degradation, which would lead to resins wastages and gaseous emissions. Similarly, if the speed of the extruder exceeds the required specification limits, then the motor will consume more energy to convert resins into plastic films.

Implementation of GLSS in Alpha-flex is also undertaken from a waste reduction perspective with the company currently working on several waste reduction projects such as landfill waste reduction, process waste reduction, and energy reduction. The company has set specific targets for landfill waste reduction and always looks at options for reducing and recycling waste. According to HSE-N1, *"from an energy conservation and a waste perspective, lean plays a role in that, you know, one of our biggest projects here is around waste"*. HSE-N1 further explained how the waste reduction was a driver for six sigma:

> *yeah, certainly our waste projects drive six sigma. I guess one of the things that we focus in on our waste projects is around reducing quality defects and*

> *we did quite well and had massive improvements in the last few years through six sigma. So that ultimately reduces waste.*

SCM-N1 asserted that environmental concern is a *"valid"* reason for lean application such as linkages of waste reduction and energy conservation are related to inventory management aspects. Since the FP manufacturing process deals with a number of plastic film structures (such as PET, polyvinylidene chloride (PVDC), BOPP, HDPE, and linear low-density polyethylene (LLDPE)), there are chances of raw material wastes that could end up in landfill in case a customer suddenly cancels their order. Therefore, using lean techniques such as JIT helps in reducing the environmental impact. According to PM-N1, "*it is a very good reason to do lean from an environmental position. There is a chance your customer leaves and you cannot use that material so it will be going to end up in landfill".*

Similarly, participants emphasized environmental issues as the driver for six sigma which are linked with defect reduction and product rejection that end up in landfill. Further, reworking and recycling of any product consumes energy, which is also an environmental waste. According to SCM-N1:

> *for environmental concerns around six sigma, anything that is not a good product has the potential of going straight into landfill. Or even if it gets recycled, it still consumes energy to regrind it and bring back into the processes. It takes money in the form of energy cost to recycle that.*

The company is implementing six sigma practices for reducing quality defects, for example, by controlling heat resistance and moisture level of cereal bags which comprises multi-layer films with a combination of HDPE, LDPE, and LLDPE. PM-N1 commented, *"we try to make sure that a defective product does not go to our customers. If there is a problem within the site, six sigma helps in identifying the source of the problem and we try to avoid doing it again".*

SCM-N1 strongly emphasized continuous improvement as a reason for executing green strategy because new grades of plastic films and papers are available in the market. The participant noted that the company always takes a step further to continuously improve the material structures to stay ahead in the market despite no customer demand. It is due to the complicated processes of testing new materials which can take a year and more*, "we have to spend a year for testing and trialling new structures and making sure we can actually work with it".*

The participants highlighted that green manufacturing has become more of a global topic and manufacturers in the FP industry want to reduce the environmental footprint. In addition, Alpha-flex is one of the signatories of the "new plastics economy global commitment" led by the Ellen MacArthur Foundation in collaboration with the United Nations (UN) environmental programme to address plastic pollution. PM-N1 explained that as a global manufacturer, the company wants to be a responsible global producer by providing environmentally sustainable solutions. According to QA-N1:

> *we are aware of what can be construed as a negative impact or a negative view of flexible packaging and we will do everything we can as a global entity to respond to the negative impacts of plastics".*

Similarly, SCM-N1 noted, "*it is not to create any more problems in the world*". According to PM-N1 and SCM-N1, resource circulation is a driver for GLSS execution. The company's research and development (R&D) team is constantly working on new material structures and new resins that can achieve the objectives of the circular plastics economy. PM-N1 noted, *"by recycling post-consumer and post-industrial resins, you are getting things a bit more circular. You are also reducing the reliance on oil and giving people the option to recycle the end product".* The company has recently developed some food packages from sugarcane for one of its customers. HSE-N1 further explained that the post-industrial and post-consumer recycled resins are used in the manufacturing of the packaging for hygiene products such as baby diapers because these resins cannot be reused in the packaging of food products due to food safety concerns.

The findings also highlight that the company is implementing a GLSS strategy for improving employee health and workplace safety. According to QA-N1, Alpha-flex is currently executing a lean 5S project driven from a health and safety perspective to identify and remove the potential hazards in this area and maintain a clean and tidy workplace.

5.2.1.2 External drivers

The participants highlighted numerous external drivers of GLSS implementation such as government pressure, public pressure, development organizations, customer pressure, competitiveness, and company image. In terms of government pressure, the participants suggested that there is a need for more environmental legislations to drive green initiatives as current regulatory requirements are not stringent enough for FP organizations in NZ. SCM-N1 highlighted that there are a few regulatory requirements for VOC emissions but there is not enough pressure from the government to standardize recycling of FP, *"it is really ad hoc in NZ, to be honest. I do not think there is a lot of legal requirements"*.

According to HSE-N1, social responsibility plays a major role in executing a green strategy due to the negative environmental consequences of FP, *"we are part of the problem, and we cannot just be creating more problem and ignoring it."* However, public pressure does not drive the company to implement green practices. PM-N1 noted, *"that time has not come yet when we expect that there may be public holding placards outside our building".* Similarly, HSE-N1 indicated that there was a little public pressure that was not necessarily visible, *"I would not say we get public pressure in terms of bad publicity or protest or anything like that. But I think it is different in the background".* Since FP manufacturing companies are in the middle of a supply chain to produce plastic packaging solutions for customers', therefore public pressure comes indirectly through customers, which leads the company to find environmentally sustainable solutions. PM-N1 remarked, *"the packaging buyers who seem to get the public pressure; they push us to find solutions, but generally we do not have direct public pressure"*.

Additionally, "The Packaging Forum" is a member-based organization that develops and promotes litter reduction and provides product stewardship solutions for packaging. It is driving the FP industry to develop recyclable flexible packaging solutions, pushing the flexible packaging manufacturing companies to initiate green practices such as recycling the soft plastics e.g., through the "Soft Plastic Recycling Scheme". In addition, Alpha-flex is partnered with "Earth Watch Institute" – a non-profit environmental organization promoting environmental awareness and green manufacturing to reduce environmental waste.

The participants also highlighted customer pressure as a significant reason for GLSS implementation. According to PM-N1, customer pressure is a key driver for green implementation because the customers have started demanding more environmentally friendly solutions, therefore, the company's R&D team keeps trialling new materials and product types. HSE-N1 argued, *"I would say at least, a good 60% of our customers demand sustainability in the product. They come and ask, what sustainable options have you got for us?".* Not only the customers but the end consumers are also aware of environmental issues of FP materials. They drive corporate customers to provide sustainable packaging options which in turn enforces the company to initiate green practices. QA-N1 stated that one of the company's major customers is now driving the company to recycle post-industrial plastic films and reuse them in the product packaging, *"so, waste generated during the packaging process is coming back and it is one type of customer pressure".*

According to SCM-N1, with increasing environmental awareness, customers give more value to green aspects and are ready to pay extra amount for environmentally friendly packaging. However, this extra cost passes on to the end consumer as well, *"some of the big customers are highly concerned with the recyclability and composability of packaging materials and they appreciate and endure extra cost for these aspects".* Many of the key customers advertise themselves as being *"green and sustainable",* HSE-N1 emphasized. In addition, customers also drive Alpha-flex to reduce costs and carbon footprint of multi-layer films which can be achieved through lean and green practices. According to PM-N1, compliance with customers' quality improvement and cost reduction requirements drives the company to implement lean and six sigma enablers. From a lean perspective, customers demand minimal pricing and on-time delivery of the products. SCM-N1 noted, *"some customers are purely price-driven and for some others, just the continuity of supply is ridiculously important".* SCM-N1 further added that customer pressure is a relevant force for driving six sigma because the customers expect the company to provide quality packaging for their products which in turn represents both the company and customer image after the product is placed on a supermarket shelf.

The participants emphasized company image as one of the key GLSS drivers. According to PM-N1, maintaining a green image is a major reason for executing a green strategy which can be viewed from the company's logo where colours and the design depict the company's awareness of public concerns with plastic pollution. Since the company is among the pioneering global FP organizations in developing a sustainable pledge, therefore a positive environmental image is essential to be a market leader. To further strengthen its green image, Alpha-flex has a target to become completely sustainable by 2025 as highlighted by HSE-N1. Additionally, as a responsible organization, Alpha-flex has a sustainability policy which helps in highlighting and maintaining its green image in the market, "*I think as a global organization, if we do not have a sustainability policy, then it would be very detrimental to our company image",* HSE-N1 noted. On the other hand, SCM-N1 refuted company image as a lean driver, rather considered it as a reason for a six sigma implementation, since six sigma directly focuses on quality attributes of packaging which are linked with the company image due to customers' requirements for quality packaging.

Competitive pressure is also considered as a key GLSS driver. It is found to be one of the main drivers of green strategy which pushes the company to use green materials and generate less VOCs. According to PM-N1, this pressure is particularly coming from offshore competitors who have expertise in producing environmentally friendly packaging. PM-N1 further emphasized that their company always considers the market situation to identify more environmentally friendly options in the FP area, for instance, changing from plastic wraps to paper wraps. According to HSE-N1, customers are heading towards green initiatives by demanding environmentally sustainable packaging options and if the organization fails to do so, they would go to competitors, *"it would be irresponsible of us not to be in that space, and we would ultimately lose customers down the track by not having those options"*. SCM-N1 stressed on competitor's pressure as a key driver for GLSS strategy to develop packaging solutions having long shelf lives with recyclable packaging at a lower price. According to PM-N1, *"we have implemented lean principles as a result of a pressure from our competitors. We need to reduce our costs to compete financially"*.

The following Table 5.2 presents the GLSS drivers from the participants of Alpha-flex.

Table 5.2: Green-lean-six sigma drivers in Alpha-flex

GLSS drivers	Main categories	Sub-categories	Participants from Alpha-flex
Internal drivers	Operational drivers	• Cost reduction	PM-N1, HSE-N1
		• Process control	PM-N1, HSE-N1
		• Waste reduction	PM-N1, SCM-N1, QA-N1, HSE-N1
	Organizational drivers	• Continuous improvement	SCM-N1, QA-N1, HSE-N1
		• Environmental responsibility	PM-N1, SCM-N1, QA-N1, HSE-N1
		• Employee health and workplace safety	QA-N1, HSE-N1
		• Resource circulation	PM-N1, SCM-N1, QA-N1, HSE-N1
External drivers	Regulatory drivers	• Environmental regulations	SCM-N1
	Society-oriented drivers	• Public pressure	HSE-N1
		• Membership and non-profit organizations	SCM-N1, HSE-N1
	Market-oriented drivers	• Competitor pressure	PM-N1, SCM-N1, HSE-N1
		• Customer pressure	PM-N1, SCM-N1, QA-N1, HSE-N1
		• Company image	PM-N1, SCM-N1, QA-N1, HSE-N1

5.2.2 Green-lean-six sigma enablers and environmental outcomes

5.2.2.1 Waste and emission reduction

All participants from Alpha-flex highlighted waste reduction as a prominent outcome of a GLSS strategy. Additionally, reducing waste also results in more efficient processes and less VOC emissions. PM-N1 stated, *"it helps our company in reducing the plastic waste to landfill"*. Alpha-flex is conducting various waste reduction projects such as process waste reduction, rework reduction, and quality rejects reduction. The waste projects also include minimizing machine downtime, machine wash ups, and setup times. Although the company does not have an ISO 14001 certification, most of its operations are based on the environmental management system. In this regard, the company follows environmental waste management practices and implements methods for reducing the environmental footprint suggested by QA-N1 and HSE-N1. SCM-N1 mentioned that the company uses JIT frequently to maintain inventory levels and focuses on minimizing large amounts of safety stock to reduce material wastes, *"we have focused a lot on reducing safety stock and wasting materials. That was the biggest lean movement I have seen in our company".*

The company stores inventories in the form of raw materials and semi-finished products and tries to maintain these as low as possible. HSE-N1 explained that Alpha-flex follows make-to-order strategy and manufactures and distributes just-in-time which results in lowering the finished product inventory. In addition, the company uses 5Whys in its manufacturing processes to investigate and reduce product defects related to packaging quality. The company is achieving the environmental benefits of 5S in the form of waste reduction and productivity improvement by segregating the process wastes. Findings highlighted that 5S is not implemented in all areas of the plant. According to HSE-N1, the company has partially implemented 5S in a few areas of production. However, in the next couple of months, 5S will be fully implemented in the entire manufacturing plant. SCM-N1 indicated that the company tries to standardize different products to reduce process waste and conserve resources such as inks, films, solvents, and adhesives through the lean enabler of WS. The company has also developed SOPs for machine setups, process checks, and jobs handover, *"we try and standardize everywhere we can just to help us along to minimize waste".*

Participants also highlighted that Alpha-flex implements the DMAIC cycle whenever a significant problem arises in the manufacturing processes. For example, the company had conducted a DMAIC project at an extrusion machine to reduce plastic waste. CA is also used to identify the causes of product defects, process wastes, and machine downtimes. QA-N1 emphasized, *"we use cause-effect analysis to investigate why are we making this mistake? why are we generating this waste, and how can we improve it?".* Further, the CA can improve the environmental performance by having multiple thoughts from different people. QA-N1 stated, *"it is always a good thing because we have a number of people on site that are concerned about the environmental aspects and they can give some good input".* Pareto diagrams are also used for analysis of environmental, health and safety, and quality issues. HSE-N1 recalled that a couple of years ago, one of the employees went on an "Earth Watch" program and investigated the ocean waste in South America using Pareto diagram to analyze the plastic waste of the company.

GLSS enablers also help in reducing air emissions such as VOCs by using environmentally friendly materials such as water-based inks instead of solvent-based in flexographic printing process. Moreover, using bio-based materials derived from renewable resources such as sugarcane, corn, potatoes, rice, soya, wheat, and trees instead of petrol derivatives contribute to reducing the carbon footprint, SCM-N1 advocated. Additionally, Alpha-flex has implemented an "Enviro Action" program for reducing the carbon footprint, water usage, and process and landfill waste. According to HSE-C1, the company's R&D team uses LCA for some materials requested by specific customers who want to use the carbon footprint information in eco-labelling. From a lean perspective, minimal movement of materials around the work floor, process waste reduction, and optimal inventory levels result in less air emission. SCM-N1 noted, *"from the point of view of having extra material in warehouse, there will be a certain carbon price to pay for that".* Further, the company has carefully designed the facility layout especially for storage and transportation of materials to minimize the travelling distance, which has further reduced the carbon footprint and cost of transportation. QA-N1 remarked, *"we are aware of storage and transportation of materials backwards and forwards. We do that efficiently and always look to reduce the number of trips".* Additionally, by using SOPs for handling and using solvents in the printing and lamination processes, there is less chance of VOCs being released in the environment. According to PM-N1, *"less VOCs are being released because we are containing them better as part of saving them and not wasting them. By using SOPs around the equipment, there is a less chance of evaporation".*

5.2.2.2 Resource conservation and recycling

Alpha-flex is implementing various GLSS enablers for resource conservation and recycling. The company has initiated several projects for less use of materials such as resins and other hazardous materials such as adhesives and solvents with the objective of cost reduction, resource conservation, and environmental safety. SCM-N1 stated that the *"company tries to do a reasonable amount of lamination work in case more than one FP structure or more than one type of plastic film is involved".* The company possesses the forest stewardship certification (FSC) that ensures the paper-based packaging products are manufactured in an environmentally friendly way through responsibly managing forests. Some of the customers also demand the products with FSC labelling as highlighted by HSE-N1. The participants emphasized the 3R as a key enabler of green strategy for achieving resource conservation and recycling benefits. According to QA-N1 and PM-N1, the company uses waste materials such as plastic film waste from the extrusion process in the testing phase of new products and daily job setting process which gives the benefits of resource conservation and waste reduction. However, inks applied to films cannot be reused in food grade products, rather these are reused in a non-food contact application. SCM-N1 argued that reusing is hard for some of the FP products because there are plastic film structures that cannot be reused. For instance, in case a customer demands to package frozen pastries in a greaseproof wrapper to be reused by consumers for baking purpose, then it will be difficult to develop a wrapper that fulfils all requirements of freezing, greasing, and baking because of variation in temperature requirements.

PM-N1 highlighted that the company also recycles the solvents and extrusion waste on-site, *"we recycle as much polyethylene coextruded packaging film as we can".* Moreover, due to an increase in the level of on-site recycling of extrusion waste, the company is having *"more ownership"* rather than sending it to an external recycler and landfill as illustrated by PM-N1. Along with the green practices, lean also helps in efficient recycling of waste such as used solvents. QA-N1 stated, "*lean removes the complications and improves the flow of recycling process. It reviews the inputs, controls the speed, and runs a cleaner and neater operation"*. QA-N1 suggested that 5S is an effective tool for segregating plastic films such as hard laminates from polyethylene and polypropylene based films facilitating efficient recycling of waste. HSE-N1 explained that within the factory, there are separate bins for different waste categories such as landfill and recycling. Alpha-flex has also implemented six sigma tools such as CBA for evaluating the recycling and disposal costs linked with plastic films, inks, solvents, and adhesives.

According to PM-N1, FP processes are "*energy hungry"* therefore, several energy management practices are followed such as LED (light emitting diode) lighting retrofits, chiller systems, and supervisory control and data acquisition (SCADA) system to track and control plant-level energy usage. Similarly, HSE-N1 highlighted that Alpha-flex has developed energy management teams that are focused on energy efficiency projects. Further, the possibility in use of *"green or environmentally friendly films"* as a packaging material was highlighted in the future production which would also reduce energy consumption. Not only does green helps in energy and raw material conservation but lean also achieves the above environmental benefits through TPM. According to QA-N1, the flexographic printing is a complex process among all other printing processes due to several job setting requirements, "*setting a 10 colours job is quite complicated".* Therefore, Alpha-flex uses SMED for the machine setups at different stages of the FP process. The setup of a new printing job requires print adjustment according to the customer's specifications which is a time-consuming process and results in energy and plastic film waste. Therefore, using SMED in the printing processes not only saves time but also provides environmental benefits such as energy savings, raw material conservation, and landfill waste and air emission reduction. PM-N1 stated that a couple of years ago, the company successfully conducted an SMED project in the printing process and achieved significant environmental benefits. Similarly, minimizing inventories through JIT resulted in reducing energy consumption and decreasing energy costs. SCM-N1 argued, *"employees have to make sure that even though that pallet of plastic films is just sitting there in warehouse, it consumes energy"*.

5.2.2.3 Environmental safety and compliance

The findings highlighted that GLSS tools also help in improving environmental safety, complying with regulatory requirements, and sustaining resources from a long-term perspective. Alpha-flex has recently developed a product (chocolate) wrapper from sugarcane which is more sustainable than petrol and crude oil. DFE guidelines were used in this development of an eco-friendly packaging solution. Similarly, six sigma has also helped Alpha-flex in innovating new sustainable packaging solutions by using statistical tools such as DOE. SCM-N1 noted, *"six sigma helps us in producing sustainable products and offering more technically advanced options"*.

Alpha-flex has an environmental board of fitness that ensures the company is fulfilling government regulatory requirements. For example, the inks, solvents, and adhesives are ventilated and dried off through correct methods during the flexographic printing process to meet the regulatory requirements. QA-N1 stressed, *"we never got any fines and penalties. We focus on achieving regulatory requirements"*. SCM-N1 and HSE-N1 highlighted that Alpha-flex is fully compliant with regulatory requirements of GHG emissions by implementing the green strategy. According to SCM-N1, *"we are complying with the regulatory requirements for VOCs because otherwise we would not be allowed to operate"*.

Alpha-flex uses water-based adhesives and inks that also minimizes the health and safety risks of employees along with air emission reduction. The company has instated an employees' safety committee comprising senior management members and employees from various departments, job functions, and shifts. The committee develops injury prevention plans and collects ideas for minimizing physical and behavioural safety risks. Further, the company has developed an environmental health and safety risk matrix to evaluate the likelihood of potential hazards and the severity of consequences. Moreover, a hazard identification, risk assessment, and risk control (HIRARC) process has also been implemented at the site as part of the green strategy.

Lean strategy has helped in decreasing environmental fines and penalties by reducing chances of spills and contaminations and increasing employees' health and safety through the use of SOPs. HSE-N1 stressed, *"well, the risk of resin discharge in waterways is a big issue for us. We have got systems in place to make sure we are not contaminating".* Most of the solvents used in the flexographic printing process contain at least one carbon and hydrogen atom and have negative effects on health and environment. SCM-N1 emphasized that the lean strategy helps in employee and workplace safety by following SOPs to handle solvents and other hazardous materials. The company also uses 5whys to ensure the employees' health and safety aspects by evaluating potential safety hazards (such as machine accidents) on the work floor. PM-N1 and HSE-N1 further illustrated the use of 5whys to analyze the quality risks and machine breakdown issues. Additionally, visual boards are regularly used to monitor the waste level and health and safety aspects in different processes of FP.

According to HSE-N1 and SCM-N1, green also contributes to sound environmental decision-making such as selecting the packaging materials after evaluating the carbon footprint and recyclability aspects. SCM-N1 noted, *"if you evaluate all your options correctly, you do not go out of your way to make things not green".* Similarly, lean and six sigma also facilitate in environmental decision-making such as selecting the right job mix through production scheduling (heijunka) to make sure the jobs are processed in a greener way.

Table 5.3 summarizes the empirical results of GLSS enablers and environmental outcomes from the participants of the Alpha-flex.

Table 5.3: Green-lean-six sigma enablers and environmental outcomes in Alpha-flex

GLSS enablers	**Environmental outcomes categories**	**Sub-categories**	**Participant from Alpha-flex**
5S, 5Whys, CA, DMAIC, eco-labelling, enviro action, EMS, JIT, LCA, Pareto diagram, SMED, visual management, WS	Waste and emission reduction	• Air emission and carbon footprint reduction	PM-N1, SCM-N1, QA-N1, HSE-N1
		• Process waste reduction	PM-N1, SCM-N1, QA-N1, HSE-N1
3R, 5S, CBA, energy management teams, lean facility layout, FSC, green films, JIT, lean mudas, renewable resources, SCADA, SMED, TPM	Resource conservation and recycling	• Less use of energy, water, and raw material	PM-N1, SCM-N1, QA-N1, HSE-N1
		• Increase in recycling	PM-N1, SCM-N1, QA-N1, HSE-N1
		• Less use of hazardous materials	PM-N1, HSE-N1
5S, 5Whys, CBA, DFE, DOE, EHS risk matrix, employee safety committee, environmental board of fitness, heijunka, HIRARC, LCA, renewable resources, environmentally friendly materials, visual boards, WS	Environmental safety and compliance	• Decrease in environmental fines and penalties	QA-N1, SCM-N1
		• Sound environmental decision-making	QA-N1, SCM-N1, HSE-N
		• Future orientation	HSE-N1
		• Improve employee and workplace safety	PM-N1, SCM-N1, HSE-N1

5.2.3 Critical success factors for implementing green-lean-six sigma to achieve environmental outcomes

5.2.3.1 Strategic factors

All participants emphasized that the leadership commitment and support is a critical issue for the effective execution of a GLSS strategy. QA-N1 explained that the workers in the lamination area had been facing a waste generation problem from one of the lamination machines requiring an investment of NZD30,000 to fix the issue. The senior management reviewed and recognized the proposal given by the shopfloor employees and approved it since waste generated from the lamination machine would be difficult to recycle due to multi-material laminates that could end up in landfill. Further, the leadership commitment also includes the direction given by the top management to the workforce, which plays a critical role in an effective implementation of GLSS as stressed by PM-N1, *"the right message from the top management for the people on the floor is important"*.

The senior management should clearly communicate the environmental goals to everyone in the organization. According to HSE-N1, "*I think everybody should have the same focus. If each department is not having the same way forward and do not follow the same principles, then everyone will be going in different directions"*. In addition, top management should communicate in such a way that employees can easily understand why these kinds of strategies are important for an organization*, "when you are setting up processes, you have to make sure that people actually follow them… that is made in a way that they should be willing to implement",* SCM-N1 cited.

SCM-N1 and HSE-N1 further highlighted financial resources as a CSF as it requires major investments such as installing regenerative thermal oxidizer (RTO) technology for abating solvent fumes and odours and eliminating hazardous air pollutants and VOCs during the flexographic printing process. Furthermore, in implementing strategies such as green, lean and six sigma, financial resources are also required for acquiring consultancy services from environmental and LSS experts as suggested by HSE-N1.

Participants also stressed on an integrated approach for GLSS as a CSF to effectively implement the green-lean-six sigma strategy. According to HSE-N1, GLSS is an integrated strategy towards environmental sustainability as, *"all three green, lean, six sigma go hand in hand"* and can provide better results. QA-N1 posited that the environmental outcomes of lean and six sigma can be seen as *"by-products"* and therefore change in one strategy can impact the other. QA-N1 further argued that there is an overlap between green, lean, and six sigma strategies such as energy consumption is associated with the process waste and product defects, therefore green, lean, and six sigma should be treated as an integrated approach.

Most of the participants refuted the reward system as a CSF for implementing green-lean-six sigma. However, HSE-N1 highlighted that their company has a reward system for waste minimization. QA-N1 asserted that instead of a reward system, there should be a recognition system for encouraging and motivating the employees and remarked:

> *we have a good thing that we run across the sites, which is recognition of people's effort. You do not go and give them million dollars. But you go out of your way to make sure that you acknowledge the work that might have gone a bit above and beyond.*

In addition, HSE-N1 emphasized on maintaining a safe and healthy workplace for employees as a critical factor for an effective utilization of a GLSS strategy, *"to me, from the perspective of keeping your employees – your best tool, safe and not injured is an essential element in GLSS implementation and I think it is probably an area which is underestimated as compared to waste and cost reduction".* The senior management of Alpha-flex is keen in undertaking health and safety, quality, and environmental initiatives which they decide in monthly meetings. PM-N1 commented, *"we are aware and we have very good initiatives driven from the top. We always focus on health and safety in the first instance. And then getting into the quality aspect as a second thing and then productivity".*

5.2.3.2 Operational factors

The participants highlighted project management as a critical factor for a successful outcome of a GLSS strategy and that the company recognizes this aspect while implementing different GLSS projects including waste projects, recycling projects, and employees' and environmental health and safety projects. SCM-N1 emphasized that the project management approach is critical while initiating projects such as recycling certain FP materials because the company has different sites where employees with different mindsets and skills are involved in these projects. According to QA-N1, *"the new manager brilliantly handled a project of dye stripping on extrusion machine by having a much greater control of the project on site".*

Additionally, the innovation and technology infrastructure is a critical success factor for GLSS implementation in the FP manufacturing industry. The findings revealed that innovation and technology upgradation helps Alpha-flex to use environmentally friendly materials and reduce discharge of air emissions and use of water-based inks. According to HSE-N1, the company has a global group that works on innovation, *"our research and development team is continuously working on innovation to develop more sustainable products, saving resources for future".*

Additionally, the company's research and development function has established a team specifically focused on integrating environmental sustainability into the design of packaging structures to achieve the company's goal of reusable and recycled packaging by 2025. Automation of processes makes things simple and facilitates lean implementation, SCM-N1 argued. The company has installed a system to track the materials and jobs. In addition, the company uses the LCA software called ASSET (advanced sustainability stewardship evaluation tool) that generates life cycle data for different packaging options. However, PM-N1 refuted information technology infrastructure as a critical success factor and stressed that *"things can be done manually".*

Participants highlighted performance measurement as one of the critical success factors of GLSS execution. SCM-N1 stated, *"if you do not measure it, how can you know what you are doing and how well you are doing? You definitely need a clear way of measuring it".* Although performance measurement in terms of machine run time, setup time, downtime, material usage, and energy consumption is undertaken on a daily basis, measuring human resource performance is challenging because an organization has *"different people having different mindsets"* as emphasized by SCM-N1.

