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**A Model to Evaluate Effectiveness of Lean and ISO 14001 Implementation on
Environmental Benefits in the Meat Industry**

A thesis presented in partial fulfillment of the requirement for the degree of Doctor of
Philosophy

in

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Abstract

Excessive emissions of greenhouse gases, production of wastes (organic and inorganic) and inefficient utilisation of resources have drastic impacts on the operational and environmental performance in the meat industry. Reducing waste and processing environmentally friendly meat products have long been desired in meat processing and is still considered as a promising strategy to yield environmentally friendly products. ISO 14001 is a voluntary environmental management system standard that provides a continuous improvement framework to reduce environmental impacts and improve environmental performance. Lean is used as a strategy for minimising waste and non-value-adding activities focusing on increasing customer satisfaction, which also has a positive impact on the environment. Besides, continuous improvement is at the very core in both approaches.

This study evaluates the environmental performance in the meat industry through the joint application of lean and ISO 14001. Further, a conceptual model is developed through literature synthesis which combines the lean and ISO 14001 strategies to achieve the environmental performance benefits that could be applied to the meat industry. The study uses the natural resource-based view (NRBV) as its theoretical lens to understand lean and ISO 14001 implementation as a combined approach for improving environmental performance outcomes in the meat industry.

A preliminary study and subsequent multiple-case studies are employed as a qualitative research design for this evaluation. In the first phase of the study, semi-structured interviews with lean and ISO 14001 consultants are conducted to evaluate the implementation of lean and ISO 14001 as a combined approach for improving environmental performance in the meat industry. Next, multiple-case studies are conducted in three meat processing organisations – two in New Zealand and one in Ireland – to evaluate the effectiveness of implementing both lean and ISO 14001 strategies together for achieving environmental benefits.

This study reveals that the application of the NRBV competencies (e.g., strategic planning and human) for a joint lean and ISO 14001 implementation helps to enhance natural capabilities (i.e., pollution prevention, product stewardship and sustainable development). For instance, lean and ISO 14001 implementation as a combined approach helps to better achieve pollution prevention (e.g., reduction of wastewater and greenhouse gas emissions), product stewardship (e.g., recycling

of wastewater and introduction of renewable resources) and sustainable development (e.g., sustainable resources usage and environmental awareness).

This research contributes to presenting key practitioner insights on the implementation of lean and ISO 14001 for improvement of environmental performance as well as provides factors for successful implementation of both strategies in the meat industry. A model is developed for lean and ISO 14001 implementation through empirical evidence and competencies and capabilities of the NRBV lens to help practitioners, policymakers, consultants and academia in their future work to improve environmental performance.

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List of Abbreviations

Abbreviation	Full form
3C	Concern, cause and countermeasure
°C	Celsius
5S	Seiri, seiton, seiso, seiketsu, and shitsuke
6S	5S+safety
E. coli	Escherichia coli
ANZECC	Australian and New Zealand Environment and Conservation Council
BBIFB	Bord Bia Irish Food Board
BOD	Biochemical oxygen demand
CEO	Chief executive officer
CO ₂	Carbon dioxide
COD	Chemical oxygen demand
CH ₄	Methane
CSFs	Critical success factors
DAFF	Department of Agriculture, Fisheries and Food
EMS	Environmental management system
EPA	Environmental protection agency
EU	European Union
e-VSM	Environmental value stream mapping
GHG	Greenhouse gases
GIDI	Government Investment in Decarbonising Industry
GJ	Gigajoules
IMPV	International motor vehicle programme
ISO	International Organisation for Standardisation
JIT	Just in time
Kg	Kilogram
KPIs	Key performance indicators
LCA	Life cycle assessment
LCT	Life cycle thinking
MS Excel	Microsoft Excel
MSD	Musculoskeletal disorders
NRBV	Natural resource-based view
NZ	New Zealand
NZQA	New Zealand Qualification Authority
NO _x	Nitrogen oxides
N ₂ O	Nitrous oxides
O ₃	Ozone
PDCA	Plan, do, check and action
PITO	Primary Industry Training Organisation
PM ₁₀	Particulate-matter-10
PPE	Personal protection equipment
QCD	Quality, cost and delivery
RBV	Resource-based view
SBTi	Science-Based Targets initiative
SN	Serial number
SOPs	Standard operating procedures
S ₂ O	Sulphur dioxide
SO _x	Sulphur oxides
SMED	Single-minute exchange of die
SQCDP	Safety, quality, cost, delivery and performance
TPM	Total productive maintenance
TPS	Toyota Production System
TSS	Total suspended solids
UK	United Kingdom
USA	United States of America
UV	Ultraviolet
VSM	Value stream mapping
WHO	World Health Organisation

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Chapter 1 – Introduction and Background

1.0.1 Introduction

Energy, environment and waste management systems are largely employed to gain operational optimisation, a healthier environment and business profits in manufacturing firms. This is achieved by reducing waste production and gaseous emissions as well as increasing effective utilisation of natural resources in these firms (Arocena, Orcos, & Zouaghi, 2023). Two major continuous improvement initiatives that are helping organisations achieve their profitability and environmental performance goals are lean and International Organisation for Standardisation (ISO) 14001 (Souza & Alves, 2018). Lean management, also known as a continuous improvement philosophy, has been on the forefront in the manufacturing industry with a focus on reducing muda (waste) to reduce costs and maximise productivity (Kalemkerian, Santos, Tanco, Garza-Reyes, & Viles, 2022). Similarly, ISO 14001 has been another endeavor adopted by the manufacturing industry that provides a continuous improvement framework to increase environmental performance for better competitiveness (Bacoup, Michel, Habchi, & Pralus, 2018).

ISO 14001 is considered as most effective and recognised standard for developing an environmental management system (EMS) framework to improve the environmental performance, which focuses on improving environmental protection by reducing degeneration and sustainable utilisation of natural resources in manufacturing firms (Arocena et al., 2023). ISO 14001 emerges as a prominent internationally accepted voluntary standard among practitioners to determine the potential effects of human activities in degrading environment through manufacturing processes and proposes potential solutions for mitigation (Arocena et al., 2023; Bashir, Ojiako, Haridy, Shamsuzzaman, & Musa, 2022). However, researchers have a split opinion about the impact and effectiveness of ISO 14001 in terms of environmental performance improvement, mitigation of gaseous emission and environment protection in the manufacturing industry. Many researchers, (e.g., Arimura, Darnall, Ganguli, & Katayama, 2016; Arocena et al., 2023; Bashir et al., 2022) advocate that ISO 14001 is a certifiable EMS to improve the environmental performance with proper evidence from literature based on qualitative (interviews) and quantitative (survey) studies in various manufacturing sectors. However, some other researchers (e.g., Blackman, 2012; Camilleri, 2022; Riaz, Saeed, Liedong, & Rajwani, 2022) argue that ISO 14001 is not a perfect continuous improvement initiative for the assessment of environmental performance based on the

inconsistent results reported certified companies. According to them, there is no statistically significant decrease in emissions after ISO 14001 implementation in these companies. Therefore, the ambiguity still exists on the effectiveness of ISO 14001 to achieve or improve the desired environmental performance in the manufacturing sector.

Lean manufacturing as a philosophy along with its tools has been adopted in manufacturing firms to identify and eliminate waste in production through continual improvement. The basic aim of waste elimination is to increase customer value and thereby improve profitability of the business, create a healthier environment and enhance the public image positively (Farrukh, Mathrani, & Sajjad, 2022). The inefficiencies of raw material utilisation and energy consumption are minimised through process improvement (Farrukh et al., 2022; Johansson & Sundin, 2014). In addition, Verrier, Rose, Caillaud, and Remita (2014) have explained that an environmental improvement strategy enables manufacturing firms to reduce the excessive use of water, power and resources and overall pollution (e.g., rubbish and greenhouse gas emissions). Their study further emphasises that the lean and environment improvement paradigms provide a framework for measuring the productivity and environmental performance on the basis of a qualitative and quantitative analysis.

Consequently, ISO 14001 and lean philosophy are primarily based on the premise of improving productivity and performance through an on-going basis, but in the real-world, some studies have found that continuous improvement is not maintained after the initial implementation of ISO 14001 (Ferrón Vílchez, 2017) and lean (Antony et al., 2022) strategies. In addition, there has been little research that evaluates the improvement of environmental performance by integrating both lean and ISO 14001 (Chen, Lujan-Blanco, Fortuny-Santos, & Ruiz-de-Arbulo-López, 2020; Puvanasvaran, Swee Tian, & Vasu, 2014; Souza & Alves, 2018). Literature conveys that lean and ISO 14001 could be implemented as a holistic combined approach for reducing operational and environmental wastes in manufacturing (Duarte & Cruz-Machado, 2013; Vasconcelos, Viana, & Neto, 2019). However, development of a comprehensive model to establish the correlation and integration between lean and ISO 14001 for environmental process improvement in manufacturing is considered a gap for future research. Very few attempts have been made to study lean and ISO 14001 implementation as a combined approach and the present literature lacks in assessing the potential synergies or conflicts in the integration of lean and ISO 14001. Therefore, there is a need for a study that investigates the implementation of lean and ISO 14001 as a combined concept

where issues and benefits of both these strategies are considered holistically for improving environmental processes and performance (Puvanasvaran et al., 2014).

1.0.2 Meat industry

In the last few decades, mankind has been facing three adverse challenges in food security, effective energy consumption and climate change. The meat industry is contributing around 65% of total food production globally. The meat sector is often blamed for inefficient utilisation of energy and production of wastes (organic, inorganic and gaseous) (Naresh Kumar & Chakabarti, 2019). The waste consists of packaging materials, inedible products and emission of greenhouse gases (GHG) produced in meat processing causes global warming (Djekic & Tomasevic, 2016). Additionally, the wastewater consists of pollutants such as meat extracts, cleaning agents and manure. On the other hand, the production loads of heat are energy intensive processes in the meat industry. Cooling and ventilation processes in meat processing are maintained by electricity consumption and heat processes are carried out using natural gas or diesel. The energy consumption in meat production per tonne has increased approximately from 14% to 48% in Europe in recent years (Naresh Kumar & Chakabarti, 2019).

The meat industry is amongst the highest contributors to environmental emissions in the food sector. Past research studies have only emphasised on identification of the environmental aspects, but not on improvement of environmental performance by utilisation of environmental practices (Djekic et al., 2016). However, lean and ISO 14001 implementation strategies are employed as environmental improvements and operational initiatives in the food industry especially in the meat facilities in recent years. Furthermore, the environmental quality assurance of food products especially meat products can be maintained by implementation of ISO 14001 and environmental performance improvement is sustained through lean strategy (Dora & Gellynck, 2015). The implementation of ISO 14001 is used in meat industry for identification of environmental aspects and impacts for environmental performance evaluation (Đekić & Tomašević, 2017).

It can be seen from the above discussion that the meat industry is struggling to mitigate waste (i.e., wastewater, GHG emissions and heat losses) for processing environmentally friendly meat products. The application of lean and ISO 14001 as a combined approach can provide a comprehensive strategy for better mitigating environmental issues in the meat industry.

1.0.3 Aim and objectives of this study

Lean and ISO 14001 concepts are used to enhance the operational efficiency and reduce the environmental impacts by minimising wastes in manufacturing facilities (Souza & Alves, 2018; Wirkus & Chmielarz, 2018). ISO 14001 is considered as a strategy for providing rules and roadmap to formulate and adopt an EMS framework (Sorooshian & Ting, 2018). The policy and procedures of ISO 14001 are utilised as a strategy for mitigating environmental impacts. Many companies have implemented lean for reducing production wastes and improving process flow. Although both implementation strategies focus on process improvement for waste elimination, yet little evidence in literature establishes synergies between lean and ISO 14001 (Puvanasvaran et al., 2014; Souza & Alves, 2018). In recent research, Touriki, Benkhati, Kamble, Belhadi, and El fezazi (2021) and Chen et al. (2020) have recommended development of an integrated concept of lean tools with ISO 14001 for sustaining environmental processes. Further, research on circular economy and energy management domains have attained enough attention on green, resilience and lean practices in recent years. However, an acute need to investigate the impact of international standard certification such as ISO 14001 and lean on environmental management has been highlighted (Touriki et al., 2021). Chen et al. (2020) have further emphasised that implementation of lean and ISO 14001 as a combined approach must be developed that could be implemented as a future strategy to achieve environmental sustainability. Therefore, this study aims to evaluate the implementation of lean and ISO 14001 as a combined approach for better improving the environmental performance.

Utilisation of natural resources and reduction of air emission with cost-effective environmental performance are considered as important factors for the implementation of ISO 14001 in the manufacturing sector (Arimura et al., 2016; Arocena et al., 2023; Bashir et al., 2022). Arimura et al. (2016) have explained that the manufacturing sector emphasises more on active utilisation of natural resources because of its contribution to cost-effective operations. However, air emission is the neglected portion of operations due to its need for expensive mitigation control technologies which is considered to increase the overall cost of production.

Many manufacturing facilities have implemented lean and ISO 14001 to reduce the environmental waste and improve operations in recent decades. However, there are barriers in effective implementation of ISO 14001 (Kafel & Nowicki, 2023) and lean (Antony et al., 2022) in the

manufacturing industry. Therefore, there is an acute need to identify the critical factors in effectively implementing ISO 14001 (Banik et al., 2020; Bravi, Santos, Pagano, & Murmura, 2020) and lean (Achanga, Shehab, Roy, & Nelder, 2006; Ainul Azyan, Pulakanam, & Pons, 2017; Belhadi, Touriki, & Elfezazi, 2018) to gain and sustain waste reduction and process improvement advantage.

Sustaining the continual improvement with certification conformity audits during ISO 14001 implementation (Fortuński, 2008) and implementation of lean tools (Alhuraish, Robledo, & Kobi, 2017) can face challenges and risks of failure due to incompetent workforce and unsatisfactory outcomes of both approaches. Ignoring these key factors can lead to less effectiveness and even failure in the deployment of these strategies as a combined approach. Therefore, researchers have suggested to identify the influential factors for overcoming the failure risks in the implementation initiatives of lean (Achanga et al., 2006; Barclay, Cudney, Shetty, & Antony, 2021) and ISO 14001 (Murphy, Guimaraes Da Costa, & Wong, 2020; Sambasivan & Fei, 2008). Since the reasons for failure are diverse, it would help to classify the CSFs in different contextual dimensions to appropriately sustain, maintain and manage the joint deployment of lean and ISO 14001 as a combined approach (Habidin, Hibadullah, Mohd Fuzi, Salleh, & Md Latip, 2018). Therefore, this study also aims to determine the CSFs for joint implementation of lean and ISO 14001 in the meat industry. The objectives of the study are as follows:

1. To investigate and analyse the environmental performance in the meat industry through the implementation of lean and ISO 14001 as a combined approach.
2. To investigate how lean and ISO 14001 strategies can be implemented together to help the meat industry in improving environmental performance and the potential synergies between these management initiatives.
3. To determine the critical success factors for implementing lean and ISO 14001 as a combined approach.

1.0.4 Research questions

The following research questions are formulated to fulfil the aim of this study.

1. *How do lean and ISO 14001 implementation strategies as a combined approach contribute to environmental performance in the meat industry?*

2. *How can lean and ISO 14001 strategies be implemented together in the meat industry and how do these strategies complement each other for improving environmental performance?*
3. *What are the critical success factors for implementing lean and ISO 14001 as a combined approach in the meat industry?*

The elements of ISO 14001 provide a framework for constructing an environmental management programme. On the other hand, lean manufacturing practices are uniform in nature, a comprehensive set of strategies that provide tools and techniques for improving the process by reduction of wastages (Puvanasvaran et al., 2014). Very few studies have proposed a comprehensive model for implementation of lean and ISO 14001 due to the limited scope of research studies investigating integration of both strategies in the manufacturing sector (Puvanasvaran et al., 2014; Wirkus & Chmielarz, 2018). An integrated system by combining an EMS framework and lean tools can be applied to streamline work processes for reducing operational and environmental wastes (Souza & Alves, 2018).

The current research develops a model to determine the effectiveness of lean and ISO 14001 implementation as a combined approach. This study utilises this model to evaluate the environmental performance indicators and assess the environment optimisation cycle in the meat industry. On the basis of this evaluation, the research questions of this study are answered.

1.0.5 Background of the Study

The basic objective of environmental process improvement, energy loss control and raw material optimisation is to address waste reduction, effective energy utilisation and reduction of production costs (Farrukh et al., 2022; Palange & Dhattrak, 2021). The earlier, mass production concept is replaced by lean manufacturing after the introduction of Toyota Production System (TPS) in the manufacturing industry (Palange & Dhattrak, 2021). Since the start of the 1980s, environment management, waste management and effective utilisation of energy are treated as an integral part of strategy and policy deployment after the introduction of TPS concepts (El-Khalil, 2022; Naeemah & Wong, 2022). Further, TPS in manufacturing has been developed on the basis of continuous improvement and waste minimisation with effective utilisation of resources.

The foundation of lean philosophy lies in TPS concepts and is based on its main goal: “To do more with less” (Azadeh, Yazdanparast, Zadeh, & Zadeh, 2017, p. 155). An optimised process can be achieved by controlling different types of wastes in lean strategy, e.g., Muda (non-value activities),

Muri (poor work conditions) and Mura (unevenness of demand) (Radin Umar, Tiong, Ahmad, & Dahalan, 2023). Lean focuses on operational waste minimisation and effective utilisation of resources to optimise the operational activities in manufacturing firms and thereby increase profitability.

This strategy leads to motivation amongst the workforce for attaining customer satisfaction and improved manufacturing systems (Antony et al., 2022). In a study conducted in the European context, it was found that the manufacturing industry consumes around 37% of total primary energy production in Europe. Europe Strategy 2020 aims to reduce 20% of the total energy consumption by implementing lean practices (May, Barletta, Stahl, & Taisch, 2015). The benefits of lean are not limited to waste elimination but also in improving the product flow by sustaining and improving the effectiveness of value-added activities (Dieste, Panizzolo, & Garza-Reyes, 2020). Furthermore, lean improves the implementation of quality standards in the service sector without any additional resources (e.g., health care facilities) (Alemsan, Tortorella, Taboada Rodriguez, Balouei Jamkhaneh, & Lima, 2022; Henrique, Filho, Marodin, Jabbour, & Chiappetta Jabbour, 2021) and also helps in maintaining the risk management in the manufacturing industry by identifying poor indicators for process improvement (Psomas, 2020). However, the effectiveness of lean as a tool for process improvement, waste minimisation and energy optimisation needs more investigation to depict the effectiveness of the overall process development in the meat industry (Simons & Zokaei, 2005).

After the launch of ISO 14001 in 1996, approximately 312,580 organisations have adopted EMS as a tool to minimise pollution, waste and achieve effective utilisation of natural resources (ISO-Survey, 2019). Neves, Salgado, and Beijo (2017) found that ISO 14001 certified firms have succeeded in reducing the excess generation of sulphur dioxide (SO₂) in around 160 countries. In the same study, reduction of carbon dioxide (CO₂) production was reported in the Italian automobile industry as a result of ISO 14001 implementation. The effective implementation of ISO 14001 as a certified EMS was also dependent on environment regulations of a particular country (Bashir et al., 2022). Although ISO 14001 emerged as a leading voluntary standard to reduce the operational costs and attain process improvement as well as a healthier environment, it is difficult to establish its effectiveness as an eco-certification to mitigate pollution (Blackman, 2012; Camilleri, 2022). Based on Campos, de Melo Heizen, Verdinelli, and Cauchick Miguel (2015), the main issues related to effective implementation of ISO 14001 in manufacturing firms

are: (i) a lack of internal maintenance system for EMS, (ii) weak integration between performance indicators and maintenance of EMS and (iii) absence of continuous cycle of assessment for environmental performance.

This study addresses these gaps reported in the literature for lean and ISO 14001 implementations to evaluate the integration of lean and ISO 14001 and their effectiveness in reducing production of waste and achieving process optimisation in the meat manufacturing industry. Moreover, this study will establish the effectiveness of lean and ISO 14001 together in controlling emission production, minimising environmental impact and achieving process optimisation.

1.0.6 Justification for selection of ISO 14001 from entire ISO 14000 family

ISO 14000 series consists of a number of standards with their unique attributes and effectiveness for improving environmental performance in manufacturing and service processes (Goldar & Majumder, 2022; Mekhantseva, Ukraintseva, & Solenaya, 2023). Fundamentally, constructing an EMS according to ISO 14000 series include ISO 14001 (EMS: Specification with guidance for use), ISO 14004 (EMS: General guidelines on principles, systems and supporting techniques) and some additional standards (Camilleri, 2022; Fortuński, 2008). However, organisations mainly obtain certification by adopting EMS framework according to ISO 14001 standard only because the additional standards in ISO 14000 series are supplementary in nature, which is the main reason for selecting ISO 14001 for this study.

Other reasons are: (a) a high adoption rate, (b) distinctive characteristics of ISO 14001 for developing an EMS framework and (c) low adoption cost, which are further explained. ISO 14001 have been adopted by approximately 320,000 organisations in 155 countries to improve environmental performance (Ferron-Vilchez, 2016). Furthermore, ISO 14001 standard is the only recommended standard for the aim of audit and accreditation in the ISO 14000 series (Camilleri, 2022; Fortuński, 2008). The implementation of the complete ISO 14000 series is an expensive adoption which only a few large companies can afford (Camilleri, 2022; Mori & Welch, 2008). The direct and in-direct expenditures of ISO 14000 series are around US\$110,000 (small firms) and US\$630,000 (large firms) (Miles, Munilla, & Russell, 1997). However, the certification costs for ISO 14001 is only about US\$15,000 to US\$20,000 in the food industry (Massoud, Fayad, El-Fadel, & Kamleh, 2010).

ISO standards 14001, 14031 and 14040 are generally implemented in the meat industry. The environmental performance indicators for meat processing operations can be determined by principles and guidelines of ISO 14031 by following the continual improvement philosophy (Cui, Yang, Shi, Liu, & Wang, 2022; Roy et al., 2012). However, ISO 14031 is a subcategory of ISO 14001 and is considered as a tool to evaluate environmental performance in a continuous cycle of operations in the manufacturing sector (Cui et al., 2022). ISO 14001, on the other hand, helps the meat industry in developing a framework for EMS to reduce waste (organic and inorganic), GHG emissions and wastewater production in meat processing (Đekić & Tomašević, 2017). Moreover, environmental aspects related to status of condition, management and operational performance can be measured in accordance to the latest standard of ISO 14001 to calculate environmental performance indicators for meat industry (Đekić & Tomašević, 2017).

Additionally, ISO 14040 develops the principles and a framework for life cycle assessment (LCA) to determine GHG emissions, energy consumption and wastewater generation in meat processing. However, ISO 14001 includes many direct and indirect parameters of life cycle thinking (LCT) to conduct environmental performance evaluation in a newly revised standard. Furthermore, the organisational decision to implement LCT for environmental performance evaluation would depend on the availability of technical and financial resources (Araújo dos Santos, Silva da Costa, Maranduba, Almeida Neto, & Rodrigues, 2023). The fundamentals of ISO 14031 and ISO 14040 are included in the elements of the new version of ISO 14001 for evaluation and improvement of environmental performance (Camilleri, 2022). By considering all of the above reasons and arguments, ISO 14001 is considered the most suitable standard in ISO 14000 series to improve environmental performance in the meat industry.

1.0.7 Justification for lean and ISO 14001 implementation strategies as a combined approach

Many different management strategies have been implemented for process improvement in manufacturing in recent decades. Lean, arguably the most subscribed manufacturing strategy, emphasises on waste minimisation (Farrukh, Mathrani, & Sajjad, 2023; Radin Umar et al., 2023). ISO 14001 pivots on environmental waste minimisation (Gomes, Caetano, Brand, Dai-Prá, & Pereira, 2023; Ofori, Li, Radmehr, Zhang, & Shayanmehr, 2023). Agile targets flexibility and speed (Vanichchinchai, 2022). Flexible manufacturing system (FMS) provides flexibility in operations with a minimum time and expenditure for changeover (Sarkar & Bhuniya, 2022). Reconfigurable manufacturing system (RMS) offers flexibility in adjusting its production

functionality and capacity by changing its structure as well as its hardware and software components (Pansare, Yadav, & Nagare, 2022). And, dedicated manufacturing line (DML) focuses on manufacturing a single component of a product in high volume over a long period (Yu et al., 2023). ISO 18404: 2015 was introduced to attain specific levels of competencies of the workforce with reference to lean, six sigma, and lean and six sigma (e.g., black belt, green belt and lean implementation) (Antony et al., 2021). However, ISO 18404 lacks a coordinated framework and guidelines for implementing lean six sigma projects (Antony et al., 2023). Further, ISO 18404 does not include yellow belt or white belt which impacted the inclusiveness of this standard by neglecting the training of the lower levels for implementing lean six sigma or lean implementation programmes (Antony et al., 2021; Antony et al., 2023). All the above management strategies have a different foci. However, lean and ISO 14001, both focus on waste elimination and improvement of resource efficiency in manufacturing processes (Habidin et al., 2018).

Mostly recently, many companies have implemented lean for improving process flow (Tiwari & Sharma, 2022). Lean manufacturing practices reiterate the importance of optimising efficiencies; they comprise a comprehensive set of strategies that provide tools for process improvements by reduction of waste (Farrukh et al., 2022). While, ISO 14001 formulates an implementation strategy outlining the rules and roadmap within an EMS framework for the manufacturing and the service sectors (Bravi et al., 2020; Fortuński, 2008). The ISO 14001 procedures lay out a clear framework for constructing an environmental programme. The environmental objectives, plans and policies with operational procedures are defined through a framework by implementing ISO 14001. Therefore, ISO 14001 provides guidelines in formulating an EMS, conducting audit and attaining ISO certification (Fortuński, 2008). However, it lacks in proposing methods/techniques to improve, measure or quantify the environmental performance (Souza & Alves, 2018). While a lean strategy transformation fails to provide a coordinated structural framework for implementation, and monitoring and control mechanisms for reducing waste (Dora, Kumar, & Gellynck, 2016; Mostafa, Dumrak, & Soltan, 2013). Further, the current environmental measurement systems still fail in providing the relevant information needed for improvement (Puvanasvaran et al., 2014). For instance, the current environmental data sources are basically designed for monitoring regulatory compliance only; they do not measure the environmental performance, which is an important parameter for identifying success and failure of any environmental strategy.

By introducing lean and ISO 14001 implementation strategy as a combined approach, ISO 14001 can help in providing a coordinated roadmap, and monitoring and controlling mechanism, and lean tools can be utilised for improving, measuring and quantifying the environmental impacts (environmental value stream mapping) for sustaining environmental performance.

1.0.8 Scope of the study

The meat supply chain management involves management of (a) livestock farms, (b) slaughterhouses, (c) meat processing units, and (d) transportation of livestock and meat. The emissions of GHG and inefficient utilisation of resources (raw materials, energy and water) are reported in all stages of the meat supply chain management. However, the scope of this research is limited to meat processing units only for quantifying the environmental aspects and their impacts on environmental performance and proposing solutions through implementing management strategies.

1.0.9 Methodology overview

The current study used a qualitative research design to answer the research questions in two stages – a preliminary study and the main study. In the preliminary study, seven semi-structured interviews were conducted with lean and ISO 14001 consultants to gain in-depth knowledge and valuable insights for better understanding the lean and ISO 140001 implementation phenomenon. In the main study, nineteen semi-structured interviews were conducted with senior managers from three meat processing facilities (two NZ and one Ireland-based organisations) that have implemented lean and ISO 14001 implementation strategies for at least three years. Further, secondary data (e.g., environmental management manuals, sustainability reports and archival records) were also analysed. An NRBV-based (e.g., competencies and capabilities) theoretical perspective was also applied to investigate the phenomenon of lean and ISO 14001 implementation as a combined approach for environmental performance. Thematic analysis was used to analyse and summarise the in-depth knowledge of the preliminary and main study informants to generate fresh insights (Braun & Clarke, 2006). Within case analysis was conducted followed by a cross-case analysis to identify various patterns in the data. The outcomes of the preliminary and main studies are discussed and analysed to explore the lean and ISO 14001 implementation as a combined approach for achieving environmental performance in the meat processing facilities.

1.1.0 Contributions of the study

This research contributes to the field by examining the lean and ISO 14001 implementation as a combined approach for improving environmental performance in the meat industry. The current literature is used as a foundation for developing an integrated conceptual model for lean and ISO 14001 implementation strategies to improve environmental performance in the manufacturing industry. ISO 14001 provides a framework to develop an EMS but does not propose environmental performance evaluation methods or improvement techniques. On the other hand, lean strategy fails to provide a structural framework, though provides tools for process improvement and monitoring and control mechanisms. This research study helps in developing a model to implement lean and ISO 14001 as a combined approach that can jointly improve environmental performance by sustaining continuous improvement through Dr. Deming's plan, do, check and act (PDCA) cycle. A preliminary investigation (with seven lean and ISO 14001 consultants) and three case studies (two from NZ and one from Ireland) were conducted to evaluate the lean and ISO 14001 implementation strategies together in the meat industry. The integrated conceptual model of lean and ISO 14001 implementation was applied to the energy intensive meat industry for evaluation and improvement of environmental performance. Further, this study also helped in identifying potential synergies between lean and ISO 14001 and determined the CSFs for implementing both strategies together to improve environmental performance.

From a theoretical perspective, the empirical findings from consultants (lean and ISO 14001) and senior managers (informants of the three case studies) were used to evaluate the lean and ISO 14001 implementation strategies together for improving environmental performance. Limited empirical research existed on this domain in previous literature. Therefore, the conduct of semi-structured interviews helped to provide in-depth knowledge for explaining the lean and ISO 14001 phenomenon. Further, the competencies and capabilities of the natural resource-based view (NRBV) were utilised to understand the lean and ISO 14001 implementation as a combined approach for advancing the current literature. Insights were captured on reduction of GHG emissions, improvement of environmental aspects and effective utilisation of resources in the meat industry by utilising the lean and ISO 14001 implementation together.

The findings of the preliminary study from lean and ISO 14001 consultants' could be used to guide practitioners for implementing lean and ISO 14001 in their companies to improve

environmental performance. On the other hand, this study’s findings can also help policymakers in implementing lean and ISO 14001 as a combined approach for improving environmental performance (by evaluating the capabilities and competencies of the NRBV lens). Further, policymakers can also facilitate consultants and practitioners to develop a combined lean and ISO 14001 policy, information sharing system and provide financial resources for implementing both these approaches together for improving environmental performance.

1.1.1 Structure of the study

The outline of this research is illustrated in Figure 1.1.