Statistical thinking plays a key role in the implementation of the GLSS strategy and provides a broad image of the process by analyzing and measuring the operational and environmental objectives. SCM-N1 commented, *"how well we are producing? are we reducing the wastes, setup times, run time, and cycle times? what are the carbon footprints?"* Similarly, QA-N1 cited, "*statistical thinking enables us to back that up and say, this is what we have done. We have reduced landfill by so many tonnes a year through running a job in a certain way*".

5.2.3.3 Human resource factors

The findings revealed that without training and education, employees cannot understand how to implement the GLSS enablers for achieving the desired outcomes. A participant cited an example in which a supervisor in the flexographic printing area provided training on time and motion study to the machine operators before initiating an SMED project for reducing machine setup time. Alpha-flex has an accelerated career development program of four years' focusing on strengthening the employees' capabilities through global projects in different countries.

According to SCM-N1, workforce involvement is one of the key CSFs for implementing a green-lean-six sigma strategy. The participant highlighted that Alpha-flex's workforce was aware of the environmental issues of FP manufacturing industry and were keen to know what the company was doing from a green perspective. SCM-N1 further emphasized that Alpha-flex has a culture of involving everyone in the organization. HSE-N1 noted that whenever their company organizes site meetings, everyone asks about *"what are we doing in the sustainable space?"*. QA-N1 stressed that employees' involvement in decision-making process is a crucial factor and explained that the assessment of quality issues in the printing process is done through daily meetings involving both supervisors and workers where the information is exchanged both ways and work floor suggestions are recorded and evaluated. In another case, based on the employees' suggestions in an SMED project, the objectives of waste and energy reduction were achieved as highlighted by PM-N1. Additionally, QA-N1 advocated teamwork as a success factor in GLSS execution and explained that the company's sales team, technical team, and operations team work closely while developing new product lines.

The findings also revealed that it is necessary to empower the work floor employees to produce quality products since they are involved in the manufacturing operations. Additionally, employee empowerment also plays a major role in change management. According to SCM-N1, *"giving your employees authorities; raise that flag nice and early of going and calling out that something might be wrong. I see a lot of importance of employee empowerment in producing a high quality good and especially not producing rubbish".* HSE-N1 asserted that employee empowerment is also necessary to build a strong and long-term relationship between the employees and the organization. Moreover, the employees working for a long period have more knowledge and expertise of the company's operations. HSE-N1 explained:

> *we are lucky, we have a very long-standing workforce that has been in the industry for a long time. We have people that are really engaged and really care about what we are doing. So, we are trying to utilize this more with some of the projects we are doing and yeah, I think it is a good thing to be using. There is a lot of knowledge there.*

5.2.3.4 External stakeholder-related factors

The participants emphasized on government support as a critical factor for executing GLSS strategy to improve the environmental performance of the FP manufacturing industry. HSE-N1 asserted that government needs to develop environmental legislations and provide infrastructure for managing the FP waste and achieve plastic recycling and circularity objectives, "*I would like to see more legislative pressure for the flexible packaging industry".* Similarly, SCM-N1 remarked, *"yeah, government support would be great from a recyclability point of view".* PM-N1 emphasized that although most of the products are recyclable, they are ending into the landfill due to a lack of recycling infrastructure in NZ. PM-N1 further noted:

> *we generate a lot of waste. We recycle what we can such as most of the polyethylene films. But a lot of other material goes to landfill as well. They are recyclable but not in NZ. We used to send that to China for recycling, but that door is closed. So, a lot of our waste goes to landfill, probably 70% of it and the rest gets recycled locally. It is about the infrastructure to deal with the materials.*

Close relationship with the customers is a significant factor in GLSS implementation. The findings revealed that Alpha-flex is continuously working on customers' feedback and suggestions for recycling existing and new products and minimizing lead times. According to QA-N1, *"yeah, for sure it is a major CSF for us. For each different customer, we have the feedback system and we work pretty closely with them, especially on new initiatives of recycling and redeveloping".* SCM-N1 also advised having a strong relationship with suppliers. The suppliers' input is crucial while developing new materials to better understand the operational and environmental wastes associated with it, *"when you have new products, you always need input from the supplier to know, how it should be run? how does it help with reducing waste?".*

The participants also highlighted the role of waste collectors and recyclers in executing the GLSS practices for improving the environmental performance of the FP manufacturing industry. The "Enviro Waste" (New Zealand's leading waste recycling company) collects Alpha-flex's process and office waste on a regular basis. It also offers compostable options for hand towels waste and recycling options for paper waste, SCM-N1 explained. Moreover, consumers should be informed and educated regarding the segregation of FP waste and resources must be provided such as home composters for compostable packaging waste. PM-N1 noted:

it is really about the consumer because everything what we make is consumer driven. There is no education at the consumer level as to what to do with our products after consumption. That is where most of the problem lies. Either there is a lack of consumer awareness or a lack of infrastructure to deal with the leftovers from what the consumers purchased. Consumers demand that the products are wrapped up in something and that is what we are doing. We are providing options to the market to minimize the footprint and give them sustainable and environmentally friendly options. But at the end of the day, it comes down to the consumer making a choice as to what they do with the packaging when they are finished with it.

The participants also emphasized that with the cooperation and coordination of forums and institutions, GLSS practices can be successfully implemented for reducing the environmental burden of the FP industry. "The packaging forum" assists the FP companies in recycling soft plastic packaging including frozen food bags, bread bags, confectionery and biscuit wrap, chip bags, toilet paper packaging, and courier envelopes. However, the bags, wraps, and films which are contaminated with food and liquid cannot be recycled.

Table 5.4 presents the empirical findings on critical success factors of GLSS from the participants of Alpha-flex.

Table 5.4: Critical success factors for green-lean-six sigma implementation in Alpha-flex

Critical success factors	Sub-categories	Participants from Alpha-flex
Strategic factors	• Leadership commitment	PM-N1, SCM-N1, QA-N1, HSE-N1
	• Resource allocation	SCM-N1, HSE-N1
	• Communication	HSE-N1, SCM-N1
	• Reward system	HSE-N1
	• Safe working environment	PM-N1, HSE-N1
	• Integrated GLSS	QA-N1, HSE-N1
Operational factors	• Performance measurement	PM-N1, SCM-N1, QA-N1, HSE-N1
	• Innovation and technology infrastructure	SCM-N1, HSE-N1
	• Project management	QA-N1, SCM-N1
	• Statistical thinking	QA-N1, SCM-N1
Human resource factors	• Employee training and education	PM-N1, SCM-N1, QA-N1, HSE-N1
	• Teamwork	QA-N1
	• Employee involvement and empowerment	PM-N1, QA-N1, SCM-N1, HSE-N1
External stakeholder-related factors	• Customer and supplier relations	QA-N1, SCM-N1
	• Consumer education	PM-N1
	• Waste collectors and recyclers	PM-N1, SCM-N1
	• Government support and policies	PM-N1, SCM-N1, HSE-N1
	• Forums and institutions	PM-N1, HSE-N1

5.3 Case 2 – Beta-flex

Beta-flex is specialized in flexible packaging products which include customized solutions for food products, pet care, home and garden, construction, and technical applications including agricultural. The company's head office and the main manufacturing plant is in Hamilton, New Zealand. Beta-flex has sales and distribution centres in New Zealand and Australia. With over 40 years of operations, the company has built a strong international reputation in product innovation and has successfully developed several world-first technologies and products including several slider innovations and compostable packaging for coffee and dry foods. Beta-flex has various certifications to their credit such as HACCP, BRC, and ISO 22000.

5.3.1 Green-lean-six sigma drivers

5.3.1.1 Internal drivers

The findings revealed that there are various drivers compelling Beta-flex for implementing a GLSS strategy. The participants highlighted continuous improvement as one of the major reasons for Beta-flex to implement the green initiatives and therefore, the company is continuously developing new structures and products which can reduce the negative environmental impacts. QA-N2 stated, *"we are continually striving to improve by developing more green products that we have been offering".* According to SCM-N2, *"for sure, it encompasses everything. This is basically what the company is all about. Continuous improvement is an essential part of our business model"*. HSE-N2 also regarded continuous improvement as a reason for lean and six sigma and noted, *"when I look at lean and six sigma, it is all about continuous improvement. We always want to keep evolving. We want to be smarter, nimbler, and quicker".* HSE-N2 further explained that Beta-flex has been struggling to maintain the best business practices, which can be achieved through lean enablers such as "shitsuke" in 5S which is about sustaining the practices, *"sustain is one of the last things in 5S. We are trying to keep it in the company, the morals, and ethics in the workforce to think about these things every day but that is probably the hardest thing we have found over the years".*

According to HSE-N2, cost reduction is not a driver for green implementation because green packaging products are expensive such as the price of a compostable bag is three times the price of oil-based bags. Some customers that prefer paper-based packaging over plastic packaging which is environmentally friendly. However, it is expensive because it takes more energy and water to produce a paper-based packaging as compared to plastic. Moreover, plastic is durable and has multiple applications. PM-N2 stated that on one hand, green practices are useful in minimizing the energy cost and wastewater reduction and on the other hand, these also require large investments, *"it increases the cost to reduce cost essentially, depends on how you look at green. If you take an initiative to reduce your water usage and power usage (in terms of gas and waste) then it is beneficial".* Similarly, HSE-N2 noted, *"when you recycle a plastic, it costs money because it goes through a machine".* On the other hand, the participants stressed cost reduction as one of the major reasons for lean and six sigma implementation to gain competitive advantage.

Process control is not regarded as a reason for green implementation by participants from Beta-flex. HSE-N2 noted that the company is applying lean practices to control processes. Heijunka is used for scheduling FP jobs in a way to balance the changeover time, cost, and inventory levels. Further, SCM-N2 highlighted that there are variation issues on multiple machines in different processes such as extrusion, lamination, printing, waxing, and slitting. Therefore, work floor teams use six sigma practices (such as CA, Pareto diagram, and DMAIC) to identify the reasons for variation and control processes. SCM-N2 stated, *"we use six sigma where we identify areas that there is a lot of variation. I mean, we have multiple machines and we have a team to analyze the data and find out where we can improve the variations".*

Beta-flex is implementing DOE and DFE guidelines to decrease the plastic waste by reducing the thickness of the plastic film used in the packaging structure. The participants highlighted that the company is implementing lean to reduce the operational wastes such as overproduction, waiting time, and excessive inventory. By reducing these operational wastes, the processes are streamlined and cost is reduced. HSE-N2 maintained that lean practices result in effective utilization of resources such as raw material, electricity, and water, *"it is like how we use our materials. We are also thinking about the materials that we do not seem to waste internally in the plant. Could we turn them into something else? Is that a resource that somebody else can use?".* Similarly, participants also indicated waste reduction as a reason for six sigma implementation through defect reduction and quality improvement.

Along with the process waste reduction, the participants also emphasized that the company is implementing a GLSS strategy for enhancing the health and safety of its employees by improving the workplace environment. The participants highlighted that the environmental safety concerns drive lean strategy in terms of preventing material spillage and decreasing the use of hazardous materials such as solvents. HSE-N2 explained that the company makes sure that little plastic resins, *"little five-millimetre beads",* are not leaked into the waste drains in case there is a breakage in the resin's plastic bag, *"we have people on our roster to go and check those drains to make sure products are cleaned away".* Moreover, the employees of

Beta-flex also put pressure on the company to implement GLSS practices due to their prior experience in competitors' organizations as highlighted by QA-N2, *"we have got people that have come to work with us from other companies where they had implemented these types of programs and thought it would be a good idea to do it here"*.

All the participants from Beta-flex emphasized that the company is aware of environmental issues associated with the FP manufacturing processes and especially with the end product. Therefore, the company's top management is taking environmental initiatives and implementing GLSS. QA-N2 emphasized:

> *we make un-environmentally friendly products which are made of plastic and plastic is getting a bad image in media at the moment. It makes sense for us to make environmentally friendly products and consider the environmental initiatives because it is just the right thing to do.*

Similarly, HSE-N2 highlighted that Beta-flex realizes its environmental responsibility and recognizes plastic as an *"environmental and public enemy"* because most of the FP waste goes to the landfill. Therefore, Beta-flex is trying to reduce the plastic waste by producing compostable products and considering recycling options of plastic films. HSE-N2 explained:

> *you know, for a number of years, we have been making compostable products. Our very first product was back in 1995 when no one was really thinking about turtles in the ocean. So, we always think how we can do better? how can we be smarter? how can we close the plastic loop, rather than just pulling oil out of the ground and sending it to landfills?*

Further, the company recognizes the emerging values within the society for environmental betterment and a sustainable future, therefore is executing green practices. PM-N2 noted:

> *we want to be culturally better. It is the right thing to do for ourselves and for society. So, there are lots of initiatives we are taking in terms of changing our practices including compostable packaging which we are developing. We hope to move a lot of our packaging to either recyclable or compostable designs.*

HSE-N2 maintained that for many years, the FP companies did not think enough about the adverse impact of plastic packaging; however, from the last five or six years, these companies have included "green" as part of their business strategy. Additionally, the companies are further enforcing their customers, suppliers, and consumers to contemplate the environmental impacts of the plastics, *"they are really pushing it to people to think, do you really need to wrap your lettuce in a plastic bag when it could be available on a supermarket shelf without a wrapper and could be consumed normally?".* Similarly, SCM-N2 stressed, *"as an environmentally conscious organization, we really want to have less impact. By sending less to landfill, we can be more efficient and more profitable".*

Beta-flex also recognizes the resource circulation as a GLSS driver and therefore, actively collaborates with recyclers to recycle the plastics. By doing this, the company is trying to close the loop by adding value to plastic waste. HSE-N2 cited, *"we can see the value that we are closing the loop whereas in the past those hard plastic wastes were traded internationally such as a large portion of waste was sent to China rather than treating in New Zealand".* Beta-flex also updates the customer about these initiatives as to how the company has saved their product ending up in the landfill. In this way, Beta-flex is trying to communicate to its customers that there are options available for reusing and bringing back the products in the loop.

5.3.1.2 External drivers

The participants also highlighted various external drivers of GLSS such as government pressure, public pressure, customer pressure, and competitiveness. QA-N2 stated that the government recommends using recyclable structures for packaging. The government pressure is further shifted to the local councils that enforce supermarkets to place environmentally friendly packaging on their shelves. This pressure is further shifted to the corporate customers through supermarkets which pushes FP manufacturing companies to use green materials and structures. Additionally, the government is also enforcing FP industry to minimize the production of single-use plastic packaging and increasing taxes on it. In an effort to minimize plastic pollution and improve environmental performance, the NZ government has recently announced that it will eliminate single-use plastics by 2025. From this perspective, the government has already restricted plastic straws and polystyrene takeaway containers as explained by HSE-N2.

HSE-N2 further added that although the government is taking green initiatives, the environmental regulatory requirements are not rigorous for FP manufacturing companies from environmental concerns. There are local and international regulatory requirements such as for food safety which are required to be followed. HSE-N2 remarked:

> *I guess there are international regulations that we consider. So, New Zealand piggybacks on Australia and Australia piggybacks on Europe and*

> *the United States of America (USA) for food safety compliance. We still meet the New Zealand Australian regulations, but they are really a small subset of Europe and the USA.*

QA-N2 stressed that public pressure is a potential reason for green initiatives because the company is producing plastic packaging product which is *"non-environmentally friendly"* and negatively impacts the company image. RDM-N2 highlighted that there is an indirect public pressure for FP companies which comes through government legislations such as public pressure is a reason of a ban on plastic bags in NZ, which prompted the government to impose such environmental legislations, *"the more people are crying, the more likely the government has to respond. Going back to that plastic bag example, the government imposed it so quickly because there was such a big support from the public".*

However, HSE-N2 asserted that public pressure is a significant driver for green implementation. HSE-N2 explained that Beta-flex is located in a small town and there are no regulatory requirements for solvent odour discharge. However, with an increase in the town size, public will start complaining about the solvent odours and then the company will have to install solvent burners to control the odour. Further, QA-N2 and SCM-N2 argued that due to increasing plastic pollution and resulting environmental consequences, media and social networking platforms are creating environmental awareness in public which are an indirect pressure for green initiatives.

The participants also emphasized customer pressure as one of the key external GLSS driver considered as a market-driven force. Most of the corporate customers are environmentally conscious and drive the company to take environmental initiatives by demanding biodegradable packaging material which adds value to their products. SCM-N2 stressed, *"we have customers that want to use biodegradable films. We have a push from our big customers to look at more green and environmentally friendly options for packaging".* QA-N2 emphasized that due to customers' pressure; the company has developed a variety of compostable packaging which is termed as "E-Classic" range of packaging. SCM-N2 maintained that the end consumer also has environmental awareness and drives the corporate customers that enforce the company to produce environmentally friendly packaging. According to HSE-N2, "*it is our customers that are selling it to consumers. So, the consumer will be unhappy with the plastic bags in their stomachs. Yeah, this bag has our company's name on it".*

While compostable materials are expensive, there are a few customers who are environmentally conscious and demand these materials because they want to differentiate themselves from large multinationals and become market leaders. HSE-N2 stated:

> *some of them jump on board and say, I understand this is more expensive, but I am actually going to sign up and be a carbon neutral company. So, they get some accreditation and they say, I am using compostable bags that do not go to landfill so I get a bigger tick and I have to buy less credits in my offsetting.*

The participants highlighted that the customers are generally not aware of the lean strategy and they do not ask for its implementation. However, the customer's influence in terms of reducing product price and on-time delivery are the lean drivers. QA-N2 remarked that the customers do not visit the company and ask about lean*, "it is like an internal thing that you would probably want to implement by yourself".* Similarly, participants also revealed that there is no such customer pressure for six sigma implementation. According to HSE-N2, Beta-flex does not have a push from many customers to implement lean or six sigma, *"the company always looked at it from a strategy of how can we be better? how can we use less resources? how can we be quicker and smarter for customers?".*

SCM-N2 explained that there is no supplier pressure towards implementing green activities instead it is the customer who demands Beta-flex to provide environmentally friendly packaging and then the company enforces their suppliers to supply the recyclable and compostable polymers. However, when the suppliers develop a specific environmentally friendly polymer, they negotiate with the company for its price. HSE-N2 remarked, *"I guess supplier pressure could be in the form of pricing when they make a new polymer quite attractive".* RDM-N2 mentioned that Beta-flex is driving its suppliers to provide environmentally friendly materials*, "we always ask them, 'do you have this? can you change this to make it more environmentally friendly and green?'"* However, the suppliers' price is a pressure on the company to implement lean strategy such as the cost of resin is "*the biggest suppliers' pressure"* since Beta-flex is importing the resins from overseas which are *"very expensive".* Consequently, the company is implementing lean practices to efficiently utilize these materials (resins).

The participants emphasized that maintaining a green image is one of the key reasons for implementing a GLSS strategy. HSE-N2 highlighted that many years ago, Beta-flex was named

"Beta-flex Plastics" when it was only producing plastic products. In 2010, the company started producing paper packaging products. Due to the increasing negative environmental impacts of plastics and the "green wave", the FP manufacturing companies initiated green practices. Beta-flex also realized the negative image of the plastics and thus it removed 'plastics' from the company's name and now it is just "Beta-flex New Zealand". *"We did some rebranding; it was like a little bit of an awakening because plastics sounds bad",* HSE-N2 noted.

Protecting a company image is also a driver for lean because it is a well-known manufacturing strategy to manage processes in an efficient manner. SCM-N2 stated, *"there is a little bit of pressure because lean is such a well-known thing in the manufacturing industry to be able to say that you are processing in a lean way so it can actually have a big drive on the company image".* Similarly, HSE-N2 explained that lean and six sigma practices are helping Beta-flex to improve its image in the FP manufacturing industry as a company that is conscious about the operational performance and can produce products on time without any defects, *"so, people want to know that you are doing your part for the environment, but you can also make a product on time without any faults".*

The participants also emphasized on competitive pressure as one of the major drivers of GLSS strategy. Both the local and international competitors are forcing Beta-flex to develop green packaging at a faster rate. However, due to the COVID situation, the pressure from the international competitors is reduced because of supply chain issues which has encouraged the customers to *"again go back"* to the local FP companies as cited by HSE-N2. The participants also highlighted that competitive pressure is a driver for lean and six sigma strategies as well. Both, local and international competitors drive Beta-flex to implement lean practices to reduce cost. According to PM-N2, *"we are not just having competitiveness within New Zealand but it's global competitiveness. We are competing on a global platform. We are competing with imports. We have to compete with the products coming from China and Asia".* Similarly, PM-N2 highlighted that Beta-flex is executing six sigma to imitate one its biggest competitors' strategy to improve the business performance. *"I was with Amcor and they are doing a lot around six sigma. Definitely we are also doing, and we should be doing that too".*

The GLSS drivers from participants of Beta-flex are presented in Table 5.5.

Table 5.5: Green-lean-six sigma drivers in Beta-flex

GLSS drivers	Main categories	Sub-categories	Participants from Beta-flex
Internal drivers	Operational drivers	• Cost reduction	PM-N2
		• Process control	QA-N2, SCM-N2, HSE-N2
		• Waste reduction	PM-N2, QA-N2, SCM-N2, HSE-N2
	Organizational drivers	• Continuous improvement	QA-N2, SCM-N2, HSE-N2
		• Employee pressure	QA-N2
		• Environmental responsibility	PM-N2, QA-N2, SCM-N2, HSE-N2
		• Employee health and safety aspects	HSE-N2
		• Resource circulation	PM-N2, QA-N2, SCM-N2, HSE-N2
External drivers	Regulatory drivers	• Environmental regulations	QA-N2, SCM-N2, HSE-N2
	Society-oriented drivers	• Public pressure	PM-N2, QA-N2, SCM-N2
	Market-oriented drivers	• Competitor pressure	PM-N2, QA-N2, SCM-N2, HSE-N2
		• Customer pressure	PM-N2, QA-N2, SCM-N2, HSE-N2
		• Supplier pressure	RDM-N2, HSE-N2
		• Company image	PM-N2, QA-N2, SCM-N2, HSE-N2

5.3.2 Green-lean-six sigma enablers and environmental outcomes

5.3.2.1 Waste and emission reduction

The participants suggested that Beta-flex is implementing various GLSS practices to reduce waste since a large quantity of FP waste ends up in landfill. As part of the green strategy, the landfill plastic waste is reduced in Beta-flex by developing compostable packaging as highlighted by HSE-N2. The company has developed compostable pillow bags for one of its key customers using green enablers such as DFE that has the potential to divert at least 10 tonnes of plastic away from landfill each year. In terms of the lean strategy, participants emphasized on WS as a significant tool for improving operational and environmental performance since the FP manufacturing industry has to deal with a variety of packaging materials. According to HSE-N2, Beta-flex is trying to reduce the process waste by standardizing some of its packaging products for its key customers, *"some big customers have seven or eight different variations in one product. Now, with one of our big customers, we are trying to rationalize those seven or eight products to a maximum of two products through standardization".*

HSE-N2 further maintained that there are three customers of a protein mix bag and their requirements for the bag size (such as width and fitness) varies. Beta-flex asked them, *"we could actually give you a better price if we had all three companies buying the same widths and the same fitness"*. As a result, Beta-flex has one set up rather than three which saves time and money. Moreover, the process waste is also reduced due to standardizing the product size. The findings also suggest that CA is used to reduce process waste. The employees in a certain department sit together to brainstorm the causes of a problem. A participant explained that Beta-flex used CA and Pareto diagram in a waste project on a coil winding machine that resulted in a 30% waste reduction, which was earlier dumped in landfill. Moreover, Pareto diagrams are also used in different processes of FP to identify the major reasons of problems such as evaluating printing defects in the printing process. SPC charts are also used for displaying data trends, decision-making, and controlling process waste. For instance, SPC charts are applied in the extrusion process to control the bubble instability in the plastic film in Beta-flex, which is considered as one of the major causes of extrusion waste.

Beta-flex has an environmental committee comprising a team of people from different departments who generally meet monthly. The committee arranges training in different departments for identifying and segregating different types of plastic waste generated by the processes. According to HSE-N2, the environmental committee reviews different waste projects and considers the environmental initiatives to close the loop for the company's products, *"are we recycling all our cardboard? are we recycling all our plastics? what do we do with a broken wooden pallet?".* Moreover, Enviro Waste – a waste management and resource recovery organization in NZ – also assists the company's environmental committee in preparing the landfill reports by providing the data of landfill per cubic meter of plastic waste as stated by HSE-N2:

> *with our environmental committee, we have yearly reports for health and safety and environmental performance. And that includes information such as energy usage and plastic waste sent to landfill because we capture numbers each month on those things. So, we get a report from Enviro Waste to analyze how often the truck visited the company? how many kilos of waste went to landfill? how many cubic meters went to landfill?*

Participants also argued that lean and six sigma also help in waste reduction by making the product right the first time. The company uses lean mudas to identify over production, waiting time, and transportation waste as noted by QA-N2. Moreover, Beta-flex has also started using VSM in current lean projects for identifying overprocessing waste such as unnecessary sampling and quality inspection of packaging products at various stages. HSE-N2 explained:

> *we have started VSM in some of the lean projects that we are doing to check if we are doing too many quality tests or are we doing too few tests and can we make the same good quality product if we reduce our sampling rate. Currently we are doing some investigations on it.*

SMED is frequently implemented in the manufacturing processes of the company to increase the process efficiency and reduce process waste, waiting time for jobs, and energy consumption. According to HSE-N2:

> *for each of our processes, there is like a Formula One team. We have lots of people that come in and change over a machine setup in a very efficient manner when we do a job change. We do not just let one operator take 20 minutes to do all the changes that are needed. We call in other staff to help them so we can set it up quickly. The setup time of our machines are not fixed, for some machines, it took four hours, and for others, it took 20 – 40 minutes.*

Similarly, six sigma is also used to reduce the process waste as per participants. For example, DOE is used in Beta-flex to reduce the thickness of plastic film which results in waste reduction and resource conservation. DMAIC is frequently used in the company's waste projects for identifying and analyzing waste issues. According to PM-N2, Beta-flex has implemented DMAIC on one of its pouch-making machines and reduced process waste from 18% to 3%.