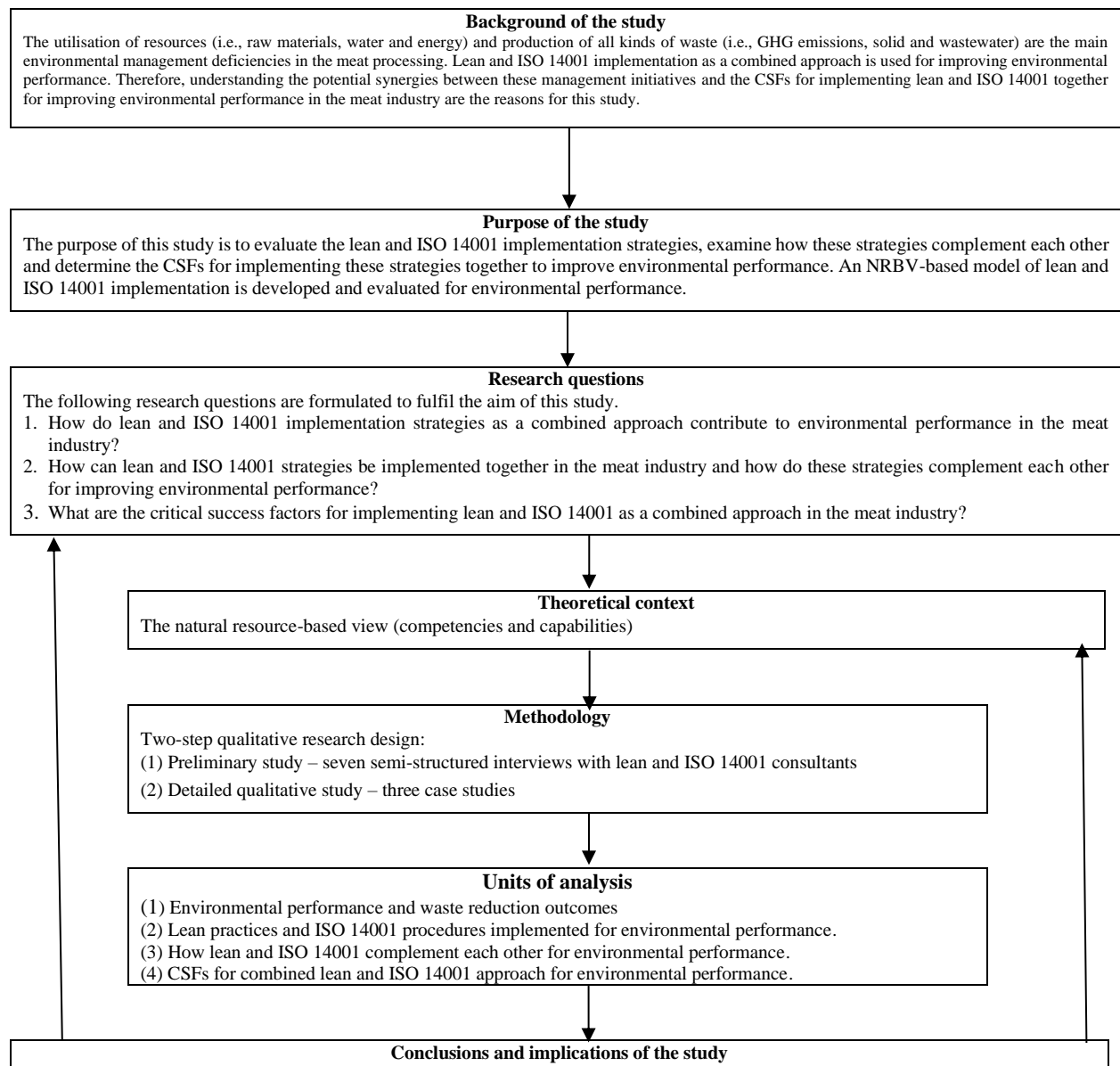


Figure 1.1: Structure of the study

The outline explains (a) background of the study, (b) purpose of the study, (c) research questions, (d) theoretical context, (e) research methodology, (f) units of analysis, and conclusions and implication of the study. Bold arrows as depicted in Figure 1.1 represent the process flow in the outline of the research

1.1.2 Outline of the thesis

This thesis is outlined as follows:

Chapter 1 presents the introduction, meat industry, aim and objectives of this study, research questions, background of the study, justification for selection of ISO 14001 from the entire family of ISO 14000, justification for lean and ISO 14001 implementation strategies as a combined approach, contributions of the study, structure of the study, and outline of the thesis.

Chapter 2 provides a comprehensive theoretical context of this study. Literature is presented on meat processing and potential waste generation, environmental performance in the meat industry, the ISO 14000 series for environmental performance, ISO 14001 requirements, principles of ISO 14001, lean, principles of lean, lean tools, lean and ISO 14001 implementation strategies as a combined approach, conceptual model of lean and ISO 14001 implementation, an NRBV based model of lean and ISO 14001 implementation, CSFs for implementing lean and ISO 14001, and benefits of lean and ISO 14001 implementation.

Chapter 3 describes the research process adopted in this study, including the research paradigm, selection of research methodology and the sampling strategy. Then, preparation of data collection and skills development, data collection methods, data analyses techniques, and reporting of the findings are explained. Finally, research quality, ethical considerations and the sequence of the research design are presented.

Chapter 4 presents the findings of the preliminary study based on semi-structured interviews with lean and ISO 14001 consultants who are experts in implementing lean and ISO 14001 in the meat industry. This chapter presents the findings on lean and ISO 14001 joint implementation, evaluates the complementarity of both strategies and determines the CSFs for executing both implementation strategies together for improving environmental performance.

Chapters 5, 6 and 7 include the findings of the main study. Multiple case studies are conducted in the meat industry – with two companies in New Zealand (NZ) and one in Ireland – through semi-

structured interviews with the senior executives who are knowledgeable about implementing lean and ISO 14001 as a combined approach. The findings of these chapters present the practitioners' perspective for successfully implementing lean and ISO 14001 as a combined approach for improving environmental performance.

Chapter 8 discusses the cross-case analysis, elaborating similarities and differences between the case findings in implementing lean and ISO 14001 as a combined approach for improving environmental performance. Drawing on the competencies and capabilities of the NRBV, the emerging themes from the findings of the NZ and Ireland based cases are discussed and compared with the literature. Finally, a conceptual model of lean and ISO 14001 implementation strategies for environmental performance in the meat industry is proposed based on the findings of the main study, and the competencies and capabilities of the NRBV.

Chapter 9 concludes the current study. This chapter provides the overall key research findings, the implications of the study (theoretical and practical for managers, consultants and policymakers), the study limitations and future research directions.

Chapter 2 – Literature Review

In Chapter 2, the literature for understanding the context of environmental performance and lean and ISO 14001 in meat processing is reviewed. Chapter 2 begins by a description of meat processing with an emphasis on environmental aspects and environmental performance improvement initiatives. Next, ISO 14000 series, ISO 14001 requirements and principles are reviewed. Then, lean manufacturing, its principles and tools with a focus on environmental performance are reviewed. Finally, the chapter concludes with a conceptual and an NRBV based model for lean and ISO 14001 implementation strategies, the CSFs for both implementation strategies and the benefits of lean and ISO 14001 implementation.

2.1 Meat processing and potential wastes generation

The increase in global warming and its effects have been discussed strategically in manufacturing since the 1950s. The generation of CO₂, methane (CH₄), nitrous oxides (N₂O) and ozone (O₃) in manufacturing operations cause the GHG effect and ultimately contribute to the global warming phenomena (Islam et al., 2023). Agriculture system, particularly livestock breeding, are the primary producer for CH₄ and N₂O emissions. The total share of agriculture sector in producing CH₄ and N₂O gases is upto 13% (Rabier et al., 2015). Meat processing is a part of livestock sector which produces large quantities of GHG emissions. The demand for meat production depends on caloric intake per capita of a particular country and the emissions of GHG in beef processing are greater than pork or chicken processing (Hörtenhuber et al., 2022; Roy et al., 2012). The meat industry contributes around 4.6 to 7.1 billion tons of GHG emissions in atmosphere each year. Currently, meat processing has a significant contribution to the environmental impacts by emitting GHG between 15% and 24%. These amounts of GHG production will further increase up to 6.3% by 2030 (Fiala, 2008).

Generic meat processing consists of three steps: input; production process and output (Djekic & Tomasevic, 2016) as depicted in Figure 2.1. The input for the meat industry is raw materials (livestock and meat carcasses), energy (electric energy and fossil fuels) and natural resource (water and packaging material). The production process phase includes slaughtering and meat processing along with emissions of GHG as well as wastewater discharge. Output phase consists of meat production and generation of inorganic wastes (paper, plastic and metal) as well as organic wastes (fat, bone, legs, head, skins, hair and offal).

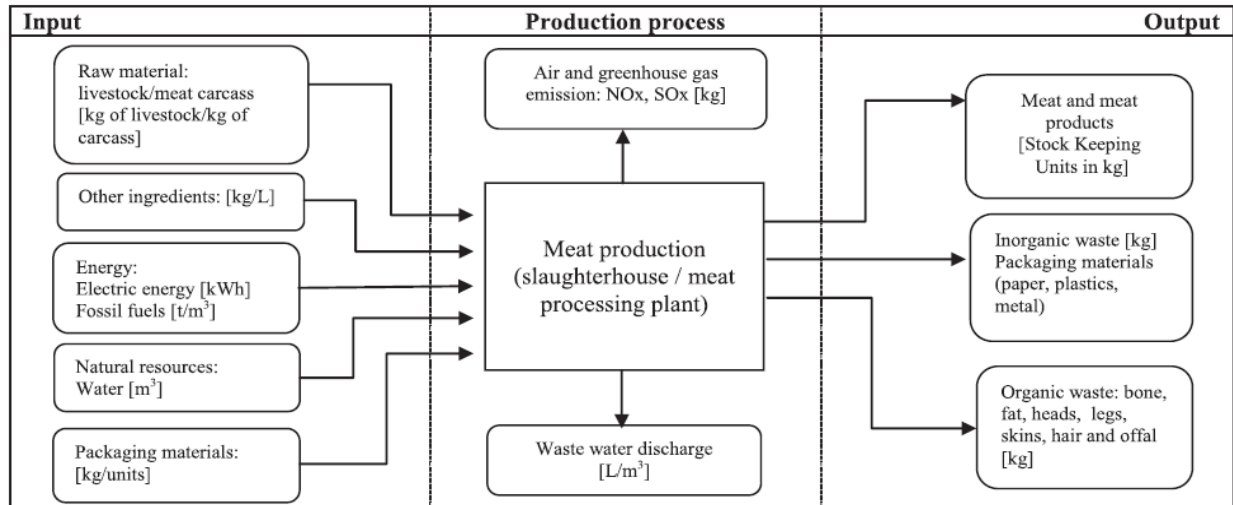


Figure 2.1: A generic model of meat processing, sourced from Djekic and Tomasevic (2016)

In meat processing, effective consumption of energy and raw water could be achieved through resource management. The heat treatment and cooling procedures in processing of meat need extensive energy consumption (Djekic & Tomasevic, 2016). The excessive and inefficient utilisation of energy is a significant source of GHG emissions in this industry. Approximately 75-90% of energy is consumed for body maintenance of animals or is lost in maintaining the by-products of meat such as skin, bones and manure during meat processing (Röös, Sundberg, Tidåker, Strid, & Hansson, 2013).

Cooling and ventilation for meat preservation also consumes considerable amount of electric energy. Additionally, fossil fuels (natural gas or diesel) are used for heating (boiling, cooking, pasteurising, sterilising and smoking) in meat processing operations (Alcázar-Ortega, Álvarez-Bel, Escrivá-Escrivá, & Domijan, 2012). The process for maintaining temperature in cooling lines during meat processing is as follows: (a) the operational temperature in freezing line is in between -35 to -40°C; (b) in preserving line, stays between -10 and -15°C; (c) the threshold temperature in air conditioning varies between 0° and -5°C and (d) in drying lines stays between -10 and -5°C (Alcázar-Ortega et al., 2012). Raw water is required from the time of entry of animals in the facility until the products are dispatched from the meat processing plant (Djekic et al., 2016). In the production process phase, emissions of GHG (i.e., N₂O, CO₂ and CH₄) and wastewater discharge during meat processing are treated as solid and liquid wastes (Djekic & Tomasevic, 2016). The generation of CO₂ is considered a potential source of acidification and eutrophication in meat

processing operations (Röös et al., 2013). Nitrogen oxides (NO_x) and sulphur oxides (SO_x) are both produced and these fatal effluents are theoretically accountable for contributing to acid rain, photochemical smog and O₃ depletion (Hamawand et al., 2017). Few reasons for generation of GHG in meat processing are: (a) utilisation of excessive energy in freezing, chilling, cooking and smoking of meat products produce toxic gases, (b) usage of chemical compounds for cleaning of meat yield volatile compounds and (c) microbial activities of organic fractions in meat that ultimately emit GHG and biomass (Rahman, Sahar, & Khan, 2014).

The amount of emissions of GHG per kg of beef, pig and chicken products are calculated as 14.8 kg, 3.8 kg and 1.1 kg respectively in meat processing facilities (Fiala, 2008). Wastewater is also produced as a result of cleaning and sanitation processes during animals slaughtering and meat processing. The wastewater contains toxic compounds such as unionized ammonia, tannins and chromium and these compounds prove to be lethal for aquatic ecosystems (Rahman et al., 2014). The wastewater of meat processing contains organic matter (blood, fats and traces of meat particles) and inorganic matter (phosphate) (Djekic & Tomasevic, 2016; Rahman et al., 2014). The end-products of meat processing consist of lean meat and meat products along with inorganic waste, packaging materials as well as organic wastes (fat, bone, legs, head, skins, hair and offal) (Djekic & Tomasevic, 2016). These materials can be wholly disposed-off or utilised as by-products after proper treatment (Rahman et al., 2014).

Meat processing produces organic by-products such as blood, fatty tissues, feet skull and offal. These organic by-products contain abundant quantities of nutrients including amino acids, minerals and vitamins, which are used as foods depending upon the country and local eating traditions (Djekic & Tomasevic, 2016; Toldrá, Mora, & Reig, 2016). The production of myoglobin, lipid and pigments oxidation in lean meat causes around 40% production losses during meat storage at meat shops. Appropriate meat packaging under vacuum or nitrogen can be helpful to decrease lipid oxidation phenomenon to reduce storage losses (Domínguez et al., 2018). Major environmental challenges in meat processing are excessive generation of solids waste, increase in wastewater and excessive energy consumption (Ghosh, Gillis, Sheviriyov, Levkov, & Golberg, 2019).

2.2 Environmental performance improvement initiatives for the meat industry

The consumption of meat protein has increased from 61g per person per day to 80g per person per day from 1961 to 2011. It is believed that the meat demand will grow globally from 250 million tonnes to 470 million tonnes by 2050 (Lynch, Mullen, O'Neill, Drummond, & Álvarez, 2018). This potential increase in demand will also become a source to generate more environmental impact in meat processing. Currently, the environmental effects of meat processing are immense due to the emissions of GHG, organic and inorganic wastes (Djekic & Tomasevic, 2016). The inefficient utilisation of energy consumption and raw materials are responsible for increase in the cost of meat processing. The processing costs are approximately US\$0.9/ kilogram (kg) (chicken), US\$1.5/kg (pork) and US\$3.5/kg (beef) (Roy et al., 2012). An effective implementation of EMS facilitates meat operations for preventing wastes generation (air emission and solid waste), helps to fulfil the legal and operational compliance requirements and achieves operational benefits and stakeholders satisfaction (Massoud et al., 2010).

Energy consumption in the meat industry can be significantly reduced by introducing new technologies such as heat pumps or heat exchange network in the operations. CO₂ generation in meat processing can be minimised by using natural gas or wood instead of heavy fuels as an energy source (Fritzson & Berntsson, 2006). Ongoing housekeeping practices in meat processing maintains efficient utilisation of energy. Additionally, energy consumption can be minimised by installing latest heat recovery systems and energy optimisation equipment in the meat industry (Djekic & Tomasevic, 2016). The combined implementation of lean and ISO 14001 manufacturing in meat processing can be considered as an effective improvement initiative for environmental performance. ISO 14001 is a systematic approach for environmental performance improvement based on internal management procedures and provides a model for environmental evaluation (Kafel & Nowicki, 2023; Ofori et al., 2023). Additionally, the lean strategy is an improvement tool for reduction of water consumption, effective utilisation of natural resources and reduction of wastes (solids and emissions of GHG) (Farrukh et al., 2022; Naeemah & Wong, 2022).

“Green thinking is thinking lean” (Johansson & Sundin, 2014, p. 104) and is considered an extended form of lean through reduction of waste generation in consumption of raw material, energy utilisation and handling of hazardous materials (Farrukh et al., 2022). Further, it is a proactive tool to reduce heat waste, noise pollution and eliminate environmental impact by

focusing on customer satisfaction through improved environmental performance. Furthermore, the implementation of lean and ISO 14001 as an integrated concept can bring about betterment in lead times, value-added times, maintaining safer working conditions for employees and providing job satisfaction and customer satisfaction (Souza & Alves, 2018; Wirkus & Chmielarz, 2018).

2.3 ISO 14000 series for environmental performance

In recent years, different standards for quality and environmental performance have been introduced to improve business systems, however, two series of standards issued by ISO have gained major traction on manufacturing and service processes: ISO 9000 series for implementation of quality management systems and ISO 14000 series for execution of EMS (Hernandez-Vivanco & Bernardo, 2022). Further, ISO 9000 series is aimed to achieve compliance with customer's requirements and quality management of processes and ISO 14000 series is focused on improving environmental performance with an objective of continual reduction of the negative environmental effects (Goldar & Majumder, 2022; Hernandez-Vivanco & Bernardo, 2022). ISO 14000 series consists of a number of guidelines, principles and standards which are focused on environmental management by minimising harmful operational impacts and achieving continual improvement for optimised environmental performance (Goldar & Majumder, 2022).

ISO 14000 series comprises of a family of standards and guidelines. These standards and guidelines can be divided into two categories: (a) organisation or process standards and (b) product-oriented standards for improving environmental performance (Chattopadhyay, 2001). ISO 14001, ISO 14031 and ISO 14040 are implemented for improving environmental aspects in manufacturing of meat products (Đekić & Tomašević, 2017; Djekic et al., 2014; Roy et al., 2012). ISO 14001 implementation in the meat industry brings improvement in environmental performance, market competitiveness and increase in sale volumes (Djekic et al., 2014). ISO 14031 works as a reference framework for selecting environmental and condition indicators (Cui et al., 2022). Further, it provides guidelines for designing environmental performance indicators in preventing pollution through continual improvement. ISO 14040 is treated as an environmental management tool for life cycle assessment of a product system to determine the potential impacts (Finkbeiner, Inaba, Tan, Christiansen, & Klüppel, 2006; Schaubroeck, 2022).

ISO 14000 adaptation has two types of costs (direct and indirect). The direct cost for adoption of ISO 14000 series involves consultancy expenditures, certification fees and registration audits and

it varies from approximately US\$10,000 (small organisation) to US\$30,000 (large organisation) (Miles et al., 1997). The indirect cost for implementation of ISO 14000 includes internal training programmes, redesign of products and advertisement initiatives for modified environmental-friendly products. It ranges from US\$100,000 (small organisation) to over US\$600,000 (large organisation) (Miles et al., 1997).

The Environmental Protection Agency (EPA) has estimated that the large organisations have spent approximately US\$1 million in sunk costs for pursuing certification. The average direct cost of ISO 14001 implementation is around US\$40,000 in the United States of America (USA) (Mori & Welch, 2008), certification costs are approximately US\$10,000 (small organisations) to US\$15,000 (large organisations) (Massoud et al., 2010). The implementation of full ISO 14000 series is an expensive adaptation as compared to the implementation of only ISO 14001 as a framework to improve environmental performance (Abisourour, Hachkar, Mounir, & Farchi, 2021; Camilleri, 2022). Fundamentally, constructing an EMS according to ISO 14000 series includes two standards – ISO 14001, EMS: specification with guidance for use and ISO 14004, EMS: general guidelines on principles, systems and supporting techniques. However, an organisation may only obtain certification of ISO 14001 standard for EMS implementation, as the additional standards in ISO 14000 series are considered supplementary (Fortuński, 2008).

2.3.1 ISO 14001: Environmental performance system

ISO 14001 as an EMS framework has been adopted by more than 32000 international organisations since its launch in 1996 to make their processes environment-friendly and achieve operational benefits (Ferron-Vilchez, 2016). ISO 14001 is a systematic approach for environmental performance improvement based on internal management procedures and provides a framework for environmental performance management (Arimura et al., 2016; Camilleri, 2022). Furthermore, EMS is an instrumental framework for improving environmental performance and serves as a business strategy. It predicts the present deficiencies in the system for future improvement and maintain environmental performance proactively (Qi et al., 2011). EMS is a conceptual framework that monitors the environmental impacts of processes, products and services in an organisation (Chattopadhyay, 2001).

ISO 14001 can be applicable to all types and sizes of organisations since this generic standard is adjustable to different cultures, geographical and social conditions (Neves et al., 2017). It is a

globally accepted standard which improves the environmental performance of both service industry (e.g., hotel industry and adaptation in university campuses) (Gomes et al., 2023; Quintás, Martínez-Senra, & García-Pintos, 2023) and the manufacturing sector (e.g., automobile, chemical and food industry) (Camilleri, 2022).

2.3.2 ISO 14031: Environmental management – Environmental performance evaluation

ISO 14031 is a subcategory of ISO 14001 and is considered as a tool to evaluate environmental performance in a continuous cycle of operations in the manufacturing sector. Two types of environmental performance indicators are evaluated in ISO 14031: environment condition indicators and organisational environmental performance indicators (managerial and operational) (Campos et al., 2015; Cui et al., 2022). The major reasons and benefits of implementing ISO 14031 as a tool for environmental performance evaluation are: (i) it can straightforwardly be adopted by an organisation, (ii) the evaluation of operational environmental indicators and local environmental condition indicators are efficiently assessed and managed and (iii) communication within the organisation is considered to be easier for results or suggestions about environmental performance (Cui et al., 2022; Scipioni, Manzardo, Mazzi, & Mastrobuono, 2012). However, the latest standard of ISO 14001 can be used to establish and evaluate the environmental performance indicators for the manufacturing industry (Bravi et al., 2020; Camilleri, 2022).

2.3.3 ISO 14040: Environmental performance – LCA – principles and framework

In ISO 14040, environmental performance is evaluated by using life cycle thinking (LCT) as a tool to investigate the current status of environmental efficiency at every step of operations and propose improvements to produce environment-friendly meat products (Araújo dos Santos et al., 2023; Geß et al., 2020). LCA philosophy in meat processing comprises four steps: (1) define goal and scope of LCA, (2) data collection on energy consumption, raw materials and wastes (water, air emission and solid), (3) evaluation of data for environmental impacts in meat processing and (4) conclusions and recommendations to improve environmental performance (Araújo dos Santos et al., 2023; Roy et al., 2012). The environmental impacts especially GHG emissions are quantified using the LCA methodology. The environmental improvements are suggested after a deep analysis of life cycle assessment for effective utilisation of resources and reduction of GHG emissions in meat processing (Araújo dos Santos et al., 2023; Roy et al., 2012). A newly revised ISO 14001 standard includes many direct and indirect parameters of LCT to conduct environmental

performance evaluation (Lewandowska & Matuszak-Flejszman, 2014). Furthermore, ISO 14001 has incorporated life cycle perspective without including a detailed LCA plan (Albertí, Balaguera, Brodhag, & Fullana-i-Palmer, 2017). Implementing LCA as a separate technique for identification of environmental aspects would depend on the availability of technical and financial resources in an organisation (Testa, Nucci, Tessitore, Iraldo, & Daddi, 2016).

2.4 ISO 14001 requirements

The requirements of ISO 14001 provide a set of elements for the effective implementation of EMS in manufacturing and service processes. These elements are discussed comprehensively to understand their role for environmental performance improvement in meat processing. Clause 1 describes the scope of EMS which includes the development of environmental performance, fulfillment of compliance requirements and achievement of environmental objectives. The second requirement of ISO 14001 is normative references. This clause entails references to be cited in textual manuscripts indicating constitution of their requirements. Clause 3 relates to terms and definitions of various elements divided into four types: (1) terms related to organisation and leadership, (2) terms related to planning, (3) terms related to support and operation and (4) terms related to performance evaluation and improvements.

Clause 4.0 is about the context of an organisation for EMS implementation and consists of four sub-clauses: (1) 4.1 clause is used to understand the current status of the environmental performance of an organisation by determining the influential external and internal factors for implementation of EMS. (2) Clause 4.2 caters to understanding the environmental performance needs and expectations of stakeholders for implementation of EMS. (3) Clause 4.3 is an important factor to define the scope of environmental performance by setting boundaries and applicability of EMS implementation. (4) Clause 4.4 is used to establish environmental policy, objectives and targets for EMS, its implementation and continual improvements. Clause 5.0 on leadership is divided into three sub-clauses: (a) leadership and commitment for EMS, (b) environmental policy and (c) leadership roles, responsibility and authorities.

The planning of EMS consists of two sub-clauses: 6.1 – actions to address environmental risks and opportunities and 6.2 – environmental planning with updated environmental objectives. Clause 7.0 on support is an important clause of ISO 14001 and contains five sub-clauses – 7.1 resources, 7.2 competence, 7.3 awareness, 7.4 communication and 7.5 documented information. The operation

clause consists of two sub-clauses – 8.1 operational planning and control and 8.2 emergency preparedness and control for effective implementation of EMS. Clause performance evaluation consists of three sub-clauses: 9.1 monitoring, measurement, analysis and evaluation, 9.2 internal audits and 9.3 management review to implement EMS. Improvement clause consists of 10.1 general improvement, 10.2 non-conformity and corrective actions and 10.3 continual improvements to implement ISO 14001 (Souza & Alves, 2018).

2.5 Principles of ISO 14001 implementation

The principles of ISO 14001 implementation is based on Dr. Deming’s well-defined PDCA cycle (Hikichi, Salgado, & Beijo, 2017; Muralikrishna & Manickam, 2017) which is described as follows:

2.5.1 Plan: To establish environmental policy and procedures

The environment policy along with objectives and targets for reducing waste and air emissions is defined in the planning phase of ISO 14001 implementation.

2.5.2 Do: Implementation of environmental procedures

The processes and procedures are effectively implemented for practical execution of EMS and documentation of environmental data. The operational controls are effectively managed in the implementation stage to provide input for evaluating environmental performance.

2.5.3 Check: Evaluation of environmental performance and report results

In the check stage, monitoring and measurement are carried out to assess non-conformance in the operational processes by comparing the environmental policy which includes the environmental objects and targets set in the planning stage against the current status of environmental performance. A periodic audit would help the organisation to evaluate the ongoing performance following the environmental performance requirements to suggest the corrective and preventive actions for effective implementation of EMS.

2.5.4 Act: Continual process improvement initiatives

After a detailed evaluation of the current status of environmental performance, the organisation must perform necessary actions (preventive and corrective) to improve their environmental

performance structure for effectively implementing the environmental policy objectives continuously.

The PDCA cycle can be applied as a tool for implementing quality standards and improving environmental performance by minimising green waste, maintaining energy consumption efficiently and utilising of natural resources effectively (Garza-Reyes, Torres Romero, Govindan, Cherrafi, & Ramanathan, 2018; Silva, Medeiros, & Vieira, 2017). The EMS complies with the PDCA cyclic business model for implementing ISO 14001 effectively (Sartor, 2019). The elements of ISO 14001 can be integrated into the PDCA model as shown in Figure 2.2, which will help the organisation understand a systematic approach of EMS (Ciravegna Martins da Fonseca, 2015).

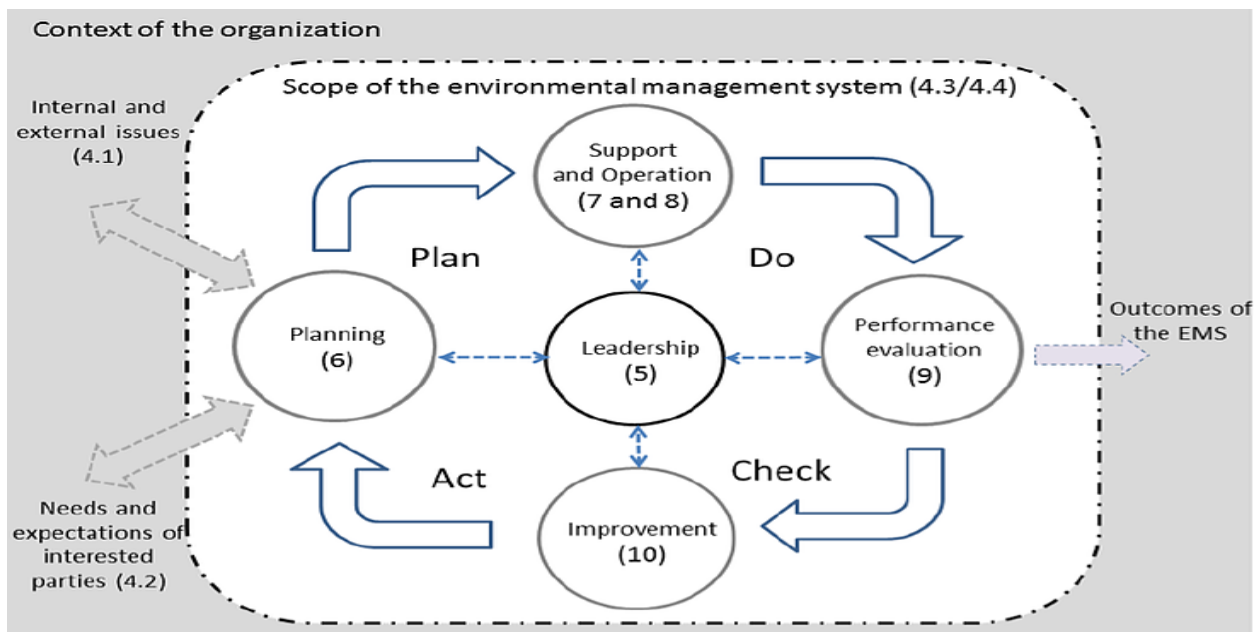


Figure 2.2: Environmental system model for ISO 14001:2015, sourced from Ciravegna Martins da Fonseca (2015)

2.6 Lean

Lean thinking or lean manufacturing as a philosophy originated from Taiichi Ohno's production paradigm, based on the early 1950s Toyota production system (TPS). The prime focus of this philosophy is on reducing waste and maximising productivity (Dahlgaard & Mi Dahlgaard-Park, 2006). After the second world war, Toyota company had changed its core business to car manufacturing from textile machineries (Droste, 2007). Toyota had laid the foundation of TPS during this period of technology transformation. Later in 1985, the international motor vehicle

programme (IMPV) researcher John Krafcik coined the term “lean” in scholarly literature (Hernandez-Matias, Ocampo, Hidalgo, & Vizan, 2020, p. 208). The IMPV researchers conducted an empirical benchmark study on waste minimisation to evaluate the productivity in automobile assembly facilities. The findings were first published in the book “The Machine That Changed the World” in 1990 by Womack, Jones, and Roos (2007). Lean is defined as a strategy to “develop the highest quality products, at the lowest cost”, while maintaining the shortest lead time for systematic and on-going reduction of waste by considering respect for human race and the environment (Cherrafi, Elfezazi, Chiarini, Mokhlis, & Benhida, 2016, p. 829). Lean is a combination of different management improvement initiatives which can be applied in a well-organised sequence to maximise productivity, cost effective operations and customer satisfaction in the manufacturing and service industries (Duarte & Cruz Machado, 2017; Radin Umar et al., 2023).

2.7 Principles of lean

The key principles of lean manufacturing are: define value, map the value stream, create flow, introduce pull and pursue perfection (Womack & Jones, 1997).

2.7.1 Define value

Value can only be defined by the customer. The identification of specific value propositions for customer is the starting point for lean implementation (de Oliveira, Forbes, Schaefer, & Syed, 2020). For instance, value parameters for customers in pharmaceutical and chemical manufacturing facilities to implement the lean strategy are: (i) robust processes and product development, (ii) low-cost products and (iii) high quality products. Value is created and improved if waste is reduced or additional features are offered by increasing the value propositions for the customer (de Oliveira et al., 2020; Hines, Holwe, & Rich, 2004).

2.7.2 Identify value stream

The set of actions to manufacture a product are defined as value stream. Value stream mapping is one of the main lean tools for understanding, designing or managing processes (Farrukh et al., 2022; Palange & Dhattrak, 2021). Value stream comprises value-adding and non-value adding activities to manufacture a product through efficient product and design flows.

2.7.3 Flow

It is a method of streamlining the processes to smoothen the manufacturing operations (Melton, 2005). The product flow and inventory management system can be influenced by the mass production systems (one piece flow and batch processes). Flow is maintained by eliminating productivity issues and line stoppages and reducing cycle times in the manufacturing processes (de Oliveira et al., 2020; McAdam, Galbraith, Miller, Moffett, & McAdam, 2016).

2.7.4 Customer pull

The pull for manufacturing the products must commence from the customer on an as needed basis. The products are manufactured and delivered according to the customer pull (de Oliveira et al., 2020; McAdam et al., 2016). The customer's proposition and needs are more important in responding to fulfil the desired level of products for the customer.