Although solvent-based inks are used which contain a high concentration of VOCs, the company is trying to use water-based inks in the printing process which can be helpful in eliminating the VOCs emissions such as xylenes, ketones, alcohols and aliphatic. However, the use of water-based inks is limited due to large investment requirements as noted by HSE-N2, *"I would say it is probably going to be in the next year, 10% of our equipment will be using water-based printing and the rest will still be using solvent-based".*

Beta-flex also considers air emission reduction by appropriate planning while placing the raw material orders because most of the company's suppliers are located overseas. HSE-N2 highlighted that the company has not done LCA for all of its products, instead, it conducts life cycle analysis as per customer demands. For example, the company has been conducting LCA to calculate the carbon footprint of one of its compostable products. The LCA results of the compostable film were compared with the oil-based film which highlighted the positive results in the form of minimum GHG emissions for compostable films. HSE-N2 further added that there are different methods available for conducting LCA which makes it difficult to use in terms of compliance and verification. HSE-N2 remarked:

> *because you know, when it comes to compliance or verification, which method do you use for the LCA? Do you use an American one? Do you use UK based one? Japanese one, which one is the best one? Because it all relies*

> *on different input information about cost of materials, location of materials, and transport costs. So, you have to use all your local data, not the ones that is generated in Europe because it is slightly different from New Zealand.*

PM-N2 further noted that lean also helps in minimizing air emissions such as VOCs by reducing setup time of printing machines in the flexographic printing process through SMED. Since the company is using offsite warehouses to store a large quantity of semi-finished products, therefore using JIT can also result in reducing the environmental impact such as energy cost and air emissions as suggested by SCM-N2.

5.3.2.2 Resource conservation and recycling

The company is also implementing different GLSS enablers for conserving resources. One of the major benefits of using the green strategy is in increasing the level of recycling of various packaging products and developing a circular economy infrastructure for recyclable products. QA-N2 asserted that one of the significant practices implemented by the company was 3R. Further, according to SCM-N2, nearly 50 tonnes of extrusion waste is recycled every month. HSE-N2 explained that the company has developed a thick layer of the plastic sheet through recycling a specific plastic waste that was difficult to convert into a plastic bag. This sheet now works as a divider for placing plastic film rolls and can be used *"more than 20 times"*. By using this divider, a large quantity of cardboard pallet waste is reduced which was earlier used as a partition between the plastic film rolls and discarded after usage. With such initiatives, plastic waste is minimized which was earlier ending into landfill. The company also conducts LCA for some of its customers to recycle their waste. According to RDM-N2, *"for some customers, we help them by doing LCA to bring back their waste. We recycle it and then we put it back into the products again"*.

The company has an on-site composter which is used for composting experiments. The compostable films are treated in it and the resulting compost is used in the company's garden to grow vegetables for the employees. According to QA-N2:

> *any of the compostable films that we have developed, we can then do our studies on them and provide our customers with confidence that these films that we are providing are going to be biodegradable. So, we are taking our own compostable stuff and treating it in the on-site composter and putting it into our garden. And we grow vegetables for staff. However, another big*

> *portion of the compostable films are also sent to another company to treat it in an industrial composter.*

Participants asserted that lean practices also enable the company towards efficient, faster, and sensible waste recycling by identifying and segregating process wastes. Beta-flex has distributed different bins for specific types of wastes to be collected for recycling which have a capacity of 300-400kgs per bin. PM-N2 highlighted that Beta-flex uses 60 tonnes of polyethylene every month and collects all its extrusion waste (clean scrap of single polymer) in a separate bin. According to participants, kaizen can also help in improving waste recycling and achieving circular economy objectives because of its continuous improvement approach involves everyone including leadership, employees, customers, and suppliers. According to HSE-N2:

> *often, we get caught up too much and just produce what we can produce and anything that is a by-product, goes to waste. I think kaizen helps us thinking about, if I got that waste, what could it be turned into, and that probably could be done by partnering with other companies, customers, and suppliers to see if they think it is a valuable resource that we could use.*

Six sigma also facilitates the waste recycling process. DOE is used to identify the optimal quantities of material mix and compatibilizer for recycling the multi-resin film structure (e.g., packaging structure of fresh produce). According to HSE-N2:

> *with six sigma, we are able to recycle our hard plastic packaging by blending it with compatibilizer and additional materials to create a much better product. We took a number 7 product that really goes to landfill. We added the compatibilizer and applied DOE to determine the optimal quantities of blending mix. We were successful in recycling that.*

While Beta-flex is not having ISO 50001 certification, it has implemented various energy management practices such as energy efficient machines in different processes. Further, energy audits are regularly conducted in the company to evaluate the energy consumption of each machine. In terms of lean practices, heijunka also helps in conserving energy by careful planning regarding the job mix on different machines. Additionally, SMED saves energy by minimizing setup time of machines. PM-N2 also noted that TPM is effectively used in the company which gives environmental benefits such as less waste and less energy consumption by regular maintenance of the machines. SCM-N2 remarked:

> *yeah, for the maintenance, we have a team of engineers on site that do the regular maintenance of each machine, just like a routine schedule of maintenance and oiling. That works really well rather than doing nothing and waiting for the machine to break down and creating all sort of headaches.*

5.3.2.3 Environmental safety and compliance

Beta-flex is also achieving the benefits of GLSS in terms of environmental safety by minimizing the risks associated with hazardous materials. The company has implemented an occupational health and safety standard as stated by HSE-N2. According to PM-N2, the company is carefully containing hazardous waste such as used solvents and inks by implementing 5S and therefore, *"has never got any environmental fines"*. Similarly, HSE-N2 suggested that Beta-flex is using poke-yoke and SOPs for minimizing the likelihood of resin discharge into drains which further decreases the risk of environmental fines and penalties. Additionally, Beta-flex has 5S teams who regularly audit the manufacturing plant to ensure *"we are not dumping resins, inks, and solvents into drains".* The environmental committee also conducts trainings on employees' health and safety aspects in different departments. Furthermore, the committee also prepares yearly reports on employees' health and safety such as a number of accidents in a month. According to SCM-N2, SOPs are strictly followed to carefully handle and store the solvents and inks which minimizes the employees' health and safety risks such as breathing problems (e.g., asthma). HSE-N2 highlighted that 5S also contributes to the employee's health and safety aspects by preventing solvent spills into the workplace environment. Along with the employees' health and safety concerns, the company has implemented the HACCP standard for food safety, which is used to identify, analyze, and control hazards before products are distributed to the customers.

SCM-N2 emphasized that Beta-flex is moving towards biodegradable and bio-based packaging structures to be more sustainable in terms of conserving resources (e.g., oil) for future use. The company has been using DFE guidelines and DOE for developing its 'E-classic' range of packaging which is a high barrier compostable packaging film. It is currently used in the packaging of products such as tea, coffee, cereal, snack bars, and drinking chocolate. According to QA-N2, *"so, it is the packaging that performs just like traditional packaging. People can put it in a composter at home and it biodegrades simply. So, it is diverting waste from landfill and saving resources".*

Beta-flex has developed compostable packaging film made from corn-starch (produced from GM-free (genetically modified) sustainably managed corn plantations). It is used in producing retail carry bags, indoor bin liners, singlet bags, and wheelie bin liners for food and organic waste collection and composed in an environment containing water, heat, soil, and oxygen. According to HSE-N2, the company is also shifting to paper-based packaging, *"currently the company is producing 80% plastic and 20% paper-based packaging, however, in the next 10 years it will be producing 50% plastic and 50% paper-based packaging.*

GLSS strategy also helps in environmental decision-making. For example, HSE-N2 explained that the LCA provides the carbon footprint data for selecting environmentally friendly materials. Similarly, six sigma also helps in sound environmental decision-making through use of SPC charts. SPC charts are developed for monitoring different variables such as melting temperature, film thickness, and air velocity in the extrusion process. By controlling these variables, the objectives of energy savings, resource conservation, and emissions reduction can be achieved. Furthermore, CBA is also used from an environmental perspective for calculating the recycling and landfill cost of a new product.

Table 5.6 summarizes the empirical results of GLSS enablers and environmental outcomes from the Beta-flex participants.

Table 5.6: Green-lean-six sigma enablers and environmental outcomes in Beta-flex

GLSS enablers	**Environmental outcomes**	**Sub-categories**	**Participant from Beta-flex**
3R, 5S, compostable packaging, CA, DFE, DMAIC, DOE, environmental committee, JIT, LCA, SMED, SPC, VSM, environmentally friendly materials, WS	Waste and emission reduction	• Air emission and carbon footprint reduction	PM-N2, QA-N2, SCM-N2, HSE-N2
		• Process waste reduction	PM-N2, QA-N2, SCM-N2, HSE-N2
3R, 5S, compostable packaging, DOE, energy audits, energy efficient machines, environmental committee, heijunka, JIT, kaizen, on-site and industrial composters, SMED, TPM, environmentally friendly materials, WS	Resource conservation and recycling	• Less use of energy, water, and raw material	PM-N2, QA-N2, SCM-N2, HSE-N2
		• Increase in recycling	PM-N2, QA-N2, SCM-N2, HSE-N2
		• Less use of hazardous materials	PM-N2
5S, environmentally friendly material, CBA, DFE, DOE, environmental committee, HACCP, kaizen, LCA, occupational health and safety standard (OHSAS), poke-yoke, renewable resources, SPC WS	Environmental safety and compliance	• Decrease in environmental fines and penalties	PM-N2, SCM-N2, HSE-N2
		• Sound environmental decision-making	PM-N2, QA-N2, HSE-N2
		• Future orientation	PM-N2, QA-N2, SCM-N2, HSE-N2
		• Improve employee and workplace safety	PM-N2, QA-N2, SCM-N2, HSE-N2

5.3.3 Critical success factors for implementing green-lean-six sigma to achieve environmental outcomes

5.3.3.1 Strategic factors

The findings revealed various strategic CSFs of GLSS strategy for improving environmental performance. From this perspective, all participants regarded leadership commitment and support as a key success factor for GLSS strategy. PM-N2 argued that the top management commitment is a critical factor in the execution of GLSS as *"GLSS is driven from the top".* QA-N2 posited that the senior management should ensure the implementation of GLSS in all departments to create a continuous flow of these strategies. Top management should also embed GLSS with business strategy and implement it across the whole organization. The willingness must be reflected through the company's mission, vision, and goals. Senior management must identify the areas of improvement, plan projects, allocate resources, develop time frames, and seek the government support to implement the GLSS strategy. According to HSE-N2:

> *you need to get management on board to say, hey, we are lagging in these areas. To be best of class, it is going to cost you time and money. We may need to get some government help or government funding to dig down to see what could be better to make those changes and then we will get the outcome. You need that willingness at the very beginning to say, yes, we are going to do it within this timeframe.*

The participants highlighted the need of financial resources for implementation of GLSS practices. QA-N2 asserted that financial resources must also be allocated for training of these practices and further explained that Beta-flex once hired a trainer who did not charge any fees however, the training did not end in the desired outcomes, *"if the company had paid for somebody, maybe it would have been better than the person that we got for free".*

QA-N2 emphasized that all three green, lean, and six sigma should be integrated and work together towards improving environmental sustainability because these strategies are related to each other and have an effect on each other. Additionally, SCM-N2 and PM-N2 highlighted that currently, the company is implementing the GLSS as an integrated approach in the FP manufacturing processes of Beta-flex. Such an approach is beneficial for achieving operational, environmental, financial, and social performance. Furthermore, the integrated GLSS strategy encompasses the requirements of ISO 9001, ISO 22000, ISO 45001, and ISO 14001 by subsequently addressing the packaging quality (ISO 9001), food safety (ISO 22000), workplace safety (ISO 45001), and environmental sustainability (ISO 14001) aspects. According to SCM-N2, over time, there are more compliances required by customers. Some customers want BRC, some require ISO 9001, others prefer ISO 14001. SCM-N2 argued:

> *however, when you start reading through all those green, lean, and six sigma practices, they all start to blur and look very similar. So, when we start writing our quality documents, an integrated GLSS approach can make it easier in writing one statement that covers the wordings of each of those different standards. So, putting them all together is better than having them separate or individual.*

PM-N2 noted that reward system is one of the success factors of GLSS and stated that the company also recognizes and rewards the teams on the successful completion of waste reduction projects, *"I think it is a valuable part. End of the day, if we make a good profit, there is a profit share for the teams".* However, according to SCM-N2, a reward system is not required for the successful implementation of GLSS because it is a temporary means of motivating employees rather, they should be involved and empowered in the company's activities. HSE-N2 stressed that there should be a feedback loop in the organization instead of a reward system that helps to understand how employees feel about the company and how can the company improve?

5.3.3.2 Operational factors

With respect to the operational factors, performance measurement plays a critical role in the success of the GLSS strategy. Beta-flex has KPIs for each department, process, machine, and employee and the relevant performance data is collected and analyzed regularly. PM-N2 recalled that in terms of environmental waste, Beta-flex is measuring the monthly air emissions generated by its processes. The participants also emphasized the role of innovation and technological advancements as a critical success factor and therefore, the company's R&D team is continuously testing and trialling new material combinations to achieve environmental performance. SCM-N2 emphasized, "*yes, we are reducing, reusing, and recycling. We have a lab team that is constantly redeveloping".* PM-N2 explained that although Beta-flex has undertaken green initiatives from the last 10 years, the life cycle for FP products is quite long due to slow innovation and technological developments in packaging materials.

HSE-C2 noted that a strong technological infrastructure helps in GLSS execution. For instance, Beta-flex has implemented Microsoft dynamic AX which holds the information of all operations and helps in organizing, automating, and optimizing the processes, *"it is like an ERP system which gathers the information and applies statistics and develops graphs which assist in decision-making*". HSE-N2 further advocated the role of industry 4.0 as a critical success factor for GLSS implementation such as in terms of getting data from the machines, the company can make better decisions by linking the machines to the ERP systems, *"so, we have got real time data to make sound decisions such as where problems are leading down to maintenance. It helps us in deciding when it is time to replace something before it actually breaks down".*

According to QA-N2, project management approach is also critical because *"it keeps things task focused and with having such an approach; things can be done quicker".* QA-N2 and SCM-N2 also stressed that the right project selection is a critical factor for the effective implementation of a GLSS strategy. SCM-N2 further emphasized that there have been a couple of projects which have failed due to a lack of a focused approach. Additionally, the projects should have a quick turnaround and should be short term to keep the employees engaged and motivated. QA-N2 noted, *"anything that is dragged on for too long, the staff becomes bored and loses interest. So, for keeping staff interested and motivated, a quick turnaround on GLSS projects is good. And it needs to operate site wide and department wide".*

QA-N2 and PM-N2 suggested that the statistical thinking is a CSF for the GLSS strategy. Further, PM-N2 maintained that it is a relevant factor from the GLSS project management perspective to measure different performance indicators and stated:

> *in terms of green, how we reduce our waste? how we improve our environmental impact? In terms of lean, it is related to how well we manufacture? In terms of six sigma, how can we measure the defects and control processes through statistical analysis? So, statistical thinking is important for all three, not only for six sigma.*

5.3.3.3 Human resource factors

Among the human resource factors, it is also necessary to educate and train the employees whenever new materials are developed, new machines are installed, and new practices are implemented. Moreover, the employees should also be informed of the potential benefits of GLSS enablers through training. SCM-N2 noted, *"we need to educate them why the company* *is doing it and placing new machines. That all comes back to training and education to ask, why we are doing this and how it is going to benefit them?".* Similarly, PM-N2 emphasized that Beta-flex is conscious about employees' training and education and invests time and money in various training and education programs. *"Training is very high up on their (senior management) list".* The company spent resources such as time and money on training its staff. Currently 50 of Beta-flex staff members are on different training programs such as basic lean initiatives and good manufacturing practices.

A competent and professional trainer is essential for the successful implementation of a GLSS strategy who can engage the employees and strategically train them on the principles and tools of these strategies. According to HSE-N2, *"we always have somebody from industry who comes in and teaches us and then assigns little group projects within the company".* Additionally, QA-N2 highlighted, *"I feel the trainer that we had in the past was not good and did not do his part of the project. Therefore, we did not get the full potential out of it".*

Employee involvement is a critical success factor in executing a GLSS strategy. Although change starts from the top management, it requires employee involvement. Moreover, successful implementation of GLSS requires cross functional teamwork which improves team bonding by including people from different areas. Teamwork also improves the communication between employees which results in employees upskilling. PM-N2 stressed that teamwork is necessary to *"bring the employees on one page"*. Everyone in the team should recognize that they are working towards uniform environmental objectives. Beta-flex has different waste teams including employees from each department which are working on environmental waste projects such as solvent reduction, plastic waste reduction, and energy reduction. QA-N2 regarded employee empowerment as a crucial factor and explained that a couple of cross-functional projects in the past were disintegrated and did not continue because the employees realized that *"their opinions were not being valued enough".*

5.3.3.4 External stakeholder-related factors

Participants also emphasized the role of different stakeholders such as customers, suppliers, recyclers, industry groups, and governments to successfully execute the GLSS strategy for improving the environmental performance of the FP industry. Although the government is encouraging FP companies to produce compostable and biodegradable packaging, there is a lack of infrastructure to collect and dispose of the non-biodegradable packaging waste which is a major issue. The government support, direction, and the local council infrastructure are critical success factors in this perspective. QA-N2 cited:

> *there is a government push to make compostable packaging but in terms of how the customers are supposed to dispose of the packaging and kerbside collection is not really easy. So, the government whether it is a local body like at a council level, they need to put in the infrastructure in place to assist this. This is what is really happening in the industry a bit.*

Strong customer relations is a critical success factor for executing a GLSS strategy because customers are the ones who are enforcing Beta-flex to provide them the environmentally friendly products, SCM-N2 noted. Similarly, strong supplier relations also play a significant role in the successful execution of GLSS practices. For example, the suppliers upgrade the raw material, provide useful information for using the material and machinery, and fulfil the company's requirements of on-time material supply. HSE-N2 argued:

> *suppliers definitely help a lot. If the suppliers got some helpful information or something they have done, whether it is a new part or a new modification for a machine to say, we have upgraded this and it helped us through a program, so we can also go and say, hey, you have already done it and learned from it, which makes it much easier for us to take that on board.*

Similarly, PM-N2 asserted on the strong supplier relationship that can result in customer satisfaction by fulfilling the customer's requirements and expectations. Moreover, the suppliers facilitate Beta-flex towards environmental initiatives, *"a lot of our suppliers support us on our initiatives and we push them to support us too"*.

A forward-thinking approach is required in recycling the resources and all the stakeholders need to actively participate in the circular loop. For instance, recyclers play a key role in the effective implementation of green practices (such as 3R). The participants highlighted that there is a third-party recycler in Auckland who collects the process waste, converts it into resins by shredding it in the grinders and then supplies back to the company. Although these resins do not meet the food safety criteria for use in food packaging, they are reused in the manufacturing of the black rubbish bags, HSE-N2 and SCM-N2 informed. Similarly, the wasted inks, solvents, and adhesives are collected in separate recycled bins and handed over to a third party that handles these kinds of wastes. Furthermore, the customers are also putting an extra effort to collect recyclable packaging products and bring them back to Beta-flex for recycling.

According to HSE-N2, plastic recyclers are *"sort of cherry picking",* they tend to recycle only those plastic packaging which are easy to recycle. Similarly, consumer awareness is another critical success factor for green implementation because plastic pollution is a social problem which requires consumer involvement. HSE-N2 remarked:

> *this is a people/social problem. We let plastic play around in the wind. We can collect it, put it in a bin, and cover it with a lid so it can stop blowing away. You know, we are the ones driving down the road in our cars with McDonald's and chucking out the window at the end of the day. So, everyone has to participate.*

Additionally, the company works closely with its recyclers to learn the new opportunities for recycling materials. According to HSE-N2, *"they (recyclers) are the ones that are offering us a compostable option for paper towels. They are interested in seeing less waste to landfill. So, they are helping us with that process to be able to recycle as much as we can".*

Table 5.7 presents the empirical findings on critical success factors of GLSS from the participants of Beta-flex.

Table 5.7: Critical success factors for green-lean-six sigma implantation in Beta-flex

Critical success factors	**Sub-categories**	**Participants from Beta-flex**
Strategic factors	• Leadership commitment	PM-N2, QA-N2, HSE-N2
	• Resource allocation	PM-N2, QA-N2, HSE-N2
	• Continuous implementation of GLSS	QA-N2
	• Linking GLSS to business strategy	QA-N2, SCM-N2
	• Communication	HSE-N2
	• Reward system	PM-N2, QA-N2, RDM-N2
	• Feedback loop	HSE-N2
	• Integrated approach	PM-N2, SCM-N2, HSE-N2
Operational factors	• Performance measurement	PM-N2, QA-N2, SCM-N2, HSE-N2
	• Innovation and technology infrastructure	PM-N2, QA-N2, SCM-N2, HSE-N2, RDM-N2
	• Project management approach	PM-N2, QA-N2, SCM-N2, HSE-N2
	• Statistical thinking	PM-N2, QA-N2, HSE-N2
Human resource factors	• Employee training and education	PM-N2, QA-N2, SCM-N2, HSE-N2
	• Employee involvement and empowerment	PM-N2, QA-N2, SCM-N2, HSE-N2
	• Teamwork	HSE-N2, RDM-N2
External stakeholder-related factors	• Customer and supplier relations	PM-N2, SCM-N2, HSE-N2
	• Waste collectors and recyclers	HSE-N2, SCM-N2, RDM-N2
	• Government support and policies	QA-N2

5.4 Summary

This chapter presented findings of the multiple case studies conducted in New Zealand to examine the GLSS implementation in two large-sized FP manufacturing companies. The theoretical model of a GLSS strategy for improving the environmental performance (Figure 2.4) was used as a guide in this analysis. Accordingly, the findings revealed various drivers, enablers, environmental outcomes, and critical success factors of GLSS emphasized by the senior corporate managers in these companies. The next Chapter-6 presents the findings of the multiple case studies conducted in the FP manufacturing companies in Pakistan.

Chapter 6

Case Studies of Pakistan Flexible Packaging Manufacturing Companies

6.1 Introduction

This chapter presents findings of the phase 2 – main study conducted in two large flexible packaging manufacturing companies of PK namely Delta-flex and Gamma-flex (pseudonyms) to investigate the views of key respondents on the implementation of a GLSS strategy for achieving environmental performance. This study collected data from practitioners of FP companies on the drivers, enablers, outcomes, and CSFs of a GLSS strategy. A theoretical model of a GLSS strategy for achieving environmental performance (Figure 2.4) was utilized to conduct this study. Semi-structured interviews were conducted with key participants who were senior corporate managers including production manager, supply chain manager, quality assurance manager, maintenance manager, procurement manager, and health safety and environmental manager in these companies. The details of the companies and the case study participants are given in Table 6.1.

Table 6.1: Details of Pakistan case companies and interview participants from Delta-flex and Gamma-flex

Company Name	No. of employees	No. of interviews	Participants' codes	Position	Years of experience
Delta-flex	> 250	5	PM-P1	Production manager	9
			PCM-P1	Procurement manager	6
			SCM-P1	Supply chain manager	21
			QA-P1	Quality assurance manager	8
			HSE-P1	Health safety and environmental manager	5
Gamma-flex	> 250	6	PM-P2	Production manager	20
			SCM-P2	Supply chain manager	30
			QHSE-P2	Quality, health, safety, and environmental manager	5
			EHE-P2	Environmental health and safety executive	2
			QA-P2	Quality assurance manager	4
			MM-P2	Maintenance manager	6

This chapter is organized as follows. Sections 6.1 and 6.2 present the overview of companies – Delta-flex and Gamma-flex and the interview findings on the drivers, enablers, environmental outcomes, and CSFs of a GLSS strategy in these companies.

6.2 Case 1 – Delta-flex

Delta-flex is a leading FP manufacturing organization in Pakistan, which provides packaging solutions by combining different materials such as plastic films, paper, and aluminium foil using both single and multi-layer films that are laminated to protect the customer products.

Delta-flex caters to a variety of FP products including soap, tea, food, detergents, personal care, pharmaceuticals, pesticides, and home care. The company has its head office in Lahore, and sales offices in different regions of Pakistan including Karachi, Multan, Islamabad, Faisalabad, Sukkur, and Peshawar.

6.2.1 Green-lean-six sigma drivers

6.2.1.1 Internal drivers

The participants from Delta-flex highlighted several internal drivers of GLSS such as waste reduction, cost reduction, process control, product characteristics, health and safety concerns, and environmental commitment. PM-P1 emphasized that process control is one of the key drivers of GLSS as *"green-lean-sigma strategy helps in increasing quality and controlling process variation".* PCM-P1 stressed that process control is a significant reason for initiating green practices such as the use of mono-layer structures (considered as green materials) which can facilitate controlling of the extrusion process as compared to multi-layer structures as these are less complex and have less variables to control. PCM-P1 further explained that laminating aluminium foil with PE requires careful process controlling due to possible grammage variation issues which could affect the packaging quality. Similarly, lean also controls processes (through SOPs) and reduces non-value-added activities from the processes (through lean mudas) as noted by PM-P1. PM-P1 maintained that controlling processes is a significant reason for six sigma adoption as well, which is achieved through use of SPC such as controlling variations in FP manufacturing processes (such as printing and lamination) and packaging parameters (such as thickness of the plastic film).

Participants also highlighted that GLSS has been adopted to reduce operational and environmental waste. SCM-P1 and PM-P1 stated that waste reduction was a key lean and six sigma driver which pushed Delta-flex to execute different tools such as lean mudas and DOE. PM-P1 also stressed that environmental waste has also compelled the company to implement the lean strategy such as managing inventory levels to minimize the outdated materials which could end up in the landfill. Similarly, the environmental waste in the form of plastic waste and VOC emissions drove Delta-flex to implement six sigma practices to reduce process rework. PM-P1 noted that the quality defects in the FP printing process could result in a wastage of printing film which would require either recycling or end up in the landfill. Further, reworking on products also consumes material and energy causing air emissions.