2.7.5 Pursue perfection

Perfection can be pursued by developing and amending the procedures and processes through continuous improvement (Dahlgaard & Mi Dahlgaard-Park, 2006; McAdam et al., 2016). Perfection is effectively pursued to promote customer value satisfaction and reduction of waste and operational cost (de Oliveira et al., 2020; McAdam et al., 2016). Pursue perfection suggests that the lean strategy must become an integral part of the organisation for achieving customer satisfaction and waste reduction in a continual manner.

2.8 Lean tools

A various combination of lean tools are used to achieve process improvements, enhance profitability and customer satisfaction in diverse manufacturing (Dieste et al., 2020; Farrukh et al., 2022). The most important lean tools are; kanban; jidoka; heijunka; one piece flow; standard work; takt time; line balancing; constraint management; u-shaped cells; self-directed teams; 5S; PDCA cycle; standard set-up; TPM; SMED; JIT; overall equipment effectiveness; visual management; value stream mapping; Gemba; Gembustu (Motwani, 2003; Oliveira, Sá, & Fernandes, 2017). However, e-VSM, JIT, TPM, SMED, 5S, standardised work, kanban and kaizen/continual improvements are the most prominent lean tools for evaluating and improving environmental performance by systematically reducing non-value-added activities (Dieste et al., 2020; Farrukh et al., 2022; Garza-Reyes, Kumar, Chaikittisilp, & Tan, 2018).

2.8.1 Value stream mapping (VSM) and environmental value stream mapping (e-VSM)

The EPA initially proposed VSM as a lean tool for identifying and managing the process waste and information flow in manufacturing (El-Khalil, 2022; Psomas, 2020). The effectiveness of a VSM implementation primarily depends on its capability in developing a framework that illustrates ideal processes and information flow (Tyagi, Choudhary, Cai, & Yang, 2015). VSM is extended to e-VSM by considering the environmental aspects for evaluation in the manufacturing processes (Faulkner & Badurdeen, 2014). e-VSM narrates the process flow and generates information regarding the different types of e-waste production in manufacturing operations in an industrial setting (Garza-Reyes et al., 2018b). e-VSM helps in maintaining an effective environment through measurement of resources consumption (e.g., water, energy and paper), monitoring of waste and promotion of recycling culture for improving the product life cycle (Dieste et al., 2020; Farrukh et al., 2022; Helleno, de Moraes, & Simon, 2017).

The implementation of e-VSM is based on establishing a current state map and proposing a future state map by a systematic and continual cycle of improvement in reduction of waste (Garza-Reyes et al., 2018b). One study conducted in five European organisations to analyse the effectiveness of e-VSM for environmental performance revealed that the environmental impacts in these companies such as oil leakage, emission of chemicals and dust were quantified and improved (Chiarini, 2014). Additionally, the effective implementation of 5S (sort, set in order, shine, standardise and sustain), total productive maintenance (TPM) and cellular manufacturing for improving the environmental performance could be measured by e-VSM. On the other hand, the effectiveness of e-VSM as an approach for measuring and improving lean wastes could be enhanced through the implementation of PDCA cycle as a continual improvement initiative (Garza-Reyes et al., 2018b).

2.8.2 Just in time (JIT)

JIT is a lean method which narrates that an organisation should yield the right quantity of goods at the right time. It contributes in effective utilisation of space and efficient inventory management and minimising the overproduction of goods (El-Khalil, 2022; Palange & Dhattrak, 2021). It is a tool for effective utilisation of resources and energy by procuring materials just when needed, eliminating non-productive inputs, optimising operations and environmental and product quality (Garza-Reyes et al., 2018a; Palange & Dhattrak, 2021). Garza-Reyes et al. (2018a) conducted a

study in 73% large and 27% medium to small organisations to find the effective implementation of lean tools. They found JIT was positively associated with (a) effective utilisation of raw material, (b) efficient energy consumption, (c) reduction of non-product output and (d) decrease in environmental impacts. Belekoukias, Garza-Reyes, and Kumar (2014) investigated the impacts of JIT on environmental performance through a quantitative survey of 140 manufacturing companies including chemical, transportation equipment and primary metals industry. They found that JIT has a positive impact on (a) quality performance, (b) reduction of times (lead time, cycle time and delivery time), (c) effective inventory management, and (d) reduction of operational costs.

2.8.3 Total productive maintenance (TPM)

TPM is a lean method that helps in optimising maintenance of machines by reducing breakdowns in manufacturing operations (Belekoukias et al., 2014; Dieste et al., 2020). TPM as a lean tool is employed to evaluate and improve the environmental performance parameters such as material use, energy consumption and pollutant release during the manufacturing activities (Farrukh et al., 2022). Additionally, the rework, scrap production and noise pollution are also reduced by effective implementation of TPM. On the other hand, TPM promotes preventive maintenance of machines to avoid process failures that cause generation of scrap and rework which ultimately improves the consumption of energy and raw materials. An effective implementation of TPM can be used in reducing emissions (volatile organic compounds, isocyanates and ammonia) in European motorcycle component manufacturing industry (Chiarini, 2014). Furthermore, TPM has a positive impact on environmental performance measures (e.g., material utilisation, energy consumption and non-product output as well as pollutant release) (Farrukh et al., 2022).

2.8.4 Single-minute exchange of die (SMED)

SMED is a lean tool for minimising time into single-digit numbers for completing equipment changeovers. It helps to reduce down time, processing lead time and improve product quality for maximising customer value while reducing the overall waste (Oliveira et al., 2017; Palange & Dhattrak, 2021). The reduction of time for equipment changeovers helps in reducing inventory and overproduction which ultimately improves consumption of materials and energy while reducing air emissions (Cherrafi et al., 2016). Furthermore, SMED helps in reducing different types of

environmental related impacts such as emissions of particulates matter, oil leakage and chemical smog.

2.8.5 5S

5S (sort, set in order, shine, standardise and sustain) is a lean tool that helps in eliminating waste and optimising productivity by maintaining a clean and organised workplace in the manufacturing facilities (Farrukh et al., 2022). It is also a good starting point for identifying waste. 5S can contribute in improving productivity by minimising materials consumption, improving solid waste treatment and reducing the utilisation of toxic/hazardous chemicals in the manufacturing processes (Dieste et al., 2020). 5S can be used to reduce risks, enhance waste management initiatives and improve safety of workers by providing clean and accident free work areas (Cherrafi et al., 2016).

2.8.6 Standardised work

Standardised work is implemented to achieve ideal outcomes in manufacturing or services by following a set of rules and procedures. These rules are used to minimise variation and inconsistency in the implementation phase (Oliveira et al., 2017). It is used for reduction of operations variability, minimisation of cost and improvement of product quality. Standardised work promotes the development of maintainable methods in operations which leads to reduced deviations in operational processes and products which further leads to reducing energy usage, raw materials consumption and air emissions generation (Cherrafi et al., 2016).

2.8.7 Kanban

Kanban is a workflow management tool to reduce idle time and minimise overproduction in the manufacturing facilities. The translation of “Kanban” from Japanese language is card (Oliveira et al., 2017). Further, Kanban cards can be used in identifying problems of production flow, material flow and inventory management among production cells. It is also used in identification of unnecessary movements and failure in various manufacturing processes, which permits an organisation to reduce consumption of resources and generation of waste (Cherrafi et al., 2016). It could help in reduction of potential wastes such as spoiled, damaged or deteriorated products through inventory control.

2.8.8 Kaizen/Continual improvement

Kaizen is a culture of continuous process improvement at the workplace involving everyone (managers and workforce) to enhance organisational competitiveness (Suárez-Barraza, Ramis-Pujol, & Kerbache, 2011). Further, it is a scientific and structured thinking approach for solving problems related to manufacturing and environmental issues (Antony et al., 2022). It is also used as a tool for efficient consumption of raw materials and energy by eliminating waste using a combination of other lean practices (i.e., 5S, e-VSM and Kanban) in a continual improvement cycle (Belekoukias et al., 2014). Furthermore, it also helps in maintaining a safe workplace by reducing material waste and air emissions.

2.9 Lean and ISO 14001 implementation strategies as a combined approach

2.9.1 Lean and ISO 14001 implementation strategies

Lean has been considered as a strategy to improve operational efficiency by reducing waste in the last few decades. It was believed in the past that the lean strategy might not have a direct intention to improve environmental performance (Puvanasvaran, Kerk Swee Tian, Vasu, & Muhamad, 2012). However, few research studies indicate that lean manufacturing not only improves the operational efficiency of an organisation but also reduces the environmental impacts such as through energy consumption and wastes (solid, air emissions and inventory). This means that implementation of lean ultimately has a positive impact on environmental performance (Radin Umar et al., 2023). On the other hand, ISO 14001 provides a framework to develop an EMS and policies and procedures for an organisation in improving environmental performance by taking actions to reduce energy consumption, generation of air emissions and utilisation of natural resources (Kafel & Nowicki, 2023).

The elements of ISO 14001 provide a clear framework for constructing an environmental programme. The environmental objectives, plans and policies with operational procedures are defined through the framework. However, the current environmental measurement systems still fail in providing the relevant information needed for improvement (Puvanasvaran et al., 2014). For instance, the environmental data sources currently used are basically designed for monitoring regulatory compliance only and not measuring the environmental performance, although, its measurement is an important parameter to identify success or failure of an environmental strategy. Lean manufacturing is a strategy that provides value to customer by eliminating waste and

maximising productivity (Farrukh et al., 2022). This strategy includes tools for waste reduction and methods for monitoring which could provide additional support to the ISO 14001 EMS processes for enhancing environmental benefits. An integrated system by combining ISO 14001 based EMS and lean tools could be applied to streamline work processes in reducing wastes (operational and environmental) as well as evaluate and improve performance (Souza & Alves, 2018; Wirkus & Chmielarz, 2018). Therefore, this research study helps in developing a conceptual model by using lean tools and elements of ISO 14001 for an integrated approach towards operational and environmental performance management by sustaining continuous improvement through Dr. Deming's plan, do, check and act (PDCA) cycle.

Firstly, the integration of lean and ISO 14001 is used as a strategy for efficient utilisation of raw materials and achieving operational effectiveness by minimising generation of wastes (i.e., energy, air and solid) (Puvanasvaran et al., 2014). Secondly, lean and ISO 14001 are both based on the continuous improvement philosophy. ISO 14001 framework operates in accordance to Dr. Deming's continual improvement cycle as a business model to improve environmental performance (Ciravegna Martins da Fonseca, 2015). Lean philosophy is also based on the processes of continual optimisation (Aguado, Alvarez, & Domingo, 2013). The continual improvement aspect enables an organisation to eliminate waste through incremental and on-going improvement of processes (Farrukh et al., 2022). Hence, lean and ISO 14001 both focus on continually improving processes to achieve operational effectiveness and environmental performance.

Thirdly, lean thinking promotes ISO 14001 adaptation as an environmental standard for the reduction of environmental impacts to achieve operational benefits (Habidin et al., 2018). Lean and environmental performance paradigms can be implemented as an integrated approach to improve environmental aspects by applying operational and quality tools and improvement of processes (Souza & Alves, 2018). Fourthly, the integration of lean and ISO 14001 enables economic benefits for an organisation by improving processes and reducing costs. The integration of environmental performance and lean leads to an improvement strategy that achieves operational and economic benefits simultaneously (Cherrafi, Elfezazi, Garza-Reyes, Benhida, & Mokhlis, 2017).

2.9.2 Integration models for lean and ISO 14001 manufacturing

Over the last few decades, global competition has been putting constant pressure on the manufacturing sector to adopt continuous improvement initiatives for enhancing performance, profitability and environmental sustainability (Mathiyazhagan et al., 2022). In the recent articles, Chen et al. (2020), Vasconcelos et al. (2019), Puvanasvaran et al. (2014), and Puvanasvaran et al. (2012) have emphasised on implementing lean and ISO 14001 as a combined approach for achieving environmental performance. However, no concrete process sequence or conceptual model has been proposed for implementing lean and ISO 14001 strategies holistically to achieve environmental benefits. A study by Chen et al. (2020) explored the impact of ISO 14001 and employee involvement on environmental performance. Further, the mediating effect of ISO 14001 on adoption of lean manufacturing was analysed. Findings have suggested an acute need for lean and ISO 14001 implementation strategies together. A case study was conducted by Vasconcelos et al. (2019) to investigate the implementation of lean and ISO 14001 jointly for improving environmental performance. However, the findings of this study suggest further investigation to explore the implementation of both strategies for achieving the environmental performance. Further, Puvanasvaran et al. (2012) attempted to develop a combined strategy for environmental performance by deploying five lean principles into ISO 14001 (as an EMS) through a survey. However, since this study was specifically developed for ISO 14001 certified original equipment manufacturer companies in Malaysia only, the findings cannot be generalised to other countries and sectors. Moreover, Puvanasvaran et al. (2014) proposed a framework for ISO 14001 and lean integration by including 18 main requirements of ISO 14001 with further extension into 42 sub-requirements, along with five lean principles with their nine core elements and critical success factors. However, the link between the elements of ISO 14001, lean methodology and success factors for environmental performance is not clear.

Rebelo, Santos, and Silva (2014), Souza and Alves (2018) and Wirkus and Chmielarz (2018) incorporated ISO management systems and lean philosophy as an integrated approach to achieve operational and environmental sustainability. Rebelo et al. (2014) explained the sequence for integration of ISO management systems comprehensively in their conceptual model, while, presenting a limited contribution of lean philosophy. Wirkus and Chmielarz (2018) conducted a case study to explore different constructs of ISO management systems and lean tools (VSM, Kanban, 5S, TPM and SMED) on operational and environmental performance, however, have

fallen short in providing a holistic conceptual model for empirical investigation. Whilst, Souza and Alves (2018) proposed an extensive model of ISO management systems (ISO 9001, ISO 14001 and OHAS 18001) and lean philosophy for sustainability (social, economic and environment). In this model, measuring the impact of ISO management systems and lean philosophy has emerged hard due to a wide scope of social, economic and environmental indicators. Furthermore, this proposed framework requires additional empirical validation before it can be executed in any industrial facilities. Table 2.1 presents all 19 articles on lean and ISO 14001 implementation strategies as a combined approach with their research descriptions and limitations.

Table 2.1: Articles on lean and ISO 14001 implementation strategies as a combined approach – authors, description and limitations

SN	Authors	Description	Limitations
1	Johnson Dana, Sun, and Johnson Mark (2007)	A survey was conducted for gathering data to identify the main constructs in implementing ISO management systems with lean as an integrated approach. The main constructs for integration described were: (1) policy and vision, (2) communication, (3) strategic plan, (4) problem solving initiatives and (5) new initiatives support and resources.	Sample size could pose a limitation for generalisability of findings because the proposed constructs have been tested in the automobile industry only. Further, a conceptual model could be developed by incorporating these constructs in a proper sequence.
2	Habidin and Yusof (2012)	A study was conducted in the Malaysian automobile industry to investigate the relationship between operational performance and lean by analysing the impacts of ISO 14001 certification as a moderating factor.	This study did not show any significant moderating impact of ISO 14001 on lean and operational performance. However, ISO 14001 adopting organisations showed a higher value of operational performance than non-certified firms.
3	Puvasanvaran et al. (2012)	The authors attempted to develop a combined strategy for environmental performance by adopting five lean principles in ISO 14001 (EMS) through a survey.	The relationship between lean principles and ISO 14001 has not been presented in a conceptual model. This study has been developed for ISO 14001 certified companies in Malaysia only and findings cannot be generalised to other countries.
4	Kurdve, Zackrisson, Wiktorsson, and Harlin (2014)	An attempt has been made to integrate lean based improvement programme with management systems (ISO 14001 and ISO 9001). Findings suggest company-specific production system shows a positive relationship with environmental performance continually.	This study has not presented integration strategy. An integration could be executed by analysing the operations, organisational culture and business opportunities of an organisation.
5	Puvasanvaran et al. (2014)	A framework based on five lean principles with nine core elements of ISO 14001 (environmental policy, planning, implementation and operations, checking and correction actions and management review) has been proposed in this study.	The proposed framework of lean and ISO 14001 integration requires more elaboration in the sequence of implementing both strategies. The study has identified policy, planning, implementation, checking, corrective actions and management review for ISO 14001 implementation only. Constructs related to lean have not been discussed.
6	Rebelo et al. (2014)	A 7-step conceptual framework has been presented for integrating lean and ISO management systems. A holistic implementation of management policy, communication, audit programme, monitoring and measurement plan, management review has been proposed in this study.	A framework for integrated ISO management systems has been proposed. Lean philosophy has been incorporated only in management review phase of this framework. This model requires more lean practices involvement for achieving benefits of integrating these strategies.

SN	Authors	Description	Limitations
7	Salleh, Kasolang, Jaffar, and Halim (2015)	The authors have conducted a survey to highlight the role of top management in implementing ISO standards and management initiatives. Policies and objectives (specific-measurable-attainable-realistic-timebound (SMART) objectives), vision and mission statement, monitoring and audit outcomes as well as corrective and preventive actions have been identified as the main attributes to establish synergies between these strategies.	The steps to develop and implement a conceptual framework has not been presented. The proposed constructs further require empirical validation before incorporating in a conceptual model.
8	Garza-Reyes, Yu, Kumar, and Upadhyay (2018)	The authors attempted to analyse the impact of total quality management and environmental management system (TQEM) as an integrated concept for environmental and waste reduction outcomes.	An implementation conceptual model for TQEM could be developed by incorporating the findings for sustaining environmental performance.
9	Ghobakhloo, Azar, and Fathi (2018)	A survey was conducted in 122 manufacturing facilities to determine the relationship between information technology (IT), lean philosophy and environmental issues. The findings of this study revealed that the IT competence acts as a major contributor in implementing lean for materialising waste and pollution reduction goals.	Small sample size and limited cross-sectional data was a limitation to pose lack of generalisability of findings.
10	Habidin et al. (2018)	A study has been conducted to determine the impact of lean practices on ISO 14001 for improving environmental performance in Malaysian automotive suppliers.	This study has not developed a process sequence to establish a comprehensive integrated relationship between lean and ISO 14001. Further, findings have indicated that the impact of ISO 14001 on environmental performance is not significant.
11	Khalili, Ismail, Karim, and Daud (2018)	A qualitative study has been conducted to determine application of a proposed framework on operations management practices (lean, total quality management, quality management system and EMS) for achieving sustainable performance. Findings suggest financial, social and environmental aspects for achieving sustainable performance.	This proposed framework for sustainable performance has not been fully explained or explored properly. Findings of this study suggest that the application of the framework must also be validated by conducting semi-structured interviews in service sector.
12	Souza and Alves (2018)	This study has explored the integration of environmental, quality and occupational health and safety with lean manufacturing principles and tools for sustainability (economic, environmental and social). A 14-step conceptual framework has been proposed to promote an integrated approach to achieve sustainability.	The scope has not been limited to lean and ISO 14001 for sustaining environmental performance only. Moreover, the conceptual framework needs further empirical validation from other industrial facilities.
13	Wirkus and Chmielarz (2018)	This study has focused on integration of lean manufacturing and ISO management systems to improve overall performance. A case study has been conducted to investigate the impacts of lean practices such as VSM, Kanban, 5S, TPM and SMED on operational and environmental performance.	The framework used in this case study requires additional validation in other industrial sectors. Further, the constructs of lean and ISO management systems require more holistic approach in developing a framework. Moreover, only one clause of ISO 14001 (improvement) has been utilised in this study for measuring environmental aspects continually.
14	Zhan, Tan, Ji, Chung, and Chiu (2018)	An empirical investigation was carried out in Chinese organisations to explore the impact of lean and environmental improvement practices for sustaining business and environmental performance.	Data collection was based on Chinese organisations which were in the early stages of lean adoption for environmental performance. Therefore, a longitudinal investigation was recommended for attaining future empirical validation of this study.
15	Choudhary, Nayak, Dora, Mishra, and	An integrated conceptual framework has been proposed by combining green philosophy and lean	A single case study was conducted to validate the proposed integrated framework of green and value stream mapping. The findings of this study

SN	Authors	Description	Limitations
	Ghadge (2019)	(value stream mapping) for packaging manufacturing.	could be further reconfirmed in different industrial contexts through multiple case studies.
16	Iranmanesh, Zailani, Hyun, Ali, and Kim (2019)	A survey-based study was conducted to investigate the impact of lean practices on organisations' environmental performance by analysing lean culture as a moderator. Findings suggested that process and equipment, product design, supplier and customer relationships showed a significant positive impact on sustainable performance.	The study sample size was limited to Malaysian manufacturing industry. The authors of this study suggested that a longitudinal study is needed to provide better picture to understand the extent lean practices impact sustainable performance.
17	Kruse, Veltri, and Branscum (2019)	A qualitative study has established compatibility of lean principles with ISO management systems. Authors have proposed constructs and motivational aspects for an integrated framework. Experts in this research have presented a list of 19 constructs. Relevant constructs for an integrated approach are: (1) policy and procedures, (2) objectives targets and programme, (3) resources, roles and authority, (4) competence, training and awareness, (5) internal and external communication, (6) documentation, (7) operational control, (8) monitoring and measurement, (9) internal and external audit, (10) management review.	The constructs of this integrated approach have been based on experts' opinions, hence, requires more empirical validation for developing an effective conceptual framework.
18	Vasconcelos et al. (2019)	A case study has been conducted in Brazilian manufacturing facilities to evaluate the lean and ISO 14001 implementation as a combined approach for improving environmental performance.	Small number of informants was a limitation to pose lack of generalisability of findings
19	Chen et al. (2020)	This study explored the impact of ISO 14001 and employee involvement on environmental performance. Further, the mediating effect of ISO 14001 on adoption of lean manufacturing has been analysed.	This study suggests an integrated lean and ISO 14001 approach adoption at macro-level for analysing the impact of both strategies on environmental performance. Findings of this study suggest an acute need for integration of lean and ISO 14001.

2.10 Conceptual model of lean and ISO 14001 implementation

A model is conceptualised for integration of lean and ISO 14001 strategies as shown in Figure 2.3. This model has been inspired from a model by Dalrymple Bay Coal Terminal's EMS programme (Dalrymple, 2019) and developed by Ahmed and Mathrani (2019) which explains the process of implementing an environmental management plan using the PDCA cycle, however developed through a rigorous review of literature. The suggested structures consist of policies and procedures of ISO 14001 and its measurement tools as well as techniques of lean for improvement of environmental performance in the manufacturing industry. An integrated approach of lean and ISO 14001 implementation is conceptualised for monitoring, measuring and improving environmental performance.

The proposed lean and ISO 14001 model is built on a continuous improvement process framework through the PDCA cycle. The model illustrates that the environmental and waste reduction policies of lean and ISO 14001 implementation are formulated, documented and communicated to relevant stakeholders in the “plan” phase. These policies link with the integrated environmental waste management plan (IEWMP) through a bold arrow which represents the integration relationship (e.g., waste elimination policies of both) and dotted arrow which depicts non-combined impacts of both policies (e.g., legal implications from ISO and operational benefits of lean). The constructs of this model are further discussed next.

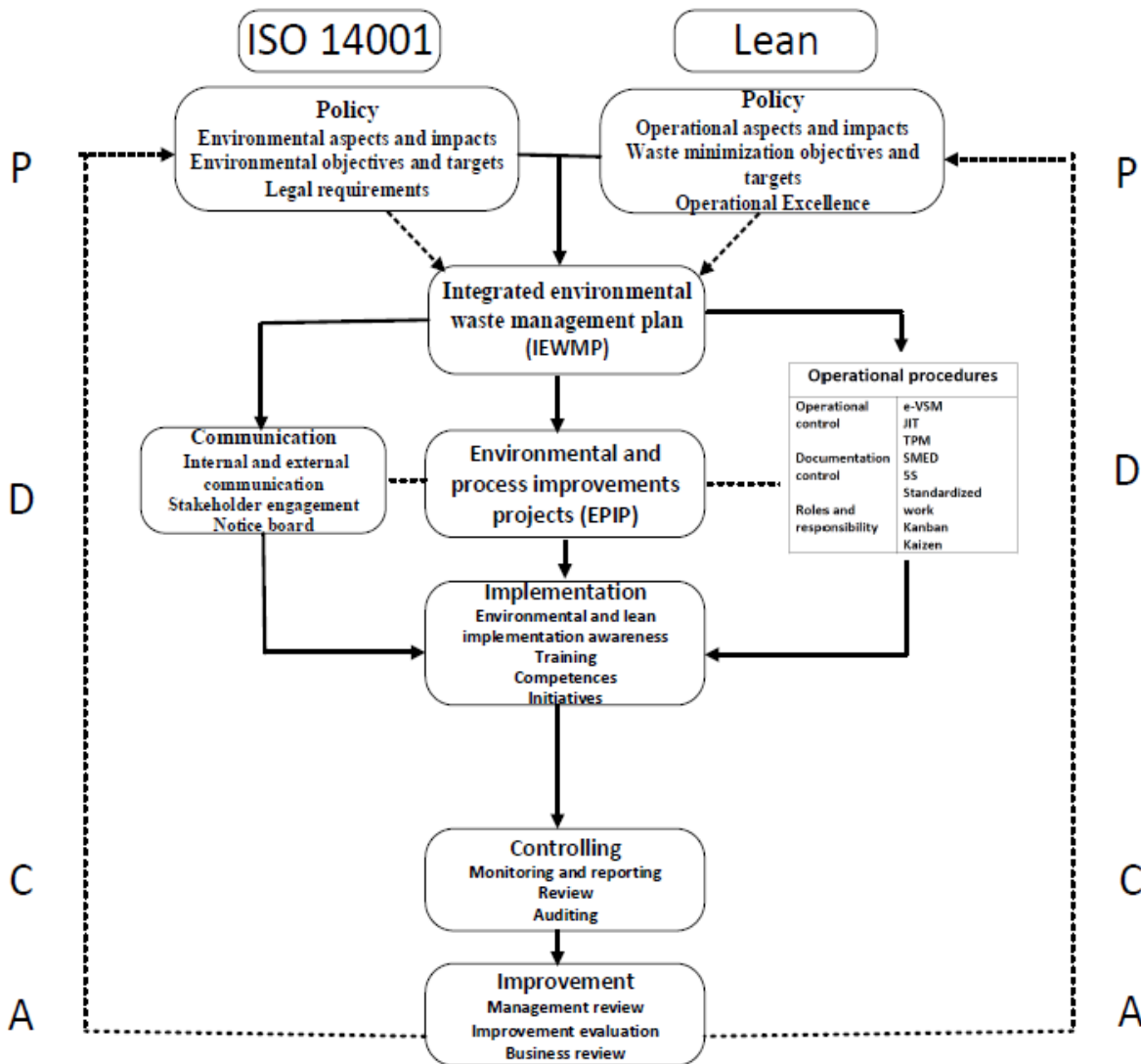


Figure 2.3: A conceptual model for an integration of lean and ISO 14001 implementation in the manufacturing industry (Source: Ahmed and Mathrani (2019))

2.10.1 Lean and ISO 14001 environmental policy

A clear definition of policy and its effective implementation is at the heart of every management strategy. The environmental policy can be defined as a short written statement which is based on the current status of the environmental performance of an organisation by indicating possible future improvements (Souza & Alves, 2018). The foundation of the environmental policy lies in the initial environmental performance review of environmental aspects, legal requirements and regulations and the current environmental procedure. The waste minimisation programme statement includes the environmental objectives and quantifiable targets for the EMS. The legal and regulatory requirements are an integral part of the EMS to reduce or eliminate the potential fines, penalties and strategic constraints for an organisation (Arimura et al., 2016). The top management sets the lean and ISO 14001 policies according to the vision of an organisation for achieving waste minimisation (Alefari, Salonitis, & Xu, 2017) and environmental performance (Arimura et al., 2016) maintaining continual improvements. The operational excellence (financial performance) is considered as an indicator for operational performance in the lean policy. Financial performance improves by reducing operational and environmental costs in the manufacturing sector (Farrukh et al., 2022). Once policies for lean and ISO 14001 are documented, it becomes possible to create a clear plan for IEWMP.

The “do” phase of PDCA’s cycle starts from IEWMP until the implementation stage in this conceptual model. The communication, environmental process improvement projects (EPIP) and operational procedures of both strategies start simultaneously indicated through the bold arrows. The in-between dotted lines depict their interrelationships.

2.10.2 Communication

The communication process consists of internal communication, stakeholder engagement and notice board. The communication between the company and its stakeholders provides the fundamentals for the successful execution and maintenance of ISO 14001 (Waxin, Knuteson, & Bartholomew, 2020) and lean strategy (Netland, 2016). An effective communication channel acts as a two-way information medium that enables the relevant stakeholders to learn about ongoing changes and exchange ideas for achieving environmental objectives and targets. This communication process remains active between an organisation and its stakeholders in different implementation stages of EMS (Sohal & Zutshi, 2004). The waste reduction objectives and targets

are clearly communicated to employees in different shifts and relevant stakeholders in producing quality products (Worley & Doolen, 2006). A clear management plan is conveyed to relevant stakeholders (employees, suppliers and contractors) through newsletters, intranet and Internet websites, bulletin boards and trade journals (Savely, Carson, & Delclos, 2007). A continual smooth flow of information can also be managed by putting the relevant details of management initiatives (policy, objectives and targets) on the notice board (Wu & Low, 2012).

2.10.3 Operational Procedures

The operational procedures are divided into lean tools as well as process control initiatives (operational control, documentation control, and roles, responsibilities and authorities). The operational planning and control includes critical activities to prevent and minimise environmental accidents, reduce emissions into the air and handle hazardous chemicals during operational processes (Foster, 2010). Document control is a mandatory requirement in EMS for documenting the procedures and scope of EMS, the environmental policy and the core elements of environmental performance. This is achieved by maintaining the EMS implementation records along with its evaluation and future improvement performance recommendations (Uzumeri, Tabor, & Stanwick, 1996). A standardised document control of an EMS and lean practices (such as continuous flow, Kaizen and 5S) is necessary for effective utilisation of resources and achieving operational and environmental performance objectives (Souza & Alves, 2018). The records of lean tools such as 5S for workplace cleanliness, SMED for changeover and TPM for maintenance must be documented for monitoring and control (Chiarini, 2011). The leadership plays a key role in defining roles, responsibilities and authorities in an organisation for execution of processes in implementing and improving EMS (Chattopadhyay, 2001). The different responsibilities are assigned to the senior, middle and lower workforce with sufficient financial and technical resources for improving the competence of the workforce through training and skill development programmes (Muralikrishna & Manickam, 2017). Top management commitment and availability of resources to implement a combined lean and ISO 14001 strategy must be included in the organisational policy (Chiarini, 2011; Souza & Alves, 2018). The top management must assign responsibility and authority to a manager as a lean champion or a lean sponsor or a Kaizen event team leader for achieving waste elimination and promoting awareness for the lean programme (Chiarini, 2011).

2.10.4 Implementation awareness, competencies development and training initiatives

The implementation phase for an integrated environmental and lean approach comprises implementation awareness, competencies development and training initiatives. Awareness amongst the workforce is an important necessity to formulate the environmental policy by comprehensively defining the environmental aspects, impacts and objectives for environmental management (Mariotti, Kadasah, & Abdulghaffar, 2014). Competencies development of the workforce to improve environmental performance is judged on the basis of their education, training and experience for developing an environmental policy and implementing the EMS as well as suggestions for improving environmental performance (Massoud et al., 2010). The pursuit of knowledge creation, skills development and performance management of employees lays down the foundation for proactive lean implementation to achieve financial benefits and employee satisfaction (Bortolotti, Boscarì, & Danese, 2015). EMS training can help employees understand the policy and principles of environmental performance and their potential role in reducing the environmental impacts by reducing air emissions, waste generation and effective utilisation of raw materials (Jabbour, Jabbour, Govindan, Teixeira, & Freitas, 2013). The involvement of employees in training programmes for deploying lean is an essential dimension towards a successful implementation by developing the skills and knowledge of the workforce for improving the organisational processes (Salonitis & Tsinopoulos, 2016). Further, the competent human resource in an organisation can play a pivotal role in selecting an ideal individual as a lean specialist or champion for implementation (Chiarini, 2011).

2.10.5 Monitoring, measurement and audit

The next phase of the PDCA cycle is “control” which is exemplified by a bold arrow indicating a link between implementation and controlling stage in the framework. The controlling stage consists of monitoring and reporting on the implemented operational procedures as well as their review and audit. The effective implementation of the waste minimisation programme helps the organisation in measuring and monitoring their environmental objectives and goals (Boudouropoulos & Arvanitoyannis, 2007). In this process, the indicators of environmental performance constitute according to the organisation’s environmental policy, objectives and targets to achieve the environmental objectives. These are attained by introducing process controls such as calibration of equipment to reduce waste and emissions and maintaining ongoing

evaluation of environmental performance to fulfil the operations and legal obligations (Muralikrishna & Manickam, 2017). The controlling of the lean initiative includes monitoring the level of success for lean implementation by comparing against the original plans (Mostafa et al., 2013). Internal audit is used as an evaluation tool to determine the current status of environmental performance against the policy, performance objectives and waste reduction targets (Foster, 2010). A lean tools implementation audit can be executed by analysing the checklist of operational inputs and outputs (Chiarini, 2011). Further, monitoring and measurement can be carried out by implementing tools such as takt time and poka-yoke instead of manually monitoring the process. Lean tools such as jidoka or autonomation can also be employed in reducing the operator attention for monitoring and measuring the process and equipment to reduce waste due to labour idle time.

2.10.6 Management review and improvement evaluation

The improvements are based on the outcomes of the “act” phase. Management review is an assessment initiative to propose future environmental improvements by introducing new performance operational requirements according to the current status of EMS (Muralikrishna & Manickam, 2017). General improvement includes the potential opportunities and actions (corrective, preventive and proactive) to identify the cause of environmental impacts, prevention strategies and elimination of environmental non-conformance during manufacturing processes for implementing the EMS effectively (Muralikrishna & Manickam, 2017). Corrective actions are of two types: (1) immediate actions which are taken as a follow-up of accidents and (2) revised actions which are made after the management review of EMS (Foster, 2010). The impacts of lean and environmental performance practices have different effects on the business (financial and market) performance. The business and environmental performance are interrelated to achieve operational optimisation. The targets are modified for business performance on the basis of lean and EMS implementation goals (Yang, Hong, & Modi, 2011). The continual improvement in the integrated lean and ISO 14001 framework is achieved through the PDCA cycle by effectively managing the environmental audits, monitoring and measuring the environmental processes and proposing improvement (proactive, preventive and corrective) actions.

2.11 An NRBV based model of lean and ISO 14001 implementation for environmental performance

A natural-resource-based view (NRBV) of an organisation helps to provide a framework for analysing various types of technological initiatives that an organisation can adopt to tackle operational and environmental constraints (Hart, 1995; Samadhiya, Agrawal, Kumar, & Garza-Reyes, 2023). This framework is considered an extension to the resource-based view (RBV). The RBV argues that competitive advantage can be achieved by the internal strategies of an organisation. Further, valuable and non-substitutable resources comprise organisational competitiveness; however, the RBV does not provide the basis to remove environmental constraints of an organisation (Hart & Dowell, 2011; Mishra & Yadav, 2021). Drawing upon the environmental insights into the RBV, Hart (1995) proposed the NRBV to postulate the interrelationships between resources, capabilities and the natural environment.

Pollution prevention, product stewardship and sustainable development are considered fundamental capabilities of an organisation to enhance environmental performance for achieving organisational competitiveness under the NRBV (Hart & Dowell, 2011; Samadhiya et al., 2023). This study adopts the NRBV environment-centric theory in creating new knowledge about the environmental performance in manufacturing organisations. This would also be of value since very few studies have so far adopted the NRBV as a theoretical lens to evaluate the environmental performance of manufacturing firms through the implementation of lean (Huo, Gu, & Wang, 2019) and ISO 14001 (Jabbour, 2015).

Pollution prevention aims to prevent emissions and waste in production and operations rather than tidying up at the “end of the pipe” (Cristina De Stefano, Montes-Sancho, & Busch, 2016, p. 1438). Lean and ISO 14001 implementations are considered proactive strategies to help an organisation attain their pollution prevention targets (Aragón-Correa & Sharma, 2003). For example, coal is considered the main source of electricity, heat and steam generation in meat processing facilities. Coal-fired plants have generated GHG emissions and are a major contributor to climate change. Further, the NRBV enhances the cross-functional capabilities for achieving a shared vision of operational and environmental performance through the pollution prevention paradigm. Pollution prevention initiatives allow an organisation to reduce the costs by (1) minimisation of inputs required (2) simplifying production and operations processes and (3) minimising liability,

environmental accidents and compliance costs for improving organisational competitiveness (Hart & Dowell, 2011). Further, operational and environmental performance targets such as wastewater reduction, efficient energy consumption and raw materials maintained through the process of continuous improvement via lean and ISO 14001 implementation are linked with pollution prevention (Hart, 1995; Souza & Alves, 2018).

Product stewardship incorporates the objective of pollution prevention by including environmental constraints in product design decisions (Farrukh, Mathrani, & Sajjad, 2021a; Hart, 1995). Ecological constraints of manufacturing operations and processes are reduced by the application of product stewardship. Reuse and recycling of resources (waste, water and renewable energy), reduction of emissions and stakeholder integration are drivers for product stewardship (Grimstad, 2011). Operational and environmental performance is enhanced by reusing and recycling of resources and reducing emissions through lean (Huo et al., 2019) and ISO 14001 (Jabbour, 2015) implementation aligned with the NRBV (product stewardship). The salient benefits of product stewardship initiatives include (a) reduction of harmful environmental processes, (b) reduction of compliance liability by improving existing product design and (c) development of products with lower life cycle cost (Aragón-Correa & Sharma, 2003; Hart & Dowell, 2011). Further, product stewardship increases the firm's competitiveness by improved environmental performance and enhanced social legitimacy in the society. Furthermore, it also addresses the aspects of life cycle (products and processes) through use of less water, energy and hazardous materials benign design characteristics (Cristina De Stefano et al., 2016; Farrukh et al., 2021b).

Pollution prevention and product stewardship achieve the sustainable development goals of an organisation by efficient utilisation of resources and reduction of negative environmental impacts through environment-oriented practices (Hart & Dowell, 2011). Meanwhile, *sustainable development* is focusing on leapfrogging by replacing existing equipment with the latest technological resources to improve utilisation of ecosystem resources and reorient energy consumption (Cristina De Stefano et al., 2016). Clean technology strategies help an organisation to obtain energy from renewable resources such as wind or solar power that reduce ecological footprints (Mishra & Yadav, 2021). Hart and Dowell (2011, p. 1471) made a clear differentiation between incremental improvements under “greening” strategies (pollution prevention and production stewardship), which focus on today's products, processing and radical future

improvements under “beyond greening” strategies (clean technology and sustainable development).

Literature on the NRBV suggests that the organisation with well-developed environmental capabilities is likely to adopt a proactive environmental strategy (PES). Hart (1995) proposed the concept of NRBV which was extended by Buysse and Verbeke (2003) who categorised the natural competencies into five groups: conventional, human, organisational, procedural and strategic planning. However, very few studies have adopted the NRBV (competencies and capabilities) as a theoretical lens to evaluate the environmental performance through implementation of lean (Huo et al., 2019) and ISO 14001 (Jabbour, 2015). This study is conducted in the meat processing organisations which are highly raw resource-intensive (raw carcasses, water and packaging material) and energy consuming facilities (Djekic & Tomasevic, 2016). It uses the competencies and capabilities of the NRBV theory to explore the implementation of lean and ISO 14001 for achieving environmental performance. Further, this study aims to investigate different constructs of lean and ISO 14001 implementation, for instance, whether the integrated lean and ISO 14001 environmental policy and integrated environmental waste management plan in a meat manufacturing firm are aligned with strategic competence and environmental awareness. Further, the training programmes are in line with human competence development as well as controlling and improving processes through lean and ISO 14001 implementation connected with procedural competence. The competencies and capabilities of the NRBV lens provide a comprehensive understanding for effective implementation of lean tools and integrated environmental waste management projects. For example, strategic planning competence is linked with the application of Hoshin Kanri, organisational competence (communication and information sharing) is linked with visual management and procedural competence is linked with the 5S audit for achieving environmental performance (Chiarini, 2011; Hart, 1995; Souza & Alves, 2018).

2.11.1 Strategic planning competence

Strategic planning competence is defined as developing accurate objectives and plans for achieving sustainability. It provides defined operational and environmental objectives, availability of financial resources and steering committees for achieving environmental performance (Brulhart, Gherra, & Marais, 2017; Hart, 1995). Strategic planning competence promotes the integration concept to improve environmental performance (Buysse & Verbeke, 2003). A well-defined policy

and an integrated environmental waste management plan for achieving operational and environmental targets by implementing lean and ISO 14001 are linked with the strategic planning competence under the NRBV lens (Brulhart et al., 2017; Souza & Alves, 2018). Further, a long-term vision and formal objectives of lean and ISO 14001 environmental planning are the fundamental elements to achieve the parameters of the NRBV capabilities.

2.11.2 Organisational competence

Hierarchical structure, coordination, allocation of missions, degree of centralisation and responsibilities for achieving sustainability are included in organisational competence (Brulhart et al., 2017). The lean tools and ISO 14001 procedures for communication help to boost coordination and information sharing between top management, the workforce and relevant stakeholders (contractors and suppliers) to achieve pollution prevention, product stewardship and environmental sustainability parameters.

2.11.3 Conventional competence

Physical resources (e.g., plants, equipment, technology, raw materials) are considered as conventional competencies for producing environmentally friendly products (Brulhart et al., 2017; Buysse & Verbeke, 2003). Physical resources such as raw materials (e.g., raw carcasses and packaging material), latest technology for wastewater (e.g., treatment and recycling) and introduction of latest equipment (e.g., water metering system) are critical parameters to achieve the ongoing improvements in implementing lean tools and improvement projects (Buysse & Verbeke, 2003; Farrukh et al., 2021a).

2.11.4 Human competence

Employee qualifications, awareness, training and participation in managing the natural environment are included in human competence (Brulhart et al., 2017; Hart, 1995). Competence, awareness and training of the workforce and relevant stakeholders for lean and ISO 14001 implementation provide the operational and environmental culture which are aligned with the environmental goals (Buysse & Verbeke, 2003; Souza & Alves, 2018). Inhouse and external operational and environmental training programmes provide the required knowledge, proactive environmental attitudes and skills to attain organisational strategic goals and competitive advantage proactively (Brulhart et al., 2017; Jabbour, 2015). Further, systematic environmental

training initiatives is considered as a crucial human factor to promote “green human resource management” in operations management to achieve environmental targets (Jabbour, 2015, p. 332). Human competence under the NRBV paradigm facilitates an organisation for attracting and retaining competent workforce (e.g., lean and ISO 14001 trained employees) (Buysse & Verbeke, 2003; Jabbour, 2015).

2.11.5 Procedural competence

Resolving environmental sustainability issues and reporting systems (e.g., auditing, assessments and certification) for improving environmental performance are used to formalise and standardise procedures (Buysse & Verbeke, 2003; Hart, 1995). Environmental performance evaluation (auditing and assessment) helps to identify the reasons for waste and environmental generation as well as propose corrective actions according to ISO 14001 operational control through procedural competence (Brulhart et al., 2017; Chiarini, 2011). Integrated audit and reviewing mechanism for environmental waste reduction management as a procedural competence helps to review targets (audit and review documents) for identifying non-conformities and proposing corrective/preventive/proactive actions (Lenning & Gremyr, 2017). Management review and procedures (e.g., ongoing internal and external monitoring and reporting on lean and ISO 14001 implementation) help to develop a performance evaluation culture for improving environmental efficiency and achieving competitive advantage (Brulhart et al., 2017; Wirkus & Chmielarz, 2018).

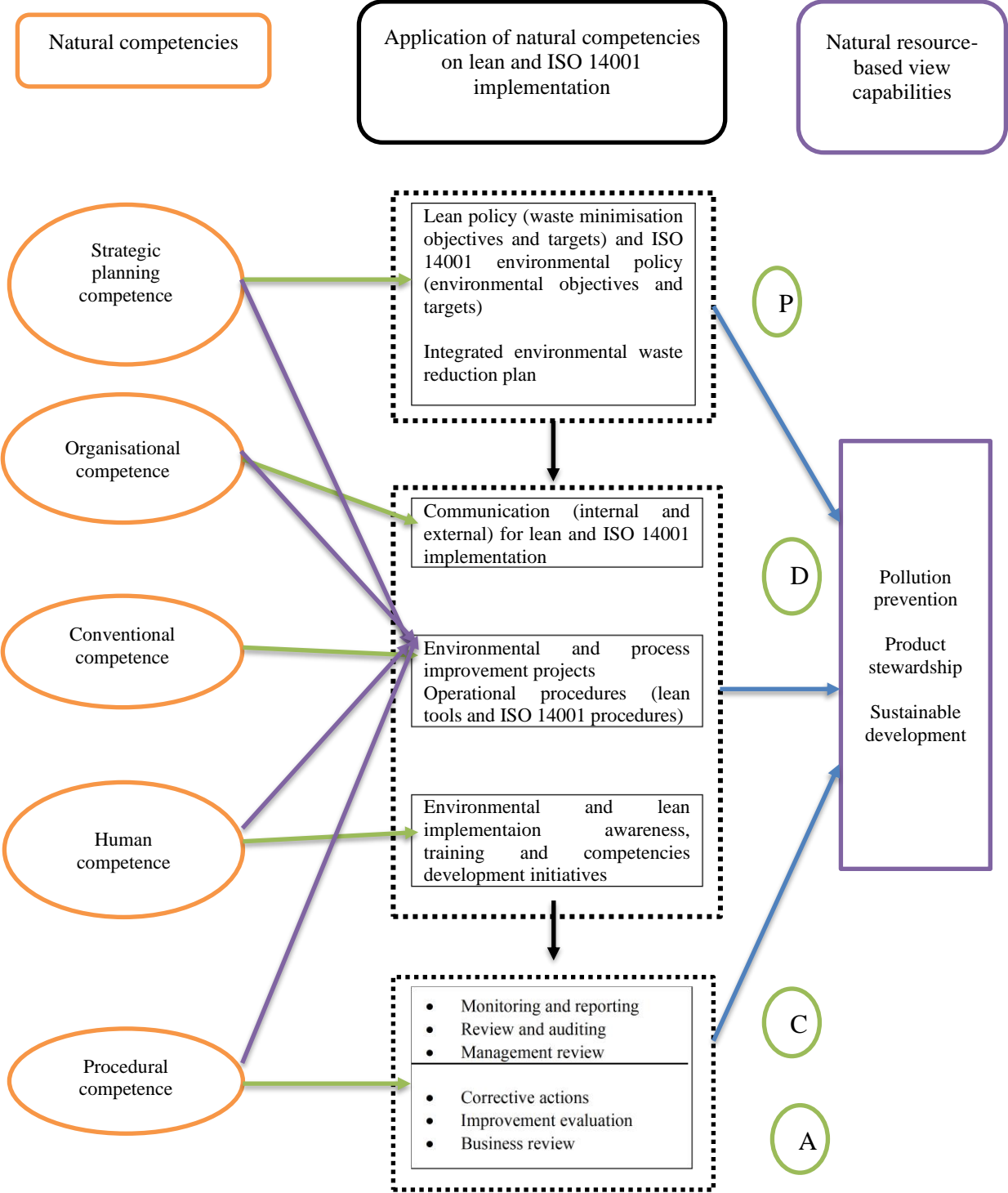


Figure 2.4: An NRBV-based model of lean and ISO 14001 implementation for environmental performance, adapted from Brulhart et al. (2017) and Hart (1995)

2.12 CSFs for lean and ISO 14001 implementation strategies

Continuous improvement is considered a major influential aspect in implementing lean and ISO 14001 as a joint strategy for enhancing operational parameters and making the environment more sustainable (Caldera, Desha, & Dawes, 2019). Similarly, Habidin et al. (2018) evaluated through a survey the impact of lean and ISO 14001 on improving internal business operations (e.g., reduction of material scrap and defect rate), customer satisfaction (e.g., reduction of overdue deliveries and customers complaints) and financial performance (e.g., improvement of sales revenues and capital efficiency). However, a successful implementation of lean and ISO 14001 as a joint approach entails ambiguous contribution of lean tools in implementing both approaches together (Jabbour et al., 2013) and weak moderating relationship between lean and ISO 14001 (Habidin et al., 2018). To overcome these operational and procedural issues, the authors (e.g., Caldera et al., 2019; Habidin et al., 2018) suggest special attention must be paid to those critical factors of lean and ISO 14001 that ensure success and high performance of a combined system. As little or no literature is available on CSFs for a combined lean and ISO 14001 implementation, there is an acute need to explore the critical factors for successful implementation of both strategies together.

A clear organisational vision for lean goals and ISO 14001 based environmental targets is a critical element for an organisation in formulating an implementation process with an environmental improvement policy (Souza & Alves, 2018). A documented policy aligned with the organisational vision is the foundational attribute in implementing lean (Knol, Slomp, Schouteten, & Lauche, 2018) and ISO 14001 (Ejdys et al., 2016) for achieving environmental waste minimisation targets. Further, setting of the appropriate targets to meet customer's needs and wants help an organisation to enhance consumer's loyalty. Achieving customer satisfaction is pivotal by reducing all kinds of undesirable waste through the lean strategy and continuously improving to meet the clients' needs (Ainul Azyan et al., 2017). It is also achieved through environmental impact reduction by adopting internationally certified environmental management initiatives (Bravi et al., 2020).

Availability of resources (financial, technical and human) is a crucial aspect in effectively implementing lean (Achanga et al., 2006) and ISO 14001 (Cassells, Lewis, & Findlater, 2012). Resources can provide a competitive advantage and strong footing in the market for an organisation. Sufficient financial resources cover the expenditure on external consultants and training initiatives for lean transformation (Al-Najem, Dhakal, Labib, & Bennett, 2013) and

expenditures on attaining ISO certification, external audits and training programmes for ISO 14001 (Tepaskoualos & Chountalas, 2017). Further, technical and human resources such as a competent workforce for implementing lean tools (Chiarini & Brunetti, 2019), monitoring process and equipment and deploying EMS specialists are key factors for a successful implementation of ISO 14001 (Quazi Hesan, 1999).

Organisational culture builds a climate of shared beliefs, attitudes and values for promoting continual environmental change (from correction to prevention) and enhancing support in implementing productivity improvement initiatives (tools/techniques) (Ainul Azyan et al., 2017; Barclay et al., 2021). Culture and change management towards waste reduction initiatives (such as lean) and environmental certification (such as ISO 14001) are considered essential elements for achieving high-performance goals. Further, a culture of continuous improvement helps a self-sustaining organisation to develop a strategic plan for solid waste reduction (Hernandez-Matias et al., 2020) and environmental performance (Sambasivan & Fei, 2008). This can also achieve optimal utility consumption and meet the compliance and statutory requirements for the organisation. An EMS framework further encourages continual improvement of environmental performance and with the support of lean practices can fundamentally create a competitive advantage through enhanced performance and profitability.

Brand value is a critical aspect impacted by lean (Mathiyazhagan, Gnanavelbabu, Kumar.N, & Agarwal, 2022) and ISO systems (Chin, Chiu, & Rao Tummala, 1999) implementation to get established as a sustainable and socially responsible corporate organisation. Further, corporate image (being seen as an environmentally friendly organisation) is a key factor to attract environmentally conscious customers and boost sales (Bravi et al., 2020). Lean as a highly flexible and robust strategy in responding to customers' needs (Belhadi et al., 2018) helps an organisation to sustain competitive advantage by achieving upward momentum in capturing market share. While ISO 14001 based EMS (Ejdys et al., 2016) provides an organisation guarantee of environmental performance and long-term efficiency to strengthen their market position.

Governmental agencies and environmental departments provide regulatory parameters such as compliance requirements for waste and handling of hazardous substances to avoid heavy penalties (Prasad et al., 2018). Meanwhile, the support to gear up production rates in organisations by implementing lean initiatives on a continual basis is also provided by the government

(Mathiyazhagan et al., 2022). Therefore, the government policies, regulations and geographical cultural parameters are most influential in implementing lean in the manufacturing industry. Further, development of multi-skilled workforce is considered as a critical factor in managing skilled middle to lower management staff for implementing lean tools (Hernandez-Matias et al., 2020) and ISO 14001 for achieving the short-term vision of an organisation (Bravi et al., 2020).

Strong management involvement permeates throughout an organisation to create a flexible environmental waste reduction culture with implementation of lean tools (Belhadi et al., 2018) and ISO 14001 (Bravi et al., 2020; Ejdys et al., 2016) for achieving their strategic vision and mission. Organisations need to know what to expect and what they will require for a successful implementation of lean strategy by analysing the strategic thinking, commitment and awareness of their skilled workforce (Al-Najem et al., 2013). Further, top management commitment is a requirement to provide financial resources for improving the expertise of the workforce and installing the latest technologies (equipment and software) to achieve a successful lean and ISO 14001 implementation. Furthermore, top management is accountable for developing and assigning the roles, responsibilities and authorities to the middle and lower management workers for adopting lean (Deranek, Chopra, & Mosher, 2017) and implementing EMS (Quazi Hesan, 1999).

Effective communication leads to better understanding of organisational processes and staff roles in the application of lean tools, reducing ambiguity in worker' responsibilities and authorities to reduce non-value-adding activities (Hernandez-Matias et al., 2020). Communication channels must be maintained among various hierarchical levels internally and with relevant stakeholders externally during the development of an EMS framework (Cherry & Weiler, 1998). Effective communication can help to provide visibility of goals such as environmental waste reduction targets more accurately and transparently for a joint lean and ISO 14001 transformation programme (Souza & Alves, 2018).

Commitment and competence of the workforce from the bottom up is key to avoid high failure risks in implementing the lean tools (Mathiyazhagan et al., 2022). Employee involvement is another essential factor for building capabilities in promoting change management and implementation of an EMS (Sambasivan & Fei, 2008). All of the scientific techniques and management initiatives are implemented in real-time by the skilled and knowledgeable employees on the production floor (Mathiyazhagan et al., 2022). Development of an organisational culture is

critical to promote a reward and recognition scheme for the employees to boost their morale in implementing strategies such as lean (Netland, 2016) and ISO 14001 (Boiral, Guillaumie, Heras-Saizarbitoria, & Tayo Tene, 2018).

Performance evaluation dimension for effective monitoring of utility parameters such as energy savings, resource savings and carbon footprints reduction are influential aspects for lean (Mathiyazhagan et al., 2022) and EMS (Souza & Alves, 2018) implementation. Performance evaluation highlights the current status of the implementation and predicts future improvement initiatives for proactive development of both strategies. Attraction and retention of competent employees is considered as a factor for competitive advantage for an organisation because a high mobility rate and short-term tenure of personnel can have a detrimental effect. Further, performance evaluation of the workforce along with training initiatives and skills enhancement through guidance from professionals help the top management to build the future competencies to achieve the organisational goals.

A training needs matrix is prepared by displaying the current status of strengths and weaknesses of the workforce to evaluate their existing competence (Tan, Denton, Rae, & Chung, 2013). The matrix can monitor the capabilities before a training programme is conducted to build-up competencies of the workforce for the future. If the staff have insufficient knowledge and skills, or lack in behavioral aspects, training is commonly initiated that can lead to improving the productivity and performance in the implementation of lean (Vega et al., 2020) and ISO 14001 (Sambasivan & Fei, 2008). Therefore, the skills development of the workforce for implementation of programmes such as lean and ISO 14001 helps to promote continuous process improvement, reduce waste and achieve competitive advantage.

Monitoring and measuring equipment performance is key for accurately tracking the environmental performance such as carbon footprints and air emissions to meet compliance requirements (Tortorella & Fettermann, 2018). Lean tools can be utilised to monitor and measure improvement initiatives such as elimination of waste, continuous improvement and occurrence of process abnormalities, which are applicable to lean transformation (Souza & Alves, 2018). Further, lean tools and ISO 14001 help an organisation in mitigating the environmental impact through reduction of air emissions and solid waste generation to decrease pressure from the relevant

stakeholders (customers and government institutions) and enhance competitiveness (by producing environmentally friendly products).

2.13 Benefits of lean and ISO 14001 integration

Lean and ISO 14001 implementation as a combined approach can achieve better waste minimisation objectives by monitoring the environmental processes using the ISO 14001 structure and improving the operational aspects through the lean methods (Souza & Alves, 2018; Wirkus & Chmielarz, 2018). Lean and ISO 14001 joint implementation can achieve on-going development of operational processes that can lead to improving the environmental performance (Kurdve et al., 2014; Souza & Alves, 2018). The integration framework will provide an opportunity to an organisation to incorporate environmental considerations into the lean tools for reduction of environmental and operational wastes (Cherrafi et al., 2019; Dieste et al., 2020). A combined approach could be used for identification of environmental and operational deficiencies to provide solutions for mitigating inefficiencies as well as setting roles and responsibilities (Kruse et al., 2019; Souza & Alves, 2018). Training programmes could be incorporated to create competencies in better achieving EMS key performance indicators (KPIs) and implementation of related tools and techniques. These factors could achieve reduction of time and effort in improving the manufacturing processes, leading to an impact on the financial performance of an organisation through process improvements such as reduction of environmental costs, scrap and waste generation, and treatment or control of waste discharge. Lean and ISO 14001 implementation as a combined approach would provide a clear vision internally to the company management and employees and externally to the suppliers, contractors and customers to achieve the EMS related organisational goals (Kruse et al., 2019; Kurdve et al., 2014; Souza & Alves, 2018).

2.14 Conclusion

This chapter has presented the theoretical context of the study. The findings in this study are used to explain the introduction and background of the study in Chapter 1, development of lean and ISO 14001 models (sections 2.10 and 2.11) in Chapter 2 and support the discussion in Chapter 8. Several research perspectives, characteristics and implications were reviewed that developed a comprehensive understanding to implement integrated lean and ISO 14001 approach for achieving environmental performance. This chapter has reviewed the extant literature on the meat industry, environmental performance improvement in this industry, ISO 14001, and lean strategy, CSFs for

implementing both strategies to present the theoretical context of this study. The earlier sections of this chapter have reviewed the latest literature that predicts the potential application of lean and ISO 14001 as a combined approach for improving environmental performance. Further, the conceptual model for integration of lean and ISO 14001 (section 2.10) proposed by Ahmed and Mathrani (2019) is an appropriate step in the right direction to provide guidelines for implementing both strategies together for improving environmental performance. Additionally, the second proposed model, an NRBV-based (e.g., competencies and capabilities) model of lean and ISO 14001 implementation for environmental performance (section 2.11) adapted from Brulhart et al. (2017) and Hart (1995) provides a suitable theoretical perspective for this study. These models stipulate a more comprehensive foundation of knowledge than the prior literature on lean and ISO 14001 for improving environmental performance. Further, the detailed literature on CSFs for lean and ISO 14001 implementation as a combined approach for improving environmental performance and the benefits of implementing both these strategies together have been presented. Chapter 3 presents the research methodology for the study.

Chapter 3 – Research Methodology

3.1 Overview

The purpose of this study is to investigate and analyse the environmental performance through the application of lean and ISO 14001 implementation strategies as a combined approach in the meat industry. This study answers the following research questions: (1) How do lean and ISO 14001 implementation strategies as a combined approach contribute to environmental performance in the meat industry? (2) How can lean and ISO 14001 strategies be implemented together in the meat industry and how do these strategies complement each other for improving environmental performance? and (3) What are the critical success factors for implementing lean and ISO 14001 as a combined approach in the meat industry? The nature of the research questions indicates that qualitative research is a suitable methodology to evaluate the complex phenomenon of implementing lean and ISO 14001 strategies together for improving environmental performance in the meat industry. In the context of current research, very little evidence is available in the literature for evaluating lean and ISO 14001 as a holistic approach to improving environmental performance (Puvanasvaran et al., 2014; Souza & Alves, 2018). Therefore, this research adopts an exploratory approach to evaluate the implementation of lean and ISO 14001 strategies holistically in achieving environmental benefits. Further, qualitative research is used to collect rich and in-depth information (Yin, 2012) for implementation of lean and ISO 14001 together to achieve environmental performance. The study utilises the NRBV-based model of lean and ISO 14001 implementation (Figure 2.4) to evaluate how both these strategies as a combined approach are implemented for improving environmental performance.

A qualitative approach was employed for both the preliminary study and the multi-case studies to examine the effectiveness of lean and ISO 14001 implementation strategies together for improving environmental performance in the meat industry. A preliminary study was conducted in the first phase of this research by interviewing seven consultants involved with lean and ISO 14001 implementation in the meat industry who are the experts in these fields. Lean and ISO 14001 consultants have in-depth knowledge and experience in implementing these strategies, therefore they are in a position to provide valuable insights on the use of these strategies in industry. This preliminary study provides the foundation for understanding the study phenomenon and preparing the interviews for multi-case studies in evaluating the effectiveness of lean and ISO 14001

implementation to achieve environmental performance in the meat industry. Semi-structured interviews were conducted with senior managers from three meat processing facilities (two NZ and one Ireland based companies) who have experience and knowledge of implementing lean and ISO 14001 strategies in their respective companies in the second phase.

The remaining chapter 3 is structured as follows: Section 3.2 presents the research paradigm for conducting this study. Next, the selection of research methodology and strategy for implementing lean and ISO 14001 as a combined approach for improving environmental performance is presented. Then, sampling strategy, preparation for data collection, data collection and analysis, and reporting for the preliminary and main study are explained. Finally, research quality, ethical considerations and sequence of the research design are presented.

3.2 Research paradigm

A research paradigm is a philosophy which categorises the essence of the world, the position of any individuals and magnitude of their possible relationships with the world and its parts (Eshlaghy, Chitsaz, Karimian, & Charkhchi, 2011). The research paradigm provides a platform for choosing and conducting an appropriate research methodology (research strategy and data collection methods) (Saunders & Lewis, 2012). Ontology, epistemology and methodology are the fundamental assumptions to describe a research paradigm that underpins the research process (Tuli, 2010). According to Guba and Lincoln (1994, p. 108), a paradigm covers the questions of “what is the form and nature of reality (ontological question), what is the nature of the relationship between the knower or would-be knower and what can be known? (epistemological question) and how can the inquirer (would be knower) go about finding out whatever he or she believes can be known? (methodological question)”

Social constructivism, also known as interpretivist perspective helps uncover cultural norms, values and beliefs through deep and systematic understanding of cultural and human experiences (Tuli, 2010). On the other hand, the positivist approach provides a foundation for quantitative research in evolving knowledge, for example hypotheses and questions, utilisation of measurements and observations, testing the theories, and cause and effect thinking (Fatimah Bahari, 2010). Post-positivism has emerged from positivism by softening the ontological and epistemological assumptions, which governed scientific enquiries for many years (Creswell, 2014; Guba & Lincoln, 1994). It brings theory (verification) and practices together by motivating the

researchers to select the appropriate techniques for data collection and analysis (Henderson, 2011). This research is exploratory in nature, evaluating the lean and ISO 14001 implementation strategies together to improve environmental performance. The theoretical perspective for the preliminary study and multi-case studies is post-positivism rather than a single reality (positivism). In the interpretivist perspective, a qualitative study can only achieve description and exploration of the theory. However, a positivist approach can achieve description, exploration and test of the theory. The post-positivist approach is utilised to bring theory (verification) and practice together by emphasising meanings explicitly (Tavallaei & Talib, 2010). Further, post-positivism is attempted to make knowledge claims more objectively by using triangulation (through different data sources, theoretical perspectives and methods) for better understanding the reality of a phenomenon (Creswell, 2014).

Ontology is the theory that we make about the nature of reality (Fatimah Bahari, 2010). Further, it is the nature of world – what it comprises of, what entities drive within it and how they interconnect to each other. Post-positivism assumes that reality (critical realism ontological assumption) exists out there, but “to be only imperfectly apprehendable because of basically flawed human intellectual mechanisms and the fundamental intractable nature of phenomena” (Guba & Lincoln, 1994, p. 110). The basis for ontology in this research is the descriptions of independent reality shared by the study informants to evaluate lean and ISO 14001 implementation as a combined approach. The epistemological perspective of this research is post-positivism as lean and ISO 14001 implementations are based on shared descriptions, perceptions and understanding of the study informants (seven consultants and 19 senior managers). Further, post-positivism approach is used to capture contextual evidence based on in-depth knowledge and experience (Henderson, 2011) of the meat processing experts from NZ and Ireland, and discovery and verification of the theory (competencies and capabilities of the NRBV lens). Qualitative research methods are applied (based on the post-positivism paradigm) for developing and refining knowledge (Creswell & Poth, 2016) on lean and ISO 14001 implementation as a combined approach.