Delta-flex has also undertaken environmental initiatives based on the attributes of the FP processes, to reduce the use of plastics, chemicals, adhesives, and solvents that have environmental impacts in the form of landfill, air emissions, solid and liquid waste, and energy consumption. Additionally, the employees' health and safety requirements also prompted the company to initiate a GLSS strategy. Delta-flex is implementing the lean practices 5S and SOPs to ensure workplace safety. A few participants highlighted cost reduction as a driver for the environmental initiatives, however, SCM-C1 and MM-P1 contradicted that cost reduction was a driver for green strategy and argued that green practices in fact increase cost due to heavy capital investment and financial requirements in research and development such as installing waste recycling plant and developing sustainable packaging materials.

Delta-flex is aware of the environmental burden of the FP products and is committed to improve the environmental performance since it is a signatory company of United Nations sustainable development goals and understands its environmental responsibility. In this regard, Delta-flex has developed an integrated management system (IMS) policy that covers the principles of green, lean, and six sigma strategies. The IMS policy reflects the corporate social responsibility aspects and management commitment towards environmental protection. SCM-P1 further highlighted that overall, the FP manufacturing industry in Pakistan, is not committed to environmental performance, however, *"Delta-flex is committed towards leading the way and it has the vision to reduce the carbon footprint to a certain extent by 2025"*.

6.2.1.2 External drivers

The findings revealed that customer requirements, company image, and competitive pressure are significant market-oriented drivers prompting Delta-flex to adopt a GLSS strategy. According to PM-P1, GLSS is a "*customer-driven"* strategy as almost 70% of the company's customers have their environmental sustainability pledges that drive Delta-flex to adopt GLSS. Similarly, QA-P1 stressed that Delta-flex has taken the environmental initiatives since it is working with renowned multinational companies such as Unilever, Nestle, and Procter & Gamble, "*therefore, the company needs to be on the same page as of its large customers"*. QA-P1 further added that a few customers (e.g., Unilever and Nestle) are very concerned about the amount of solvent used in the manufacturing of FP products. These customers also demand solvent retention reports from Delta-flex to be informed about the quantity of various solvents used in the packaging and the company's initiatives to minimize consumption of such hazardous materials.

Along with fulfilling the local customers' requirements, Delta-flex is largely producing FP products for multinational customers, who require the company to follow environmental guidelines set by their customers or the international environmental regulations. In some cases, these requirements are even more stringent than the local environmental laws as stated by HSE-P1. From a lean perspective, customers influence Delta-flex to implement lean practices since they do not want to pay extra for operational wastes such as long setup times, which has an impact on the delivery time. SCM-P1 indicated that most of the customers such as Unilever, Nestle, and PepsiCo have implemented the lean strategy in their organizations and require Delta-flex to implement in its operations for streamlining the processes. Additionally, Delta-flex has also started some joint lean projects with its customers on plastic waste reduction and the customers are supporting the company in their lean implementation. PM-P1 revealed that customer pressure is also a driver for six sigma since customers tend to make purchasing decisions based on the appearance and quality of the packaging and stated, *"when it comes to packaging, the customers tend to make decisions based on the looks and quality of the wrapper".*

Delta-flex is also implementing GLSS due to supplier pressure which comes from the organization's internal suppliers as some of the FP materials are purchased from sister companies of Delta-flex. For instance, printing inks are purchased from XYZ supplier which is a joint venture of ABC chemicals and located within the premises of Delta-flex, therefore, the inhouse suppliers compel the company to consider environmental issues, QA-P1 noted.

Delta-flex is a leading FP organization in Pakistan and has manufacturing plants in South Africa, Sri Lanka, and Canada. From all these plants, the company is selling FP products to four continents across the globe. Accordingly, Delta-flex has adopted GLSS practices to benchmark itself in international market to compete with international competitors such as Amcor and Huhtamaki who are the global leaders in this segment as stated by PM-P1. According to QA-P1, competitive pressure has also played a role because of which Delta-flex has implemented six sigma. QA-P1 remarked, *"six sigma attracts customers when you go into the market and try to maximize getting orders. So, highlighting six sigma practices and their benefits to the customers results in competitive advantage".*

SCM-P1 emphasized that Delta-flex has implemented various GLSS practices and invested in environmental initiatives to maintain its image in the local and international market and satisfy the government authorities. While the company is conscious about the CSR and has an intent towards serving the community, it also has a *"hidden agenda"* of improving the company image as well, PM-P1 noted. The findings also revealed that public pressure is an emerging driver of the GLSS strategy for Delta-flex. Nevertheless, the company has encountered significant public pressure in South Africa and Canada as compared to Pakistan and Sri Lanka.

SCM-P1 argued that there is no public pressure in Pakistan and it is easy to consume plastic bags. However, Delta-flex has started a few plastic waste reduction projects in Pakistan due to the increasing public awareness as stated by PM-P1. In addition, since Delta-flex is located in a populated area, the general public requires the company to protect the environment from the adverse environmental impacts of plastic, gaseous emissions, and solvent odour, QA-P1 highlighted.

According to PM-P1 and HSE-P1, both the national and provincial regulations require Delta-flex to implement a green strategy. The NEQS and Punjab Environmental Quality Standard (PEQS) provide the environmental requirements regarding air emissions (e.g., stack emissions), noise pollution, and industrial gases and effluents to be followed by the companies. Accordingly, Delta-flex has developed its IMS policy to address the environmental regulations. SCM-P1 stressed that the provincial regulations are more stringent as compared to the national rules. The participant highlighted that in 2020, Lahore high court ordered the EPA to implement a complete ban on the manufacturing, sale, and single use of plastic bags in Punjab in Pakistan. However, the government and institutions need to ensure that the implementation of these regulations and legislations are managed through reliable mechanisms. SCM-P1 further suggested that the *"government has to lead the way. I think government has to be the enforcer".* Table 6.2 presents the GLSS drivers from participants of Delta-flex.

Table 6.2: Green-lean-six sigma drivers in Delta-flex

GLSS drivers	Main categories	Sub-categories	Participants from Delta-flex
Internal drivers	Operational drivers	• Cost reduction	PM-P1, SM-P1
		• Process control	PM-P1, PCM-P1
		• Waste reduction	PM-P1, QA-P1, SCM-P1, HSE-P1, HSE-P1
	Organizational drivers	• Employee health and workplace safety	HSE-P1
		• Environmental responsibility	PM-P1, SCM-P1, HSE-P1, PCM-P1
External drivers	Regulatory drivers	• Environmental regulations	PM-P1, HSE-P1, SCM-P1
	Society-oriented drivers	• Public pressure	PM-P1, QA-P1
	Market-oriented drivers	• Competitor pressure	PM-P1, QA-P1, SCM-P1
		• Customer pressure	PM-P1, QA-P1, SCM-P1, HSE-P1
		• Supplier pressure	QA-P1
		• Company image	PM-P1, SCM-P1, QA-P1

6.2.2 Green-lean-six sigma enablers and environmental outcomes

6.2.2.1 Waste and emission reduction

The findings reveal that Delta-flex has implemented a variety of GLSS practices for waste and emission reduction such as ISO 14001, ISO 50001, SMED, 5S, DOE, and QFD. HSE-P1 and SCM-P1 confirmed that their company is using LCA for only a few products to measure the carbon footprint, and all aspects of LCA are not covered such as environmental analysis from cradle-to-grave. HSE-P1 highlighted that Delta-flex has implemented an ISO 14001-based EMS centred on the PDCA cycle to control air emissions as part of the company's IMS policy. Delta-flex has also installed a heat recovery system that recovers heat from the exhaust of heavy fuel oil (HFO) based engines and produces steam as an energy input in the processes. By doing so, not only the non-renewable resources (e.g., coal and oil) are saved but the air emissions are also reduced. Similarly, by installing a solvent recovery plant, the VOCs and GHG emissions (e.g., methane) have been reduced. Additionally, the company has undertaken a certification from WWF Green Office diploma, which is an environmental program that aims to reduce the carbon footprint and ecological footprint in companies.

Delta-flex is also using one of the lean tools called ECRS (eliminate-combine-rearrange-simplify) in the manufacturing process of FP. This tool has an impact on environmental performance by reducing process waste and unnecessary energy consumption. QA-P1 cited:

> *we ask different questions at each stage of ECRS such as "what are the unnecessary steps that can be removed? how can we combine two steps and get the two-for-one effect? how do we rearrange the steps to optimize the process? how can we simplify the process"?*

The company has also implemented 5S in all processes and regularly conducts 5S audits according to the pre-defined checklist. QA-P1 remarked that *"we have implemented 5S and it has done wonders, it has improved the environmental performance by reducing the chemical, energy, and material waste".*

The findings have highlighted that lean and six sigma practices also help in minimizing air emissions such as SMED reduces the air emissions by decreasing the setup time of machines. PM-P1 noted, "*JIT is difficult to implement in FP manufacturing organizations due to a large variety of raw materials. Some of the materials (such as resins) are imported therefore, due to longer lead times and container size requirements, it is difficult to implement JIT"*. Nevertheless, JIT helps in managing excessive inventory of hazardous materials such as solvents, which result in less VOC emissions release as stressed by QA-P1. Additionally, the company is using six sigma tools for controlling emissions such as the use of DOE in adjusting the viscosity of the printing inks which has an impact on the release of VOC emissions.

QA-P1 explained that *"seven to eight years ago, the total FP process waste was around 9-10% and then top management decided to implement six sigma to reduce waste".* Delta-flex initiated various DMAIC projects which resulted in process waste reduction. Delta-flex also started using CA to evaluate customers' complaints and product defects to determine the root causes. SCM-P1 mentioned, *"around 40% of the food waste is linked with the inadequate packaging characteristics which is an environmental issue"* and therefore, the company's research and development team is using QFD and DOE to protect the customers' products from oxygen, moisture, and light. Control charts are also implemented in the manufacturing processes such as lamination, extrusion, slitting, and printing. These charts help Delta-flex in controlling the grammage variation of extruded films in the extrusion process, which not only reduce the plastic waste but also helps to reduce the recycling requirements.

6.2.2.2 Resource conservation and recycling

Delta-flex has installed solar panels as a renewable energy resource in their main office and the manufacturing plant. The company has also implemented ISO 50001, which emphasizes optimal use of energy. Additionally, the company's energy team monitors daily energy consumption in production halls, offices, and machines as explained by QA-C1. Delta-flex is using 3R practices to conserve the resources such as the printing substrate for oil and ghee extruded films is recycled in the company. The PE waste from the extrusion process is sent to recyclers who convert this waste into resins and supply it back to the company as noted by SCM-P1. Although the recycled resins are not 100% compatible with virgin material, these are mixed with the virgin resins in the manufacture of PE films. Similarly, Delta-flex has installed a de-inking setup to remove inks from the printed films. The company reuses these inks in the printing process, whereas the plastic films are used in the job setting process on printing machines. In this manner, Delta-flex improves environmental performance through conserving material and reducing landfill. QA-P1 stated:

> *after six years of struggle, the company has successfully implemented a solvent recovery plant in which the used solvents from the lamination and printing processes are collected, distilled, and reused in the manufacturing processes and cleaning purposes.*

The findings further revealed that Delta-flex is recycling the extrusion waste by re-palletizing and reusing it as a raw material in the extrusion process. Similarly, the used solvents from the printing process are filtered through distillation plants and reused for cleaning of ink drums and floors with ink splashes as highlighted by PM-P1. Moreover, the company is trying to develop some recycling solutions for the multi-layer films with a lamination of PE and PP as remarked by SCM-P1.

QA-P1 explained that the job setting on a printing machine requires the print process setup and dye adjustment on low machine speed (around 50 meters per minute). The print process setup consumes extensive energy, printing substrate (films), inks, and solvents during the print adjustment. By using SMED, not only the setup time is reduced but also the raw materials and energy are conserved, as well as air emissions are reduced. The findings revealed that Delta-flex is using kaizen to address environmental performance. According to HSE-P1, hot air is used to dry the printing inks on the plastic films through the heated oil that flows in the pipelines near the printing machines. Following kaizen principles, Delta-flex has reduced the length of the pipelines by changing their route. Accordingly, not only the heat losses are reduced but also the energy consumption for heating the oil is decreased. Similarly, Delta-flex has installed variable frequency devices (VFDs) to optimize electricity consumption by reducing the amount of electricity consumed by machines after matching the frequency with motors.

6.2.2.3 Environmental safety and compliance

The findings revealed that the GLSS enablers help Delta-flex in achieving environmental safety and compliance. Delta-flex is considering environmental safety along with product safety through the use of DFE guidelines. QA-P1 mentioned that the company is working with one of its key customers – Nestle, in developing the recyclable wrappers for one of its products through sustainable packaging materials by using DFE guidelines. PCM-P1 stressed that Delta-flex is also initiating the use of sustainable packaging materials such as mono-layer film structure which are environmentally friendly and easy to recycle as compared to a multi-layer structure - *"super laminates"*- comprising a mix of aluminium foil, PET, and PE, which generally end up in landfill due to lack of recycling and may take "*thousands of years to decompose"*. Furthermore, several environmental aspects are addressed in the WWF green office diploma such as energy and water conservation, sorting and recycling of materials, air emission reduction, and sustainable procurement. Similarly, Delta-flex has obtained FSC certification, which ensures sustainable procurement of pulp and paper through responsible sources; thus, playing a role in forest conservation as emphasized by SCM-P1. Since the decomposition of plastics may take thousands of years; therefore, the company is using LCA to develop solutions for its decomposition. PCM-P1 commented that Delta-flex is using oxo-biodegradable materials to speed the degradation process, which fragments the plastic into microplastics to decompose in the natural environment. Moreover, the environmental aspects and impacts matrix are used to determine the severity of environmental risks (associated with the materials and industrial waste) to the community, employees, and the environment, HSE-P1 noted.

According to QA-P1, FP methods involve the use of some aggressive solvents and adhesives in the printing and lamination processes such as ethyl acetate, which can impact the human respiratory system if mishandled. To address these safety issues, 5S techniques and SOPs are implemented for storing and handling such kinds of hazardous materials. SCM-P1 asserted the significance of kaizen in improving workplace safety through an example of a printing machine where the operators placed a small piece of cardboard around the ink tanks to avoid the ink splashes on the work floor and parts of the machine. This small step saved the time, effort, and materials (such as solvents) for cleaning the work floor and improved the workplace environment. Similarly, six sigma is also used to improve workplace safety. The manufacturing excellence department of Delta-flex has executed a DMAIC project in which control charts, Pareto diagram, and CA are used to analyze and control the noise pollution from an extrusion machine as stated by HSE-P1.

Participants also highlighted the GLSS practices that facilitate environmental decision-making. HSE-P1 argued that LCA is used when buying new material and new equipment to determine the associated environmental impacts and stated, "*LCA is used to determine, does the equipment have any environmental impact? how severe it can be? how can we control these impacts"*. Further, ISO 50001 facilitates energy-related decision-making by providing reliable data through energy audits. Similarly, both lean and six sigma help in environmental decision-making such as through gemba walks, which are conducted to determine the reasons for work floor problems and identify solutions. DMAIC and control charts provide the facts and figures which help in effective decision-making. Additionally, the company is also implementing CBA from an environmental perspective. SCM-P1 quoted an example:

> *the company did a cost-benefit analysis while purchasing the pulp used in the manufacturing of soap wrappers. Although it was available at a lower price, the supply chain department preferred purchasing a higher-priced FSC certified pulp due to the environmental sustainability aspects.*

Table 6.3 presents the GLSS enablers and environmental outcomes from the participants of Delta-flex.

Table 6.3: Green-lean-six sigma enablers and environmental outcomes in Delta-flex

GLSS enablers	Environmental outcomes categories	Sub-categories	Participant from Delta-flex
CA, ISO 14001, JIT, kaizen, LCA, lean facility layout, renewable energy sources, SMED, SOPs, air audits, DOE, ISO 50001, SPC, VFDs, WWF green office diploma, ECRS, 5S, DMAIC, QFD, Pareto diagram, 5Whys, QC boards	Waste and emission reduction	• Air emission and carbon footprint reduction	PM-P1, QA-P1, PCM-P1, SCM-P1, HSE-P1
		• Process waste reduction	PM-P1, QA-P1, PCM-P1, SCM-P1, HSE-P1
3R, use of environmentally friendly materials, DOE, renewable energy sources, IS0 50001, energy audits, SMED, ECRS, kaizen, VFDs, SPC, WWF green office diploma, FSC	Resource conservation and recycling	• Less use of energy, water, and raw material	PM-P1, QA-P1, HSE-P1
		• Increase in recycling	PM-P1, SCM-P1, QA-P1
5S, CBA, CA, DFE, DMAIC, JIT, ISO 14001, ISO 45001, Pareto diagram, renewable energy sources, SOPs, SPC, environmental aspects and impacts matrix, FSC, GW, ISO 50001, JIT, kaizen, LCA, WWF green office diploma	Environmental safety and compliance	• Sound environmental decision-making	SCM-P1, HSE-P1
		• Future orientation	QA-P1, PM-P1, SCM-P1
		• Improve employee and workplace safety	QA-P1, SCM-P1, HSE-P1

6.2.3 Critical success factors for implementing green-lean-six sigma to achieve environmental outcomes

6.2.3.1 Strategic factors

The participants indicated numerous strategic critical success factors for a GLSS strategy to achieve environmental performance. QA-P1 stated that the top management must pay close attention to GLSS strategy implementation. According to PM-P1, "*GLSS tools require a drive from the top management wherever these have to be implemented. Their engagement throughout the initiation and implementation is critical for the GLSS execution*". In addition, GLSS implementation requires financial resources, for instance, it may require some changes in the process layout and product design which require investment. Therefore, the top management should allocate an yearly budget for these practices as noted by QA-C1.

The willingness from the top management is necessary for initiating a GLSS strategy. The management should be strongly committed to the implementation of GLSS that can reflect through resource allocation as suggested by HSE-P1. Moreover, it is significant to link the GLSS strategy with the business strategy, SCM-P1 and QA-P1 emphasized. According to SCM-P1, *"it is quite relevant to link the GLSS with the overall business strategy as the concept behind this strategy is to remove the waste, produce quality products, and improve the organization's operational, environmental, and social performance*".

HSE-P1 maintained that the culture and communication play an important role in the GLSS implementation towards achieving environmental performance*, "organizations have their own* *culture and if they have an adaptive culture where people welcome new changes and support the implementation of new ideas, then it will contribute to the implementation of GLSS".*

All the participants strongly asserted that an integrated GLSS approach is a critical success factor as all three green, lean, and six sigma complement each other due to the common characteristic of waste minimization. Delta-flex has implemented GLSS in an integrated manner which reflects through its IMS policy. PM-P1 explained:

> *we have our environmental sustainability targets on an annual basis. In our integrated management system, we have come across a set of tools that we have picked from these strategies. So, whatever benefit is there, it is coming through an amalgamation of all three green, lean, and six sigma.*

PM-P1 further added*, "we don't go for a TPM certification from Japan Institute of Plant Maintenance. We may pick up kaizen and autonomous maintenance, DMAIC, and Pareto wherever needed".* Similarly, HSE-P1 highlighted that Delta-flex has implemented an IMS addressing the energy, environment, food quality, and health and safety aspects. In its IMS, all systems and standards (such as BRC, FSC, ISO 14001, ISO 50001, and ISO 45001) are working together. HSE-P1 further explained that in their current IMS, the ISO 9001 quality management system (QMS) covers the quality aspects related to lean and six sigma, while ISO 14001 and ISO 50001 cover the environment and energy-related aspects associated with the green strategy. Furthermore, HSE-P1 stated that previously their QMS was individually operated, however, since last year, Delta-flex has integrated it with the IMS to optimize processes. HSE-P1 stressed that the QMS has a large scope covering all the company's operations including marketing, sales, production, accounts, and supply chain in comparison to ISO 45001 and ISO 14001, which encompassed only the production operations. Delta-flex decided to extend the scope of these two standards from production operations to all other departments by integrating the QMS with the ISO 45001 and ISO 14001. Thus the *"the scope of QMS has not been reduced, instead, the scope of other standards has been increased by integrating QMS with those standards",* HSE-P1 cited. Similarly, SCM-P1 asserted the significance of an integrated approach and argued, *"these are integrated. You cannot achieve the environmental performance with only one strategy alone. So, if you want to be green, you have to include lean and six sigma strategies".*

PM-P1 posited that the reward system was a critical success factor for motivating the employees in achieving the environmental performance targets. Similarly, QA-P1 suggested while initiating GLSS practices, the management must have a reward system for appreciating the employees. The participants highlighted that their company organizes a kaizen conference every year to recognize the GLSS projects accomplished by the employees in all sections for improvements such as energy, environment, and quality of the product. The employees are recognized and awarded for that. However, HSE-P1 contended that rewarding the employees may not be a good idea, *"after all, we are engineers and it is our responsibility to add value to the systems, this might not be a good idea. This may not be an encouragement factor instead this could be an influential factor but not a critical factor".*

HSE-P1 further added that Delta-flex has energy, quality, and safety championships to recognize the employees' efforts, in which energy, quality, and employees' safety-related projects including environmental achievements from different departments are presented and the winner gets a reward. This activity is considered as an encouragement factor that is performed on a monthly basis for the last two years. Delta-flex has received a good response to these championships. According to SCM-P1, the issue of reward and recognition is one of the significant factors, *"employees should be rewarded for their good job so they feel motivated and certainly a motivated employee can do miracles".*

6.2.3.2 Operational factors

The findings revealed performance measurement, innovation and technology, statistical thinking and project management as the critical operational success factors of GLSS for environmental performance. According to QA-P1, Delta-flex regularly monitors operational parameters such as solvent quantities used in the printing process of FP. Since the company is using solvent-based inks for printing, performance indicators are used to evaluate their monthly consumption. The VOC emissions resulting from the use of these solvents are also monitored. SCM-P1 mentioned that performance measurement system is one of the key success factors for GLSS implementation as it facilitates the company in sustaining environmental performance. Delta-flex analyzes plastic waste on a monthly basis according to predefined waste targets. Similarly, PM-C1 highlighted that the company is monitoring the drainage system to evaluate and control the effluent discharges from FP manufacturing processes.

HSE-P1 stated that innovation and technology is a critical success factor for GLSS execution. The company's R&D is efficiently working on new materials to minimize the environmental impact. Two years ago, Delta-flex's R&D team worked closely with one of its customers who is manufacturing powdered milk. The R&D team successfully reduced the quantity of PE, aluminium foil, and PET in the milk powder packaging through use of GLSS tools such as

DFE and QFD by incorporating the customers' requirements regarding product and environmental safety. HSE-P1 further maintained, "*R&D team is reducing the quantity of materials used in the flexible packaging, which will eventually reduce the amount of flexible packaging being thrown out in the waste yards, dumpsites or maybe even ending up in the ocean".* PM-P1 emphasized the need of information technology in the successful execution of GLSS, "*with IT support, things get easy".* HSE-P1 clarified that the energy incident reporting is now executed through a software which was earlier reported manually. In addition, the IT infrastructure has helped in data analysis and decision-making.

According to PM-P1, statistical thinking is a critical success factor for the GLSS strategy. Statistical analysis facilitates in better understanding of the problem such as using Pareto diagram and control charts to analyze the issues in product quality and the reasons for variations. Similarly, energy audits provide energy consumption data which are used in energy evaluations. In addition, the project management approach is also recognized a critical success factor for GLSS implementation as stated by HSE-P1 and SCM-P1. Project management is a disciplined approach of organizing work activities in a GLSS project, SCM-P1 noted.

6.2.3.3 Human resource factors

The participants highlighted several CSFs for GLSS execution under the human resource category. QA-P1 and HSE-P1 stressed that the employees are the ones who are implementing the GLSS practices, thus their full involvement is required for successful execution. PM-P1 emphasized that employee involvement and satisfaction is required during the implementation of GLSS practices. The employees need to recognize the benefits and the value addition through use of the GLSS strategy. According to SCM-P1, "*GLSS cannot be implemented if the employees are not involved from their heart. You have to convince your employees".*

PM-P1 and HSE-P1 suggested that employees need to be empowered when they are executing the GLSS strategy. The employees bring in new ideas for improvement which can enable implementing the GLSS strategy. In addition, employee empowerment helps in improving the employees' efficiencies and increasing their motivation. According to SCM-C1, *"when they feel empowered, they implement the things in a better way and it gives them satisfaction as well".* PM-P1 mentioned that teamwork is a key factor in GLSS implementation by engaging the workforce. Further, QA-P1 stressed that employee awareness in implementing the GLSS strategy for improving environmental performance is a critical success factor*, "they have some negative reviews in their mind, for example, it can be time-consuming".*

Employee training and education plays an important role in the successful implementation of GLSS. Delta-flex provides training on use of GLSS tools. It is an important aspect even if the employees are willing to execute GLSS, training and education is necessary to undertake these practices. The company has provided training to its employees on various environmental and health and safety programs along with specialized training in lean and six sigma. SCM-P1 noted, *"the human resource department of Delta-flex had trained and produced competent manpower".*

6.2.3.4 External stakeholder-related factors

The participants from Delta-flex highlighted various CSFs related to the external stakeholders' involvement. SCM-P1 emphasized the role of government policies and involvement in the effective utilization of green practices due to lack of environmental regulations. SCM-P1 further added that around 55bn to 112bn plastic bags each year are consumed in PK resulting in clogging of drains, polluting the natural waterways, and impacting the digestive system of animals. While the Punjab government has banned single-use plastic shopping bags, this rule has not been effectively implemented due to a lack of monitoring and transparency. SCM-P1 cited:

> *in Pakistan, as a developing country, there is a lot that can be done. To implement environmental initiatives in Pakistan, some legislations for shopping bags have been developed over the last year. However, there is a lot more that need to be done. The government and private institutions need to ensure that all these regulations and legislations are implemented, and people/industries should be dealt with strictly in case of negligence. The government has to lead the way for us, legislations have to be in place.*

Similarly, PM-C1 asserted that government legislations, policies, guidelines, and standards are required for green implementation. According to QA-C1, the government of Pakistan is not overtly concerned about the environmental pollution of post-consumer FP waste as compared to other countries. The involvement of the government and strict environmental regulations is necessary for motivating the top management of FP companies to implement green practices for environmental sustainability. SCM-P1 highlighted that although the environmental regulations were developed several years ago, there was a lack of implementation and accountability on these regulations. Since last 3 to 4 years, the new government is efficiently working on the environmental pollution aspects and auditing the industrial waste of the FP manufacturing companies, however, the fine and penalties are not significant in case of negligence. PCM-P1 remarked, *"it started maybe four or five years ago, it is being implemented stricter. The rules were formed many years ago but now the government is paying considerable attention to this matter"*.

According to PM-P1, financial institutions play a critical role in the success of GLSS practices. The International Finance Corporation - a member of the World Bank Group, has recently approved a five-year loan of US$25 million for Delta-flex to modernize its operations and reduce its water and energy use. By accomplishing these objectives, the company will be able to decrease GHG emissions by 11,000 tons of carbon dioxide annually. SCM-P1 stressed that consumers need to be educated regarding the hazardous environmental impacts of single-use plastic.

HSE-P1 emphasized that both the customers and suppliers must understand the significance of GLSS towards reducing the negative impact of FP manufacturing industry. It will strengthen their relationship with the company. Similarly, PM-C1 and SCM-P1 noted supplier and customer engagement as a crucial aspect in GLSS execution. Delta-flex involves its suppliers in annual reviews and meetings to discuss the initiatives taken by the suppliers and share knowledge towards implementing best practices. According to SCM-P1, *"we have regular sessions with our suppliers to determine what strategy they are implementing and how it is contributing towards environmental performance?"*.

SCM-P1 further argued that through collaboration with the customers, Delta-flex is introducing sustainable packaging. The company has recently launched paper-based straws for one of its key customers' milk and juice product lines by replacing the plastic-based straws which helped in minimizing the consumption of plastic and has positive impacts in the form of resource conservation, emission reduction, and landfill reduction. PM-P1 advocated that customer satisfaction was a key success factor in GLSS implementation and stated:

> *finally, it is the customer for whom you are manufacturing the product and who is eventually helping you to run this business. He should be able to recognize the value addition and the benefits of GLSS practices. The customer should be satisfied with GLSS.*

The participants also highlighted that waste collectors and recyclers also play a critical role in the GLSS implementation for reducing environmental impacts of the FP manufacturing industry. The company's PE waste is collected by a third party who recycles this waste into PE resins and supplies back to the company to reuse it in manufacturing of PE films as noted by QA-P1.

Table 6.4 presents the critical success factors of green-lean-six sigma from the participants of Delta-flex.

Table 6.4: Critical success factors for green-lean-six sigma implementation in Delta-flex

Critical success factors	Sub-categories	Participants from Delta-flex
Strategic factors	• Leadership commitment	PM-P1, QA-P1
	• Resource allocation	QA-P1, HSE-P1
	• Culture and communication	HSE-P1
	• Linking GLSS to business strategy	QA-P1, SCM-P1
	• Reward system	PM-P1, SCM-P1, QA-P1, HSE-P1
	• Integrated GLSS	PM-P1, SCM-P1, HSE-P1
Operational factors	• Performance measurement	PM-P1, QA-P1, SCM-P1
	• Innovation and technology infrastructure	PM-P1, HSE-P1
	• Project management approach	HSE-P1, SCM-P1
	• Statistical thinking	PM-P1, QA-P1
Human resource factors	• Employee training and education	PM-P1, SCM-P1, HSE-P1
	• Employee involvement and empowerment	PM-P1, QA-P1, HSE-P1, SCM-P1
	• Teamwork	PM-P1
	• Employee awareness	QA-P1
External stakeholder-related factors	• Government support and policies	PM-P1, QA-P1, SCM-P1, PCM-P1
	• Financial institutions	PM-P1
	• Consumer education	SCM-P1
	• Waste collectors and recyclers	PM-P1, QA-P1, SCM-P1
	• Customer satisfaction	PM-P1
	• Customer and supplier relations	PM-P1, HSE-P1, SCM-P1

6.3 Case 2 – Gamma-flex

Gamma-flex specializes in the manufacture of flexible packaging products. The company has its head office in Lahore and sales offices in Karachi, Lahore, Multan, Sahiwal, and Islamabad. Gamma-flex offers customized packaging solutions according to customer requirements in several product segments including personal care, snack food, shampoo, confectionery, pharmaceuticals, poultry, detergents, processed food, oil, dairy, water, and beverages.

6.3.1 Green-lean-six sigma drivers

6.3.1.1 Internal drivers

The findings revealed that waste minimization as one of the key drivers of GLSS adoption in Gamma-flex. The company has implemented various practices such as EMS, lean mudas, SPC, and FSC. According to QA-P2, Gamma-flex has yearly waste reduction targets for different processes such as reducing the trim waste from the slitting process which reduces environmental pollution and landfill disposal. Further, HSE-P2 emphasized that the company is implementing lean to remove both the process and environmental waste and noted, *"we are implementing lean to reduce the eight types of waste which has an impact on the environmental* *performance. Further, we are trying to reduce the VOC emissions which can cause the respiratory issues".* Similarly, Gamma-flex is implementing six sigma to reduce process waste through quality inspection at various stages in the FP manufacturing processes such as collecting samples from the printing process to analyze the printing defects (e.g., ink splashes on the plastic film) to ensure the quality of the printed film is according to customer requirements. EHE-P2 mentioned that it is critical to determine the printing defects prior to the lamination process to reduce environmental waste, since if the defective printed film is laminated with another substrate, it could end up in landfill.

SCM-P2 argued that Gamma-flex has limited production capacity. Hence, it is implementing lean and six sigma to improve their productivity and increase process efficiencies by removing process waste. *"We have increasing demand from our customers; however, we have a limited capacity. Therefore, we have implemented lean and six sigma strategies to be more productive and efficient by reducing waste".* Further, lean and six sigma help in controlling process parameters such as adhesive grammage and inks viscosity (e.g., through SOPs and control charts) noted by PM-P2. Cost reduction has also prompted the company to implement GLSS which is achieved by waste reduction. Further, by reducing the operational cost, Gamma-flex is also minimizing the environmental cost such as energy cost associated with the warehouse requirements. QA-P2 stated that the top management is generally concerned about cost reduction in any of the six sigma projects implemented in the company and cost reduction targets are set in the project charter before initiating any project. However, in the case of green strategy, the cost increases, for example, the company requires to pay the contractors to drain off the hazardous materials and chemical waste, PM-P2 highlighted.

The findings also revealed that Gamma-flex is implementing GLSS practices as an initiative taken by the management as a result of environmental responsibility and commitment. QA-P2 asserted that increasing global greenhouse emissions and plastic waste have compelled Gamma-flex to initiate a GLSS strategy and stated, *"our organization is trying to contribute towards the global mission of environmental protection by reducing the plastic waste and air pollutants generating from the FP industry".* Additionally, SCM-P2 emphasized that the company is undertaking environmental initiatives due to the negative environmental impacts associated with the FP manufacturing processes and post-consumer use.

The findings also highlighted that Gamma-flex has implemented the GLSS strategy as a requirement of the board of directors of the Sundar Industrial Estate (SIE) as the top management stressed the implementation of EMS in the organization. PM-P2 mentioned that six sigma was adopted in the company as a result of management initiatives and noted, *"it was a demand from the top management that we should systemize the processes and use some process improvement tools and techniques like six sigma".* Continuous improvement has also compelled the company to implement GLSS practices. For instance, PM-P2 stated that the company had started the implementation of QMS, followed by food safety standard, and then environmental safety standard. Further, the company has integrated various systems such as QMS, EMS, and Food Safety System Certification (FSSC) (ISO 22000) due to continuous improvement, QA-P2 cited.

6.3.1.2 External drivers

Amongst external drivers, the findings revealed that provincial government pressure is a key GLSS driver for Gamma-flex. The company is located in the SIE that belongs to the Punjab Industrial Estates Development and Management Company (PIEDMC) which is owned by the Government of Punjab. Therefore, the companies located in the SIE are required to comply with the Punjab environmental protection regulations laid by the provincial government. These companies are responsible for handling and managing their solid waste removal which include segregating the organic, inorganic, and hazardous wastes at the source before handing over to the collectors. SCM-P2 noted that Gamma-flex has a shredding machine to shred the industrial plastic waste instead of burning it which was the earlier waste management practice followed. However, due to increasing government pressure, the company now shreds the plastic waste and the union council's waste collectors collect this waste for further recycling.

PM-P2 and HSE-P2 highlighted that Gamma-flex is implementing the GLSS practices to maintain its company image in the market, society, and the government. Moreover, the company is utilizing its certifications such as ISO 9001, ISO 14001, ISO 45001, and FSSC (ISO 22000) for strengthening its company image. The ISO 14001 certification has helped Gamma-flex in highlighting the company's green image in the international market in countries such as the United Arab Emirates and South Africa where it is exporting their FP products. QA-P2 explained that Gamma-flex has implemented lean and six sigma to improve the company image, gain customer's confidence, and enhance market value. *"The company image and customers' trust increase when the customers visit the organization and do not find the eight types of lean waste within the factory premises".*

HSE-P2 argued that in Pakistan, the public is not aware of the environmental burden of FP products and stated, *"in Pakistan, most of the people are not educated and environmentally conscious".* Additionally, the participants also stressed that there is no such public pressure for environmental initiatives since Gamma-flex is located in an industrial area. In terms of competitive pressure, both the local and international competitors actively prompt the company to adopt a GLSS approach. HSE-P2 noted that one of the competitors – Packages Limited – has also implemented GLSS practices (such as EnMS – ISO 50001) to attract customers and increase their market share. The findings revealed that Gamma-flex is implementing lean and six sigma to be competitive in terms of operational costs and product prices. SCM-P2 maintained that there is intense competition in the FP manufacturing industry and stated, *"there are several converters who are willing to serve our customers and with our limited production capacity, we want to be more efficient. This has led us to implement the green-lean-six sigma strategy"*.

Customer pressure is also one of the key drivers of GLSS adoption for Gamma-flex. Most of the company's clients are multinational companies who are environmentally conscious and have implemented GLSS, thus propelling Gamma-flex to adopt this strategy. HSE-P2 mentioned that Gamma-flex is working with Unilever and PepsiCo who have already implemented GLSS and noted, *"they are persuading us to implement these strategies as business criteria"*. HSE-P2 highlighted that one of their customers is forcing them to reduce and manage the process waste (such as printed waste) properly since the customers' name is printed on the FP products. HSE-P2 further emphasized that there is also an increasing trend of six sigma implementations in customer organizations and Gamma-flex has adopted six sigma as an anticipated future demand from customers. PM-P2 explained that Gamma-flex has implemented six sigma due to customers' influence as they are keen to know the root causes of the packaging issues because the packaging defects could further lead to customers' product waste. Even a small hole in the packaging of chips wrapper can affect the product quality and result in food waste. Table 6.5 presents the GLSS drivers from Gamma-flex.

Table 6.5: Green-lean-six sigma drivers in Gamma-flex

GLSS drivers	GLSS drivers	Sub-categories	Participants from Gamma-flex
Internal drivers	Operational drivers	• Cost reduction	• PM-P2, QA-P2
		• Process control	• PM-P2, QA-P2, HSE-P2, SCM-P2
		• Waste reduction	• PM-P2, QA-P2, HSE-P2, EHE-P2, SCM-P2
	Organizational drivers	• Continuous improvement	• PM-P2, QA-P2
		• Top management requirement	• PM-P2
		• Environmental responsibility	• QA-P2, SCM-P2
External drivers	Regulatory drivers	• Environmental regulations	• SCM-P2
	Market oriented drivers	• Competitor pressure	• HSE-P2, SCM-P2
		• Customer pressure	• PM-P2, HSE-P2
		• Company image	• PM-P2, HSE-P2, QA-P2

6.3.2 Green-lean-six sigma enablers and environmental outcomes

6.3.2.1 Waste and emission reduction

A range of GLSS enablers is implemented in Gamma-flex for managing waste and reducing emissions. The findings revealed that Gamma-flex is monitoring and controlling air emissions and VOCs release through use of GLSS enablers. QHSE-P2 stressed, *"our company is measuring nitric oxide (NO) and CO_2 emissions (annually) generating from the forklift trucks used in the factory premises through ISO 14001 guidelines for monitoring and evaluation which are given in clause 9".* MM-P2 highlighted that air emissions such as CO_2 are reduced after the company has switched to hydro power for energy generation in its plants which was earlier produced through diesel generators. Further, Gamma-flex has changed its facility design by implementing the lean facility layout tool to reduce the transportation cost, travel distance, and lead time, which has also resulted in energy-savings and air emissions reduction (due to less use of forklift trucks). According to QA-P2:

> *we were facing the problem of material transfer and long cycle time for different processes because some processes such as lamination, printing, and slitting were far away from each other. So, we redesigned the layouts of the processes to improve the internal supply chain and reduce the transportation time. Now the processes are aligned in the same line.*

TPM also helps in minimizing air emissions through preventive maintenance of machines in different processes such as printing, lamination, extrusion, and slitting. PM-P2 noted that due to TPM, the machines run in an optimum condition and at their maximum speed to efficiently process the raw materials. This results in reduced VOC emissions as compared to running a machine at a slow speed which can generate emissions through solvent evaporation from ink trays in the printing machines. MM-P2 further added that TPM is effectively implemented to prevent machine breakdown and minimize the breakdown time which has resulted in environmental outcomes such as reduced noise pollution, liquid discharge, and air leakages. MM-P2 maintained that machine breakdowns not only result in energy waste but also material waste which may end up in landfill or need recycling. For instance, the extrusion machine cannot be completely shut down for maintenance due to the continuous process requirements and remains on a heating mode during breakdown, which consumes energy. Secondly, a breakdown on an extrusion machine can result in a large quantity of process waste depending on the type of material. According to MM-P2, *"around 400–500 kgs extrusion waste can be generated if the material is nylon and there could be 250– 300 kgs waste if the material is*

LDPE”. In addition, if the downtime on an extrusion machine increases from 8 hours to 16 hours or 24 hours, then not only material waste is generated but also air emissions are released due to material (resins) burning in the extrusion machine.

Furthermore, PM-P2 stated that Gamma-flex has used SMED on an FP printing machine which has not only reduced the setup time from 90 minutes to 74 minutes but also reduced the setup process waste and energy consumption. SCM-P2 remarked, *“although [our] company is trying to implement JIT for managing raw material inventories, it has become a challenge due to limited capacity of suppliers and the logistic issues due to the current COVID-19 situation”.*

PM-P2 asserted that six sigma also helps in reducing air emissions such as SPC is used to control the temperature in printing and lamination processes to minimize the evaporation of solvents, which reduces the VOCs release and improves the workplace safety and air quality. Six sigma practices such as Pareto diagram and CA are used in identifying the major reasons for machine downtime and analyzing the resulting environmental waste. Additionally, Gamma-flex also develops non-conformance reports (NCRs) in case of an environmental issue in which root cause analysis is conducted to identify the causes of failure.

6.3.2.2 Resource conservation and recycling

Gamma-flex is working on several energy reduction projects such as installation of energy-efficient lights throughout the plant. The sunlight is also used to reduce energy consumption in production halls as part of the energy management practices. Gamma-flex has installed different inverters on oversize motors of machines to optimize energy consumption. Moreover, the company is planning to install solar panels as a renewable energy source. According to HSE-P2, “*the company is recycling hot air and using it as an energy source in the printing and waxing process thus saving the natural gas, which was earlier used for heating purpose in these processes.* The participants highlighted that Gamma-flex is not recycling its process plastic waste, instead, it is collected by a third-party contractor who recycles this waste. However, the company uses a baler machine for baling recyclable materials such as plastic film waste into compact bales which can be easily stacked and transported for recycling. Additionally, the contractors of the union council recycled the company’s shredded FP waste of the printing, lamination, and slitting processes into resins and sell it for reuse in some other applications such as pipe manufacturing or injection moulding. Further, SCM-P2 highlighted that the company is reusing the solvents in the printing process and cleaning the ink cylinders in printing machines.

The findings revealed that Gamma-flex has initiated 5S practices in FP manufacturing processes. With the use of 5S, the company has increased environmental benefits such as energy conservation by removing unnecessary motors and pumps from machines. Furthermore, check sheets are used to measure the daily energy consumption and energy cost. The DMAIC technique is used to manage various environmental projects such as increasing energy efficiency by reducing setup time. QA-P2 indicated that Gamma-flex incorporates the corporate objectives of resource conservation, energy optimization, and cost reduction in the project charter of six sigma projects.

6.3.2.3 Environmental safety and compliance

GLSS practices are also used to increase environmental safety and compliance in Gamma-flex such as ISO 14001 and SPC help the company in controlling the environmental factors including radiation emitting from the thickness gauge of extrusion machines. Such radiations must be contained within the specified limits set by the government regulatory authorities. These limits require careful monitoring due to the possible acute and chronic effects (radiation sickness) on workers' health as stated by EHE-P2. Similarly, Gamma-flex has installed lux meters to check the intensity of lights in the workplace. It not only saves energy but also helps in improving the workplace environment, and employees' safety and productivity, as low lux levels can cause fatigue and muscle strain. In addition, regular internal and third-party audits are conducted to analyze the noise levels in the production halls. Gamma-flex is using ISO 14001 as an effective tool to manage noise levels and maintain workplace safety.

From a lean perspective, several tools facilitate in improving workplace safety in Gamma-flex such as the use of 5S to maintain a safe working environment, which has a positive physical and mental impact on workers' health. Similarly, the company has developed SOPs for all FP manufacturing processes to ensure environmental safety. For instance, the workers are required to follow the SOPs and use personal protective equipment while handling solvents in the lamination and printing processes. Additionally, the lean facility layout has helped in addressing the environmental safety requirements. EHE-P2 explained that proper ventilation is implemented in a quality control lab since various hazardous solvents are used to check the quality of FP products which can affect the nervous system, respiratory system, eyes, skin, liver, and kidneys. SCM-P2 argued that SIPOC is also used to improve the environmental and workplace safety aspects and stated:

> *we asked our suppliers to improve their raw material packaging to reduce the number of accidents in our warehouses, which occurred due to*

inadequate packaging of materials supplied from the supplier. We also asked them to standardize their packaging and measure each roll's weight before shipment and suggested they use standardized transport for shipment.

The participants also stressed that GLSS practices help in environmental decision-making such as CBA, which is executed while developing a new product to analyze the related cost and the economic and environmental benefits. Similarly, six sigma helps in sound radical decision-making by utilizing data and tools such as control charts to measure the grammage deviation of resins in the extrusion process and Pareto diagrams to indicate key contributors in an environmental issue. Table 6.6 summarizes these findings on the GLSS practices for environmental performance in Gamma-flex.

Table 6.6: GLSS enablers and environmental outcomes in Gamma-flex

GLSS enablers	Environmental outcomes	Sub-categories	Participant from Gamma-flex
5S, CA, DMAIC, ISO 14001, JIT, kaizen, LCA, lean facility layout, NCRs, Pareto diagram, renewable energy sources, SMED, SOPs, SIPOC, SPC, TPM, VSM	Waste and emission reduction	• Air emission and carbon footprint reduction	PM-P2, QA-P2, MM-P2, QHSE-P2
		• Process waste reduction	PM-P2, SCM-P2, MM-P2
3R, renewable energy sources, 5S, SMED, project charter, SOPs	Resource conservation and recycling	• Less use of energy, water, and raw material	QA-P2, HSE-P2, SCM-P2
		• Increase in recycling	HSE-P2
5S, CBA, CA, DFE, DMAIC, JIT, ISO 14001, ISO 45001, Pareto diagram, renewable energy sources, SOPs, SPC, lean facility layout, lean mudas, lux level, SIPOC, TPM	Environmental safety and compliance	• Improve employee and workplace safety	PM-P2, EHE-P2, SCM-P2
		• Sound environmental decision-making	PM-P2, QA-P2

6.3.3 Critical success factors for implementing green-lean-six sigma to achieve environmental outcomes

6.3.3.1 Strategic factors

The participants from Gamma-flex highlighted different strategic factors crucial for implementing GLSS to achieve environmental performance such as management commitment, resource allocation, communication, recognition and an integrated GLSS approach. As per the participants, management commitment is required for GLSS implementation which is indicated by the willingness and attitude of the top management towards execution of this strategy for environmental performance. The timely availability of financial resources also shows top management commitment as asserted by QA-P2 and HSE-P2. Along with the resource allocation, the top management must communicate its vision through organizational policies and develop and maintain a culture of continuous improvement in the organization to effectively implement GLSS, SCM-P2 emphasized. According to HSE-P2:

> *if you are planning to implement something and you cannot communicate it at the grassroot level, then you cannot implement it. So, you need to develop a culture in your company where you can easily communicate to the grassroot level workers to implement these practices.*

PM-P2 suggested that an integrated approach is required for implementing GLSS. In this respect, Gamma-flex executes the GLSS strategy in a cohesive manner such as in the case of any nonconformity, the company applies the appropriate green, lean or six sigma tools according to the nature of the problem. *"Yes, we are using the tools in an integrated manner".* QA-P2 mentioned that the company has integrated the QMS and EMS to optimize the environmental performance.

The findings revealed that the reward system is a critical success factor to motivate employees for implementing GLSS. Based on the performance evaluation, Gamma-flex rewards and recognizes the employees' activities. For example, the company nominates "star of the month" for an effective 5S implementation. Gamma-flex also gives quality awards at the departmental level, QA-P2 noted. Similarly, the company awards *"employee of the month"* and *"employee of the quarter"* on specific target achievements. In addition, there are cash prizes for competent employees based on their performance, SCM-P2 informed.

6.3.3.2 Operational factors

QA-P2 highlighted that performance measurement is a CSF for implementing a GLSS strategy. Gamma-flex has developed KPIs for every function which are evaluated by the human resource department. For example, implementation of 5S on a continuing basis and maintaining good housekeeping is a KPI for every department. If a department fails to meet the 5S objective, then it is not considered for a reward in the performance appraisal. Similarly, HSE-P2 noted that Gamma-flex has installed meters on different machines to measure daily energy consumption. The company has also implemented a DMAIC approach in an energy-related project on a highly energy-intensive machine to monitor the energy consumption before and after the implementation of an energy conservation plan. Further, QA-P2 emphasized that external audits were a critical success factor for GLSS execution. Since Gamma-flex has an ISO 14001 certification, there is always a pressure of external audits. Therefore, the company has implemented PDCA that helps in the internal and external performance evaluation and continuous process improvement.

Statistical thinking is also required for a successful implementation of GLSS. According to HSE-P2, *"statistical thinking helps in understanding the problem and the use of right tools for solving it. So, if you do not think statistically, you cannot drive accurate results out of it".* In addition, IT infrastructure is also required for GLSS implementation to improve environmental performance. Gamma-flex has installed an automatic quality inspection system in the printing process, which gives more accurate information and reduces the process waste as mentioned by SCM-P2.

Project management is also critical for the successful implementation of GLSS. QA-P2 highlighted that the *"project champions"* in Gamma-flex have implemented a 5S project in which "seiri" has been implemented all over the company in the first phase and "seiton" in the second phase. The timelines and the targets are set for all these phases. Currently, the company is implementing "seiso" across all departments. Similarly, HSE-P2 illustrated downtime reduction as a project on a printing machine as another example. HSE-P2 strongly emphasized availability of reliable and robust data for successfully implementing GLSS. *"The key factor is the data, the right data for the right decision is the most critical thing for implementing GLSS. Wrong data will take you go in the wrong direction".*

6.3.3.3 Human resource factors

PM-P2 argued that GLSS implementation depends a lot on the training and education of employees. *"The management provided training on six sigma tools to its employees to solve the shrinking issue of cores which further resulted in plastic film waste reduction during film winding process".* After this training, the employees were able to identify the root causes of the shrinking problem, which was determined as the *"release of moisture in the cores"*. The suppliers were informed about this issue who suggested maintaining a certain percentage of moisture in the cores. HSE-P2 explained that Gamma-flex has three plants and from each plant, three or four employees are selected for training on different GLSS practices. HSE-P2 further informed that Gamma-flex has recently conducted training on the six sigma green belt and black belt, and ISO 14001 as *"a continuous environmental improvement technique"* to twelve employees, four from each of its three plants. These employees further trained relevant staff in their plants on these GLSS practices. Gamma-flex has also trained its staff to follow SOPs for energy conservation. As a result, the production staff turn off the motors and drives in the manufacturing plant, which are not required during the job change process, SCM-P2 explained.

Teamwork is also suggested by the participants as a crucial factor for GLSS implementation. QA-P2 highlighted that Gamma-flex has developed 5S teams in different departments known as 5S tigers or 5S champions. The company has also appointed a 5S steering committee. Similarly, there are cross-functional teams in Gamma-flex who execute the environmental improvement projects. *"QA department works closely with R&D and HSE in designing the products and processes to save the environment and to comply with the legal requirements",* QA-P2 cited.

Employee involvement and empowerment is also a CSF for GLSS implementation. According to QA-P2, *"we give authority to the 5S steering committee and 5S champions to decide for process improvement".* QA-P2 maintained that employee awareness plays a major role for an effective implementation of GLSS and Gamma-flex faces this challenge. According to QA-P2:

> *when we train them and ask them to implement 5S or any green or six sigma tools in the processes, they initially think that it is an extra responsibility. They initially think that it is the responsibility of only the quality department. But we educate them with outcomes and convince them that it is ultimately the benefit of the process owners.*

Further, for increasing the employees' environmental awareness, Gamma-flex has installed big screens in the dining halls and production floors demonstrating the significance of the GLSS tools in reducing process waste and improving environmental safety as stated by HSE-P2.

6.3.3.4 External stakeholders' involvement

PM-P2 and QA-P2 suggested that government support and policies play a critical role in the successful execution of a green strategy. Gamma-flex is located in an area owned by the government of Punjab with stringent environmental policies. The government has introduced a regulation to minimize the consumption of PE bags and shredding of plastic waste instead of burning, which has achieved a positive environmental impact. According to QA-P2, the company in its coordination with customers and suppliers has communicated its policy to reduce and recycle waste. "*So basically, it is a supply chain, we cannot do anything ourselves. We have to coordinate with our suppliers and customers as well".* In addition, waste collectors and recyclers also play a critical role in reducing the environmental impacts of the FP industry. PM-P2 and EHE-P2 highlighted that the company's solid waste (plastic film waste) and hazardous liquid waste are collected by contractors who recycle this waste. QA-P2 explained that there is hazardous waste generated from the FP processes such as cotton rags which are used to clean the solvent-based inks in the printing process. Such waste is picked up by the waste collector who incinerates it, and reports about the management of this hazardous waste to the company. Table 6.7 presents the CSFs of a GLSS strategy in Gamma-flex.