It is important to emphasise that very little attention has been given in literature so far to investigating the successful implementation of lean and ISO 14001 as a combined approach for improving environmental performance in the meat industry. This study explains the concept of implementing lean and ISO 14001 strategies together based on common descriptions, understanding and clarification provided by using the constructs of NRBV model (Figure 2.4) and

experienced industry experts to explain the reality of the phenomenon (improvement of environmental performance in the meat industry).

3.3 Selection of research methodology and strategy

The choice between quantitative and qualitative research strategies should be determined by the research questions of the study and not by the partiality of the researchers (Marshall, 1996). The qualitative approach is an appropriate research strategy for answering ‘how’ type questions in this study (Yin, 2014). The objective of this study is to examine the phenomenon of how lean and ISO 14001 can be implemented together and their contribution to environmental performance in the meat industry, how these strategies complement each other and the CSFs for their joint implementation. Further, "qualitative research is especially helpful when it provides us with someone's perceptions of a situation that permits us to understand his or her behavior" (Krathwohl, 1998, p. 230). In-depth descriptions from the consultants (lean and ISO 14001) and informants from three meat processing organisations helped to explain the lean and ISO 14001 implementation phenomenon for improving environmental performance.

The qualitative research method is utilised in the following circumstances: “(a) when there is rarely any information available about the topic (b) when the researcher’s variables are unclear and unknown and (c) when a relevant theory base is missing in any sense” (Tavallaei & Talib, 2010, p. 571). The reason for selecting and adopting qualitative research in this study (both the preliminary and main study) is to gain appropriate information and provide clarity on the application of the lean and ISO 14001 phenomenon. Further, this study also stipulated a theoretical foundation that investigated through the competencies and capabilities under the NRBV lens. Therefore, this study adopts the qualitative method to verify a conceptual model in providing a relevant theory base (an NRBV perspective) for lean and ISO 14001 implementation strategies where literature (i.e., case study or survey investigations) is limited on this topic to answer the research questions of this study (Duarte & Cruz Machado, 2017; Souza & Alves, 2018; Vasconcelos et al., 2019).

This study adopts qualitative research as an appropriate methodology for collecting rich and in-depth information from consultants and senior management professionals for evaluating the specific study phenomenon (implementation of lean and ISO 14001 for environmental performance). On the other hand, quantitative methodology (a deductive approach) can limit in-

depth investigation to explore this phenomenon in this study (Marshall, 1996; Vaismoradi, Turunen, & Bondas, 2013). An inductive approach permits the research "to gain an understanding of the way in which humans interpret their social world" (Saunders, Lewis, & Thornhill, 2012, p.126). Further, this approach is likely to be predominantly related to the context in which the events are taking place. The comprehensive inductive approaches have been applied as a qualitative research methodology for this study to investigate the experience of experts and knowledgeable practitioners in the environment of the specific research settings (Creswell, 2014; Patton, 2002).

A case study can be defined as an empirical investigation that discovers an existing phenomenon within its real-life perspective, particularly when the boundaries between the phenomenon and context are ambiguously defined (Yin, 2014). The case study is an appropriate design to answer how meat facilities use lean and ISO 14001 strategies as a combined approach for achieving better environmental performance. It is generally applicable where there is a lack of theoretical perspective and paucity of empirical evidence for an evolving research phenomenon (Collis & Hussey, 2014). Further, case study also allows to explore the unknown variables for better understanding the research phenomenon (Voss, Tsikriktsis, & Frohlich, 2002). The current literature indicates limited application of the lean and ISO 14001 implementation phenomenon for improving environmental performance. Further, case study is an appropriate strategy to evaluate the application of the NRBV (competencies and capabilities) lens for investigating the missing theoretical perspective in implementing lean and ISO 14001. Furthermore, it provides an opportunity for exploring and describing a phenomenon by using various sources of data, developing theory and evaluating programmes as it is flexible and rigorous (Baxter & Jack, 2010). Additionally, it is a strategy that facilitates exploring the lean and ISO 14001 phenomenon by using multiple facets of information, for instance, primary data (i.e., semi-structured interviews with senior management), secondary data (i.e., environmental manuals and sustainability reports) and verification of the NRBV lens.

Well-defined research questions, and a priori specification of constructs and units of analysis are considered essential elements for conducting a case study (Eisenhardt, 1989). The research questions for this study are clearly defined in section 1.0.4, Chapter 1. The research questions are based on two 'how' questions and one 'what' question for evaluation of lean and ISO 14001

implementation strategies as a combined approach for improving environmental performance in the meat industry. A priori specification of constructs is used to help in shaping the initial design of theory building for critically evaluating the constructs of a theoretical model based on the literature review (Dubé & Paré, 2003; Eisenhardt, 1989).

An NRBV-based model of lean and ISO 14001 implementation for environmental performance (Figure 2.4) has been developed based on the literature review linked with the competencies and capabilities of the NRBV in Chapter 2. The constructs of this NRBV model are defined as strategic planning, organisational competence, conventional competence, human competence and procedural competence to comprise the capabilities of the NRBV in this study. These constructs are analysed by using the empirical data (findings of semi-structured interviews) to assess the capabilities of the NRBV and enrich the theoretical foundation of this study. For instance, the competencies of the NRBV (e.g., strategic planning and human competence) are used to develop waste and environmental reduction policy, and conduct training programmes for better joint implementation of lean and ISO 14001 (Brulhart et al., 2017; Buysse & Verbeke, 2003). On other hand, lean and ISO 14001 implementation as a combined approach can help to achieve the NRBV capabilities (i.e., pollution prevention, product stewardship and sustainable development) (Hart & Dowell, 2011). The priori specification of constructs of the NRBV-based model of lean and ISO 14001 implementation for environmental performance is presented in Table 3.1.

Table 3.1: Constructs of an NRBV-based model of lean and ISO 14001 implementation for environmental performance

Level	Constructs of the model (the NRBV competencies)	Lean and ISO 14001 constructs for combined implementation	Capabilities of the NRBV
Plan	Strategic planning	Lean policy (waste minimisation objectives and targets) ISO 14001 environmental policy (environmental objectives and targets) Integrated environmental waste reduction plan	Environmental and process improvement projects Operational procedures (lean tools and ISO 14001 procedures implementation) Pollution prevention Product stewardship Sustainable development
Do	Organisational competence	Communication (internal and external) for lean and ISO 14001	
	Conventional competence	Environmental and process improvement projects Operational procedures (lean tools and ISO 14001 procedures implementation)	
	Human competence	Environmental and lean implementation awareness, training competencies and initiatives	
Check	Procedural competence	Monitoring and reporting Review and auditing Management review	
Act		Corrective actions Improvement evaluation Business review	

Identification of appropriate units of analysis provided a foundation to generate realistic implications and a theoretical perspective on this study (Dubé & Paré, 2003). This study includes four units (embedded cases) of analysis: (1) environmental performance and waste reduction outcomes, (2) lean practices and ISO 14001 procedures implemented for environmental performance, (3) how lean and ISO 14001 complement each other for environmental performance, and (4) CSFs for a combined lean and ISO 14001 approach for environmental performance. These four embedded units of analysis are related to the research questions of this study as shown in Table 3.2.

Table 3.2: Units of analysis

SN	Units of analysis	Research questions
1	Environmental performance and waste reduction outcomes	RQ1
2	Lean practices and ISO 14001 procedures implemented for environmental performance.	RQ2
3	How lean and ISO 14001 complement each other for environmental performance.	RQ2
4	CSFs for a combined lean and ISO 14001 approach for environmental performance.	RQ3

3.3.1 Preliminary study

The preliminary or pilot study enables the researcher to better understand the study phenomenon, improve instruments for data collection and develop the appropriate units of analysis (Dubé & Paré, 2003). Further, it also assists the researcher to better conduct the case studies by highlighting any possible ambiguities and limitations in the research design and data collection method (Dikko, 2016; Lancaster, 2015). Since the relevant literature for lean and ISO 14001 implementation as a combined approach is limited, this initial study was used for increasing the credibility of the main study, improving the capacity of the researcher to conduct the main study and reducing issues (ethical and practical) (Kim, 2011; Precott & Soeken, 1989).

Kim (2011) suggested that through a preliminary study, qualitative investigators can focus on expanding or narrowing their proposed research topic and the focus of the topic can also be conceptualised clearly. Further, the preliminary study was utilised for preparing interviews and developing observation techniques for qualitative research by a novice researcher. The preliminary study for this research had significant importance in producing insights from lean and ISO 14001 consultants to evaluate lean and ISO 14001 implementation as a combined approach for improving environmental performance. Semi-structured interviews were conducted with the consultants as these individuals are multi-skilled and have diversified knowledge in executing lean and ISO 14001 projects in the meat industry. These were further used to enhance the credibility (validity

and reliability) of the research instrument (semi-structured interviews) for collecting data in the main study (Dikko, 2016). Additionally, it allowed the researcher to determine the suitability of the interview schedule and evaluate the ability of the interview questions to explain the lean and ISO 14001 implementation phenomenon (Gill, Stewart, Treasure, & Chadwick, 2008).

3.3.2 Main study

The main study was conducted in three meat processing organisations (two from NZ and one from Ireland) to evaluate lean and ISO 14001 implementation strategies as a combined approach. The case study was used as a framework for collecting and analysing data in this study. Yin (2014) defined three steps – case definition, selection of cases and utilisation of theory – for implementing a case study design in qualitative research. The implementation of lean and ISO 14001 strategies together for better environmental performance is defined as a case in this study since both approaches are mentioned as phenomenon in the research questions. The competencies and capabilities of the NRBV have been utilised as the theoretical grounding for achieving analytical generalisation for this study (the third postulate of a case study design). The case study method is particularly useful in circumstances where contextual situations of the event being examined are critical (environmental performance is considered a critical phenomenon in the meat processing facilities) and where the investigator has no control over the proceedings as they are revealed (Yin, 2014).

A multi-case study (two meat groups from NZ and one group from Ireland) design was selected to evaluate the lean and ISO 14001 implementation phenomenon for improving environmental performance. A single case can produce sufficient and rich information; however, three case studies produce appropriate grounds for theory building in this study (Eisenhardt, 1989). Further, a multi-case study design allowed for exploring the differences within and between the cases. Qualitative research does not anticipate verification of a hypothesis, but the multi-case study method has a profound ability to describe, analyse and interpret the constructive facets of the social world (Tavallaei & Talib, 2010). The evidence generated from three case studies is considered compelling, robust and reliable to encapsulate the informants' knowledge for generating theories from their recommendations on lean and ISO 14001 implementation in the meat industry (Baxter & Jack, 2010). Furthermore, the credibility of the data and external validation are enhanced by using multiple data sources (Dubé & Paré, 2003). In-depth empirical data were collected from

three meat processing companies who are in the mature phase (three years of implementation experience) of implementing lean and ISO 14001. The findings from the three case studies are used to examine and compare the lean and ISO 14001 implementation in NZ and the Irish meat processing organisation as well as determine the main factors for implementing lean and ISO 14001 together for improving environmental performance.

The replication logic in qualitative study is used to determine whether the results of a case study are reproduced to generalise theory and build comprehensive research knowledge (Bergen & While, 2000; Bettis, Helfat, & Shaver, 2016). There are two forms of replication – literal and theoretical. The literal replication causes predicting similar results and the theoretical replication forecasts contrasting results with predicted reasons (Yin, 2014). According to Yin (2014), a few cases (2 or 3) as a guideline for conducting the multiple case study design can help to predict similar outcomes (literal replication). Further, Mintzberg’s advice is “no matter how small our sample or what our interest, we have always tried to go into organisations with a well-defined focus” (Mintzberg, 1979, p. 585). Further, Yin (2014) has stated that more than two cases help produce a stronger effect in conducting the case studies. The number of cases selected in this qualitative inquiry is three considering the recommendations, the breadth and depth of the current study and use of the literal replication logic in the multi-case studies.

3.4 Sampling strategy

Selecting an appropriate sample is a critical aspect of collecting data, analysing the findings and ensuring the validity when conducting a qualitative investigation. The selection criteria of each case study in multi-case design is critical “so that it either, (a) predicts similar results (literal replication) or (b) predicts contrasting but for predictable reasons (a theoretical replication)” (Yin, 2014, p. 47). Multi-case studies are focused on replication logic which is appropriate for the current research to create and verify new interpretations (analytical generalisation) (Ridder, 2017). The literal replication perspective for this study is further explained under research quality (see section 3.5). Three research questions, a theoretical framework for implementing lean and ISO 14001 together, rich information through semi-structured interviews for ensuring analytical generalisation, reliable information for explaining the lean and ISO 14001 implementation phenomenon, ethical considerations and assessment of benefits and risks, and a comprehensive sampling plan are the main attributes of the sampling strategy (Miles & Huberman, 1994).

A purposeful sampling approach is considered an appropriate technique for identifying and selecting skilled lean and ISO 14001 consultants and information-rich cases (informants from three cases) as the lean and ISO 14001 implementation phenomenon has rarely been investigated for improving environmental performance in the meat industry. The samples are normally small in qualitative investigation, they are evaluated largely and produce abundant information (Curtis, Gesler, Smith, & Washburn, 2000). Further, the snowball sample based on the recommendation by knowledgeable people is a suitable strategy for the selection of informants to conduct the cases (Creswell, 2014; Patton, 2002; Ridder, 2017). The three cases of this study have been referred by lean and ISO 14001 consultants interviewed during the preliminary study who were the most knowledgeable individuals with intensive implementation experience of lean and ISO 14001 projects in the meat industry.

Seven consultants from lean and ISO 14001 implementation firms were selected in the preliminary study. The inclusion criteria for the consultants in the preliminary study were (1) being an expert in lean or ISO 14001 implementation and (2) having at least three years' experience of lean and/or ISO 14001 implementation in the meat industry, as depicted in Table 3.3.

Table 3.3: Criteria for selecting lean and ISO 14001 consultants

SN	Criteria for selecting lean and ISO 14001 consultants
1	All seven consultants must belong to the meat processing industry
2	All seven consultants must have implemented lean and/or ISO 14001 for at least three years

On the other hand, multi-case studies have been conducted in two NZ and one Irish meat processing organisation to achieve the objectives of understanding how lean and ISO 14001 are successfully implemented for improving environmental performance. Data collection in a case study is the main significant process which affects the contingent (richness and in-depth) information (Njie & Asimiran, 2014). The predetermined criteria for selecting cases in this study are: (a) all three cases must belong to the meat industry, (b) all three case must have implemented lean and ISO 14001 strategies for at least three years, and (c) all informants must have three years of in-depth knowledge and experience in implementing lean and ISO 14001, as depicted in Table 3.4.

Table 3.4: Criteria for case selection

SN	Criteria for case selection
1	All three cases must belong to the meat processing industry
2	All three must have implemented lean and ISO 14001 for at least three years
3	All the informants must have implemented lean and ISO 14001 for at least three years

The shared conditions of the same industry (meat manufacturing) helped in comparing the findings and controlling the environmental variations in this study. Further, the same setting and conditions as indicated in the description of criteria for case selection helped to achieve literal replication; however, slight variations in outcomes of the findings are also anticipated within each case. The human resource department was contacted to suggest suitable informants from processing departments with a minimum of 3 years' experience of lean and ISO 14001 implementation. Informants were selected based on their competence, experience and knowledge for implementation of lean and ISO 14001 to achieve rigour and validity in the case study approach.

The specification of this population (an informant with at least three years' experience in implementation of lean or/and ISO 14001) reduced extraneous variation and clarified the domain of the empirical findings from the meat processing facilities (representing a specific type of environment). The findings from the three case studies are likely to extend or replicate the evolving theory relating to lean and ISO 14001 implementation for improving environmental performance. The nineteen most relevant informants based on their experience in implementing lean and ISO 14001 were suggested for collecting primary data from the meat industry. In-depth semi-structured interviews were conducted with six informants in the first case organisation, seven informants in the second case and six informants in the third case in the main study for exploring the lean and ISO 14001 implementation for improving environmental performance. The selection of the above informants for conducting the main study was based on their in-depth knowledge, skills and participation in implementing lean and ISO 14001 projects in the meat facilities.

The set criteria (informants from the meat industry, experience of the informants and maturity of implementation of lean or/and ISO 14001) may demonstrate literal replication, reduce cross-variations and provide rich comparative analysis. The predetermined criteria may pose a challenge in selecting appropriate informants; however, the empirical findings were strengthened through common emergent trends in explaining the phenomenon (e.g., lean and ISO 14001 implementation) by providing insights, unique experiences and events (Patton, 2002).

3.5 Preparation for data collection and skills development of the researcher

Skills development and training of the researcher are considered prerequisite requirements before conducting a case study. The development of skills and training initiatives for enhancing the

competence of the researcher to conduct the case studies are described in detail in the following sections.

3.5.1 Skills development of the researcher

Desired skills and personal traits of the researcher (i.e., intellect, knowledge, ego and emotions) played an essential role in conducting a case study (non-standardised approach). A knowledgeable and well-trained researcher collected and analysed the qualitative data for evaluating the lean and ISO 14001 phenomenon for improving environmental performance. Further, the ability of the researcher is critical to understand the phenomenon and ask appropriate questions in comprehending the theoretical considerations and collecting precise information in this qualitative investigation. A literature review, interview questions (Appendix D), the outcomes of the preliminary (Chapter 4) study and publications (Ahmed & Mathrani, 2023; Ahmed, Mathrani, & Jayamaha, 2020; Ahmed, Mathrani, & Jayamaha, 2021), as well as formal and informal meetings with supervisors and practitioners (from NZ and Irish meat processing organisations) helped the researcher to better understand the lean and ISO 14001 phenomenon.

The interviews were semi-structured and followed a formal plan for collecting qualitative primary data in this study. The constant interactions of the researcher with the supervisors, colleagues and practitioners from the meat industry helped to control the personal bias of the researcher in this study. Further, effective listening is a prominent skill of the researcher to ensure accurate observation, interpretation of the information received, expression and assimilation of the qualitative findings by avoiding potential bias and discarding or elucidating vague information. The semi-structured interviews were audio recorded (Zoom meetings), notes were taken and probing questions were also asked in collecting precise information. Furthermore, flexibility and adaptiveness of the researcher are essential in handling situations and mitigating unexpected changes to follow the research procedures and plan for collecting accurate qualitative data. The researcher faced difficulties during the unexpected Covid-19 pandemic on the global stage. Sometimes, the interviews were rescheduled due to the busy schedule of the informants and lockdown situations in NZ and Ireland.

3.5.2 Training and preparation for this study

Training and preparation for a researcher is a crucial aspect in conducting a specific study (Yin, 2014). Training programmes, doctoral consortia and international conferences are important tools

to help design a case study, read on the subject matter and solve issues in conducting a specific investigation from the start of the research study. The researcher presented and discussed the conceptual framework (Ahmed & Mathrani, 2019) at the International Conference on Information Resource Management, Auckland in the formative stage. The detailed proposal for conducting the current investigation was reviewed by a senior academic committee; that led to transition from provisional registration to full registration.

The researcher presented papers at different international conferences during the various stages of the study (Ahmed & Mathrani, 2019; Ahmed & Mathrani, 2021; Ahmed et al., 2020). Further, the researcher attended a doctoral consortium (50th Annual Conference of the Decision Sciences Institute, New Orleans, USA) to discuss and review the study. Further, the researcher also attended (online) the New Zealand Universities Joint PhD course: Making a Theoretical Contribution, held by University of Waikato and Victoria University of Wellington. Participation in conferences, a doctoral consortium and a joint PhD course helped in improving the research design, ensuring clarity on the subject and bringing more focus on lean and ISO 14001 implementation phenomenon.

3.6 Data collection method

Robust data collection is considered a critical technique for producing rich insights and descriptions in exploring the combined lean and ISO 14001 implementation phenomenon for improving environmental performance (Bowen, 2009; Yin, 2014). The interview is considered an instrumental, powerful and logical method for collecting detailed and in-depth information in exploratory qualitative research (Schultze & Avital, 2011). Further, interviews are conducted for collecting data based on knowledge, beliefs, values, and experience of the informants. Interviews were used as an appropriate approach for collecting data to evaluate lean and ISO 14001 implementation strategy as a combined approach for improving environmental performance. There are three main types of interviews: (a) open-ended, (b) structured, and (c) semi-structured (Dikko, 2016). In open-ended (unstructured) interviews, there is no planned structure of questions for investigating the facts and opinions. The findings from unstructured interviews are considered to lack stability and reliability. Further, structured interviews are usually based on a delineated list of questions and permit the informants minimum deviation in explaining the study phenomenon (Dikko, 2016; Yin, 2014). Structured interviews are mostly used in quantitative research (Yin,

2014). On the other hand, semi-structured interviews are suitable for conducting case studies (Hancock & Algozzine, 2006) for explaining the lean and ISO 14001 implementation phenomenon same industry. Additionally, semi-structured interviews provide a flexible and non-standard approach based on a list of questions (Dikko, 2016).

Semi-structured interviews are particularly suitable for the preliminary and main study in gaining in-depth insights from the relevant informants on lean and ISO 14001 implementation phenomenon. Further, they provide a primary source of data to offer flexibility in explaining lean and ISO 14001 implementation phenomenon systematically. The semi-structured (non-standard) interview format consists of key questions on the current study phenomenon and allows the researcher or informants to diverge (Gill et al., 2008) in order to explain the lean and ISO 14001 implementation strategies together for improving environmental performance in detail. Interview probes were also utilised for obtaining more clarity, removing confusion and retrieving better quality information from the informants.

An interview protocol (rules and guidelines) was developed to provide flexible pre and post interview guidelines and set the interview questions for conducting interviews systematically in the preliminary and main study (Dikko, 2016). The Massey University ethics approval letter and information sheet (Appendices A and B) were sent (via email) to the informants in both stages (preliminary and main study) before conducting the interviews. The interview questions (Appendix D) were sent (via email) to the informants after receiving the initial confirmation from the informants to participate in the study. The information sheet (Appendix B) and interview questions (Appendix D) for the preliminary and main study were developed as part of the study protocol. Further, the informants were also requested to confirm their agreement to participate in the study by signing a consent form (Appendix C) before the start of the interview.

The details of the informants in the preliminary study are provided (for more detail, see section 4.2.2, sample for preliminary study). Further, the details of the nineteen informants (positions and role descriptions), total duration of interviews and mode of conducting interviews from cases are described and explained in the case study settings of Alpha, Beta and Gamma respectively (for more detail, see sections 5.2, 6.2 and 7.2). Semi-structured interviews were conducted in the preliminary study (seven interviews with consultants) and main study (nineteen interviews with

senior executives) for collecting the views of the informants on the lean and ISO 14001 implementation for improving environmental performance phenomenon.

The interviews were recorded by digital audio recording via Zoom meeting (with the permission of the informants) to enhance the reliability and trustworthiness of interview data. The interviews were based on pre-decided questions that lasted between 45 to 90 minutes in this study. The interviews were transcribed (via voice recognition software Otter.ai) and shown to each informant for confirmation. Further, the informants were also contacted successively to ask follow up questions for validation of the interviews, getting feedback on the interview transcripts and obtaining more clarification on the study phenomenon. Publicly available documents as secondary data (i.e., environmental management manual, organisational reports on environmental sustainability and web sites of the organisation) were reviewed to gain in-depth insight on the lean and ISO 14001 implementation phenomenon. Semi-structured interviews (the preliminary and main studies) and secondary data were utilised for enhancing the quality and rigour of the current study (for more detail, see the research quality section). Figure 3.1 represents the research onion model suggested by Saunders, Lewis, and Thornhill (2012) for this current investigation including the research paradigm (e.g., post-positivism), research approach (e.g., inductive) and method (e.g., qualitative), research strategy (e.g., case study) and time horizon (e.g., cross-sectional), and data collection method (semi-structured interviews) as discussed in the above sections.

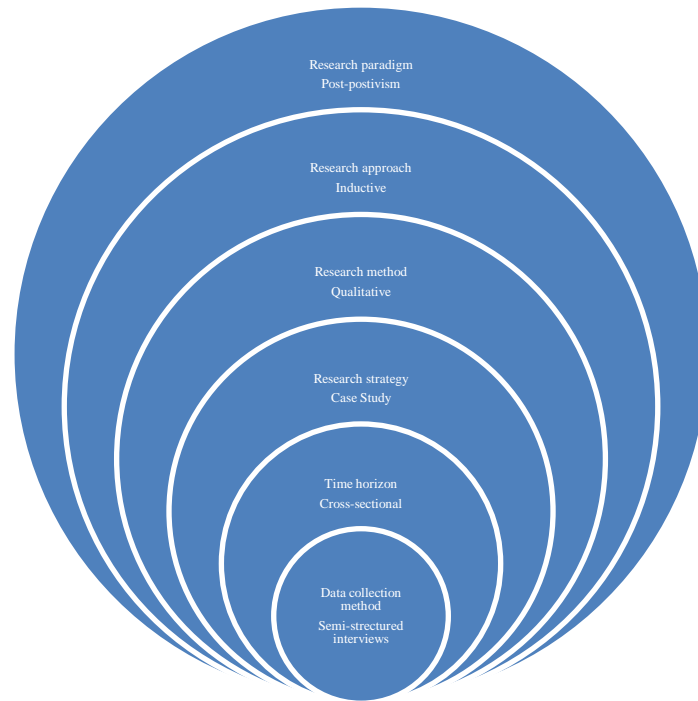


Figure 3.1: Research onion adapted from Saunders et al. (2012)

3.7 Data analysis techniques

The purpose of data analysis is to prepare, transcribe and shape data for understanding the lean and ISO 14001 implementation strategies as a combined phenomenon in this study (Vaismoradi et al., 2013). Further, analysis of qualitative data is used to develop a sense of the data by scrutinising, evaluating and interpreting data from various sources (semi-structured interviews and secondary data) for understanding lean and ISO 14001 implementation phenomenon (Guba, 1981; Morse, Barrett, Mayan, Olson, & Spiers, 2002). The qualitative data analysis is used for reduction of data, displaying output, verification and drawing conclusions. After analysing the data, the analytical categories are formulated based on inductive approach. Abundant textual (descriptive, interpretation-based and diverse) data is produced in qualitative research. Thematic analysis is considered a suitable method of data analysis to identify, analyse and interpret the qualitative data patterns in this study (Bowen, 2009; Marshall, 1996). The thematic analysis a suitable method for analysing qualitative data has been conducted based on stages suggested by Braun and Clark (2006). The interview data were digitally transcribed and reviewed various times to identify the concepts, meanings, and emergent patterns from the data (e.g., primary and

secondary) through thematic analysis which helped in understanding the lean and ISO 14001 implementation phenomenon for achieving environmental performance.

Within-case analyses were conducted as described in chapters 6, 7 and 8 to identify the emergent patterns from the NZ and Irish case studies. Further, a cross-case analysis was used to identify the similarities and differences across the three cases. The salient steps for analysing qualitative research were as follows: (1) organising and transcribing data, (2) exploring data and developing codes, (3) describing and developing themes, (4) representing, displaying and reporting findings, and (5) interpreting findings (Creswell, 2014; Eisenhardt, 1989). Semi-structured interviews were transcribed via real-time transcription software (Otter.ai) and organised by sorting and arranging the qualitative data for understanding successful lean and ISO 14001 implementation as a combined approach to improve environmental performance.

A manual coding process was utilised to generate different codes to analyse the successful lean and ISO 14001 implementation strategies as a combined approach. Codes were used to develop main themes and sub-themes (description and thematic development) for answering the research questions and gaining in-depth knowledge of the central lean and ISO 14001 phenomenon, complementarity of both approaches and success factors of lean and ISO 14001 implementation. Furthermore, analysis of semi-structured interviews and secondary data helped uncover the correlations between the findings, and the competencies and capabilities of the NRBV theory. The researcher performed comprehensive qualitative analysis (within-case and cross-case analysis) for generating concepts and themes (categories and sub-categories) to explain the lean and ISO 14001 implementation phenomenon for improving environmental performance.

Within-case analysis helped the researcher to discover the unique patterns of each case and provide familiarity with the data of each case to conduct cross-case analysis. However, within-case methods (individual analysis of findings from each organisation) are less effective in developing generalisations for implementing lean and ISO 14001 experiences drawn from the multi-case studies (Ayres, Kavanaugh, & Knafl, 2003). On the other hand, cross-case analyses based on multi-case studies were performed for generating concepts (categories and sub-categories) across the three case studies (Yin, 2014). The categories are developed by comparing concepts to relate to a similar phenomenon. For instance, codes were used to develop the main themes (i.e., emission control category) based on sub-themes (i.e., reduction of PM₁₀, heat losses and GHG emissions)

in explaining lean tools implementation (see Table 8.6) based on a priori specification of constructs. Furthermore, through thematic analyses of the three case studies, several first-order codes were developed (i.e., top management commitment) and categorised into second-order themes (i.e., developing policy and availability of resources) for explaining the CSFs of lean and ISO 14001 implementation – leading to the fourth unit of analysis under the current study. An overall case analysis is offered according to within-case and cross-case analysis for evaluating the study phenomenon in each of the cases and reviewing replication logic (Yin, 2014) which led to the development of lean and ISO 14001 implementation models for achieving environmental performance.

3.8 Reporting

The empirical findings from the preliminary and main study (three case studies) were reported in the narrative descriptions and tabular presentations in this study. Identification of report audience, structural composition and composing the case study are considered as fundamental requirements for composing the case study report (Yin, 2014). Firstly, academic scholars, lean and ISO 14001 experts, corporate managers from meat industry and policymakers were identified as potential audience for presenting the findings of this study. Secondly, structural composition for reporting the case study was developed based on the initial case design along with its components. Thirdly, reporting of the case study was begun at the start to bring clarity into the following parameters: (1) research findings, (2) analysis of empirical findings, (3) resolution of issues, (4) monitoring of tasks, and (5) timely completion of the study.

3.9 Research quality

The research quality of this study is evaluated by determining the validity and reliability for ensuring rigour of the research findings (Morse et al., 2002; Ridder, 2017). It is highly important to pay attention to the validity and reliability in case study investigations. The quality of case study investigation design is evaluated by conducting four tests: (a) construct validity, (b) internal validity, (c) external validity, and (d) reliability (Yin, 2014). The validation process is considered the main method to ensure credibility or accuracy of the research findings in determining the research quality (Creswell, 2012).

The triangulation principle is used to reinforce the construct validity of the research in case study design (Thurmond, 2001). The types of triangulation are a combination of two or more of the

following: data sources, methodological strategies, investigators, and theoretical perspective. In the data triangulation, data is collected from multiple sources (i.e., people, groups and communities) (Dubé & Paré, 2003; Mathison, 1988). Data triangulation was achieved in this study by collecting data from multiple sources through semi-structured interviews via a preliminary study (seven consultants of lean and ISO 14001) and multi-case studies (senior executives). Further, methodological triangulation was achieved through data collection using different methods (Mathison, 1988; Thurmond, 2001). The methodological triangulation was established by comparing data from different sources such as the preliminary study (semi-structured interviews, journal logs and field logs) and multi-case studies (semi-structured interviews, environmental manuals and sustainability reports) and literature. Furthermore, theoretical triangulation is obtained by using more than one theoretical perspective or hypothesis to examine a phenomenon (Thurmond, 2001). Two theoretical perspectives of the NRBV (competencies and capabilities) were used to explore the lean and ISO 14001 implementation strategies for improving environmental performance in the meat industry. The validity and reliability for this study is maintained through triangulation methods (data and methodological triangulation). Further, the records of the case study (semi-structured interviews of the preliminary and main study), organisational documents and archival records of lean and ISO 14001 implementation were maintained as a logical chain of evidence to ensure construct validity (Dubé & Paré, 2003). The case study database is maintained to retrieve and trace the specific information of the semi-structured interviews for external reviewers (if the informants of this study asked for review).