Table 6.7: Critical success factors for green-lean-six sigma implementation in Gamma-flex

Critical success factors	Sub-categories	Participants from Gamma-flex
Strategic factors	• Leadership commitment	• PM-P2, QA-P2, QHSE-P2, SCM-P2, MM-P2
	• Resource allocation	• QA-P2, HSE-P2
	• Culture and communication	• SCM-P2, HSE-P2
	• Reward system	• QA-P2, SCM-P2
	• Integrated GLSS	• PM-P2, QA-P2
Operational factors	• Performance measurement	• QA-P2, HSE-P2
	• Reliable data	• HSE-P2
	• Innovation and information technology infrastructure	• SCM-P2
	• Project management	• QA-P2, HSE-P2
	• External audits	• QA-P2
	• Statistical thinking	• HSE-P2
Human resource factors	• Employee training and education	• PM-P2, HSE-P2, SCM-P2
	• Employee involvement and empowerment	• QA-P2
	• Employee awareness	• HSE-P2
	• Teamwork	• QA-P2
External stakeholder-related factors	• Waste collectors and recyclers	• PM-P2 EHE-P2, QA-P2
	• Customer and supplier relations	• QA-P2, SCM-P2
	• Government support and policies	• PM-P2, QA-P2

6.4 Summary

This chapter presented the findings of the multiple case studies conducted in Pakistan to examine the GLSS implementation in two large-sized FP manufacturing companies. The theoretical model of a GLSS strategy for achieving the environmental performance (Figure 2.4) was used a guide for these studies. The findings revealed various drivers, enablers, environmental outcomes, and critical success factors of a GLSS strategy as emphasized by the senior corporate managers in these companies. The next chapter-7 discusses the overall findings of the phase 1 – preliminary and phase 2 – main study conducted in NZ and PK building on the NRBV, ITBV, and ICBV theoretical lenses.

Chapter 7

Discussion

7.1 Introduction

This chapter discusses the empirical findings of the preliminary (phase 1) and the four main case studies (phase 2) conducted in New Zealand and Pakistan drawing on the NRBV, ITBV, and ICBV. A GLSS model for achieving environmental performance has been developed integrating the empirical findings with the above-mentioned organizational theories. This chapter is organized as follows. Section 7.2 presents a discussion on the GLSS drivers building on the NRBV and ITBV, which answers the first research question. Section 7.3 discusses the GLSS enablers drawing on the NRBV theoretical lens in answering the second research question. Next, section 7.4 presents a discussion on the critical success factors of a GLSS strategy linking with the ICBV in answering the third research question. Finally, a holistic model combining the GLSS drivers, enablers, environmental outcomes, and CSFs with the NRBV, ITBV, and ICBV is presented and explained in section 7.5.

7.2 Green-lean-six sigma drivers

In answering the first research question, this study examines the GLSS drivers for manufacturing organizations from NZ and PK through an empirical investigation with LSS and environmental consultants and senior corporate managers in FP manufacturing companies from these countries. The NRBV and ITBV theoretical lenses are used to explain the GLSS drivers. Drawing on the NRBV and ITBV, the GLSS drivers for environmental performance are based on the findings under the internal and external drivers' categories. A consolidated and summarized illustration of the GLSS drivers from the preliminary and main study in NZ and PK is presented in Table 7.1.

Table 7.1: Consolidated illustration of GLSS drivers from the preliminary and main study in New Zealand and Pakistan

GLSS drivers	Categories	Sub-categories	Preliminary study		Main study (multiple case studies in flexible packaging companies)			
			NZ	PK	NZ		PK	
			Consultants	Consultants	Alpha-flex	Beta-flex	Delta-flex	Gamma-flex
Internal drivers	Operational drivers	Cost reduction	✓	✓	✓	✓	✓	✓
		Process control	✓	✓	✓	✓	✓	✓
		Waste reduction	✓	✓	✓	✓	✓	✓
	Organizational drivers	Continuous improvement	✓		✓	✓		✓
		Resource circulation	✓	✓	✓	✓		
		Top management requirement						✓
		Employee pressure				✓		
		Environmental responsibility	✓	✓	✓	✓	✓	✓
		Employee health and workplace safety			✓	✓	✓	
External drivers	Regulatory drivers	Environmental regulations	✓	✓	✓	✓	✓	✓
	Society-oriented drivers	Public pressure	✓	✓		✓	✓	
		Development organizations	✓	✓				
		Membership and non-profit organizations			✓			
	Market-oriented drivers	Customer pressure	✓	✓	✓	✓	✓	✓
		Company image	✓	✓	✓	✓	✓	✓
		Competitor pressure	✓	✓	✓	✓	✓	✓
		Supplier pressure				✓	✓	

Building on the NRBV, the empirical findings from the main study highlighted internal GLSS drivers such as waste reduction as an operational driver for manufacturing organizations in both NZ and PK which is also aligned with the preliminary study findings. This finding reveals that waste associated with the operational aspects and environmental issues such as overproduction, inventory, defects, excessive transportation, water footprint, and energy footprint propel the GLSS adoption in these countries (Farrukh et al., 2021a; Powell et al., 2017; Tiwari et al., 2020) which is linked with the pollution prevention strategic capability of preventing waste and emissions (Gabriel et al., 2018). This indicates that operational and environmental waste reduction is a major concern for manufacturing organizations in NZ and PK to improve quality, reduce cost, and address increasing pollution and climate change issues. In addition, NZ manufacturing organizations are more concerned with maintaining their clean and green company image, thereby adopting GLSS to reduce waste and emissions. Further, the findings from the preliminary and main study highlight cost reduction as a GLSS driver for both NZ and PK manufacturing organizations, which is primarily associated with the manufacturing cost including waste, process improvement, and lifecycle costs (Diaz-Elsayed et al., 2013). These aspects, however, link with both the pollution prevention and product stewardship strategic capabilities. The findings reveal that manufacturers in NZ mainly implement the GLSS strategy to reduce their compliance costs including fines and penalties associated with environmental waste such as wastewater and air emissions (Farrukh et al., 2021a; Gabriel et al., 2018). On the other hand, PK companies are more focused on reducing the operational cost to become more efficient (see Chapter 4). Further, by reducing the operational cost, the environmental cost (such as energy cost, see Chapter 6) is also reduced.

The analysis from both the preliminary and main study highlighted that manufacturing firms in NZ are implementing GLSS to follow both open-loop and closed-loop practices as part of the resource circulation issue (see Chapter 4 and Chapter 5). Meanwhile, resource circulation seems to be an emerging organizational driver of GLSS adoption in manufacturing organizations in PK and varies in different regions of the country as per the preliminary study results (see Chapter 4). Further, open-loop practices are followed more in PK organizations. This difference may be associated with the increased awareness and recognition of product stewardship aspects, resource conservation for future use, and government regulations in NZ as compared to PK, which showcases the increased environmental commitment and responsibility in developed nations (Agyemang et al., 2019). However, in PK, resource deficiency issues such as water scarcity and energy crises have compelled manufacturers in certain areas to manage resources through recycling (Agyemang et al., 2019; Farrukh et al., 2021a).

The findings of the preliminary and main study also highlight continuous improvement as a GLSS driver for NZ manufacturing firms, whilst it is not regarded as a significant GLSS driver for PK manufacturing organizations except as indicated by the Gamma-flex case from the main study findings (see Chapter 6). This difference can be attributed to the lack of skilled labour, outdated machinery and manufacturing systems, and insufficient resources such as raw materials, water, and electricity in developing countries as compared to the developed countries (Carvalho et al., 2019; Maware et al., 2021). Interestingly, the findings from the main study (see Chapters 5 and 6) revealed that the FP manufacturing organizations in both countries (both case companies from NZ and Delta-flex from PK) are adopting the GLSS strategy to address the employees' health and safety issues. This finding can be attributed to the realization and recognition of the increasing global social sustainability aspects in the workplace in both developed and developing countries along with managing the environmental and economic sustainability performance which are explored in only a few studies (e.g., Caldera et al., 2018; Tiwari et al., 2020).

Additionally, the findings of this study support the significance of the instrumental factors of ITBV by indicating how manufacturing firms in NZ and PK are adopting the GLSS strategy due to external drivers and managing the shareholders' concerns, customers' requirements, competitive environment, environmental regulations, and social pressure (Cherrafi et al., 2017; Darko et al., 2017; Oelze et al., 2016; Sajjad et al., 2020). Drawing on the ITBV, coercive pressures by the government to drive environmentally responsible practices are quite stringent in NZ and manufacturing organizations regularly follow the environmental guidelines (as per preliminary study findings – Chapter 4). This finding confirms the result of a study conducted by Govindan et al. (2015) in which strict environmental regulations in developed countries drive manufacturing organizations to implement environmental practices. However, the findings from the case studies in NZ (see Chapter 5) highlighted the need for more effective legislation for recycling waste and controlling VOC emissions due to the increasing environmental burden of the FP manufacturing industry in the form of plastic waste, a recycling ban from China, and inadequate plastic waste management infrastructure in NZ (De Bhowmick et al., 2021; Sustainable Business Network, 2021).

In contrast, generally, the government requirements for environmental performance are not stringent in PK as per preliminary (see Chapter 4) and main study (see Chapter 6) findings and therefore, manufacturing organizations do not generally consider the environmental aspects in their manufacturing operations. This finding resonates with the findings of Hussain et al. (2019) and Zhang and Yang (2016) who pointed out similar issues in the developing world context. Further, due to the lack of environmental monitoring and accountability in developing countries such as PK, international companies can easily conduct their business operations in a low-cost and low legislation environment. However, international environmental regulations force export-oriented manufacturers in PK to embrace GLSS. This can be attributed to the environmental regulations in developed countries that have caused an increase in institutional pressures for achieving environmental performance by manufacturing organizations in developing countries (Saeed et al., 2018). This is in alignment with, for example, the European Community Directive on Waste Electrical and Electronic Equipment (WEEE), which compels export-oriented electrical and electronic component manufacturers in developing countries to take back used products or pay premiums (Sarkis et al., 2011; Yu et al., 2006).

However, the provincial environmental laws such as PEQS are more stringent in PK, which can be attributed to the environmental awareness, active administration, and effective implementation of the environmental regulations at the provincial level such as Punjab (Naureen, 2009). The findings also revealed that although the government of Pakistan has developed several environmental laws (Hafeez, 2014; Korai et al., 2017) and EPA has been functioning in each province of Pakistan, there is a lack of enforcement of these regulations and their implementation seems fragmented in different regions of the country (Korai et al., 2017; Masood et al., 2014). Due to weak enforcement of the government regulations and poor infrastructure, the international environmental regulations prompt companies to adopt the GLSS strategy when exporting products to an international market, which also aligns with the study results of Hussain et al. (2019) and Zhang and Yang (2016).

Public pressure is a significant driver in NZ which was identified from both preliminary (Chapter 4) and main study (Beta-flex – Chapter 5) findings since most people in NZ are aware of ecological aspects. In contrast, public pressure is not generally considered a strong driver in PK as per preliminary and main study findings; however, it is a driver for those organizations operating in residential areas as per the preliminary study results. This variance can be related to a lack of understanding and awareness among the general public regarding the environmental issues (such as plastic waste) and the importance of green aspects in developing countries as compared to developed countries, which is also consistent with the study results of Gandhi et al. (2018), Rehman and Shrivastava (2013), Korai et al. (2017), and Mahar et al. (2007).

Interestingly, government, membership organizations, and local development bodies (e.g., The Packaging Forum, Plastics NZ (industry association), the NZPSC, and Rata) in NZ promote GLSS practices in manufacturing firms as per the preliminary and main study findings. Conversely, international development organizations support and drive GLSS strategy in Pakistan based on the preliminary study findings. However, the main study (see Chapter 6) findings from PK did not reveal this aspect. Although the flexible packaging association of converters of Pakistan (FLEXPACK) aims to increase the economic growth of the FP manufacturing industry in Pakistan, none of the corporate managers mentioned the role of FLEXPACK in enhancing environmental performance and prompting FP companies to adopt the GLSS practices.

The empirical findings (both preliminary and main study) suggest that end consumer and customer organizations (local and international) drive the manufacturers in NZ towards environmentally responsible practices. This can be attributed to the environmental consciousness and education of consumers and customers (local and international) in developed countries (Sarkis et al., 2011). Conversely, the empirical findings (both preliminary and main study) from PK highlight the international customer organizations (e.g., Nestle, Unilever, PepsiCo, Nike) as a driver of GLSS since these organizations have already adopted the GLSS strategy in their home countries. With the awareness of the environmental benefits of this approach, these organizations compel the manufacturing companies in developing countries to adopt such practices. Further, international customers require certifications (e.g., ISO 14001, ISO 9001, ISO 450001, and ISO 50001) from manufacturers in PK and insist on achieving social compliance along with environmental requirements conformity. Such imposition might be the result of a lack of legal requirements in PK, which is also suggested by Seuring and Müller (2008) as a reason for developing countries to adopt these strategies where such legal requirements either do not exist or are not enforced. In contrast, NZ has a good reputation for implementing world-class business practices, which alleviate the customers’ requirements for such certifications. Nevertheless, the adoption of voluntary environmental governance programmes such as ISO 14001 in developing countries can facilitate the manufacturing organizations in seeking global trade opportunities and increasing cooperation with global supply chain members (Boys & Grant, 2010; Liu et al., 2020).

While competitiveness plays a significant role in encouraging organizations in developed countries to implement environmental practices (Aerts et al., 2006), the findings from the preliminary study (see Chapter 4) revealed that it is not a strong driver of GLSS in NZ due to the low number of organizations in the manufacturing sector, while having high profit margins. However, the main study findings from NZ (see Chapter 5) highlighted that the local and offshore competitors drove GLSS adoption, which could be attributed to the several manufacturing firms working in the FP manufacturing industry and increased demand for FP products in NZ. Alternatively, the findings from the preliminary and main study in PK suggested that manufacturing organizations are compelled to implement GLSS due to both the local and international competitive pressure, which could be associated with a large number of manufacturing organizations in PK and the FP sector. This finding can be related to the benefits of globalization that have created opportunities for manufacturers in developing countries to learn from foreign competitors in implementing environmental practices (Christmann & Taylor, 2001; Saeed et al., 2018; Sarkis et al., 2011).

Company image is primarily regarded as a GLSS driver for manufacturing organizations in both NZ and PK as per the preliminary and main study findings. From the NZ perspective, it can be argued that company image is a reason for the GLSS adoption in developed countries to maintain their reputation in both the local and international market as environmentally responsible manufacturers. In addition, the analysis from the PK preliminary study reveals that manufacturing organizations are trying to maintain their reputation mainly in the international market and attract multinational companies. However, the main study on PK companies highlighted company image as a GLSS driver to improve the reputation of the FP manufacturers in both the local and international markets and for the government authorities as well (see Chapter 6).

7.3 Green-lean-six sigma enablers and environmental outcomes

In answering the second research question, this study sought to analyze the GLSS enablers and outcomes in manufacturing organizations from both a developed and developing country context using the environment-centric NRBV theoretical lens. The empirical investigation with LSS and environmental consultants from NZ and PK and the corporate managers from FP companies in both countries reported about the GLSS enablers and their environmental outcomes in these countries. Table 7.2 presents the consolidated illustrations of the GLSS enablers from the preliminary and main study in NZ and PK.

Drawing upon the pollution prevention strategic capability of NRBV, the most used GLSS enablers for waste and emission reduction derived from the empirical findings (preliminary and main study) from both NZ and PK are 5S, JIT, LCA, EMS, SPC, DMAIC, and VSM. These findings are consistent with the study results of Chugani et al. 2017, Klochkov et al. (2019), Ruben et al. (2017), and Tiwari et al. (2020) since these enablers facilitate manufacturers in identifying and minimizing both the operational and environmental waste associated with the industrial operations. For example, VSM enables an organization to map its processes from start to end and identify wastes within the processes (Chiarini, 2014). Similarly, 5S helps in identifying and preventing leakage and spills, thus reducing material waste (Chugani et al., 2017).

In addition to the above GLSS enablers, findings from the main study from NZ and PK also identified SMED as a potential practice for reducing process waste and air emissions including GHG and VOCs; however, it has not been frequently addressed in prior studies. The reason can be associated with the process and machinery characteristics, inadequate organization of the setup activities of the machines, and lack of research in the continuous process industry, particularly in the FP manufacturing organizations (Chiarini 2014; Farrukh et al., 2022b; Panwar et al., 2017; Powell et al., 2017).

The preliminary and main study findings also revealed other GLSS enablers in NZ as carbon calculators, DFE, eco-labelling, Enviro-mark, environmental committee, environmentally friendly materials, WS, E-WOF, and the Natural Step. On the other hand, the preliminary and main study findings from PK also suggested various other GLSS enablers such as environmental circles, heijunka, higg index, kaizen, lean mudas, MFCA, Pareto diagram, ZDHC, ZLD, ISO 50001, lean facility layout, WWF green office diploma, ECRS, QFD, QC boards, TPM, NCRs, and SIPOC. The analysis highlighted that air emission-related enablers are more used in NZ (e.g., eco-labelling, enviro action, Enviro mark, EWOF, and LCA). This might be due to the stringent environmental regulations regarding the air emissions in NZ to maintain its ‘clean green’ image. Conversely in PK, although emission-related enablers are used (e.g., EMS, SMED, and LCA), energy and material waste-oriented enablers (such as ECRS, 5S, CA, DMAIC, SPC) are mainly implemented by manufacturers, which can be associated with the higher levels of process waste generated in PK firms due to their type of manufacturing activities and/or lack of enforcement of environmental laws regarding air emissions.

Table 7.2: Consolidated illustration of GLSS enablers and environmental outcomes from the preliminary and main study in New Zealand and Pakistan

GLSS enablers						**Environmental outcomes sub-categories**	**Environmental outcomes categories**
Preliminary study		**Main study (multiple case studies in flexible packaging companies)**					
NZ	**PK**	**NZ**		**PK**			
Consultants	**Consultants**	**Alpha-flex**	**Beta-flex**	**Delta-flex**	**Gamma-flex**		
5S, EMS, energy audits, JIT, SPC, VSM, carbon calculators, DFE, ecolabelling, enviro mark, EWOF, LCA, The natural step, WS	5S, EMS, energy audits, JIT, SPC, VSM, CA, DFSS, DMAIC, DOE, environmental circles, heijunka, higg index, kaizen, lean mudas, MFCA, Pareto diagram, ZDHC, ZLD	5S, 5Whys, CA, DMAIC, eco-labelling, enviro action, EMS, JIT, LCA, Pareto diagram, SMED, visual management, WS	3R, 5S, compostable packaging, CA, DFE, DMAIC, DOE, environmental committee, JIT, LCA, SMED, SPC, VSM, environmentally friendly materials, WS	CA, EMS, JIT, kaizen, LCA, lean facility layout, renewable energy sources, SMED, SOPs, air audits, DOE, ISO 50001, SPC, VFDs, WWF green office diploma, ECRS, 5S, DMAIC, QFD, Pareto diagram, 5Whys, QC boards	5S, DMAIC, EMS, JIT, kaizen, LCA, lean facility layout, NCRs, Pareto diagram, renewable energy sources, SMED, SOPs, SIPOC, SPC, TPM, VSM	Air emission and carbon footprint reduction Process waste reduction	Waste and emission reduction
3R, 5S, energy audits, JIT, lean mudas, SPC, hazardous substance inventory tools, process mapping, VSM	3R, 5S, energy audits, JIT, lean mudas, SPC, CA, DFSS, DMAIC, DOE, EMS, EnMS, environmental circles, higg index, MFCA, multivariable regression analysis, Pareto diagram, REMC	3R, 5S, CBA, energy management teams, facility layout, FSC, green films, JIT, lean mudas, renewable energy resources, SCADA, SMED, TPM	3R, 5S, compostable packaging, DOE, energy audits, environmental committee, heijunka, JIT, kaizen, on-site and industrial composters, SMED, TPM, environmentally friendly materials, WS	3R, use of environmentally friendly materials, DOE, renewable energy sources, IS0 50001, energy audits, SMED, ECRS, kaizen, VFDs, SPC, WWF green office diploma, FSC	3R, renewable energy sources, 5S, SMED, project charter, SOPs	Less use of energy, water, and raw material Increase in recycling Less use of hazardous materials	Resource conservation and recycling
DMAIC, EMS, lean mudas, renewable energy sources, SPC, VSM, hazardous substance inventory tools, JIT, PDCA, WS	DMAIC, EMS, lean mudas, renewable energy sources, SPC, VSM, 5S, box plots, CA, DFSS, DOE, environmental circles, heijunka, EnMS, Pareto diagram, QFD, REMC, ZDHC	5S, 5Whys, CBA, DFE, DOE, EHS risk matrix, employee safety committee, environmental board of fitness, heijunka, HIRARC, LCA, renewable resources, environmentally friendly materials, visual boards, WS	5S, environmentally friendly material, CBA, DFE, DOE, environmental committee, HACCP, kaizen, LCA, OHSAS, poke-yoke, renewable energy resources, SPC, WS	5S, CBA, CA, DFE, DMAIC, EMS, ISO 45001, Pareto diagram, renewable energy sources, SOPs, SPC, environmental aspects and impacts matrix, FSC, gemba walks, ISO 50001, kaizen, LCA, environmentally friendly materials, WWF green office diploma	5S, CBA, CA, DFE, DMAIC, EMS, ISO 45001, Pareto diagram, renewable energy sources, SOPs, SPC, lean facility layout, lean mudas, lux level, SIPOC, TPM	Decrease in environmental fines and penalties Sound environmental decision-making Future orientation Improve employee and workplace safety	Environmental safety and compliance

Based on the product stewardship strategic capability, the commonly addressed GLSS enablers for resource conservation and recycling from the preliminary and main study from NZ and PK are identified as 3R, 5S, and energy management practices including renewable energy sources and energy audits. Among these enablers, 3R and 5S have been frequently cited in prior studies (Antony et al., 2018; Chugani et al., 2017; Farias et al., 2019; Gaikwad & Sunnapwar, 2020a) as enabling manufacturing firms to efficiently use the raw materials and save resources. However, the use of energy management practices is not frequently highlighted in prior studies, which indicates limited research on the application of GLSS enablers in energy-related issues (e.g., Caiado et al., 2019; Sony et al., 2019). The findings indicate that both regional domains significantly embed the energy conservation aspects in their environmental performance indicators and implement energy-related GLSS enablers such as energy audits and renewable energy sources. The preliminary and main study findings (Delta-flex) from PK further revealed that among these energy management practices, manufacturing organizations are also obtaining ISO 50001 certifications to manage the increasing energy-related issues in PK.

The analysis from the preliminary and main study in NZ revealed that among the 3R practices, manufacturing organizations are focusing more on waste recycling such as FP waste which can be attributed to increasing product stewardship concerns in NZ. This has prompted the NZ organizations to adopt recycling practices. Conversely, manufacturing organizations in PK are more focused on reducing waste as compared to recycling. This difference can be attributed to the lack of awareness of product stewardship and recycling facilities and the infrastructure available in developing countries as compared to developed countries (Wernink & Strahl, 2015).

Linking with the sustainable development strategic capability of NRBV, the commonly used GLSS enablers for environmental safety and compliance in both countries are 5S, energy management practices such as renewable energy sources, and SPC. Among these enablers, 5S and SPC are aligned with the findings of Ruben et al. (2017) and Tiwari et al. (2020) which can facilitate manufacturing firms in achieving environmental compliance, saving resources for future use, and improving employee health and safety (Ruben et al., 2017; Tasdemir et al., 2019). However, the use of renewable energy sources is not highlighted in prior studies, which indicates that both regional domains are now embedding the long-term sustainability attributes in their manufacturing operations. The findings from the main study of NZ (see Chapter 5) also emphasized environmental board of fitness, environmentally friendly materials such as water-based inks and biodegradable and bio-based materials, DFE, DOE, and WS. These findings revealed the corporate environmental consciousness of conserving natural resources and protecting the natural environment of FP manufacturing companies in NZ (Mura et al., 2020). On the other hand, the main study findings from PK companies (see Chapter 6) also highlighted the GLSS enablers including EMS (ISO 14001), DMAIC, ISO 45001, JIT, and SOPs. The findings from PK revealed that companies are using these GLSS enablers from environmental and employee safety perspectives and are less focused on using biodegradable and environmentally friendly materials. The reasons can be associated with the limited financial resources of manufacturers in developing countries (such as PK) to afford environmentally friendly materials such as water-based inks and biodegradable and bio-based materials (Kozake et al., 2021; Pongpimol et al., 2020).

Overall, the findings revealed that manufacturing firms in NZ are deploying GLSS enablers to comply with stringent environmental regulatory requirements, avoid penalties, save natural resources, improve employee health and safety, and maintain their clean green image. On the other hand, manufacturing organizations in PK are executing GLSS enablers to satisfy international customers, improve employee and workplace safety, and create a green image. This difference may be attributed to an enhanced focus on avoiding environmental regulatory fines in NZ, while employee and workplace safety is more relevant in PK due to international customers' requirements. In addition, the analysis also revealed that the use of six sigma enablers is lower in NZ manufacturing firms than in PK. The reasons for the lower adoption of six sigma in NZ might be due to (1) lack of experts with adequate experience in implementing six sigma in the manufacturing firms and (2) lack of large manufacturing companies with complex processes operating in NZ as compared to the companies operating in PK.

7.4 Critical success factors for implementing green-lean-six sigma to achieve environmental outcomes

In answering the third research question, this study sought to analyze the critical success factors of implementing a GLSS strategy from both developed and developing country perspectives. Based on the empirical findings of the preliminary and main study, strategic, operational, human resource, and external stakeholder-related CSFs are identified based on the green structural, green human, and green relational capital of ICBV theory. Table 7.3 presents the consolidated illustrations of the GLSS critical success factors from the preliminary and main studies in NZ and PK.