Internal validity is an essential parameter in determining causal relationships and developing interferences that one event led to another in a research study. However, a qualitative case study investigation does not determine a causal relationship of variables in explaining internal validity. Pattern matching, explanation building and a logical model are used to determine the internal validity in this study. The pattern-matching strategy is suitable for achieving internal validity in this study by comparing the findings of three case studies. Cross-case analysis of three case studies was utilised for verifying themes, trends and patterns to achieve pattern matching. Further, pattern matching is used to compare themes based on the empirical findings with predicted patterns identified in the theoretical framework based on an intensive literature review. The logical model of the current study is the theoretical model of lean and ISO 14001 implementation as a combined approach for improving environmental performance.

External validity is used to generalise the outcomes of the case study analytically to other situations that were not a fundamental part of the original research study. The current study adopted multi-case studies (cross-case analysis) to achieve replication logic in attaining analytical generalisation for developing external validity. The multiple case studies exploring the lean and ISO 14001 phenomenon have more external generalisability than a single case study. The results of empirical findings of three cases (two cases from NZ and one case from Ireland) are compared (cross-case analysis) for generalising a theory and achieving literal replication. Within-case analysis (as evident in chapters 5, 6 and 7) was conducted before conducting cross-case analysis for achieving replication logic in this study. Further, thinking theoretically is a critical aspect to validate and generalise the empirical data of the current qualitative research. Emerging ideas from the already collected data are reconfirmed with the new data by proactively checking and rechecking without making cognitive leaps to build a solid theoretical perspective (through thinking theoretically) (Morse et al., 2002). Soundness of case study – criteria for research quality, tactic employed and occurrence phase is presented in Table 3.5.

Table 3.5: Criteria for research quality, adapted from Yin (2014)

Criteria for research quality	Tactic employed	Occurrence phase
Construct validity	<ul style="list-style-type: none"> • Priori specification of constructs usage • Multiple interviews in a case study • Multiple sources of evidence • Chain of evidence 	<ul style="list-style-type: none"> • Data collection • Data analysis
Internal validity	<ul style="list-style-type: none"> • Theoretical framework • Pattern matching • Theoretical triangulation 	<ul style="list-style-type: none"> • Case selection • Data collection • Data analysis
External validity	<ul style="list-style-type: none"> • Clear sampling criteria • Descriptions of multiple cases by tables • Replication logic 	<ul style="list-style-type: none"> • Case selection • Case analysis
Reliability	<ul style="list-style-type: none"> • Case study protocol • Purposeful sampling (snowball sampling) • Case study database 	<ul style="list-style-type: none"> • Case selection • Data collection • Data analysis

Case study protocol is considered as comprehensive guidelines to demonstrate interview questions and procedures for conducting the research (Yin, 2012). This is a fundamental prerequisite for conducting the case study. It is a key method to guide the researcher in collecting and analysing reliable empirical data. The case study protocol for this study is presented in Table 3.6.

Table 3.6: Case study protocol for this study

Components	Description
Organisation	Three meat processing companies (2 NZ and 1 Ireland based organisation) with at least 3 years' experience of lean and ISO 14001 implementation.
Units of analysis	<ul style="list-style-type: none"> • Environmental performance and waste reduction outcomes • Lean practices and ISO 14001 procedures implemented for environmental performance • How lean and ISO 14001 complement each other for environmental performance. • CSFs for a combined lean and ISO 14001 approach for environmental performance.
Purpose	The purpose of this study is to investigate the lean and ISO 14001 implementation strategies as a combined approach, the potential synergies between these management initiatives and CSFs for implementing lean and ISO 14001 together for improving environmental performance in the meat industry.
Timeframe	<ul style="list-style-type: none"> • First case study (approximately 7 months) • Second case study (approximately 5 months) • Third case study (approximately 3 months)
Data source	<ul style="list-style-type: none"> • Semi-structured interviews with lean and ISO 14001 consultants • Semi-structured interviews with senior executives • Organisational documents • Archival records
Internal validity	<ul style="list-style-type: none"> • Pattern matching • Explanation building • Theoretical model
Construct validity	<ul style="list-style-type: none"> • Available recoded data from interviews • Organisational documents • Archival records
External validity	<ul style="list-style-type: none"> • Replication logic by cross-case analysis
Key questions	<ul style="list-style-type: none"> • How do lean and ISO 14001 implementation strategies as a combined approach contribute to environmental performance in the meat industry? • How can lean and ISO 14001 strategies be implemented together in the meat industry and how do these strategies complement each other for improving environmental performance? • What are the critical success factors for implementing lean and ISO 14001 as a combined approach in the meat industry?

3.10 Ethical considerations

This study was evaluated by peer review and judged to be a low risk. Further, the preliminary study and main study did not require any confidential or personal information from the lean/ISO 14001 consultants and informants of the case studies. Therefore, a low-risk notification was sought from the Massey University Human Ethics Committee before the commencement of this research. The researcher communicated to the informants that they could contact the Massey University Human Ethics Committee if they had any concerns about the conduct of the study. However, the informants did not report any concerns.

The informants were notified via email about all relevant information of the study such as the research topic, the aim of the study, nature and type of the interview and details of the low-risk notification. Further, the informants were clearly informed about the estimated time for participating in the interview and asked permission to digitally record the interview. The written consent of the informants was obtained at the start of the interview. The interviews were recorded

by a digital audio recording device with permission from the study informants. The confidentiality and anonymity of the organisations and informants were maintained during the interviews, analysis and writing-up of results. Written consent from the informants with their signature was obtained prior to the interviews.

3.11 The sequence of the research design

The sequence of the research design summarising the different stages of qualitative preliminary and multi-case study methods and procedures is depicted in Figure 3.2.

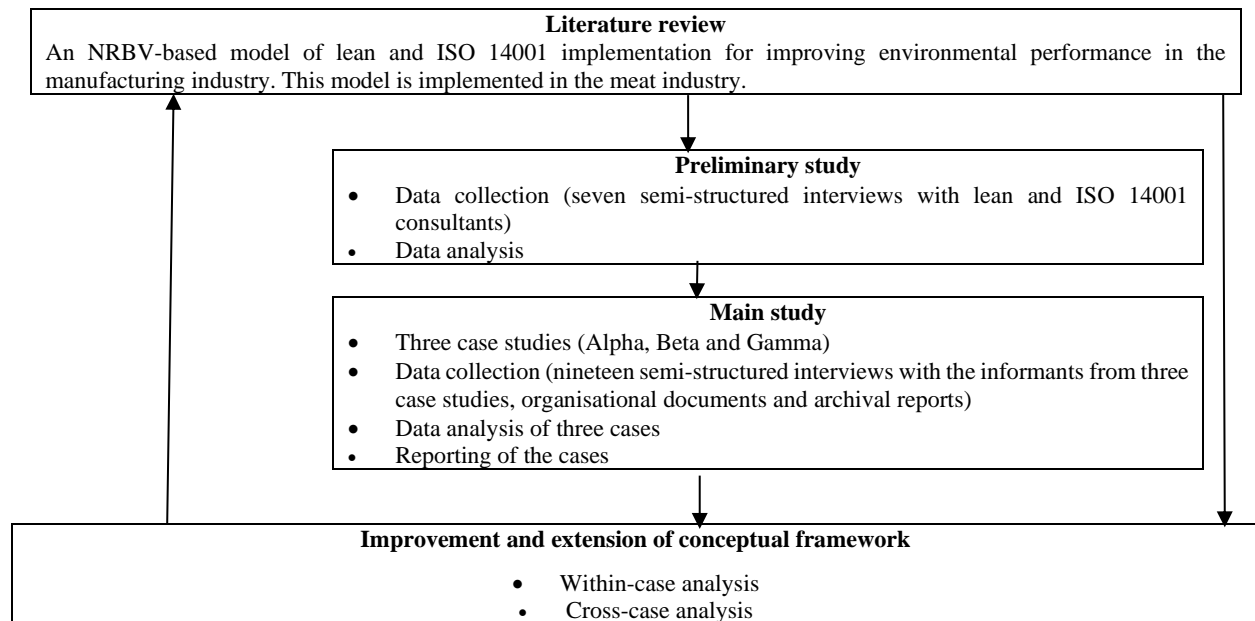


Figure 3.2: Qualitative (preliminary study and multi-case study) research design

3.12 Conclusion

This chapter described the comprehensive strategy and methodology for the research. A qualitative (preliminary and multi-case study) methodology is employed for evaluating the environmental performance in the meat industry through the application of lean and ISO 14001 strategies. A model of lean and ISO 14001 implementation is used to conduct the study. The selection of research method, sample size, and unit of analysis as well as reliability and validation of the research through the triangulation process have been presented.

Chapter 4 – Preliminary Study

4.1 Introduction

The preliminary study presents and discusses the empirical findings of the interviews conducted with lean and ISO 14001 consultants to gather expert insights on how both these strategies can be implemented in an integrated manner for environmental performance in the meat industry. During the interviews, the lean and ISO 14001 consultants share their experience and knowledge about the implementation of both management strategies and identify the appropriate critical success factors for implementing these strategies in the meat industry. The extensive experience, knowledge and skills of the lean and ISO 14001 consultants offer new insight in understanding the effective implementation of lean and ISO 14001, increasing the practical application of these strategies in an organisational context. Further, these viewpoints will also help the practitioners in reducing environmental waste at their workplaces and the success factors will assist in better execution of lean and ISO 14001 strategies.

The remaining chapter is structured as follows: Section 4.2 presents the research design, sample and process for data collection and the analysis and evaluation of the preliminary data. Section 4.3 provides the research findings for environmental waste reduction by implementing lean and ISO 14001 as an integrated approach. Section 4.4 presents the empirical findings for evaluating the main constructs of an integrated model of lean and ISO 14001. Section 4.5 explains the critical success factors for implementing lean and ISO 14001 in the meat industry. Section 4.6 discusses the findings for environmental waste reduction, implementing lean and ISO 14001 as an integrated approach and the critical success factors for this approach. Finally, section 4.7 presents the concluding remarks of the preliminary study.

4.2 Methodology

4.2.1 Research design for preliminary study

A preliminary study was conducted with lean and ISO 14001 consultants, who were specialists in these fields, to gain knowledge and understand their perspective on the benefits of a joint implementation of these strategies on environmental performance. The preliminary study was also used for refining the process of data collection (content and procedure for collecting the data) (Yin, 2014).

The NRBV-based model of lean and ISO 14001 implementation for environmental performance Figure 2.4 has been used as a guide for an empirical investigation. The major aspects of the research context such as a detailed description of the informants, data collection method, data collection periods, duration of interviews, analysis and evaluation of data are explained in the following sections.

4.2.2 Sample for preliminary study

Semi-structured interviews were conducted with lean and ISO 14001 consultants specific to the meat industry for collecting the primary data. The semi-structured interviews were conducted between March and July 2020 with managing directors, managers and senior consultants in the most prominent NZ consulting firms as shown in Table 4.1.

Table 4.1: Key informants of the preliminary study

Informant ID	Description	Years
Lean-ISO1	Managing director who has experience in both lean and ISO 14001 domains	10
Lean-ISO2	Managing director who has experience in both lean and ISO 14001 domains	6
Lean-ISO3	Lean and quality development consultant	7
Lean-1	Senior lean consultant	11
Lean-2	Director and lean manufacturing specialist	18
ISO-1	Environmental system management (ISO 14001) lead auditor	8
ISO-2	Technical manager on management systems	10

4.2.3 Process

The formal data collection process was started by the initial contacts made with the lean and ISO 14001 consultants in the meat industry. This was carried out through email requests sent to informants to participate in the preliminary study. The introductory email providing the information of the study and a request for participating in the interviews was sent to the informants. When the informants confirmed their participation, the research information sheet and interview questions (included in Appendices B and D) were shared with the informants. The informants were also requested to sign the consent form (included in Appendix C) for further confirmation to participate in the study before starting the formal interview. The interviews were based on pre-decided questions that lasted between 45 to 90 minutes with the lean and ISO 14001 consultants.

4.2.4 Analysis and evaluation

Relevant data were collected in an environmental performance context based on the constructs of the proposed conceptual model (Figure 2.4) and the critical success factors for implementing lean and ISO 14001 in the meat industry. The thematic analysis has been conducted to classify and

summaries the fresh insights of the preliminary study informants according to the phases suggested by Braun and Clarke (2006). The interviews were digitally recorded and subsequently transcribed by using the match transcription technique. The transcriptions of the interviews were reviewed numerous times for pulling out the meanings, concepts, meanings and emerging patterns which helped in understanding the phenomenon (e.g., implementation of lean and ISO 14001 together for improving environmental performance). The manual process was followed to analyse lean and ISO 14001 implementation as a combined approach and evaluating CSFs of both strategies together. This process was utilised for developing codes, trends and themes based on the empirical findings to present the study results. These codes were classified into main themes and sub-themes which were evaluated and refined to confirm their validity emerged from the entire data set. Various names were assigned to themes. Through the thematic analysis, various first-order codes were formulated and categorized into second-order themes under the main dimensions of successful lean and ISO 14001 implementation as a combined approach.

4.3 Environmental performance and waste reduction outcomes by implementing lean and ISO 14001

The findings of this preliminary study reveal that the implementation of an integrated lean and ISO 14001 approach much contributes to reducing the wastewater generation, optimising packaging materials and minimising organic waste in the meat industry. Lean and ISO 14001 consultants explained that both strategies help to improve operational (reduction of wastewater and organic waste) and environmental (mitigation of air pollution for instance minimisation of nitrogen and sulphur dioxides) performance by implementing an EMS framework and developing a waste reduction culture in the meat industry. Further, the overall financial gains for the companies through cost reduction in operational activities and for internal stakeholders (via appraisals and rewards) are considered as additional benefits after adopting lean and ISO 14001 approaches.

Lean-2 revealed that lean provides tools and ISO 14001 framework for developing an improvement programme in which a meat processing facility can minimise operational and environmental wastes. Various requirements and procedures of ISO 14001 such as operational control, communication, awareness and training, audit and improvement initiatives can be incorporated into a lean tools/technique for continual improvement. Lean-ISO3 explained that ISO 14001 provides a framework for standardising processes and lean helps to create a culture of waste elimination by implementing lean tools. Lean and ISO 14001 as a combined approach can be used

for better reducing operational and environmental waste in meat processing in the following sequence: (a) by identifying all kinds of wastes through monitoring and reviewing of the current indicators in the value stream processes and (b) by proposing and implementing future improvement performance initiatives. Lean-ISO2 elaborated that ISO 14001 provides a framework and guidelines to develop an EMS, while the application of lean tools provides a standardised approach for continual waste minimisation.

Both lean and ISO 14001 adopt a risk-based approach in identifying risks as well as opportunities through the PDCA cycle for continual improvement. Lean-ISO1 emphasised that a business organisation should focus on the biggest gains, risks and opportunities through a risk-based thinking while implementing lean and ISO 14001. Additionally, the consultant explained that ISO 14001 has adopted the plan-do-check-act (PDCA) philosophy from the lean strategy for continual improvement. Lean is used to identify the process improvement opportunities and procedures of ISO 14001 that would help to achieve operational excellence. Procedures of ISO 14001 such as identification of objectives and targets, management reviews, assessment of non-conformities, introduction and evaluation of corrective actions implemented through internal audit programme help maintain the lean processes.

Lean achieves a cycle of continual improvements, while ISO 14001 is implemented as a standardised process improvement strategy in developing an EMS framework for reducing the operational and environmental wastes. Both these strategies are based on the PDCA cycle and used as an improvement programme for optimising resource conservation, reducing environmental non-conformances and effectively utilising energy. Lean-ISO1 further elaborated that the waste minimisation process sustains the operational excellence requirement by applying lean and ISO 14001 through the PDCA cycle approach:

Lean and ISO 14001 management initiatives are based on PDCA's cycle for continual improvement by minimising the waste. Of-course, ISO 14001 provides a framework for EMS and lean facilitates in providing tools and techniques for standardising operational processes and procedures to manufacture environmentally friendly meat products.

Implementation of lean and ISO 14001 approaches enhance the quality and environmental performance during the meat processing by mitigating pollution (reduction of GHG) and meeting the government regulatory requirements to generate effluents and reduce process waste (organic,

inorganic and wastewater). ISO-2 and Lean-2 suggested that lean and ISO 14001 should be preferably implemented together for better environmental performance. Once the identification of operational or environmental issues is carried out in meat processing and analysed for solution, the lean tools and ISO 14001 based EMS can simultaneously work towards better production of standardised meat products.

Lean-1 and Lean-ISO2 explained that the implementation benefits of lean and ISO 14001 approaches are not limited to environmental (i.e., reduction of GHG emissions) and waste (i.e., wastewater, suspended solids and meat contamination) minimisation but also include the financial stability and satisfaction of all the stakeholders (employees, vendors and customers). Lean and ISO 14001 implementations positively contribute to optimise costs in meat products manufacturing as well as motivating and satisfying the workforce by creating the ability for company managements to reward them financially (e.g., reward and recognition for effectively implementing improvement initiatives). Further, the execution of lean and ISO 14001 to perform processing tasks contributes in (i) reducing environmental issues (by implementing processes to decrease emissions and waste), (ii) increasing profitability (through operational cost savings), (iii) promoting welfare of internal employees (with better facilities and motivation for doing a good job) and (iv) achieving customer satisfaction (by supplying quality and environmentally friendly meat products at lower prices). Lean-1 described the triple-bottom line benefits of lean and ISO 14001 implementation:

All stakeholders will be better off, for instance, by quality meat products to customers, education of the workforce and environmental optimisation when meat facilities apply lean and ISO 14001 strategy together. Meat industry needs to make sure that internal workforce is highly motivated and enjoy coming to work while implementing innovative management initiatives. Additionally, lean and ISO 14001 as a combined approach contributes to triple bottom line benefits; welfare of the stakeholders, waste minimisation (air emission reduction, wastewater mitigation and solid waste elimination) and financial gains to all stakeholders.

Lean-ISO2 suggested that in the presence of an effective lean management system with efficient quality, documentation and environmental policy procedures can help achieve EMS certification as well as evolve into an integrated lean and ISO 14001 system easily. Further, lean tools and ISO 14001 procedures can be integrated as a combined system by maintaining the following

procedures: (1) standardising the meat processes, (2) establishing documentation, (3) communication and conducting training programmes and (4) conducting internal audits for monitoring and evaluation. Moreover, Lean-2 explained that ISO 14001 is used for monitoring the compliance requirements by applying EMS procedures and lean is applied as culture of eliminating waste continually. In lean and ISO 14001 as an integrated programme, procedural compliance is determined by ISO 14001 and elimination of operational and environmental waste is carried out by the lean culture. Continuously eliminating waste by the lean behavior and culture becomes normal and implementation of ISO 14001 further improves this process through a joint implementation of these strategies.

Lean-1 noted that an integrated lean and ISO 14001 system becomes complimentary to each other once an organisation starts to apply both strategies together. Implementing lean tools along with ISO 14001 procedures could lead to improved environmental outputs (reduction of wastewater, pollutants and energy consumption), increased cost savings (reduction of penalties for non-compliance and reduction of inventories) and enhanced morale of the workforce (attaining job satisfaction, rewards and appraisal). The transformation of lean and ISO 14001 as a combined strategy is influenced by the competence of the workforce in executing these strategies. As ISO-1 stated:

What I find a challenge with integrated management systems is the competency of the people that are implementing these integrated management systems. If they have an equal competency in lean and ISO 14001, then I'm saying yes, it's going to benefit. But what I find most of the time is that they lean towards one side, either they are more competent under ISO 14001, or more competent under lean and then they favor that one, when they implement the system.

4.4 Implementation of lean and ISO 14001 as a combined approach

The findings of this preliminary study highlighted eight themes that emerged based on the constructs of theoretical model of lean and ISO 14001 (Figure 2.4) through the coding of interview transcripts, revealing a strong relationship between both strategies as a combined approach for sustaining environmental performance in the meat industry.

4.4.1 Integrated lean and ISO 14001 environmental policy

Respondents of this preliminary study have confirmed that lean and ISO 14001 environmental policy is formulated by considering the vision and mission aspects as well as the objectives and targets for reducing operational and environmental wastes. Lean-ISO1 explained that the lean and ISO 14001 policies are like foundational bricks for building a house. If the brick is put in the wrong place or it slightly deviates from where it should be, the entire house could later have quality issues. Therefore, lean and ISO 14001 policies are highlighted as foundational guidelines for establishing the plans, objectives and targets for achieving environmental performance. Lean-ISO1 further elaborated that an integrated lean and ISO 14001 environmental policy can be included as a part of the organisational commitment in implementing the environmental waste reduction objectives. Further, Lean-ISO2 emphasised that an integrated lean and ISO 14001 environmental policy based on SMART (specific, measurable, assignable, realistic and time-related) environmental goals can be utilised in developing a culture for environmental performance. At the operational level in the meat industry, a management system is established by developing the processes and procedures for meat manufacture to achieve the environmental objectives. ISO-1 defined the environmental and waste minimisation policy as follows:

High-level document that guides the effectiveness of that system is the policy. A policy illustrates top management's commitment and their intent: what do they want to achieve in the next twelve months? And this is all very nicely ring-fenced in this environmental and waste reduction policy.

Lean-ISO1, Lean-1 and ISO-1 suggested that the meat industry must have an integrated policy instead of separate lean and ISO 14001 policies for environmental and waste minimisation. Lean-ISO-1 explained that operational productivity and environmental performance can be enhanced by setting coherent environmental and waste minimisation objectives and goals for implementing lean and ISO 14001 as a combined approach. Further, ISO-1 elaborated that an integrated policy can include waste minimisation, emission reduction, water quality improvement and other environmental policies in one overarching policy document for achieving sustainable environmental performance. Lean-1 and Lean-2 have further suggested that the vision and mission of an organisation for environmental waste minimisation must be included in the integrated environmental policy for achieving more clarity in articulating execution.

Lean-1 emphasised that a policy for environmental and waste minimisation must be stemmed out from the values (small virtues) and the strategic plans in order to provide the underpinning support. Further, according to lean-ISO2, 5-Whys and fishbone diagram are basic and well-established lean tools for identifying the root cause of problems which can assist in setting environmental objectives, compliance and continuous improvement processes based on the requirements of ISO 14001. Organisational objectives, goals and targets are comprehensively defined and explained in an integrated environmental waste reduction policy for minimising the environmental aspects. Lean-ISO3 explained that the attributes for an integrated lean and ISO 14001 strategy in achieving environmental and waste reduction impacts are included in the policy:

If a business wants to improve its environmental impacts by minimising waste, they can utilise ISO 14001 and lean to help that. And, if they build it into the policy by saying this is what we want to do, these are our goals, these are our objectives and be able to measure those objectives, then, it will help the overall organisation to achieve the goal of reduction of waste and just be more efficient in those sort of things.

The informants explained that the objectives and targets need to be SMART for executing lean and ISO 14001 as an integrated approach. Further, aligning the SMART objectives with organisational values, strategic plans is instrumental in achieving environmental performance and operational excellence during the different stages of the improvement programme. ISO-1 explained the use of SMART objectives and goals in measuring the environmental performance as follows:

Once you've got the policy, the policy leads to your objectives and the objectives need to be SMART, specific, measurable, attainable, realistic and timely, which is once again very detailed. And that makes it much more measurable, meaning we know what we want to achieve, we can check our results throughout the year.

Lean-2 suggested that lean tools such as A3 thinking and 5S are used in developing an environmental strategy. A3 thinking (a lean tool) is applied to identify environmental problems, while the communication procedure (ISO 14001 procedure) is employed to share the vision for improving the environmental performance. Lean-ISO3 further elaborated that an integrated lean and ISO 14001 policy is included as a part of the organisational commitment and intention in defining and implementing the environmental waste reduction objectives and targets. At the

operational level in the meat industry, a management system is established by placing the processes and procedures for meat manufacture to achieve the environmental goals. Lean-1 further emphasised that the policy based on vision, mission and values must be cascaded down to all levels through an effective communication channel.

4.4.2 Integrated plan and projects of lean and ISO 14001 implementation

Findings of this study reveal that an environmental waste management plan has a strategical importance in implementing lean and ISO 14001 approaches as environmental process improvement projects. Lean-2 elucidated that an environmental waste management plan is used for identifying the KPIs and setting up an action plan to execute environmental process improvement projects. ISO-1 described environmental waste plan as a strategic initiative:

An environmental plan is a list of the environmental waste actions, which should be performed, or what are we going to do? That is our strategic plan and is normally for the next year or two, or if it is long-term, it is for the next three to five years.

Lean-ISO1 suggested that lean based on its continual improvement framework can be used for establishing the environmental waste management plan and executing improvement projects. Further conveyed that by applying ISO 14001, also a continual improvement initiative incorporated with the lean framework, enhances the environmental performance:

Forget about the word lean or ISO 14001 for a bit and let's just call it continuous improvement and therefore, the delivery of value by the elimination of waste. And now within that any waste; resource waste and any loss; environmental loss, meat fat loss can be in a continuous improvement framework.

Environmental improvement projects can be pursued by executing a waste reduction action plan through implementation of lean and ISO 14001. ISO-1 explained that environmental improvement projects help in achieving strategic milestones of an organisation and these projects produce positive outcomes:

A project includes the actual environmental improvement process for execution of these actions, these little milestones for achieving that plan overall. And yes, I definitely believe in having an integration of ISO 14001 and lean, that if you have an integrated plan and an integrated project, which is effectively implemented, you will have effective results.

Moreover, ISO-1 explained that the top managements propose many environmental waste management plans and projects for achieving the desired environmental objectives. During execution of these environmental process improvement projects, internal audits and performance review meetings are carried out to measure the effectiveness of management initiatives and identify the performance gaps. These performance gaps can be minimised by incorporating appropriate changes in the planning and execution phases of environmental process improvement projects.

Objectives and targets set in the planning phase for executing environmental process improvement projects are communicated with the workforce and stakeholders. ISO-2 stressed that a successful implementation of the environmental process improvement project depends on effective staff engagement with the work and efficient management of the communication channel. Moreover, Lean-ISO3 explained that the top management propose many environmental waste management projects for achieving the desired environmental objectives and targets. During execution of these environmental process improvement projects, internal audits and performance review meetings are carried out to measure the effectiveness of management initiatives and identify the performance gaps. These performance gaps can be minimised by incorporating appropriate changes in the planning and execution phases of the environmental process improvement projects.

4.4.3 Communication and information sharing

Communication is an important aspect for implementing an integrated lean and ISO 14001 transformation programme. A comprehensive communication management helps an organisation in maintaining information flow and improving industrial competitiveness. Lean-1 noted that frustration and confusion among the workforce in implementing a combined lean and ISO 14001 approach can be minimised by managing an effective communication system. The top management is responsible for communicating strategic objectives and goals with all stakeholders for transforming lean and ISO 14001 programme. Lean-ISO2 suggested that effective communication management is one of the most important activities and it can be maintained in the following way:

All the interested parties should be informed through different channels about what the strategic direction of the company is and you can use like different forums, meeting platforms, communication platforms, newsletters, debates, performance reviews,

whatever, you should use all your communication tools to make sure that everyone will be engaged in this transformation process.

ISO-1 revealed that internal communication is carried out through performance review meetings, annual reports, internal newsletters or email campaigns. On the other hand, an external communication deals with environmental and industrial groups by organising seminars and meetings. Lean-2 pointed out that the quality and environmental issues are communicated with internal and external stakeholders by displaying them in visual indicators. Visual management is used as a communication tool for clarifying the goals and targets to achieve better environmental sustainability.

Lean-ISO3 suggested that visual management (e.g., team/white board, or quality, cost and delivery (QCD)) board, or safety, quality, cost, delivery and performance (SQCDP) must be included for communication to improve the information sharing channels in implementation of lean and ISO 14001 as an integrated strategy. Further, the SQCDP board as a visual indicator (visual management) is used to compliment communication as part of lean, which is also a key requirement for ISO 14001. This includes a visual representation of environmental targets highlighted on a single board for better communication and execution. Further, lean tools and ISO 14001 procedures have synergies in combining audit programmes such as in applying 5S audits as well as internal audits based on the EMS protocol. Procedures for monitoring and evaluation of the environmental performance are combined with SQCDP board (visual management) and value stream mapping processes. Moreover, documentation of lean and ISO 14001 is maintained and displayed into a visual management flow that would be accessible and understandable to all stakeholders.

Visual management (a lean tool) is also used for smooth communication with internal (employees) and external (vendors and customers) stakeholders for continual improvement. The examples of visual management are digital information boards, visual work instructions, Kanban cards, evacuation alarms and Andon boards. Visual management is applied in displaying environmental problems (such as occurrence of non-compliance in regulatory limits of effluents) and proposing solution in accordance to lean tools or ISO 14001 procedures or other management improvement initiatives through digital information boards and visual work instructions. Further, Lean-2 pointed out that the quality and environmental issues are communicated with relevant stakeholders

(employees, vendors and customers) by displaying them in visual indicators. Visual management is used as a communication tool for clarifying the goals and targets:

Visual management uses the things like whiteboards, which are interactive and visually display performance against accepted goals or targets. And so, our meat manufacturing management would meet around the appropriate board to review the staff's performance and communicate and share. So, I mean, that's visual management in its simplistic view.

4.4.4 ISO 14001 procedures

Most respondents have suggested that ISO 14001 procedures are dependent on the PDCA cycle of continual improvement. Lean-ISO1 suggested that environmental policy is the most important procedure in identifying risks and opportunities for proposing an action plan to achieve the environmental goals and objectives. Additionally, Lean-ISO2 explained that the operational controls of ISO 14001 such as preparedness plan, documentation, communication, roles and responsibilities, non-conformance and corrective actions are considered as the critical procedures to implement an EMS. Lean-ISO2 further explained that the roles, responsibilities and authorities of every employee must be documented in an organisation chart. A new employee's roles and responsibilities must also be established and communicated during the induction programme.

ISO-1 emphasised that the most important and critical procedures of ISO 14001 are in defining: (1) scope of an organisation, (2) aspect and impacts or risk identification, (3) roles and responsibilities, (4) communication, (5) documentation (6) monitoring, measurement and evaluation and (7) internal audit. ISO-2 explained that the operational planning and control is also a critical aspect in ISO 14001 to maintain an effective meat processing process (from meat carcass till the packaging of the meat-products). Further, the other most important ISO 14001 procedures are assigning the responsibilities, identifying non-conformance and educating the workforce to improve environmental performance.

4.4.5 Lean tools

An environmental and waste reduction policy is the foundational step for executing lean and ISO 14001 as an integrated approach. Lean-1 explained that Hoshin Kanri (a lean tool) can be used as a foundation block in establishing the strategic direction for improving environmental performance. Hoshin Kanri is based on management by objectives for developing, controlling and

managing policy as an effective method for integrating strategic management with daily routine management initiatives.

There are tools like you know, to do your strategic planning. We call it Hoshin Kanri in Japanese. So, you need to apply Hoshin Kanri, cascading your policies and your strategy down to the coalface so that everybody is on the same page.

Lean-2 suggested that A3 thinking is considered as a powerful tool for identifying and solving the environmental and waste issues. It is a lean problem-solving approach based on the look-ask-model-discuss-act learning cycle in designing and developing knowledge creation for processes or products. The problems and solutions/corrective actions can be presented in a single A3 sheet of paper sharing the most critical information on one page for resolving the operational problems. Further, this approach can be integrated with Hoshin Kanri to achieve the organisational strategic policy (objectives and goals) to solving problems in the processes. By using A3 thinking, the critical information about the environmental issues are gathered and a solution is proposed to mitigate them in a simplistic manner. Additionally, 5S is also employed with A3 thinking as a complimentary tool for improving the environmental performance:

They use A3 thinking to develop and drive their environmental strategies. 5S is also a component of it. 5S is the foundation stone of lean and therefore, has an application in implementing any improvement philosophy, including ISO 14001. I would think, well, in the workplace 5S is very powerful in meat processing plants.

Lean-ISO2 stated that value stream mapping, 5-Whys and fishbone diagram are used for identification of environmental waste generation. Further, 5-Whys and fishbone diagram are employed for analysing the problems to identify the root cause of the environmental issues. Moreover, 5S is used for standardising the meat processing units to improve the working conditions of the operational facility by managing and reducing the environmental waste continually. Lean-2 explained the root cause analysis as a systematic lean technique for proposing solutions to resolve the problems occurring in manufacturing operations. It is a four-step process of data collection, casual factor charting, identification of root cause and recommendation for improvement. Root causes of a problem are generally identified by applying tools such as cause and effect diagram (fishbone diagram), 5-Whys analysis and tree diagram. Additionally, flowcharts, cause-and-effect diagram, scatter diagram and control charts could be employed to

resolve quality related issues. 5-Whys method could also be utilised for identifying the cause-effect relationship of problems or failure events encountered by asking the question “Why” for five times repeatedly.

Lean-ISO3 further highlighted visual management as another essential lean technique for enhancing information flow and sustaining continual improvement. The main purpose of visual management is to provide an holistic system based on visual information for helping the workforce to understand their role and responsibilities in implementing operational optimisation initiatives. This technique uses visual indicator boards such as SQCDP for indicating operational and environmental performance continually. Lean-ISO3 further explained that 5S, teamwork, problem solving (5-Whys, A3 thinking and fishbone diagram) and visual management are implemented as foundational tools during a lean transformation programme. After attaining a reasonable maturity level in lean implementation, other tools such as JIT, SMED, TPM, Heijunka or Jidoka are also employed.

In the meat industry, the implementation of 5S, is also sometimes considered as the first step in implementing the lean strategy. 5S consists of a set of self-discipline activities for sustaining workplace cleanliness and improving environmental performance continually. Lean-1 narrated about their meeting with founder of Kaizen institute, Mr. Masaaki Imai, to explain the importance of 5S implementation:

5S is a very important tool. Our founder, Masaaki Imai, says that if you can't do 5S, you can't do lean, you can't do Kaizen. You must be able to commit to the smaller things like cleaning every single day. If you can't do that, I tell you, you haven't got the discipline to make the bigger improvements in your organisation. It all starts with small, little self-discipline activities in an organisation, that will lead to excellence and will lead to environmental improvements as well.

Lean-ISO2 explained that JIT and kanban are utilised to fulfil the desired quantity of an order by a customer. Once a customer places an order, the concept of JIT is used to estimate the livestock required and the kanban ticketing system assists in producing meat-products based on the demand. Calculating the required number of livestock and executing the ticketing system means less generation of operational waste and air pollutants into the environment. Further, a machine

operator is guided through a step-by-step approach or written guidelines or flow diagrams to produce meat-products smoothly and improve environmental performance.

Lean-ISO1 further explained the importance of JIT application to maintain an appropriate level of stock for meeting the required demand of meat and thus avoiding the maintenance cost to handle excessive meat carcass. One day worth of meat stock can be placed as a buffer to avoid the impact of stock being late or handling excessive meat carcass. Furthermore, total preventative maintenance (TPM) is used as a tool for avoiding breakdowns and accidents by monitoring and maintaining the equipment and machinery. Lean-2 noted that heavy machinery such as blister wrapping and meat slicer machines are maintained by avoiding the occurrence of processing abnormalities in meat facilities by automation. Higher level of lean tools such as rapid changeovers (SMED) and automation are effectively implemented by competent workforce in meat processing. A list of lean tools in the meat industry, based on the descending order of the number of informants who cited them, is presented in Table 4.2.

Table 4.2: Lean tools for operational and environmental performance in the meat industry

SN	Lean tools	Informants
1	5S	Lean-ISO1, Lean-ISO3, Lean-1 and Lean-2
2	Root cause analysis (5-Whys, fishbone diagram)	Lean-ISO1, Lean-ISO2 and Lean-2
3	Value stream mapping	Lean-ISO1, Lean-ISO2, and Lean-ISO3
4	JIT	Lean-ISO1, Lean-ISO2, and Lean-ISO3
5	A3 thinking	Lean-2 and Lean-ISO3
6	SMED	Lean-2 and Lean-ISO3
7	Hoshin Kanri	Lean-1 and Lean-2
8	Standardised work	Lean-ISO1 and Lean-1
9	TPM	Lean-ISO1 and Lean-ISO3
10	Visual management	Lean-ISO3
11	Kanban	Lean-ISO2
12	Automation	Lean-2

4.4.6 Implementation awareness, competencies development and training of the workforce

This study has revealed that competencies development, implementation awareness and training of the workforce plays a pivotal role in implementing an integrated lean and ISO 14001. Competency (knowledge, skill and behavior) of the workforce and awareness programmes are fundamental in understanding the strategic values, objectives and targets for reducing environmental impacts. In the absence of experienced workforce in these strategies, a training programme is initiated to improve competency levels for raising operational productivity and environmental performance. Training or skills matrix is used in identifying the need for conducting awareness and training programme. Lean-ISO2 explained:

First of all, you have to have a very good established skill matrix, which indicates the level of competencies of every individual in different areas and based on that you will go and give them the right knowledge related to different lean and ISO 14001 aspects to every individual based on their needs.

Lean-ISO3 explained that a skilled and competent workforce enables the meat processing facilities to improve the quality and environmental performance by implementing lean and ISO 14001. The presence of a competent workforce means that the employees have sufficient knowledge and professional skills to escalate and attain higher performance levels:

Training and awareness are not as high in skills as competency. So, if you replace that with competency, you improve, you escalate the quality and the knowledge of your system one or two steps higher.

Training programmes are planned and executed based on a training needs matrix. This matrix is a tool for organising and displaying the status of strengths and weaknesses of an individual. ISO-1 explained that induction and subsequent detailed training are carried out to improve the knowledge and skill levels of the workforce for executing the lean and ISO 14001 approaches:

You need to have a training needs analysis or training needs matrix. What I find is critical for all employees, contractors and visitors, is induction training and that needs to include an overview of ISO 14001 as well as lean, so, that's an overview. Then you need to go to the next step and that is in the areas where the focus is specific, for example, the slaughter of the animals. Now you need to go down deeper, now you need to do more a two-day or three-day in-depth course about lean and ISO 14001.

ISO-1 explained that the root-cause of any non-conformance in the meat processing is identified by using 5-Whys (a lean tool for root cause analysis). A training programme is initiated to overcome the environmental or operational non-conformance after identifying the root cause of the problem. Lean-1 suggested that an internal training programme is the best method for a company management to educate their workforce otherwise they can start off with external professionals to get the ball rolling. External training programmes must lead to achieving internal benefits by improving the skills and knowledge of the workforce in implementing lean and ISO 14001. ISO-2 stated that the internal training (e.g., induction) for newly hired employees and inexperienced workers and supervisors helps the workforce to perform the meat processing tasks

effectively. Furthermore, the technical aspects of meat processing to maintain meat properties can also be taught through external courses and training programmes.

4.4.7 Environmental performance evaluation

Environmental performance is evaluated by analysing the KPIs. Data from monitoring and reporting records are utilised for periodic evaluation of the environmental waste minimisation objectives. The performance evaluation parameters and strategic directions of the meat industry for minimisation of waste are communicated with all stakeholders at regular intervals. ISO-2 stated that performance evaluation is conducted by measuring, evaluating and reporting on key parameters. Further, outcomes of the performance evaluation (conformance or non-conformance) and corrective actions are communicated to all stakeholders on a weekly, monthly and annual basis for improvement and controlling.

A series of audits is used for evaluating the organisational performance in achieving the environmental waste reduction objectives and targets. An effective audit programme of lean and EMS is implemented in improving environmental performance continually. Regular audits are carried out to maintain the process checking, monitoring and reporting system. Lean-2 explained that any environmental programme always starts by analysing the currently reported data on environmental aspects such as the air emission status and waste generation through operational losses to understand the environmental impacts.

Lean-ISO2 additionally stated that a continual environmental performance evaluation includes internal auditing to identify non-conformances and corrective actions through on-going checking and reporting, for achieving the waste reduction targets. Records of environmental, safety and operational incidents are effectively maintained during the checking and reporting phases of performance review. An effective implementation of 5S audits and internal audits of ISO 14001 enables companies to identify the non-conformities. However, the frequency of an internal audit is the most important factor to provide performance data for analysis on a regular basis, generated during lean and ISO 14001 implementation. ISO-1 suggested that an internal audit must occur frequently (if possible on a weekly basis) for helping an organisation in producing statistical trends to evaluate the performance of their meat facilities. Lean-ISO1 recommended that effectiveness of an integrated lean and ISO 14001 audit can be enhanced by incorporating corrective actions, suggestions and learning initiatives in this holistic evaluation programme.

4.4.8 Environmental management review

Management reviews are structural meetings for analysing the current performance as well as recommending new initiatives and corrective actions to improve the existing procedures and processes in an organisation. ISO-1 stated that the management and improvement reviews help the meat firms in creating an organisational culture to manufacture environmentally friendly meat-products. These reviews also assist in identifying the role of the top management to establish a sense of accountability in the workforce for achieving environmental performance:

We've got a saying: 'garbage in, garbage out'. The example that management is setting becomes the culture. Management review is a very important word for the entire organisation. So, by management, doing management reviews and improvement reviews, they are setting an example and a culture that we care about and it's not about just business and bottom-line profit.

Management reviews are used to measure the effective implementation of objectives and targets, identify the potential reasons for failures and propose improvement initiatives/ corrective actions in the manufacturing environment. Lean-2 explained that a management review based on monthly reports can dig out the issues in meat processing such as reasons for production delays. It enables the top management to remove the bottlenecks, keep tracking the improvement programmes and hold the workforce to account for improving the organisational performance. Lean-ISO1 suggested that management reviews can effectively be carried out by evaluating the criteria of performance and monitoring and measuring in the improvement evaluation phase.

Successful implementation of lean and ISO 14001 is effectively maintained by receiving continual feedback on the environmental improvement initiatives from the workforce, suppliers and customers. Lean-ISO2 noted that an analysis of the performance parameters such as environmental key performance indicators (e-KPIs) is carried out to identify the leading or lagging parameters for improvement. Corrective actions with revised performance goals can be proposed including use of latest technologies and state-of-art equipment to mitigate the non-conformities in meat processing. Lean-1 explained that more frequent management reviews based on constructive feedback timely provide the guidelines to the top management in improving areas required for environmental performance. Further, ISO-1 stated that the management reviews must be

conducted quarterly or at least after every six months. However, once a year is just not adequate for continual improvement in the meat industry.

4.5 Critical success factors for implementing lean and ISO 14001 as a combined approach

A critical success factor approach is a systematic way for identification of main areas where the process must go right for achieving performance goals and organisational competitiveness in an organisation. Adaptation of lean and ISO 14001 as a cultural transformation enhances the environmental performance, engagement of the workforce and cost reduction of the meat processing. ISO-1 stated that implementation of both these strategies as an integrated approach can be effectively implemented by pursuing them as a culture and way of life:

Making lean and ISO 14001 a way of life and not just something to get a certificate up against the wall as part of an image or reputation, but to make it a way of life for the organisation.

Findings have revealed that management approach is considered as the main factor for executing lean and ISO 14001. The top management's commitment is of immense importance for developing a clear strategic plan, supporting the workforce and providing the financial resources in implementing lean and ISO 14001 as an integrated strategy. Lean-ISO3 explained the critical role of management approach in the following way:

Management commitment is on the top, they have to lead. The second one is the organisational knowledge; they always have to assess the people's commitment and the people's knowledge. They have to develop a very comprehensive skills matrix and put training programmes in place. So, they will be continuously offering support to the staff. And after that is the communication. It must be there. Continuous communication is essential to understand people frustrations, to understand how we can do it better.

Lean-2 further emphasised the importance of top management commitment, engagement and leadership in implementing lean and ISO 14001. Leadership permeates a strategic vision for environmental performance and the expected outcomes of a lean and ISO 14001 transformation programme. Furthermore, the top management is responsible for rewarding or holding the workforce accountable after analysing the outcomes of an improvement programme. Lean-1 further explained that the top management fosters a culture in defining performance aspects of lean

and ISO 14001 for improving environmental performance, providing support to the workforce and maximising the financial benefits to the stakeholders.

Successful implementation of lean and ISO 14001 as an integrated approach also depends on capabilities and engagement of the workforce. Lean-1 stated that the workforce needs appropriate knowledge, skills and sufficient resources in order to improve environmental performance. ISO-2 stated that a competent workforce plays a pivotal role in achieving the environmental waste minimisation objectives and targets. Evaluation and measurement of the employee's contribution is pointed out as a top-level factor for executing lean and ISO 14001:

I think one of the critical success factors is in seeing how engaged the staff are and what they're doing. It's a bit hard to measure.

Internal competence and capability of the workforce is of paramount importance for implementing lean and ISO 14001. However, the external consultants can be hired in the absence of internal capabilities for implementing these strategies as an integrated approach. Availability of the financial resources for hiring the external professionals is essential for conducting the awareness and training programmes to improve the competence and skill levels of the workforce. Lean-1 stated:

Unless you have the internal capabilities of a person who's maybe skilled in ISO 14001 and lean, if you have recruited a person like that, it is good to have those internal capabilities and that'll not cost you a certain amount. But if you want to make use of external agencies or consultants, you need budget for that, you need to have the financial resources.

Lean-1 suggested that utilisation of latest technology can be beneficial in the form of new software systems, new IT systems and artificial intelligence robotics. However, these latest technologies can be adopted after attaining a better environmental performance, improving the processes performance and having sufficient financial resources. With use of technology, the meat industry can digitise their problems, environmental impacts and operational waste. Lean-ISO1 explained that technical aspects for implementing successful environmental projects are crucial in sustainable meat processing. An effective implementation of lean and ISO 14001 projects is evaluated by tracking the records of environmental performance indicators during an internal audit programme.

Lean-ISO1 further suggested that checking, monitoring and auditing of the KPIs are considered as essential for sustainability of the meat processes:

Key performance indicators are an absolute must, when it comes down to lean projects and when it comes down to an ongoing basis as well, but when it comes down to an ISO project then it's the internal auditing of those processes and procedures and everything that the company has agreed to do.

The interview findings suggest that an integrated lean and ISO 14001 implementation is a proactive and continual strategy for improving environmental performance. Furthermore, a competent workforce and implementation of advanced technologies are the key success factors for executing this holistic approach for improving environmental performance. ISO-1 explained:

By having ISO 14001 and lean in place, we shift our focus to a proactive approach, meaning implementing advanced technologies, implementing better production processes, appointing highly or more competent people and the combination of all of those, for me, would definitely lead to better improving environmental performance.

Lean-ISO2 stated that availability of financial resources is vital for covering the cost of certification, external audits of ISO 14001 and consultancy expenditures in implementing lean and ISO 14001. Moreover, the commitment and time of the workforce are considered as the success factors in implementing the lean strategy.

Certification comes with a cost if you want to get certified. But in terms of implementing lean and implementing the framework, it's not measured as a cost. It comes with your time and your commitment.

A list of the critical success factors for executing an integrated lean and ISO 14001 strategy in the meat industry, based on the descending order of the number of informants cited, is presented in Table 4.3.

Table 4.3: Critical success factors for an integrated lean and ISO 14001 strategy

SN	Critical success factors	Informants
1	Awareness and training of workforce	Lean-ISO1, Lean-ISO2, Lean-1, Lean-2, ISO-1, and ISO-2
2	Top management commitment, engagement and support for workforce	Lean-1, Lean-2, ISO-2, Lean-ISO1, and Lean-ISO3
3	Organisational knowledge	Lean-1, Lean-2, ISO-2, and lean-ISO3
4	Communication	Lean-ISO1, Lean-ISO3, Lean-1, and Lean-2
5	Availability of financial resource	Lean-1, Lean-2, ISO1, and Lean-ISO1
6	Organisational objectives, targets and policy	Lean-1, Lean-2 and Lean-ISO1
7	Availability of financial resources for external consultants, training, software installation and certification	Lean-1, ISO-1 and Lean-ISO2
8	Accountability and reward of the workforce	Lean-1, Lean-2 and Lean-ISO1
9	Software application	Lean-2, ISO-1 and Lean-ISO2
10	Engagement of workforce	ISO-2 and Lean-ISO3
11	Audit and Management review	Lean-ISO1
12	Role of external consultants	Lean-1

4.6 Discussion

Based on the aims of this preliminary study, first, the contribution of lean and ISO 14001 implementation strategies as a combined approach for improving environmental performance in the meat industry is determined. Second, how could these strategies be implemented together to help the meat industry in improving environmental performance and the potential synergies between these management initiatives are reviewed. Third, the main critical success factors are identified and discussed in detail on the basis of the empirical evidence for executing lean and ISO 14001 together in the meat industry.

The main themes emerging from the analysis of lean and ISO 14001 integration based on the empirical findings (environmental and waste policy, communication, environmental waste management plan and environmental process improvement projects, operational procedures, implementation, controlling and improvement) mostly align with the constructs of the conceptual model (Figure 2.4) developed in this study. Key findings by the lean and ISO 14001 consultants on environmental performance, lean and ISO 14001 implementation and CSFs for implementation of both initiatives are presented in the following sections.

4.6.1 Summary of environmental and waste reduction outcomes by implementing lean and ISO 14001

The first objective of this study was to understand the lean and ISO 14001 implementation strategies as a combined approach for sustaining environmental performance. Overwhelmingly,

the informants of this study agreed that environmental and waste reduction benefits are realised by implementing lean and ISO 14001 together in Table 4.4.

Table 4.4: Summary of environmental and waste reduction outcomes by implementing lean and ISO 14001

SN.	Environmental and waste reduction benefits from lean and ISO 14001 implementation as a combined approach
1	Reduction of air pollution and operational wastes <ul style="list-style-type: none"> • Reduction of wastewater • Reduction of GHG emissions (i.e., CO₂, CH₄ and N₂O) • Reduction of health and safety issues • Reduction of solid waste • Less electricity/energy usage • Less raw material consumption • Less water consumption
2	Continual waste reduction by applying PDCA cycle
3	Waste minimisation by applying advanced technologies and recruiting competent workforce
4	Triple bottom line benefits

Findings of this study suggested that lean and ISO 14001 implementation strategies as a combined approach provides more clarity in implementing lean and ISO 14001 procedures for an enhanced environmental performance. The informants reported that a joint lean and ISO 14001 programme helps an organisation to improve operational and environmental parameters (e.g., effective utilisation resources, reduction of air emissions and minimisation of waste generation (organic and in-organic)). Further, the findings from this study have suggested that lean and ISO 14001 implementation strategies as a combined approach not only improve operational and environmental performance but also enhance financial gains and social welfare of all stakeholders. For instance, this preliminary study revealed that welfare of the workforce (development through training, appraisal and rewards) and benefit to the society at large (by providing quality products and a cleaner environment) are achieved by implementing lean and ISO 14001 together. Lean tools and regulatory setting of ISO 14001 have permitted processing facilities to reduce air pollution and operational waste in producing environmentally friendly products (Puvanasvaran et al., 2014; Vasconcelos et al., 2019), which is consistent with the interview findings of this study. Additionally, the current scholarly literature such as Souza and Alves (2018) and Vasconcelos et al. (2019) have also explained the multidimensional benefits of lean initiatives and ISO 14001 on the triple bottom line (operational, environmental and social), which is also consistent with the findings of this study to explain the potential triple bottom line benefits of both strategies. Further, meat facilities that reduce their air emissions, waste generation and maintain efficient utilisation of natural resources by sustaining operational and environmental performance can yield substantial cost savings.

The informants of this study explained that ISO 14001 provides guidelines and framework to develop an EMS and lean helps an organisation to apply tools for achieving environmental sustainability. Further, they explained that a competent team and introduction of the latest technologies (i.e., latest IT software packages and advanced pollution control equipment) provides more operational flexibility to optimise natural resource utilisation and reduce different types of wastes (solid and emissions of GHG). State of art IT software packages are widely used to share information for achieving desired KPIs targets through effective implementation of operational and environmental practices. Lean as a philosophy and ISO 14001 as a framework for developing an EMS along with advanced technologies and competent workforce have been used for waste minimisation, which aligns with this findings of the previous studies such as Souza and Alves (2018) and Vasconcelos et al. (2019). Arimura et al. (2016) have explained that installation of an air pollution control technology provides more flexibility for an organisation to achieve environmental policy attributes, performance goals and improve operating practices. Further, De Camargo Fiorini, Chiappetta Jabbour Charbel, Lopes de Sousa Jabbour Ana, Oliveira Stefanelli, and Fernando (2019) verified that application of an advanced technology such as an information system can be applied in planning organisational policy, designing operational practices and establishing communication channels to improve environmental performance during the adoption of EMS.

4.6.2 Summary of implementation of lean and ISO 14001 together for improving environmental performance

The second objective of this study was to understand how lean and ISO 14001 strategies could be implemented together to help the meat industry in improving environmental performance and what are the potential synergies between these management initiatives. Interview findings suggest that an integrated lean and ISO 14001 implementation can raise operational productivity and enhance environmental performance based on the synergistic impact of the two strategies. The informants of this study explained that a coherent lean and ISO 14001 environmental policy along with quantifiable goals provide guidelines and direction to an organisation in achieving operational and environmental sustainability. Further, a well-established policy provides clarity on how to operate to meet compliance requirements. The scope of lean and ISO 14001 environmental policy would reflect the organisational strategic plans and provide guidelines to achieve operational and environmental goals. Further, an integrated lean and ISO 14001 policy would depict organisational

commitment to establish a culture of enhancing environmental sustainability. Effective monitoring and reviewing procedures for a combined environmental policy would reap benefits through the structure of an ISO 14001 EMS framework aligned and intertwined with the implementation of lean tools.

The findings from the preliminary study are aligned with the strategic planning competence of the NRBV for implementing lean and ISO 14001 together to improve environmental performance. A strategic direction of an organisation for elimination of waste (operational or environmental) is set by considering the organisational values, vision and mission (Bellisario & Pavlov, 2018). The SMART method is used in developing measurable objectives for implementing and monitoring a management improvement programme (Bjerke & Renger, 2017), that can help an organisation in setting the strategic direction for implementing an ISO management system and lean jointly (Salleh et al., 2015). Further, aligning the overall organisational goals with values, vision and mission of a company is instrumental for providing direction to evaluate strengths and weaknesses in achieving operational excellence and environmental performance during the different stages of an improvement programme. The findings of the preliminary study suggest that the SMART method, vision and mission of a company are used to enhance the strategic planning competence for achieving the capabilities under the NRBV lens.

Informants emphasised that development of information sharing systems (visual indicators) is essential aspect for implementation of organisational policy, improvement projects and performance review meetings. Souza and Alves (2018) have emphasised that the employees should be informed about the implementation of management initiatives and process improvement activities during the planning and improvement phase. The findings from the preliminary study indicated that an efficient visual management helps to achieve the organisational competence (communication) for achieving the NRBV competence (i.e., organisational competence). Informants of this study explained that an integrated information sharing platform by incorporating lean communication tools (e.g., visual management) and ISO 14001 based EMS procedures (incorporating environmental targets) helps an organisation in communicating the sustainability goals with the relevant stakeholders and monitoring progress in achieving them.

Informants of this study explained that the role of the relevant internal stakeholders (top management and workforce) and external stakeholders (customers, contractors and suppliers) is

crucial in implementing continuous improvement initiatives to achieve sustainability goals. Involvement of the relevant stakeholders such as top management of an organisation, government institutions and special environmental groups play a paramount role in establishing operational and environmental targets, implementing optimisation projects and evaluating performance. Stakeholders are considered as an influential group of people for successful implementation of a management improvement initiative to achieve better operational excellence (Elias, 2016).

The informants of this study explained that VSM is implemented to evaluate the current status of environmental compliance and propose future improvement opportunities, while JIT (with buffer setting) and kanban (ticketing of animals) assists in producing meat-products based on the customer demand. Further, TPM, SMED and automation are employed to avoid breakdowns, accidents and occurrence of processing abnormalities for achieving operational and environmental sustainability. Findings of this study emphasised that 5S, kanban and standardised work help in creating a productive workplace, enhancing productivity and achieving continuous environmental performance. Informants of this study explained the application of 5S as a foundational lean tool for improving operational and environmental performance, kanban system for better product flow and standardised work instructions for achieving performance continuously. 5S helps the manufacturing and service departments in maintaining workplace organisation, improving product quality and reducing waste (operational and environmental) (Farrukh et al., 2022). Further, the kanban system enables maintaining the required material movement between the different workstations in a single production line for achieving better product flow (Gupta & Jain, 2013) which validates the findings. Standardised work enables a processing facility to achieve the same results all the time by providing the best measurable operational practices for continual improvement (Oliveira et al., 2017).

Findings of this study explained that Hoshin Kanri is used as a fundamental tool for setting policy targets to manage operational and environmental performance. Further, the informants explained the importance of root cause analysis, 5-Whys and A3 thinking to determine the main reasons of non-conformities in an organisation. These lean tools are extensively utilised for solving of complex operational and environmental issues through introducing corrective and preventive activities. Hoshin Kanri as a foundational lean tool that sets up the strategic direction for enhancing and sustaining environmental performance continually (Tortorella, Cauchick-Miguel, & Gaiardelli, 2019). These findings reveal that Hoshin Kanri is aligned with the strategic planning

competence under the NRBV lens. Additionally, root cause analysis is a structural problem-solving tool for improving product quality and customer satisfaction by reducing waste problems and scrap losses and fishbone diagram by considering the 4M's, i.e., man, machine, material and measurement. 5-Whys, fishbone diagram and A3 thinking are basic tools in determining the reasons for environmental problems through the brainstorming method and proposing preventative actions (Gangidi, 2019). Further, the A3 thinking is a powerful lean tool for achieving a consensus in solving complex problems and promoting continual improvement. The application of lean tools such as root cause analysis (5-Whys, fishbone diagram and A3 thinking), visual management and Hoshin Kanri are also undertaken to create capabilities of the NRBV for achieving the environmental targets. The interview findings thus suggest that aspects of an integrated process (environmental policy, identification of process non-conformities and environmental improvement programme, communication, documentation process, audit, monitoring and performance evaluation) can be maintained by combining lean tools and ISO 14001 procedures together for environmental sustainability. Informants of this study suggested that a coherent lean and ISO 14001 environmental policy provides a clear direction and guidelines to an organisation in achieving short and long-term operational and environmental targets. Further, operational control of ISO 14001 helps an organisation to identify non-conformities, while lean tools such as root cause analysis and VSM are widely implemented in identification of non-compliance of a system. By incorporating lean tools and operational control processes can assist an organisation for identification of performance irregularities and proposing actions (corrective, preventive and proactive) in achieving operational and environmental performance. The application of lean tools (i.e., root case analysis) and ISO 14001 procedures (i.e., setting environmental objects, identification of compliance status and training initiatives) are consistent with the previous literature on lean (Ashok Sarkar, Ranjan Mukhopadhyay, & Ghosh, 2013; Gangidi, 2019) and ISO 14001 (Kruse et al., 2019; Souza & Alves, 2018). Furthermore, maintenance of an effective communication is an integral procedure of ISO 14001, while lean tool (visual management) is employed in sharing information on ongoing performance parameters with relevant stakeholders. Summary of implementation of lean and ISO 14001 as a combined approach from the preliminary study is presented in Table 4.5.

Table 4.5: Summary of implementation of lean and ISO 14001 as a combined approach from the preliminary study

<p>Key findings on lean and ISO 14001 implementation as a combined approach</p> <p>Integrated lean and ISO 14001 environmental policy</p> <ul style="list-style-type: none"> • Vision and mission for waste minimisation and environmental performance • Operational and environmental aspects and impacts • SMART waste and environmental objectives and targets <p>Integrated plan and projects of lean and ISO 14001 implementation</p> <p>Communication and information sharing</p> <ul style="list-style-type: none"> • Internal and external communication • Stakeholder engagement • Visual management (Team or white board, QCD, SQCDP board) • Newsletter, performance review meetings and reports <p>ISO 14001 procedures</p> <p>The important operational procedures of ISO 14001 are:</p> <ul style="list-style-type: none"> • Roles, responsibilities and authorities • Documentation control and • Operational control <p>Lean tools</p> <ul style="list-style-type: none"> • Hoshin Kanri • Root cause analysis (fishbone diagram and 5-Whys) • A3 thinking • KPIs • VSM • Visual management • Standardised work • 5S • TPM • JIT • Kanban • SMED and • Autonomation <p>Implementation awareness, competencies development, and training programme</p> <ul style="list-style-type: none"> • Implementation awareness programme and induction training • Competencies development (knowledge, skill and behavior) of the workforce • Internal and external training <p>Environmental performance evaluation</p> <ul style="list-style-type: none"> • Performance evaluation by monitoring and reporting • Internal and external audits (corrective actions, suggestion and learning) <p>Environmental management review</p> <ul style="list-style-type: none"> • Management review • Improvement evaluation (criteria, monitoring and measurement)

A comprehensive and combined communication management can be effectively maintained to monitor operational and environmental targets in a single digital board for smooth information sharing. Findings from the informants suggest that information from documentation of VSM and visual management along with ISO 14001 procedures (document control and performance evaluation) are used for evaluation of operational and environmental performance. Further, performance evaluation of processes can be better achieved through analysis of 5S audit and internal audit during ISO 14001 implementation for monitoring operational and environmental performance. These findings on identification of issues, performance evaluation, and audit and

documentation processes for implementing lean and ISO 14001 together are consistent with the previous studies on lean tools (i.e., A3 thinking, visual management and VSM) (Eaidgah, Maki Alireza, Kurczewski, & Abdekhodae, 2016; Souza & Alves, 2018) and ISO 14001 procedures (i.e., internal audit, document control and performance evaluation) (Souza & Alves, 2018). A summary of the lean and ISO 14001 procedures employed as a combined approach for environmental performance are presented in Table 4.6.

Table 4.6: A combined approach of lean tools and ISO 14001 procedures for environmental performance

Process aspects	Lean tools	ISO 14001 procedures
Identification of environmental problems for setting targets	Root cause analysis (5-Whys) and fishbone diagram	Framework for setting environmental objectives, compliance and continuous improvement
Identification of process non-conformities and improvement programme	Root cause analysis (5-Whys) and other lean tools	Process non-conformance identification and competencies training programme
Communication	Visual management (SQCDP board)	Internal and external communication for effectiveness of EMS
Identification of environmental issues and information sharing with stakeholders	A3 thinking	Communication with stakeholders for evaluation of issues and solutions
Audit of processes	5S audit	Environmental performance monitoring (internal audit)
Monitoring and performance evaluation	Visual management (SQCDP board) and VSM	Performance evaluation for improvement
Documentation of processes	Visual management and VSM	Process support (document control)

4.6.3 Summary of the CSFs for implementing lean and ISO 14001 as a combined approach

The third objective of this study was to identify the critical success factors for implementing lean and ISO 14001 as a combined approach in the meat industry. Findings indicate that top management commitment, engagement and support are crucial in articulating policy, objectives and targets for implementing lean and ISO 14001 as an integrated approach. Further, the role of top management in allocation of resources (financial, human and technical), accountability of the workforce and creating a culture of continual improvement is of foremost importance in successful lean and ISO 14001 transformation. Management approach is the main success factor for establishing policy, managing communication channels and providing financial resources in continual implementation of lean and ISO 14001 (Souza & Alves, 2018). Further, the findings of this study suggest that an internal competence of the workforce is crucial for implementing an integrated approach of both strategies. Shortfall in in-house competence and skills of the workforce is a hampering aspect for achieving operational and environmental targets.

The findings of this study indicated that on implementing lean tools and ISO 14001 procedures, utilisation of advanced waste management technologies further assist in improving the

environmental outcomes. Implementation of the latest IT systems, artificial intelligence robotics and audit tracking systems is critical in attaining more sustainable meat processing. Ni (2019) has stated that advanced waste processing and treatment technologies enable an organisation to improve environmental impacts. On the other hand, Negrao, Godinho, and Marodin (2017) concluded in their research that production excellence and environmental performance are enhanced by promoting workforce involvement as well as controlling and standardising operational activities by applying lean tools. Further, in-house and external training initiatives are critical for improving skill levels of the workforce to implement lean tools and the ISO 14001 standard. The advanced training programmes and skill development initiatives are used to enhance the autonomy, competence level and decision-making capacity of the workforce in implementing lean and ISO 14001 as a combined strategy for improving environmental performance (Habidin et al., 2018).