Table 7.3: Consolidated illustrations of GLSS critical success factors from the preliminary and main study in New Zealand and Pakistan

Critical success factors	**Sub-categories**	**Critical success factors of GLSS**					
		Preliminary study		**Main study (multiple case studies in flexible packaging companies)**			
		NZ	**PK**	**NZ**		**PK**	
		Consultants	**Consultants**	**Alpha-flex**	**Beta-flex**	**Delta-flex**	**Gamma-flex**
Strategic factors	Leadership commitment	✓	✓	✓	✓	✓	✓
	Resource allocation	✓	✓	✓	✓	✓	✓
	Communication	✓	✓	✓		✓	✓
	Reward system			✓	✓	✓	✓
	Linking GLSS to business strategy	✓			✓	✓	
	Change management	✓	✓				
	Feedback loop				✓		
	Safe working environment		✓	✓	✓		
	Continuous implementation of GLSS	✓			✓		
	Integrated GLSS	✓	✓	✓	✓	✓	✓
Operational factors	Performance measurement	✓	✓	✓	✓	✓	✓
	Reliable data						✓
	Innovation and technology infrastructure		✓	✓	✓	✓	✓
	Project management	✓	✓	✓	✓	✓	✓
	Analytical thinking	✓					
	Adequate utilization of GLSS tools	✓	✓				
	External audits						✓
	Statistical thinking	✓	✓	✓	✓	✓	✓
Human resource factors	Employee training and education	✓	✓	✓	✓	✓	✓
	Employee involvement and empowerment	✓	✓	✓	✓	✓	✓
	Employee awareness					✓	✓
	Competent employees	✓					
	Teamwork	✓	✓	✓	✓	✓	✓
External stakeholder-related factors	Waste collectors and recyclers			✓	✓	✓	✓
	Customer satisfaction					✓	
	Consumer education			✓		✓	
	Customer and supplier relations	✓	✓	✓	✓	✓	✓
	Forums and institutions			✓		✓	
	Government support and policies	✓	✓	✓	✓	✓	✓

Building on the green structural capital context of the ICBV, the findings (preliminary and main study) from both countries highlighted the role of strategic factors such as top management commitment, communication of the organization’s objectives, and resource allocation in the successful execution of a GLSS strategy, which are aligned with the study findings of Caiado et al. (2018), Ershadi et al. (2021), Niñerola et al. (2020), and Powell et al. (2017). Additionally, the preliminary study findings with consultants from both countries highlighted change management as a CSF for a GLSS strategy which is not primarily addressed in prior studies. However, the main study findings with manufacturers from both countries did not reveal this aspect. This finding can be attributed to knowledge and expertise of the environmental and LSS consultants in handling a variety of projects as compared to the corporate managers in FP manufacturing companies. For example, LSS experts play a key role in the change management process by emphasizing the stakeholder involvement for the successful deployment of LSS projects (Antony et al., 2018). Further, the findings of the preliminary and main study from both countries revealed that GLSS must be implemented in an integrated manner, which is also addressed in limited research studies such as that of Kaswan and Rathi (2019). This can be attributed to the lack of awareness about the environmental benefits of an integrated GLSS approach as an emerging strategy. Additionally, the findings from the main study from both countries (see Chapters 5 and 6) also revealed that an integrated GLSS can address the requirements of various certifications and systems related to quality (e.g., ISO 9001), environment, (e.g., ISO 14001) and employee (e.g., OHSAS and ISO 450001) and food safety (ISO 22000) aspects which is also lacking in the GLSS literature.

In addition, the preliminary study findings from both NZ and PK highlight that the reward system is not a significant factor in GLSS implementation, which undermines the study results of Kumar et al. (2015), Raval et al. (2018), and Swarnakar et al. (2020). The reasoning can be attributed to the explanation given by the participants that a reward system can only make employees happy for a certain time and is a temporary means of motivating employees. However, the main study findings from NZ and PK highlighted the reward system as a CSF for a GLSS strategy.

Drawing upon the ICBV, the preliminary and main study findings from both countries suggested operational factors including project management, performance measurement, and statistical thinking as the CSFs for a GLSS approach, which are also linked with the green structural capital. Among these CSFs, the project management approach and performance measurement system are also emphasized in prior studies by Kaswan and Rathi (2020b), Mishra (2018), and Ruben et al. (2017). However, statistical thinking as a CSF for a GLSS strategy is only addressed in limited studies such as Alhuraish et al. (2017). Further, the analysis of the preliminary study from both countries also reveals adequate utilization of the GLSS tools, which is lacking in the literature. The reason can be associated with the lack of in-depth understanding of these tools and their alignment with the organizations' operational and environmental objectives (Garza-Reyes et al., 2018). The main study findings from NZ and PK also suggest innovation and technology infrastructure as a crucial factor since technological and innovation aspects are significant due to the increasing need for recycling technologies and advanced methods of delamination and compatibilization to ensure the recycling of FP film structures (Ferraioli et al., 2021; Horodytska et al., 2018).

The analysis has also highlighted various CSFs of a GLSS strategy related to organizations' human resource management which are associated with the green human capital aspects of the ICBV theory. From this perspective, employee training and education, teamwork, and employee involvement and empowerment are the CSFs identified in the preliminary and main study findings from both countries, which are consistent with the study results of Caiado et al. (2019), Marrucci et al. (2020), and Pampanelli et al. (2014). It is interesting to note that the preliminary study findings from both countries also highlight the identification of competent employees as a significant factor in the effective utilization of the GLSS strategy, which is not mentioned in prior studies.

Building on the green relational capital facets of ICBV, the empirical findings from both NZ and PK emphasized various external stakeholder-related factors such as government support and policies as crucial in effectively implementing the GLSS strategy for achieving environmental performance (Hussain et al., 2019). While strong customer and supplier relations are essential for implementing a GLSS approach (Caldera et al., 2019; Mangla et al., 2018), the preliminary study findings from NZ and PK did not reveal this aspect. This can be attributed to the limited role of consultants in the execution of GLSS practices within the manufacturing operations of an organization such as in engaging with supply chain activities. Conversely, in the main study, it has been regarded as a crucial factor since the FP manufacturing companies are in the middle of the supply chain, thus customer and supplier involvement is required to execute GLSS practices for environmental performance. In addition, the main study findings from both countries highlighted the role of waste collectors and recyclers in the implementation of a GLSS strategy which is not addressed in prior studies.

However, this finding is of significant importance as it addresses the concerns of environmental protection and resource conservation aspects related to a GLSS strategy.

The empirical findings from both countries, however, undermined the role of financial institutions as a CSF in the execution of GLSS. This can be attributed to the lack of competitiveness and high profit margins in NZ manufacturing firms (see Chapter 4) as well as the role of manufacturing establishments and the religious sentiments against advances in PK (see Chapter 4). However, some international financial institutions (such as International Finance Corporation) are facilitating a few manufacturing organizations in PK to develop renewable energy sources and efficient use of resources (see Chapters 4 and 6).

7.5 A GLSS model for achieving environmental performance in manufacturing organizations

A theoretical model for a GLSS strategy for improving the environmental performance of manufacturing organizations, developed in Chapter 2 (Figure 2.4), has guided this research study. Although the GLSS-related frameworks for addressing environmental issues have been acknowledged in the literature (Cherrafi et al., 2019; Garza-Reyes 2015a; Gaikwad et al., 2020a), these frameworks have limitations (see Table 2.3). Further, none of the prior studies integrated organizational theories with these models. In addition, prior studies lack an in-depth understanding and a holistic view of the GLSS aspects such as drivers, enablers, environmental outcomes, and CSFs. Accordingly, this study addresses the above gaps by developing a holistic GLSS model (Figure 7.1) for manufacturing organizations addressing their environmental issues. The model includes the empirical findings of the preliminary study conducted with the LSS and environmental consultants and main study in the FP sector, which is one of the most environmentally polluting sectors within the manufacturing industry in both a developed and developing nation. Thus, it can be argued that the model proposed in this study is generic in nature identifying novel insights into various aspects of GLSS implementation. Consequently, manufacturing organizations facing similar environmental challenges could benefit from this model and the implementation of the GLSS strategy. Since the preliminary and main study findings reveal various GLSS drivers, enablers, environmental outcomes, and CSFs, the model includes a set of these aspects (drivers, enablers, environmental outcomes, and CSFs) based on those most cited by the participants (i.e., ≥ 10 participants for GLSS drivers and CSFs and ≥ 5 participants for GLSS enablers leading to environmental outcomes).

Drawing on the NRBV, ITBV, and ICBV, this study has identified various drivers, enablers, environmental outcomes, and critical success factors of GLSS strategy in both NZ and PK. The holistic GLSS model for achieving environmental performance is presented in Figure 7.1 encapsulated with the organizational theories. The proposed model illustrates three interrelated constructs of a GLSS strategy – drivers, enablers and environmental outcomes, and CSFs. In particular, the model highlights the GLSS drivers (RQ1) leading to the GLSS enablers for achieving environmental outcomes (RQ2), while the critical success factors (RQ3) facilitate the effective execution of the GLSS enablers for achieving environmental performance.

First, building on the NRBV and ITBV, the model presents internal and external drivers of a GLSS strategy. The internal drivers comprise the operational and organizational drivers. The operational drivers include process control, cost reduction, and waste reduction (Cherrafi et al., 2017; Costa et al., 2018; Garza-Reyes, 2015a; Powell et al., 2017; Tiwari et al., 2020). The organizational drivers comprise continuous improvement, environmental responsibility, and resource circulation (Caldera et al., 2018; Chaplin & O'Rourke, 2018; Parmar & Desai, 2019; Sarwar et al., 2019). Both operational and organizational drivers are linked with the pollution prevention, product stewardship, and sustainable development capabilities of NRBV. The external drivers comprise the regulatory drivers (i.e., government pressure), society-oriented drivers (i.e., public pressure), and market-oriented drivers (i.e., customer pressure, competitor pressure, and company image) (Cherrafi et al., 2017; Darko et al., 2017; Sajjad et al., 2015; Gandhi et al., 2018; Tiwari et al., 2020; Zhang et al., 2019). These are linked with the coercive, mimetic, and normative isomorphisms of ITBV as shown in Figure 7.1.

Due to the internal and external drivers, manufacturing organizations are implementing a mix of enablers under the umbrella of a GLSS approach for improving environmental performance in a holistic manner (Kaswan & Rathi, 2020a). This resonates with the study results of Hart et al. (2010) that the bundle of resources creates complexity and thus can bring competitive advantage. Therefore, using a diverse set of GLSS practices can bring optimal environmental performance as compared to using any one in a standalone manner (Green et al., 2019). From this perspective, the model indicates a variety of GLSS enablers encapsulated by the NRBV theory, leading to environmental performance by achieving outcomes in waste and emission reduction, resource conservation and recycling, and environmental safety and compliance. Based on the empirical findings, the GLSS enablers for waste and emission reduction including 5S, EMS, SOPs, DFE, DOE, Pareto diagram, DMAIC, JIT, SMED, SPC, CA, VSM, and WS are linked with the pollution prevention strategic capability of NRBV.

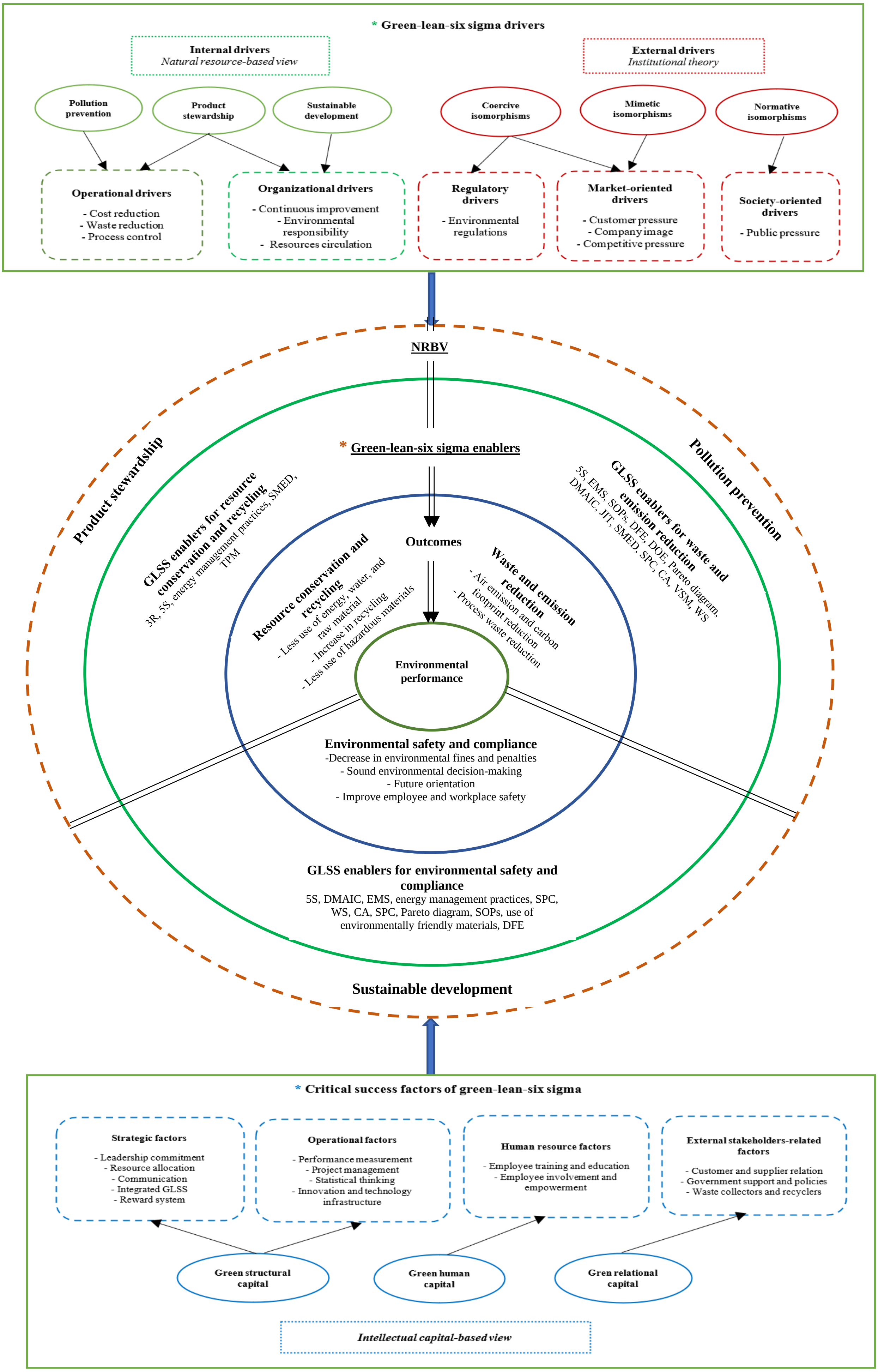

Figure 7.1: A GLSS model for achieving environmental performance in manufacturing organizations

* Research question 1, * Research question 2, * Research question 3

These enablers can help manufacturing organizations in reducing process waste, air emissions, and carbon footprint, thereby enhancing their pollution prevention strategic capacities (Besseris 2011; Gholami et al., 2020, Marrucci et al., 2020; Powell et al., 2017; Sony & Naik, 2019; Tiwari et al., 2020). Further, removing pollutants (such as VOCs) from the manufacturing processes can increase efficiency through process simplification, minimum input requirements, and compliance cost reduction (Hart et al., 2010).

The GLSS enablers for resource conservation and recycling include 3R, 5S, energy management practices, SMED, and TPM, which are associated with the product stewardship strategic capability of NRBV. Using these enablers, manufacturing firms can minimize the use of hazardous materials, save raw materials, energy, and water, and increase the reuse and recycling of resources, thus strengthening their product stewardship strategic capabilities (Ruben et al., 2017; Chaplin & O'Rourke, 2018; Kendrick et al. (2017); Marrucci et al., 2020). This also reduces the product life cycle cost and increases focus on product development (Hart et al., 2010). Further, the GLSS enablers for environmental safety and compliance comprising 5S, DMAIC, EMS, energy management practices, SPC, VSM, WS, CA, SPC, Pareto diagram, SOPs, 5Whys, DFE, and use of environmentally friendly materials are related to the sustainable development strategic capability of NRBV. These enablers can facilitate manufacturing companies in improving their "beyond greening" strategies (Hart et al., 2010, p. 1471) related to sustainable development by decreasing environmental fines and penalties, making sound environmental decisions, improving employee and workplace safety aspects, and future orientation of environmental protection and natural resource conservation (Cherrafi et al., 2016; Kazancoglu et al., 2018, Tasdemir & Gazo, 2019, Tiwari et al., 2020).

While the GLSS strategy can achieve better environmental performance, the implementation of GLSS could face some challenges such as lack of strategic focus, lack of external cooperation, and lack of human resource management (Hussain et al., 2019; Kumar et al., 2016; Sreedharan & Raju, 2018). Therefore, there is a need to overcome these challenges by determining the factors responsible for the success of this strategy (Mishra, 2018). Accordingly, the integrative model presents the critical success factors of a GLSS strategy facilitating the GLSS enablers in improving environmental performance. Building on the three green intellectual capabilities of ICBV, the strategic, operational, human resource, and external stakeholder-related factors are presented. According to Lopez-Gamero et al. (2011), structural capital improvements, environmental strategies, and technology and innovation are needed to achieve environmental performance. Thus, strategic CSFs comprising leadership commitment, financial resources, communication, reward system, and an integrated GLSS approach are linked with the green structural capital of ICBV. Similarly, the operational CSFs such as performance measurement, project management, innovation and technology infrastructure, and statistical thinking are also related to the green structural capital of ICBV. These CSFs can enable manufacturing organizations to effectively execute the GLSS practices in producing positive environmental outcomes, increasing employee wellbeing, and improving financial performance. In addition, corporate managers should invest in developing information systems to protect their green intellectual capital. From this perspective, the organizations can retain and store the environmental knowledge gathered from the stakeholders and employees (Yusoff et al., 2019).

Further, CSFs related to the human resource factors including employee involvement and empowerment and employee training and education are linked with the green human capital of the ICBV. Manufacturing organizations should provide training to the employees on implementing the GLSS enablers accordingly to the organization’s environmental objectives and awareness regarding the significance of this approach for environmental protection (Yusoff et al., 2019). In addition, employees’ competencies including knowledge, skills, experiences, and values can have a positive effect on promoting innovation (Loucks et al., 2010) and increasing environmental thinking (Yusoff et al., 2019) in using the GLSS practices (such as Ergo-VSM and lean facility layout) that not only improve environmental performance but also social performance. Lastly, the CSFs linked with the external stakeholders such as customer and supplier relations, waste collectors and recyclers, and government support and policies are associated with the green relational capital of the ICBV. Strong relationships between organizations, suppliers, recyclers, customers, and governments on environmental aspects can lead to environmental awareness in stakeholders, which can result in reducing negative environmental impact (Dickel et al., 2018; Yusoff et al., 2019). Additionally, networking activities (stakeholders’ relationships) are significant in the execution of environmental practices (Hansen, 2014).

7.6 Summary

This chapter discussed the empirical findings of the phase 1 – preliminary and phase 2 – main study from NZ and PK building on the organizational theories. First, the drivers of a GLSS strategy were discussed linking with the NRBV and ITBV which highlighted the internal (operational and organizational) and external (regulatory, society-oriented, and market-oriented) drivers compelling the manufacturing organizations to adopt GLSS practices.

Second, the enablers of a GLSS strategy comprising a mix of green, lean, and six sigma tools have been identified and evaluated in correlation with the NRBV. From a NRBV perspective, the GLSS practices for waste and emission reduction, resource conservation and recycling, and environmental safety and compliance have been discussed and aligned with pollution prevention, product stewardship, and sustainable development strategic capabilities. Third, the critical success factors of a GLSS strategy have been illustrated by linking to the ICBV theoretical lens. In this context, various strategic, operational, human resource, and external stakeholder-related CSFs have been considered in relation to the green structural, green human, and green relational capital of the ICBV. Finally, a GLSS model comprising the drivers, enablers, environmental outcomes, and CSFs for achieving environmental performance encapsulated with the NRBV, ITBV, and ICBV theories was developed and explained.

Chapter 8

Conclusion, Implications, and Future Research Directions

8.1 Introduction

This study investigates the GLSS strategy for improving the environmental performance of manufacturing organizations in developed and developing country contexts. This chapter is organized as follows. Section 8.2 presents an overview of the study. Next, the key findings on the drivers, enablers, environmental outcomes, and critical success factors of GLSS are presented in section 8.3. Section 8.4 discusses the theoretical, practical, and policy implications. The limitations of this study are highlighted in section 8.5 followed by section 8.6 which presents the future research directions.

8.2 Overview of the study

The purpose of this study was to examine the drivers, enablers, environmental outcomes, and critical success factors of a GLSS strategy in developed and developing country contexts and develop a GLSS model for improving the environmental performance of manufacturing organizations. To achieve this purpose, the study attempted to answer the following research questions.

RQ1: What are the drivers of a green-lean-six sigma strategy in manufacturing firms for achieving environmental performance? How do these drivers compel manufacturing firms to adopt a GLSS strategy in a developed and developing country?

RQ2: What are the enablers and environmental outcomes of a green-lean-six sigma strategy in manufacturing firms for achieving environmental performance? How do manufacturing firms use these enablers to achieve environmental outcomes in a developed and developing country?

RQ3: What are the critical success factors for implementing a green-lean-six sigma strategy for achieving environmental performance? How do these CSFs help manufacturing firms to execute a GLSS strategy in a developed and developing country?

To address the research questions, this study comprised two phases of research: the phase 1 – preliminary study and phase 2 – main study. A qualitative research methodology was applied through semi-structured interviews with LSS and environmental consultants (preliminary study) and senior corporate managers (main study) in FP manufacturing organizations in NZ and PK. Along with the primary source of data collection (semi-structured interviews), the companies' websites, sustainability reports, published case studies, and brochures were analyzed to support the study findings which facilitated achieving triangulation. Three organizational theories – natural resource-based view, institutional theory-based view, and intellectual capital-based view have been used to understand the GLSS strategy. In particular, the NRBV and ITBV were used to explain the internal and external GLSS drivers. Additionally, the NRBV theory was applied to determine and understand the GLSS enablers for achieving environmental outcomes including waste and emission reduction, resource conservation and recycling, and environmental safety and compliance. Moreover, the ICBV theory was used to explain the strategic, operational, human resource, and external stakeholder-related CSFs for implementing a GLSS strategy. The following section briefly summarizes the key research findings of the preliminary and main studies.

8.3 Key findings of the study

This study has revealed various internal and external drivers that compel manufacturing organizations in NZ and PK to adopt GLSS, which answers the first research question of the study. The findings from the preliminary and main studies highlight that the operational drivers including cost reduction, process control, and waste reduction and organizational drivers such as environmental responsibility are the key drivers of GLSS adoption in both NZ and PK. Additionally, the findings from the preliminary and main studies reveal that resource circulation and continuous improvement are the key GLSS drivers for NZ manufacturing firms which indicate the concerns of product stewardship, resource conservation, and government regulations in NZ. Drawing on the theoretical integration of the empirical findings, these drivers are linked with the environment-centric NRBV (see Figure 7.1). Among the external drivers, different institutional pressures and mechanisms were observed using the ITBV theoretical lens. From this perspective, environmental regulations and public pressure are identified as the key regulatory and society-oriented drivers from the preliminary and main study findings of NZ as compared to PK where these drivers seem to be emerging forces to initiate environmental practices. Based on these findings, it can be argued that the environmental regulations are quite stringent in NZ and the public is generally conscious of the environmental consequences of manufacturing firms. Similarly, customer pressure, company image, and competitor pressure are revealed as the key market-oriented GLSS drivers for both regions. Overall, the findings indicate that operational drivers (internal) and market-oriented drivers (external) are mainly compelling manufacturing companies in both countries to adopt the GLSS strategy for improving environmental performance.

In answering the second research question, the findings from both NZ and PK domains have highlighted several GLSS enablers leading to environmental outcomes in manufacturing firms using the NRBV theory. Implementation of the key GLSS enablers such as 5S, JIT, LCA, EMS, DMAIC, SPC, and VSM by the manufacturing companies in both NZ and PK has led to achieving a reduction in waste and air emissions in both regions which are revealed from both the preliminary and main study findings. In addition, SMED is revealed as the key GLSS enabler from the main study findings from both countries facilitating environmental waste reduction such as plastic waste and VOC emissions.

For resource conservation, 3R and energy management practices are the key GLSS enablers used in both NZ and PK manufacturing firms according to the preliminary and main study findings. However, NZ manufacturing firms are more focused on recycling waste following the open and closed-loop practices due to recognition of circular economy aspects. On the other hand, PK companies are mainly focused on reducing process waste and primarily following the open-loop practices due to a lack of recycling infrastructure and technological advancement. In addition, energy management practices such as the use of renewable energy sources and energy audits are commonly used in both regions; however, the use of energy management systems such as ISO 50001 is also implemented by manufacturing companies in PK to cope with energy-related issues. On the other hand, SMED, TPM, and WS are the additional key enablers used in NZ companies which are identified from the main study findings. Conversely, SMED is identified as the key GLSS enabler along with 3R and energy management practices from the main study findings of PK.

To achieve environmental safety and compliance, EMS and SPC are identified as the key GLSS enablers from the preliminary study findings of NZ and PK. SOPs and environmentally friendly materials such as biodegradable and bio-based materials are frequently used in NZ companies according to the main study findings whereas 5S and SOPs are used most in PK manufacturing firms to address the environmental safety concerns. In addition, the main study findings from PK highlighted that manufacturing organizations are using GLSS enablers such as 5S, SOPs, and SIPOC to improve environmental and employee safety while they use less environmentally friendly materials such as water-based inks and biodegradable materials which can be attributed to a lack of financial resources in developing countries to afford environmentally friendly materials.

In answering the third research question, this study highlights various CSFs of a GLSS strategy in the manufacturing firms of NZ and PK categorized into strategic, operational, human resource, and external stakeholder-related factors using the ICBV theory. The key strategic factors include top management commitment, communication, resource allocation, and GLSS implementation in an integrated manner in both PK and NZ according to the preliminary and main study results. In addition, the reward system is considered the key strategic CSF from the main study findings of both NZ and PK. The key operational factors in both NZ and PK are project management, performance measurement, innovation and technology infrastructure, and statistical thinking which are highlighted in the preliminary and main study findings. Further. the key human resource factors include employee involvement and empowerment and employee training and education as per the preliminary and main study results.

Both the preliminary and main studies highlight the government support and policies as a key external stakeholder-related factor in both NZ and PK. Interestingly, customer and supplier relations and the role of waste collectors and recyclers are revealed as the key external stakeholder-related factors for the effective implementation of GLSS in both NZ and PK identified from the main study findings. Based on the preliminary and main study findings from both regions, a holistic model (Figure 7.1) comprising drivers, enablers, environmental outcomes, and CSFs of a GLSS strategy for addressing the environmental performance of manufacturing organizations was developed.

Finally, since the regional results of this study from NZ and PK mostly conform across the findings from the consultants in the preliminary study and the corporate managers in the main study across the two cases in those specific regions, the findings can be generalized to a larger population of manufacturing companies in the developed and developing countries. In addition, the main study was conducted in one of the most polluting industries – flexible packaging – within the manufacturing sector; therefore, the study findings are significant and can be transferable to the wider manufacturing industry in improving environmental performance.

8.4 Implications of the study

This study has several theoretical, practical, and policy-related implications which are presented next.

8.4.1 Theoretical implications

From a theoretical perspective, this study contributes to the GLSS subject domain in several ways.

First, it is argued that this is one of the first studies that has been conducted from both a developed and developing country perspective to provide a holistic understanding of the GLSS strategy. Thus, adds significant knowledge regarding the theoretical constructs (drivers, enablers, environmental outcomes, and CSFs) of the GLSS approach from both regional domains.

Second, this study draws on multiple theories – NRBV, ITBV, and ICBV – to examine the drivers, enablers, environmental outcomes, and CSFs which are largely missing in the GLSS literature, hence providing theoretically enriched insights regarding the GLSS approach. The NRBV, ITBV, and ICBV helped in better delineating the complex GLSS approach and identifying thematic framing for analyzing empirical findings. Additionally, the integration of NRBV, ITBV, and ICBV with the empirical findings contributes to the extant literature by explicating the salient linkages between the GLSS strategy, organizational theories, and environmental performance of manufacturing organizations. From this perspective, the NRBV theory helped in understanding the GLSS drivers (internal) and practices related to the environmental performance of manufacturing organizations with the opportunity to sustain competitive advantage through the accumulation of environmental and operational practices. Further, the NRBV theory facilitated the theoretical mapping of the empirical findings according to the three strategic capabilities – pollution prevention, product stewardship, and sustainable development. Since this study examines the GLSS strategy from a developed (NZ) and a developing country (PK) perspective, the use of ITBV facilitated the analysis of various institutional forces and mechanisms (such as legislative requirements, public pressure, customer requirements, and development organizations/institutions) which can play a significant role in the adoption of a GLSS strategy and linking these with the external GLSS drivers. In addition, the use of ICBV helped in understanding the importance of the various strategic, operational, human resource, and external stakeholder-related factors in the successful execution of the GLSS strategy and linking green structural, green human, and green relational capital with these CSFs.

Third, the investigation of a GLSS strategy in FP manufacturing organizations provides novel insights for building academic research as prior studies have mostly ignored the process industry, which is facing environmental issues from excessive energy consumption, natural resource depletion, GHG emissions, and waste generation. While a few studies (e.g., Gholami et al., 2020; Powell et al., 2017) have investigated the GLSS approach in the process industry for reducing wastewater production, material and energy consumption, this study contributes to the GLSS literature by identifying various practices and their impact in terms of different environmental sustainability criteria. This study extends the scope of the GLSS practices in reusing and recycling resources, improving workplace safety, and long-term environmental performance.

Fourth, this study highlighted some useful tools including VSM, kaizen, EMS, SIPOC, and lean facility layout in addressing the social performance of manufacturing firms which was lacking in prior studies as most studies have addressed these tools from operational and environmental perspectives.

Fifth, this study examined the GLSS strategy addressing the environmental issues of the FP manufacturing industry including sustainable production and consumption of natural resources (e.g., petroleum and bauxite) and reducing the environmental burden of plastic packaging which has become a global issue.

Sixth, using a qualitative research design, this study adds significant knowledge and in-depth information regarding the application of GLSS for improving the environmental performance of manufacturing organizations as prior studies have mostly adopted the quantitative research approach using survey methodology.

Finally, the development of a GLSS model (Figure 7.1) for improving the environmental performance of manufacturing firms is a significant contribution to the GLSS literature as the model provides a holistic view of this strategy.

8.4.2 Implications for consultants

This study has significant implications for consultants from both countries in advising manufacturing organizations to implement a GLSS strategy that can address both their operational and environmental concerns. While in the consultancy realm, LSS and environmental experts individually conduct different projects in organizations, there is a potential for a new breed of GLSS consultants who hold a diverse array of skill sets, knowledge, and expertise in implementing a GLSS approach. Moreover, the consultancy firms can also introduce and develop GLSS focus groups comprising a team of LSS and environmental experts to assist manufacturing firms in improving their environmental performance. Following this suggestion, consultancy firms could effectively promote the GLSS approach using the expertise and knowledge of GLSS focus groups that could enable their client organizations to simultaneously improve operational excellence and environmental performance.

Using this study's findings, the consultants can recommend the manufacturing organizations a mix of GLSS enablers such as EMS, VSM, SPC, EnMS, DFE, and LCA for environmental management. Since the consultants specialize in conducting various LSS and environmental projects in both discrete and process industries, they can facilitate policymakers to develop environmental policies according to the processes and operational requirements of manufacturing organizations. For example, the consultants can assist policymakers in articulating environmental policies using the findings from this research for managing the operational and environmental waste in their companies such as GHG emissions, wastewater discharge, and solid waste.

8.4.3 Managerial implications

This study provides corporate managers with valuable insights regarding the GLSS strategy as follows.

First, the GLSS model (Figure 7.1) provides a roadmap for industrial managers in improving their environmental performance while maintaining operational performance.

Second, the study offers an opportunity for business practitioners to examine the contextual factors while adopting the GLSS strategy for achieving environmental objectives. This could also help industrial managers in deciding how to invest resources and efforts (such as investment in green materials – biodegradable and bio-based through the application of the CBA tool) in the GLSS strategy. Further, this study can facilitate practitioners in both regions to consider the local values, social aspects, and regulations to guide them in initiating GLSS practices and making appropriate decisions.

Third, the findings can assist the senior managers in adopting GLSS enablers for reducing waste and emissions (e.g., EMS, LCA, TPM, VSM, SPC, and CE), conserving and recycling resources (e.g., 3R, SPC, and 5S), and increasing environmental safety and compliance (e.g., EMS, 5S, CBA, and DFE) which can enhance their organizations' strategic capabilities of pollution prevention, product stewardship, and sustainable development.

Fourth, senior managers can benefit from the study findings in ensuring the significant role played by the strategic, operational, human resource, and stakeholder-related CSFs in GLSS execution that can strengthen the organization's relationship with its intangible resources (i.e., green structural, green human, and green relational capital) leading to better environmental performance.

Fifth, the analysis suggests the application of a combined implementation of GLSS enablers, which could further support the change initiatives in the respective countries, since waste is a common aspect in all three green, lean, and six sigma strategies. Using a GLSS approach will be more efficient in effective decision-making since an organization will be looking through a single holistic lens to identify where the improvements are required. The study findings have suggested manufacturers combine these strategies by adding environmental aspects in a continuous improvement cycle such as PDCA and DMAIC to enhance the environmental performance. By implementing such a combined approach, manufacturing organizations can simultaneously achieve better operational, environmental, and social performance through the integration of green, lean, and six sigma enablers (e.g., energy audits, 5S, Pareto diagram, and DOE).

Sixth, the study findings also encourage the corporate managers to identify the potential hot spots in the FP manufacturing processes requiring immediate attention to improve environmental and social performance such as sustainable use of resources, careful handling of solvents and chemicals, and adequate management of industrial waste. The findings can further assist managers in formulating strategies and decision-making while selecting GLSS tools (see Table 7.2) for managing environmental issues including natural resource depletion, air pollution, landfill, recycling issues, and workers' health and safety risks. By doing so, the findings can facilitate managers in the FP manufacturing industry in minimizing the use of natural resources such as oil-based resins and hazardous substances including solvents and initiating sustainable packaging methods and materials. In this way, they can contribute to minimizing the environmental burden of plastics.

Seventh, the results can also help the corporate managers in improving customer relationships using GLSS tools such as QFD, CE, and DFE for addressing customers' complaints and meeting their requirements for environmentally friendly products. Similarly, by using the practices such as JIT, sustainable packaging materials, and SIPOC, the companies can play a significant role in supplier development and increasing suppliers' environmental awareness which can further strengthen their supplier relationships. Additionally, corporate managers, particularly in the developing countries can benefit from the findings in improving their green image in both the local and international markets by embracing key GLSS practices such as ISO 14001, ISO 50001, FSC, WWF green office diploma, and ISO 450001, thus reducing customer pressure to implement environmental and workplace safety practices. The findings are drawn from the experiences of managers and executives working in cross-functional departments of the FP companies, highlighting that effective implementation of GLSS depends on the participation of every functional department.

8.4.4 Policy implications

This study has several implications for policymakers to formulate and enforce effective environmental laws for manufacturing organizations in both developed and developing countries that enable them to reduce negative environmental impact and promote a green image.

First, policymakers can use the study findings in designing policies and legislations including subsidies, landfill levies, and taxes.

Second, the results of this study can guide them in facilitating collaboration between industry, academia, consultancy firms, and stakeholders such as customers, suppliers, waste collectors, and recyclers for improving the environmental performance of manufacturing firms.

Third, the policymakers can benefit from the study findings in environmental initiatives such as providing adequate recycling infrastructure and creating new markets for the FP manufacturing industry (such as managing multi-layer FP waste through mechanical recycling and chemical recycling), thus moving to a circular plastic economy. In addition, the policymakers in developing countries can develop the industrial areas/parks which need regulation by the district-level authorities to avoid environmental risks to the public.

Fourth, the findings can guide the policymakers in identifying the opportunities for cross-country collaboration between the developed and developing countries which can help in mitigating the environmental burden of plastic waste since a large quantity of plastic packaging waste is entering the oceans as a result of mismanaged solid waste practices in developing countries.

8.5 Limitations of the study

While this study provides novel insights and contributes to the GLSS literature, it has some limitations which need to be acknowledged.

First, the study findings lack statistical generalization as a qualitative research methodology was applied in this research to gain an in-depth understanding of the GLSS strategy which facilitated analytical generalization.

Second, since this study was conducted with consultants and senior corporate managers from NZ and PK, the findings of the GLSS strategy may vary in other regions due to the differences in cultural and social values, working conditions, and legislative requirements.

Third, this study has investigated the GLSS strategy in the manufacturing sector in NZ and PK; therefore, the drivers, enablers, outcomes, and critical success factors could be different in other sectors such as healthcare, service, and education.

Fourth, although the case companies in the main study (FP manufacturing industry) were selected carefully to enable analytical generalization, the level of significance of the GLSS constructs could vary based on the nature of industrial processes and/or the industrial characteristics (such as technology intensity) in the manufacturing organizations.

Fifth, the semi-structured interviews were conducted with LSS and environmental consultants and senior managers in FP manufacturing companies; however, the information from other stakeholders such as customers, suppliers, and policymakers were not collected which may affect the overall findings of the study.

8.6 Future research directions

Based on the analysis of the findings of this study and the above limitations, the following future research directions are suggested.

Future research needs to explore the application of GLSS practices in other manufacturing industries including chemicals, paints, leather, textile, and pharmaceuticals, which are also handling hazardous materials and facing serious environmental sustainability issues, which can extend the transferability of the study findings. This will bring new insights into the effects of industrial characteristics on the GLSS implementation for improving environmental performance.

Future research can be conducted in manufacturing organizations facing environmental challenges using a mixed-method research design including the survey methodology to investigate the GLSS approach from a statistical generalization perspective.

Since this study was conducted in large FP manufacturing organizations, future studies can also be performed in small and medium-sized companies to investigate the GLSS application in overcoming environmental issues in this sector, addressing the impact of organizational characteristics (e.g., organization size, ownership structure, and organization maturity) on GLSS execution.

Since the study was conducted in NZ and PK, it would be interesting to verify the findings in other geographic contexts and investigate the effect of economic, legislative, and cultural aspects on the GLSS implementation.

Future research studies need to investigate the role of other stakeholders including customers, suppliers, recyclers, and policymakers in the effective GLSS execution for achieving better environmental performance.

The findings from this study emphasize that the environmental outcomes achieved by GLSS enablers in the form of waste and emission reduction, resource conservation and recycling, and environmental safety can provide a gateway towards CE which also includes the objectives of waste reduction, efficient consumption of resources, and environmental protection (Gholami et al., 2020; Kazancoglu et al., 2018). Additionally, manufacturing organizations are increasingly shifting their attention from the traditional manufacturing paradigm – a linear business production model – to a closed-loop, cleaner production, and CE model. In this respect, future research can explore the GLSS approach as a 'circular business strategy' for manufacturing organizations to achieve the CE goals (Gholami et al., 2020, p. 4).

Since the literature review and empirical findings highlight the significance of technological advancement in the effective implementation of a GLSS strategy, future research could also investigate the integration of the GLSS strategy with the Industry 4.0 concept (Belhadi et al., 2020) to enhance environmental performance by reducing waste, conserving resources, and predicting energy consumption.

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Appendix A

Ethics approval letter

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Date: 05 November 2019

Dear Amna Farrukh Farrukh

Re: Ethics Notification - **4000021931 - A Framework to Evaluate the Impact of Green, Lean, and Six Sigma in Reducing Environmental Effects of Manufacturing Systems**

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our system which is reported in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

If situations subsequently occur which cause you to reconsider your ethical analysis, please contact a Research Ethics Administrator.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:
"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director - Ethics, telephone 06 3569099 ext 85271, email humanethics@massey.ac.nz."

Please note, if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to complete the application form again, answering "yes" to the publication question to provide more information for one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

Research Ethics Office, Research and Enterprise
Massey University, Private Bag 11 222, Palmerston North, 4442, New Zealand **T** 06 951 6841; 06 95106840
E humanethics@massey.ac.nz; animalethics@massey.ac.nz; gtc@massey.ac.nz

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Appendix B

Information sheet and interview questions of preliminary study

Information Sheet

Investigator: Amna Farrukh

Supervisors: Dr. Sanjay Mathrani and Dr. Aymen Sajjad

Invitation to Participate in the Research

As a PhD student under the supervision of Dr. Sanjay Mathrani and Dr. Aymen Sajjad in Massey University, Auckland, New Zealand, I am conducting a research to evaluate the impact of green-lean-six sigma in minimizing environmental impacts of manufacturing organizations. The main supervisor of this research, Dr. Sanjay Mathrani is a senior lecturer in product development in School of Food and Advanced Technology, Massey University, New Zealand. His research expertise are lean and agile manufacturing systems, collaborative product development practices in distributed environments, quality and performance management strategies, and knowledge-based technologies. The co-supervisor of this research, Dr. Aymen Sajjad is a senior lecturer in School of Management, Massey University, New Zealand. His research expertise are business sustainability, sustainable supply chain Management, green supply chain management, sustainable development goals, corporate social responsibility, and business ethics.

I would like to invite you to take part in this preliminary study which is phase 1 of this research study. Before you decide whether to participate, it is essential for you to understand what is the research about, why am I doing this research, how you can participate in this study, what is the research procedure, and what are the participant's rights?

Please read the following information carefully and let me know if anything is not clear or requires more information.

1. What is the research about?

Environmental issues in the form of greenhouse gases, wastewater, hazardous compounds, and resource conservation have made manufacturing firms conscious about the environmental sustainability and efficient utilization of resources. To achieve these objectives, the concept of green-lean-six sigma (GLSS) is proposed. In this concept, green focuses on the environmental performance and resource conservation by using different environmental practices whereas lean targets the removal of wastes and non-value-added activities with the help of various tools and techniques. Along with lean and green strategies towards waste reduction, six sigma also minimizes the defects through a continuous improvement methodology. Literature reveals that these strategies can be helpful in overcoming various challenges which manufacturing organizations are facing in the form of environmental impacts, increasing environmental legislation, and resource scarcity. Therefore, the purpose of this research is to investigate the utilization of these strategies as a holistic approach towards environmental performance of the manufacturing firms.

2. Why am I doing this research?

The overall aim of this study is to analyze the role of green-lean-six sigma strategy in overcoming environmental issues of manufacturing organizations. The research objectives of this study are to determine:

a. The drivers of a green-lean-six sigma strategy in manufacturing firms to reduce the environmental impacts.

b. The green-lean-six sigma practices deployed in manufacturing organizations which can improve environmental concerns.

c. The effects of green-lean-six sigma enablers on environmental performance.

d. The critical success factors (CSFs) for achieving success in executing green-lean-six sigma strategy.

e. The development of a GLSS framework for achieving environmental performance.

3. Why you have been invited to take part in this research?

In this preliminary study, semi-structured interviews will be conducted with the LSS and environmental consultants. You have been invited to participate in this research as you are an expert in this area and you can provide practical insights in these strategies by sharing your knowledge and experience.

4. What will you need to do if you take part in this research?

As an expert of implementing these strategies, you will be requested to provide the information on the application of these strategies regarding environmental performance. In this regard, a face-to-face interview will be conducted with you and questions regarding these strategies will be asked.

5. What are the possible outcomes of the research?

The proposed research can address the objectives of waste minimization, environmental protection, and resource conservation. The core contribution of this research work is the novelty of a framework, which combines the concepts of green, lean, and six sigma as a single approach towards environmental improvement. The exploration of the drivers, enablers, environmental outcomes, and CSFs can provide more insights into the impact of these strategies on utilizing resources and resulting environmental performance. A combination of these strategies will emerge as an approach towards environmental improvement by reducing wastes such as carbon footprints, release of toxic pollutants, volatile organic compounds, and resource saving. Furthermore, manufacturing organizations can improve their decision-making towards implementation of these strategies for environmental performance and resource conservation. Overall, this study will be helpful for both academia and practitioners in understanding the holistic impact of a green-lean-six sigma strategy towards environmental performance.

6. What is the research procedure?

As you will be participating voluntarily in this study; therefore, no incentives are offered to the participants. A copy of the study results would be shared at the conclusion of the research. Face-to-face interviews will be carried out in the research process, which are expected to take approximately 40-50 minutes. Interviews will be recorded using a digital voice recorder at the participants' workplace. A written consent form with the participant's signature will be obtained prior to the interviews.

7. What are the participant's rights?

You are free to decide whether or not to take part in this research study. If you decide to participate, you have the right not to answering any question. As a research participant, you can withdraw the research process at any time during the interview. The confidentiality of the company and anonymity of participants will be maintained throughout the research. The information obtained from the interview questions will be kept confidential and will only be utilized for this research purpose. A digital recorder will be used to record the interviews and participants can request to switch it off during any stage of the interview. Participants can contact to the Massey University Human Ethics Committee in case of any concern regarding the research work. The results and findings of the research will be shared with the research participants on the completion of the study.

8. How to contact us?

If you have any queries or require more information about this research, the following contact information is available.

Amna Farrukh (main researcher)
School of Food and Advanced Technology
Massey University, Auckland, New Zealand
Contact details: +64 210 8710983

Email: A.Farrukh@massey.ac.nz

Dr. Sanjay Mathrani (primary supervisor)
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Dr. Aymen Sajjad (co-supervisor)
School of Management
Massey University, Auckland, New Zealand
Email: A.Sajjad@massey.ac.nz

Contact details: +64 (09) 213 6387

Committee approval statement

This research project has been reviewed and approved by the Massey University Human Ethics Committee: Ethics Notification No. 4000021931. In case of any ethical concerns and queries, please contact Professor Craig Johnson (Committee Chair), Massey University Human Ethics

Committee, Massey University, Research office, Private Bag 11222, Palmerston North, 4442, New Zealand.

Telephone: 063505573; 062505575

Email: humanethics@massey.ac.nz

Interview questions

Q1: What makes manufacturing organizations consider environmental initiatives?

Q2: What motivates manufacturing firms to implement lean and six sigma strategies?

Q3: Please explain which green tools do manufacturing organizations implement. How do these tools impact environmental performance and help in conserving resources?

Q4: What do you think about other manufacturing strategies such as lean and six sigma for achieving environmental impacts and resource conservation? If so, what are the tools that help in increasing environmental performance and why these tools are useful for increasing environmental performance?

Q5: Do you think lean and six sigma can be used as an intervention to combine with green practices in a manufacturing organization for environmental impact? Will the environmental performance increase if an organization considers green, lean, and six sigma strategies as a combined approach?

Q6: What are the environmental outcomes expected on implementing green-lean-six sigma practices and why?

Q7: While implementing green-lean-six sigma practices in manufacturing organizations, what are the critical success factors according to you for successful implementation of these practices and why?

Appendix C

Information Sheet and interview questions of main study

Information Sheet

Investigator: Amna Farrukh

Supervisors: Dr. Sanjay Mathrani and Dr. Aymen Sajjad

Invitation to Participate in the Research

As a PhD student at Massey University, Auckland, New Zealand, I am conducting research to evaluate the impact of green-lean-six sigma strategy to minimize environmental impacts of manufacturing organizations.

I would like to invite you to take part in this research. This research analyzes the role of green-lean-six sigma strategy to overcome environmental issues of manufacturing organizations. The information regarding the various aspects of the study are given below.

1. What is the research about?

Environmental issues in the form of greenhouse gases, wastewater, hazardous compounds, and resource conservation have made manufacturing firms conscious about environmental sustainability and efficient utilization of resources. To achieve these objectives, the concept of green-lean-six sigma (GLSS) is proposed. In this concept, green focuses on environmental performance, lean targets the removal of wastes and non-value-added activities, and six sigma minimizes the defects through process improvement. Literature reveals that these strategies can be helpful to overcome various challenges which manufacturing organizations are facing in the form of environmental impacts, stringent environmental legislation, and resource scarcity. Therefore, the purpose of this research is to investigate the utilization of these strategies as a holistic approach towards the environmental performance of manufacturing firms. The research objectives of this study are to determine:

a. The drivers of green-lean-six sigma strategy in manufacturing firms to reduce the environmental impacts.

b. The green-lean-six sigma practices deployed in manufacturing organizations which can improve environmental concerns.

c. The effects of green-lean-six sigma enablers on environmental performance.

d. The critical success factors (CSFs) for achieving success in executing green-lean-six sigma strategy.

e. The development of a GLSS framework for achieving environmental performance.

2. Why you have been invited to take part in this research?

In this study, semi-structured interviews will be conducted with the corporate managers. You have been invited to participate in this research as you are a user and implementer of these strategies in your organization and you can provide practical insights on these strategies by sharing your knowledge and experience.

3. What will you need to do if you take part in this research?

You will be requested to provide information on the application of these strategies regarding environmental performance. In this respect, either a face-to-face or Skype interview will be conducted with you for which the questions will be sent to you separately.

4. What are the possible outcomes of the research?

The proposed research can address the objectives of waste minimization, environmental protection, and resource conservation. The core contribution of this research work is the novelty of a framework, which combines the concepts of green, lean, and six sigma as a holistic approach towards environmental improvement. The exploration of the drivers, enablers, environmental outcomes, and critical success factors can provide more insights into the impact of these strategies on utilizing resources and resulting environmental performance. A combination of these strategies will emerge as an approach towards environmental improvement by reducing wastes such as carbon footprints, the release of toxic pollutants, volatile organic compounds, and resource saving. Overall, this study will be helpful for both academia and practitioners to understand the holistic impact of a green-lean-six sigma strategy towards environmental performance.

6. What is the research procedure?

As you will be participating voluntarily in this study, therefore, no incentives are offered to the participants. A copy of the study results would be shared at the conclusion of the research. Face-to-face interviews will be carried out in the research process, which are expected to take approximately 40-50 minutes either at the participants' workplace or via Zoom/Skype. A written consent form with the participant's signature will be obtained prior to the interviews.

7. What are the participant's rights?

If you decide to participate, you have the right not to answer any question. As a research participant, you can withdraw from the research process at any time during the interview. The confidentiality of the company and anonymity of participants will be maintained throughout the research. The information obtained from the interview questions will be kept confidential and will only be utilized for this research purpose. A digital recorder will be used to record the interviews and participants can request to switch it off during any stage of the interview. Additionally, the file comprising interview data (recordings) will be confidentially handled. Participants can contact the Massey University Human Ethics Committee in case of any concern regarding the research work. The results and findings of the research will be shared with the research participants on the completion of the study.

8. How to contact us?

If you have any queries or require more information about this research, the following contact information is available.

Amna Farrukh (main researcher)
School of Food and Advanced Technology
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Committee approval statement

This research project has been reviewed and approved by the Massey University Human Ethics Committee: Ethics Notification No. 4000021931. In case of any ethical concerns and queries, which you wish to raise with someone other than the researcher, please contact Professor Craig Johnson (Committee Chair), Massey University Human Ethics Committee, Massey University, Research office, Private Bag 11222, Palmerston North, 4442, New Zealand.

Telephone: 063505573; 062505575

Email: humanethics@massey.ac.nz

Interview questions

Q1: As a flexible packaging manufacturing organization what made your company consider environmental initiatives?

Q2: What drove your organization to implement lean and six sigma strategies?

Q3: Please explain which green tools has your organization implemented. How have these tools impacted environmental performance and helped in conserving resources?

Q4: What do you think about lean and six sigma strategies for achieving environmental impacts and resource conservation? Which lean and six sigma tools have helped in increasing environmental performance and why?

Q5: Do you think lean and six sigma can be used as an intervention to combine with green practices in a manufacturing organization for environmental impact? Will the environmental performance increase if an organization considers green, lean, and six sigma strategies as a combined approach?

Q6: What are the environmental outcomes achieved on implementing green-lean-six sigma practices and why?

Q7: While implementing green-lean-six sigma practices in your organization, what are the critical success factors according to you for successful implementation of these practices and why?

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Appendix D

Consent Form

A Green-Lean-Six Sigma Model for Environmental Performance in Manufacturing Organizations: A Study of a Developed and Developing Nation

This research is being conducted by Amna Farrukh, PhD student, Massey University, Auckland, New Zealand. This research project has been reviewed and approved by the Massey University Human Ethics Committee. In case you have any ethical concerns and queries, and wish to raise with someone other than the researcher, you may contact Professor Craig Johnson (Committee Chair), Massey University Human Ethics Committee, telephone 063505573, email humanethics@massey.ac.nz.

I have read the Information Sheet and the details of the study have been explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time. I agree to the interview being audio recorded.

I agree to participate in this study as per the conditions described in the Information Sheet.

Participant's Name: ______________________________

Participants' Signature: ______________________________ Date: ________________

Researcher's Signature: ______________________________ Date: ________________

Appendix E

Invitation letter

Dear Mr/Ms.

<u>Subject: Invitation to participate in the research work</u>

I am a postgraduate student doing a PhD study in the School of Food and Advanced Technology, Massey University, Auckland, New Zealand. My research investigates the impact of a green-lean-six sigma strategy in reducing environmental effects of manufacturing organizations. An essential part of this research is seeking information and practical insights from practitioners who have experience in the implementation of green, lean, and six sigma strategies in manufacturing firms. As a practitioner in this area, I believe you will be able to assist me in my research work.

This research requires face-to-face interviews at your workplace to answer a few related questions. However, due to current COVID-19 situation, interviews can be conducted via Zoom/Skype. I have developed an information sheet and some questions which I will send before the interviews and I will look forward to getting the answers during the interview. The interview is estimated to take 40-50 minutes. This research will be helpful for both academia and practitioners in understanding the holistic impact of a green-lean-six sigma strategy towards environmental performance.

As a PhD student of Massey University, I am obliged to follow ethical considerations during the research work. I would like to assure you that all the information provided by you will be kept confidential and you will be having a right to withdraw from the process at any stage of the interview. I am hoping that you will be able to help me in this research work by giving your valuable time and sharing your experience. I would like to request you to please suggest a convenient time for the interview. I am also happy to share with you the research findings of this study once it is completed.

Please find the attached information sheet.

I would be pleased to provide you any additional information if you may require.

Thanking you in anticipation.

MASSEY UNIVERSITY
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UNIVERSITY OF NEW ZEALAND

Best Regards,

Amna Farrukh

Ph.D. Student

School of Food and Advanced Technology

Massey University, Auckland, New Zealand