In the absence of internal capabilities, the findings of this study suggest that the external consultants can be hired to enhance the competence of the workforce. Lean and ISO 14001 implementation also observed that awareness and training programmes by external consultants improve the skill and knowledge levels of the workforce (Souza & Alves, 2018; Wirkus & Chmielarz, 2018). The critical success factors for implementing lean and ISO 14001 as combined strategy from the consultants are presented in Table 4.7.

Table 4.7: Critical success factors for implementing lean and ISO 14001 as combined strategy from the consultants

SN	Critical success factors
1	Awareness and training of workforce
2	Top management commitment, engagement and support for workforce
3	Organisational knowledge
4	Communication
5	Availability of financial resource
6	Organisational objectives, targets and policy
7	Availability of financial resources for external consultants, training, software installation and certification
8	Accountability and reward of the workforce
9	Software application
10	Continual improvement
11	Engagement of workforce
12	Audit and Management review

4.7 Conclusion

This preliminary study has presented a detailed evaluation of the lean and ISO 14001 strategies contribution as a combined approach on environmental performance, how could these strategies be implemented together and the critical success factors for their implementation. The outcomes of this preliminary study provide the foundation in developing the concepts and the study protocol

for the multi-case studies in the next phase to evaluate implementation of lean and ISO 14001 strategies in the meat industry for environmental performance. Furthermore, the lean and ISO 14001 consultants of this preliminary study helped to identify three suitable meat facilities for conducting the main study to collect the empirical data. The selection criteria for these case studies were: (1) cases must belong to the meat industry and (2) cases must have implemented lean and ISO 14001 for at least three years. Chapter 5 presents the first case of the main study.

Chapter 5 – Case Study Findings from Alpha

This chapter presents the data collected from the first case study. This chapter presents the empirical findings from a company that will be called Alpha (a pseudonym) for the purposes of this thesis. Alpha introduced lean practices and attained ISO 14001 certification for more than a decade in their facilities. The company originally registered for ISO 14001 in 2008 to ensure compliance of the regulatory and resource consent requirements for achieving environmental sustainability targets. The lean philosophy was included in their manufacturing excellence programme to identify opportunities for operational improvement and produce environmentally friendly meat products. This chapter aims to investigate the contribution of lean and ISO 14001 strategies as a combined approach for improving environmental performance, the potential synergies between them and how are these strategies implemented by Alpha to help reduce undesirable wastes and achieve environmental improvements. Further, the CSFs for a joint implementation of these approaches are also identified and analysed to achieve success in the NZ meat industry. This chapter is organised as follows.

First, the case study interview setting for Alpha and details of the informants are presented. The next section introduces Alpha and provides background on its operations. This is followed by an investigation to evaluate the impact of lean and ISO 14001 implementation to minimise undesirable wastes using the format of the NRBV model for lean and ISO 14001 implementation (Figure 2.4) to investigate the environmental performance in the meat industry. Finally, key findings on the CSFs for lean and ISO 14001 implementation in producing environmentally friendly meat products are presented.

5.1 Alpha case study settings

A series of semi-structured interviews with the informants from Alpha were held between March 2021 and September 2021. An initial contact was made in March 2021 with the chief executive officer (CEO) of Alpha and email correspondence was initiated for conducting a case study to investigate the impact of lean and ISO 14001 implementation on environmental performance. The CEO shared the information sheet and interview questions with the relevant people to attain their consent to participate in this study. Six informants agreed to participate in the investigation. The informants included a general manager, group environmental manager, technical compliance

manager, research and development manager, manufacturing excellence lead, and environmental manager.

The positions of the informants and role descriptions are presented in Table 5.1. Six interviews were conducted via Zoom because of unavailability of the informants for face-to-face meetings due to the Covid-19 situation. These interviews lasted 45 to 90 minutes and were conducted based on pre-selected questions and recorded digitally for data analysis.

In addition to Zoom meetings, access was obtained to their environmental management manual, organisational reports on sustainability and the 2035 organisational strategy. Further, promotional material, data on the KPIs and websites of the organisation were reviewed to gain in-depth insight into Alpha’s operational and environmental performance. The summary of positions and role descriptions of the informants are depicted in Table 5.1.

Table 5.1: Positions and role descriptions of the informants

SN	Position	Role description
1	General manager	Implementing and sustaining manufacturing excellence practices across multiple sites throughout NZ for over five years.
2	Group environmental manager	Managing environmental management system, complex resource consenting and implementing decarbonisation projects at Alpha, Invercargill NZ for over four years.
3	Technical compliance manager	Managing internal and external compliance audits, and responsible for developing strategic initiatives and risk management programme for over five years.
4	Research and development manager	Responsible for conducting meat research, implementing continuous improvement initiatives and successfully leading Primary Growth Partnership Programme across NZ for over 20 years.
5	Manufacturing excellence lead	Operationalising and maintaining a number of continuous manufacturing excellence programmes at Alpha, Timaru NZ for over four years.
6	Environmental manager	Effectively managing EMS, environmental impact assessment and wastewater treatment at Alpha, Invercargill, Southland NZ.

5.2 Company overview

Alpha has been based in NZ and producing high quality grass-fed lamb, venison and beef since 1948. The earliest meat processing facilities were set up in Lorneville and Invercargill in 1960 and 1980, respectively. Currently, seven sites throughout NZ are providing red meat and co-products and approximately 95% of these products are exported to more than 65 countries around the globe. Around 6 million lambs, 1 million sheep, 0.2 million cattle, 0.27 million calves and 0.115 million deer are processed annually.

Alpha is the largest meat producing company in NZ, with offices in NZ, the United Kingdom (UK) London, North America and Asia (Singapore). A team of over 5000 employees is working to produce high grade red meat products. Alpha’s total annual turnover was NZ\$1.8 billion, profit

before provisions and tax NZ\$41.9 million and a net profit of NZ\$24 million after tax at September 2021 closing. The company distributed NZ\$16.7 million in loyalty payments to reward platinum and gold shareholders. Alpha is producing sustainable environmentally friendly products by focusing to achieve decarbonisation (31% reduction in carbon emissions) by 2023. The company has already achieved energy utilisation improvement (2.92%) since 2000 and cleaner water consumption and discharge according to the United Nations sustainable development goals. Further, environmental sustainability is maintained by identifying measurable impacts, developing clear objectives and targets and monitoring progress through a certified environmental management system.

Alpha has carried out a manufacturing excellence programme for improving plant reliability (by maintaining automation), enhancing yield performance (by installing the latest processing technologies) and boosting the skill level of the workforce (through introducing training programmes) since 2015. Adopting innovative packaging (barrier vacuum shrink bag) technology helped to eliminate 39,000 kilograms of poly-bags waste and the installation of the latest heat recovery system has saved approximately 21,951 tons of carbon per annum. Further, state-of-the-art disinfection plants will be installed in the company's processing facilities for improving wastewater discharge by 2024.

5.3 Environmental and waste reduction outcomes by implementing lean and ISO 14001

Utility resource optimisation aspects and targets have been set in Alpha's 2035 environmental management strategy. Operational and environmental performance targets are set and financial resources are allocated in a documented strategy for achieving a sustainability vision of 2035. A number of improvement initiatives and projects based on ISO management systems and a manufacturing excellence programme (lean tools) have been carried out for optimising utility and material (e.g., water, electricity and packaging material) consumption in Alpha's meat facilities for more than a decade.

At the moment, we are currently conducting a number of improvement projects based on lean and ISO management systems for optimising utility consumption such as water, electricity and steam in our facilities. (general manager)

The informants of this case study explained that their meat processing units focused on preventing air pollution and surface water, minimising electricity consumption and reducing wastes (organic,

inorganic and packaging). Further, they noted that strict compliance requirements, community expectations and rapid increase in utility (water, electricity and packaging) costs encourage the energy and resource-intensive meat industry to explore process optimisation and mitigation opportunities through implementation of management initiatives. The manufacturing excellence lead explained that an EMS framework based on ISO 14001 and lean tools based on waste minimisation and customer satisfaction help in achieving operational and environmental KPI targets. He further explained that an EMS framework and lean strategy have procedural similarities and synergies (through an integrated lean and ISO 14001 environmental policy, communication sharing and combined training programme) in achieving operational and environmental targets.

An integrated lean and ISO 14001 strategy have certain procedural synergies such as a combined organisational policy, information sharing and training initiatives for achieving compliance requirements and environmental sustainability targets in our company. (manufacturing excellence lead)

The group environmental manager elucidated that a manufacturing excellence programme similar to lean strategy is implemented for reducing waste in meat processing activities through standardised work (producing standard products), visual management (effective communication) and root cause analysis (solving operational and environmental issues). Meanwhile, ISO 14001 is employed to meet the compliance and consent requirements (e.g., for hygiene, sanitisation and product quality) against their performance parameters and provide awareness and training for implementing environmental sustainability initiatives.

We've invested in developing our manufacturing excellence programme over the last decade and we've focused on producing standardised meat products and mitigating environmental non-conformities. Our EMS framework is continuously looking for opportunities to meet the compliance requirements, develop new environmental solutions and improve competency of the workforce. Collectively, both these optimisation initiatives have shown a positive impact on reducing operational and environmental waste in the meat processing activities. (group environmental manager)

The informants of this case explained that a manufacturing excellence programme based on lean tools along with ISO 14001 based EMS framework are utilised to manage consumption of utility resources (carcasses, water, electricity and packaging materials) for continual operational and

environmental performance. Waste and environmental KPI objectives for setting project plans are communicated through a visual board (a lean tool) and ISO 14001 procedures for optimising resource consumption. The performance evaluation of projects based on waste and environmental impact reduction targets indicated positive outcomes for operational and environmental performance. In recent years, a number of optimisation projects were initiated for achieving optimal utility consumption by the application of ISO management systems and manufacturing excellence (lean) programme in Alpha's meat processing facilities. These projects mainly included: (a) decarbonisation, (b) water quality and consumption and (c) reduction in waste. The group environmental manager explained that Alpha have invested NZ\$2.7 million for reducing emissions, improving storm-water discharge quality and managing water consumption. KPI targets are set for reducing total carbon emission, hot/cold water consumption and refrigeration heat losses, improving wastewater quality (content of nitrogen, phosphorus and total suspended solid) and consumption of water to achieve better operational and environmental performance. These KPI-based projects are included in the organisational policy and communicated by displaying on digital/white boards (a lean tool) and through communication (email correspondence). A management review concluded that based on benchmarking of KPIs, air emissions were reduced by 13.1%, water consumption dropped by 30% and water quality improved by reducing contents such as nitrogen, phosphorous and solid particles in water at one of the company's meat processing plants.

Basically, having combined lean and ISO 14001 optimisation initiatives have helped meat processing in setting up KPI benchmark targets around environmental performance, cascading the information of these projects in integrated digital boards by implementing lean tools and ISO 14001 procedures together. Performance evaluation of these projects indicated a clear improvement in decarbonisation and utility consumption such as raw carcasses, water and electricity, and reduction of air emissions, for instance, total carbon emissions, boiler stack heat losses and generation of suspended solid particles. (group environmental manager)

The research and development manager explained that waste management practices in meat processing include rendering of organic waste, turning blood into bone meal and treating wastewater by anaerobic lagoons. Further, the non-conformities in boiler house operations are

removed by the application of corrective measures and installation of the latest equipment for reducing air emissions and particulate matter (ash generation).

5.4 Implementation of lean and ISO 14001 as a combined approach

The findings of this case study highlighted eight themes that emerged based on the constructs of the theoretical model for lean and ISO 14001 implementation (Figure 2.4) through the coding of interview transcripts, revealing a strong relationship between both strategies as a combined approach for sustaining environmental performance in the meat industry.

5.4.1 Integrated lean and ISO 14001 environmental policy

The informants of this case confirmed that a combined ISO 14001 environmental and lean waste reduction policy was formed by incorporating the objectives of the 2035 environmental management strategy for achieving operational and environmental performance. The group environmental manager revealed that the group manager, environmental manager and plant managers are mainly responsible for establishing an overall organisational policy by considering quality, environmental and safety targets. Short term (one-to-three-year strategy) and long term (five-to-ten-year strategy) for quality, environmental and safety targets are included in the high-level policy manual. Further, the environmental manager emphasised that an integrated lean and ISO 14001 environmental policy works better for achieving performance objectives and targets. The environmental manager explained the overall environmental and waste reduction policy from the organisational environmental manual as follows:

Recognised as an environmentally responsible company that respects the environment in which we operate while processing high quality products and services. Our commitment is to manage the processing operations in an environmentally sustainable manner whilst maximising the value for the company, our customers, farmers, co-workers and the community. (environmental manager)

The informants stated that targets for decarbonisation (reducing carbon emissions by up to 77%) and improving wastewater discharge (reducing nitrogen content, escherichia (E.) coli and suspended solids by up to 75%, 90% and 50% respectively) are included in the overall organisational policy to achieve the 2035 environmental management strategy of the Alpha. Further, the informants confirmed that water utilisation intensity is being reduced by 30% per lamb equivalent and they have managed to bring down the waste parameters (organic and inorganic) to

the minimum for landfill. More interestingly, the manufacturing excellence lead mentioned that a comprehensive lean and ISO 14001 environmental policy was formulated by considering the following parameters: (a) environmental effluents (carbon footprint, nitrogen and sulphur oxides and particulate matter), (b) electricity savings (refrigeration, air compression and motors) and (c) effective utilisation of water.

We focus on three key utility areas while analysing and establishing a comprehensive operational and environmental strategy for our group: usage of water in slaughtering, carcasses washing and protein processing, savings of electricity and minimisation of effluents by reducing carbon footprint and air emissions. (manufacturing excellence lead)

Further, the technical compliance manager emphasised that reduction of packaging waste and effective utilisation of coal are also considered relevant sustainability targets in formulating a waste and environmental impact reduction policy.

Right sizing of the packaging materials and minimisation of plastic waste generation are considered as crucial parameters for setting the environmental policy's targets across each of the seven plants. By replacing coal with alternative renewable fuels or replacement of a system for instance, biomass as fuel or electrode boilers as a system can be helpful in reducing carbon footprints to achieve environmental sustainability in our group. Both these fuel switching alternatives have depicted an immense potential in the recent months for reducing the decarbonisation impact to realise a low emission future. (technical compliance manager)

The informants have explained that KPIs such as consumption of water, fuel and electricity (for cleaning, chilling and freezing of meat products) are also considered prominent factors for effective utilisation of resources. The informants explained through environmental reports and manuals that the ideal limits of KPI targets for consumption of fuel, electricity and generation of total CO₂ for long-term environmental strategy are as follows: (1) utilisation of boiler fuel (0.50 Gigajoules (GJ)/tonne fuel adjusted production¹), (2) utilisation of electricity (2.52 GJ/tonne equivalent frozen weight²) and (3) production of total fuels CO₂ (fuel CO₂= 141kg/tonne meat

¹ **Fuel-adjusted production** – total weight of frozen and chilled product adjusted to reflect the relative energy (electricity) input required by the two product types.

² **Equivalent frozen weight** – total weight of dressed meat, tallow, blood, meat and bone meal, soup stock and wool adjusted to reflect the relative energy (fuel) input required by the different product types.

equivalent³ and electricity CO₂= 70kg/tonne meat equivalent). Moreover, the environmental manager further identified that odour of contamination waste, GHG emissions and effective packaging are considered as meat processing aspects with high potential risk in conjunction with the KPI targets for producing meat products. The environmental manager further explained that the odour of contamination waste is considered as air emissions that arise from wastewater lagoons and untreated wastes (organic and in-organic). An odour management plan is included in the implementation of lean and the core commitment of ISO 14001 environmental policy (pollution prevention) for achieving the operational and environmental targets. The general manager explained the importance of setting different operational and environmental KPIs for achieving the objectives and targets set in the overall policy of the group as follows:

Once we have the lean and ISO 14001 environmental policy in place, we collect the operational and environmental data at a group level and analyse KPIs for monitoring and reviewing performance outcomes against performance targets on a weekly, monthly and yearly basis. The main KPIs at all levels of our business are included such as effective utilisation of water, electricity and fuel to produce prime meat and by-products. (general manager)

The informants of this case study emphasised that an integrated policy for waste and environmental optimisation was formulated instead of individual/separate ISO 14001 environmental and lean policies. Furthermore, Alpha's overall policy (lean and ISO 14001) is communicated with the workforce and the relevant stakeholders (suppliers and contractors) for achieving the 2035 environmental management strategy.

5.4.2 Integrated plan and projects of lean and ISO 14001 implementation

Integrated environmental and waste planning mechanisms for meeting compliance and regulatory requirements to reduce undesirable waste demonstrated the level of thinking and commitment of the organisation in implementing an integrated lean and ISO 14001 project. The general manager suggested that understanding the overall meat processing chain is crucial before identifying potential risks and proposing corrective action plans based on ISO 14001 operational control for achieving short and long-term organisational strategy. Risk analysis is a non-mandatory procedure

³ **Meat equivalent** – this is derived from the fuel-adjusted production and equivalent frozen weight for expressing total production in terms of the overall energy requirement.

but an organisation can adopt this procedure for risk assessment, while risk management programme by lean helps an organisation for planning, organising and controlling resources in achieving organisational goals. Risk assessment is carried out by identifying the potential risk associated with handling of raw carcasses, processing, packaging and storage of meat products. Top management proposed the potential solutions for reducing the impact of high-risk activities in the planning phase.

I think, it is just about understanding all of the processes across our meat business before planning for a process optimisation project. What are the resources going into and coming out in meat processing and how these inputs and outputs have the impact on operational and environmental performance? Risk assessment is carried out based on these process parameters, then a plan is formulated to reduce the impact of high-risk activities on potential operational and environmental wastes in different phases of meat processing chain. (general manager)

The research and development manager explained that an integrated lean and ISO 14001 environmental policy helps the meat processing facilities to set better targets for fuel, electricity and water consumption by developing improvement and optimisation plans and projects. Short and long-term environmental and waste reduction plans are set and projects are executed by quality, environmental and health and safety managers. The research and development manager asserted that the foundation for developing the plans for environmental sustainability is as follows:

For setting up an environmental waste management plan, we must have operational and environmental objectives, targets and regulatory requirements for meat processing. Waste management plan is used in making sure that we have our waste and environmental policies and procedures in place for achieving targets by executing optimisation projects. (research and development manager)

The manufacturing excellence lead explained a plan for efficient water consumption in meat processing by analysing accurate data in developing and implementing KPI targets for an optimisation project.

An effective plan for utilisation of resources, for instance, water consumption can be proposed through analysing the information gathered from management review meetings and VSM information on slaughterhouse, processing area on operational condition of

isolation valves, water recirculation performance and data from flow meters. The accurate data on utility parameter such as water consumption can be used in planning phase for implementing and achieving effective KPIs target (water utilisation). (manufacturing excellence lead)

Planning of the environmental and waste reduction projects is executed by analysing VSM data on current operational activities, opportunities and risk assessment associated with the meat processing. Operational control procedure for ISO 14001 implementation (roles, responsibilities and authorities for providing financial, technical and human resources) is clearly defined and communicated (digital boards) with the workforce during the planning and implementation stages of an integrated optimisation project.

We identified the environmental and waste reduction plans by analysing VSM data on potential risk assessments and improvement opportunities for achieving organisational sustainability vision. Top management is responsible for maintenance of the relevant documents, sharing of information and arranging the required resources, for example, financial, technical and human to achieve the targets set in the planning phase of a project. (research and development manager)

Current issues associated with meat processing processes and their potential improvement by the application of lean and ISO 14001 procedures are highlighted in detail in the following examples based on empirical findings and secondary data (reports and process and environmental manuals). The research and development manager noted that project management software is applied to identify the need for continuous improvement initiatives (lean and ISO 14001 strategy). Further, Information Leader software and Microsoft (MS) Excel spreadsheets are used in controlling documentation for managing set targets to implement continuous optimisation projects.

We have project management software to look after the environmental plans from a continuous improvement point of view to manage structured waste reduction projects in handling carcasses, optimising consumption of water and electricity and packaging material in meat processing facilities. Further, data from Information Leader and MS Excel spreadsheets are used to maintain the KPI records around decarbonisation, reduction of all kinds of waste such as wastewater, inorganic and organic waste and effective electricity consumption. (research and development manager)

The technical compliance manager mentioned that a project was carried out to convert sheepskins into a small volume of compost material for landfill. The market for sheepskins collapsed a few years ago and the handling and storage of sheepskin became an issue due to their large volume. They tried to remove this waste after processing it through rendering to landfill; however, the problem worsened due to a rapid increase in sheepskin levels in their storage areas. The company's top management arranged a number of brainstorming sessions (root cause analysis was conducted) and decided to buy shredding equipment to convert sheepskins into a small volume of compost pelts for landfill until the market for such skins returned to normal. In another project, the group environmental manager highlighted that the production of high volumes of organic waste out of the wastewater system became a big concern (occurrence of a non-conformity) due to limited availability of landfill sites around NZ. Initially, organic solid waste was converted into small volumes (corrective actions according to ISO 14001) by a rendering process for landfill. However, most recently, their research and development department suggested utilising this solid waste in boilers (after processing and drying) as a renewable fuel due to the reasonably high calorific value of ash particles (continual improvement according to ISO 14001). Further, they suggested that this organic waste can be utilised as a raw material for fertilizers and biogas (continual improvement initiative according to ISO 14001) due to the suitable content of phosphorus and calorific values of this solid residual paunch.

Interestingly, the environmental manager reported a non-conformance in boiler operations due to poor quality of environmental discharge (increase in particulate matter, excess generation of carbon monoxide and nitrogen oxides). These air emission parameters are monitored very closely every day to retain environmental quality compliance under ISO 14001 framework to fulfil the consent requirements set for environmental discharge with the environmental groups and local councils. Their environment team, quality assurance manager and boiler engineer conducted a series of meetings to analyse non-conformities (by utilisation of root cause analysis, 5-Whys and A3 thinking) and suggest potential mitigation solutions (corrective actions according to ISO 14001) for improving their environmental discharge targets in boiler operations. They proposed to improve internal operations such as effective utilisation of baghouse filters/electrostatic precipitators, use of renewable fuels along with coal and installation of the latest carbon monoxide/effluent measurement meters to monitor and reduce environmental discharge from boiler stack. They further suggested that strict limits (establishing KPI targets) of environmental

discharge (particulate matter, CO₂ and sulphur and nitrogen oxides) should be included as compliance requirements in developing future targets and policy for environmental performance.

The environmental manager reported that organic waste with high water content and poor-quality wastewater coming from a beef plant can create issues (major non-conformance reported during the internal audit of ISO 14001) for landfill and riverside disposal. The company's top management analysed the potential causes of these non-conformances using brainstorming, process mapping and root cause analysis by utilising A3 thinking format. They proposed two process optimisation plans (corrective actions according to ISO 14001) to tackle these non-conformities. The first corrective action was based on rendering the organic waste and composting the wastewater sludge with dirt to create biogenic material minimising landfill waste. The second solution was based on wastewater treatment (i.e., proposing Kaizen event actions to handle the wastewater effectively) for reducing harmful bacteria (*E. coli* and listeria) and chemical contaminants before disposal to riverside. Handling and transportation costs are reduced (value-added activities) by rendering the organic waste into small compost pellets and meeting compliance requirements through improved quality of wastewater.

Earlier, the manufacturing excellence lead reported communication with environmental groups and Canterbury Regional Council (external communication according to ISO 14001) to investigate the reasons and propose viable solutions for reducing the sludge content in wastewater discharge. A comprehensive investigation was conducted following the A3 thinking process to determine the causes of additional sludge content generation in the wastewater disposal ponds. The A3 thinking report suggested that high levels of *E. coli* content, organic and inorganic wastes were present in the sludge wastewater. These are the parameters considered to calculate the extent of sludge treatment before disposing it into the riverside or wastewater ponds. The following countermeasures in the wastewater optimisation plan were suggested for minimising such wastes according to A3 thinking. Excessive *E. coli* component in the wastewater was removed by coagulating it with aluminium sulphate and organic polymer. Meanwhile the organic waste sludge was minimised by treating it and utilising it as a renewable fuel or compost material. Further, undesirable organic and solid components of wastewater from the slaughterhouse were minimised by using an ultrafiltration process before entering the wastewater into the riverside. The environmental manager mentioned a project to decrease water consumption and wastewater production in meat processing areas. The managers of two sites decided to install water isolation

valves and flow meters to improve the water flow and utilisation. Further, they proposed managing the hot water circulation through isolation valves on low production days such as weekends and reduce leakage of water by managing water flow meters. These best practices for reducing excessive wastewater sludge are documented in the revised standardised work instructions to achieve better environmental performance.

5.4.3 Communication and information sharing

All informants explained the importance of comprehensive communication management in effectively sharing information on environmental and waste minimisation targets within the different departments of meat processes (slaughterhouse, processing, packaging, chilling and freezing and boiler house). The environmental and waste targets are displayed on visual/white boards in processing and canteen areas of each processing unit. The general manager highlighted the process of structural internal information flow by utilising different operational attributes such as consumption of water, generation of air effluents and packaging waste in a single visual/white board (visual management is a lean tool). The manufacturing excellence lead further explained the importance of regular structural meetings on analysing previous targets and setting new targets as follows:

Structural communication through meetings and discussions is critical between operators, supervisors and production managers and later on with general manager to analyse the targets set around wastewater, air effluents and packaging waste on regular basis. These targets are displayed, monitored and regularly revised within the lean programme through visual or white boards. (manufacturing excellence lead)

The informants of this case further emphasised the importance of internal communication across the different hierarchical levels in collecting data, analysing and suggesting improvements for achieving manufacturing excellence. Monthly utility KPI datasheets are used as information sources for monitoring, comparing and evaluating performance improvements. The environmental manager explained the importance of sharing information regularly for maintaining continuous improvement as follows:

We do have an appropriate system in terms of internal communication. KPIs weekly or fortnightly reports on electricity consumption, wastewater and fuel consumption are collected by group environmental and general managers from all seven sites via email for

performance evaluation. Based on this critical communication, we monitor existing performance and suggest improvements regularly in meat operations for continuous improvement. (environmental manager)

The technical compliance manager stated that visual white boards are employed for displaying input (operational and environmental targets set) and output (targets achieved or underperformed) through light-emitting diode screens:

We put production, environmental and waste targets in a single visual matrix through visual digital boards. Microsoft Excel spreadsheets are further readily available to all relevant internal stakeholders for sharing information on KPIs and targets for analysing the current operational and environmental performance status. (technical compliance manager)

The manufacturing excellence lead reported that public and environmental groups contacted Canterbury Regional Council about their concern regarding noise pollution and the unbearable odour of wastewater (high contaminated pollutant load) in the waste stream. Canterbury Regional Council shared the complaints and proposed a mitigation strategy based on the guidelines of the Australian and New Zealand Environment and Conservation Council (ANZECC) with the top management in a face-to-face meeting. Later on, the operational and environmental team took corrective actions to improve the situation and proposed proactive measures for the future. These corrective and proactive measures were communicated to the relevant community groups and Canterbury Regional Council through email correspondence. The group environmental manager further elaborated the importance of external communication with relevant stakeholders (regional council, environmental groups and end-consumers of meat products) as follows:

We do regular communication with regional councils and environmental interest groups through emails or face-to-face meetings regarding the compliance status of our operational and environmental performance against consent conditions. Further, our customers from the UK frequently asked about our environmental and waste minimisation targets and how we are going to achieve these targets for producing high grade meat products. We have got some reasonably basic operational and environmental manuals that have been developed to share with our local and overseas customers. (group environmental manager)

5.4.4 ISO 14001 procedures

Most informants said that the roles, responsibilities and authorities for the workforce are set in the implementing procedures of the EMS framework to achieve compliance and regulatory requirements. The informants of this case explained that lack of operational control contributes to deviation from objectives, targets and environmental policy. The manufacturing excellence lead suggested that only significant environmental aspects with high risks such as air pollution, generation of organic and inorganic waste and packaging material usage and electricity consumption need a documentation procedure. Further, identifying and establishing the criteria for significant operational control procedures require clear justification to the external auditors of a certification body during EMS revision. Effective maintenance of documentation of operational and environmental procedures is a crucial requirement. The research and development manager explained the roles and responsibilities of the workforce as follows:

Workers, departmental supervisors and production manager or plant manager must know their responsibilities and authorities for their particular role specifically when the top management is setting up ISO 14001 procedures and lean practices. Top management is responsible in developing EMS and continual improvement projects, while the remaining workforce is responsible for meeting the compliance obligations and operational targets. (research and development manager)

The group environmental manager explained that operational controls measure the effective implementation of EMS and manage environmental impact to improve environmental sustainability. The manager reported that an environmental team (group environmental manager, environmental manager and environmental officers) plays a critical role in (1) establishing environmental targets around effective utilisation of carcasses, consumption of utility and optimised boiler operations, (2) reviewing actual performance against targets set and (3) introducing corrective actions to overcome performance deviations. The environmental manager explained that the documentation control (environmental policy, results of internal audit and management review, results of corrective action) is mainly included for implementing environmental procedures and practices. In the same string, the research and development manager highlighted that Information Leader software is installed to maintain a document management system in collecting data of KPI targets for monitoring, measuring and auditing from an environmental perspective. Further, standard operating procedures (SOPs) for yielding

environmentally friendly meat products must be recorded, documented and communicated at all levels across all meat processing facilities under the Alpha.

Additionally, the group environmental manager elaborated that documentation control based on Information Leader can only be edited by a few authorised individuals to update the existing targets, compliance status and risk assessment on environmental performance. The environmental manager further explained that Information Leader is applied to electronically maintain the documentation and compliance requirements from food safety, operational and environmental performance perspectives. Internal auditors went out to different meat processing areas and wrote up the forms, reports and documents each day. The evaluation of environmental KPIs and corrective actions are documented in Information Leader. The documented outcomes of performance evaluation and proposed preventive/corrective actions are notified and communicated to the workforce. Moreover, the manufacturing excellence lead further explained the maintenance of documentation in meat facilities as follows:

We maintain a number of documents under operational control procedure of ISO 14001. These document procedures are such as organisational overall policy, environmental impact assessment manual, KPI reports based on analysis of inputs and output targets, audit reports, annual management review findings and preventive or corrective actions. (manufacturing excellence lead)

5.4.5 Lean tools

The informants of this case study explained that lean tools are implemented for producing environmentally friendly meat products. The majority of the informants emphasised the importance of root cause analysis, 5-Whys, A3 thinking, 5S, environmental and waste reduction benchmarking KPI targets, standardised work, VSM and visual management, as the main lean tools for achieving manufacturing excellence. Additionally, other lean tools such as JIT and TPM are also explained in this case study. Most of the informants emphasised that root cause analysis, fishbone/Ishikawa diagram, A3 thinking and KPIs are the most prominent tools used for reducing water and electricity consumption as well as air emissions.

The group environmental manager reported that approximately $53 \mu\text{g}/\text{m}^3$ particulate-matter-10 (PM₁₀) was generated in the air stack and ash pit of the boiler house. The maximum level of PM₁₀ to meet the compliance requirement is $35 \mu\text{g}/\text{m}^3$; however, a coal-based boiler can produce PM₁₀

50 $\mu\text{g}/\text{m}^3$ once in a two-year period. The top management initiated an investigation to determine the reasons for generation of excessive sticky PM_{10} in boiler operations (air stack and ash pit). The group environmental manager stated that root cause analysis is used in meat processing operations to identify the issues in daily routine processes. Boiler engineers, supervisors and the group environmental manager made an assessment to identify the root causes of excessive PM_{10} generation by applying a fishbone/Ishikawa diagram. Quantity (53 $\mu\text{g}/\text{m}^3$) of PM_{10} (measurement), irregular particulate size (material), mishandling of coal feed (personnel) and inefficient management of primary and secondary air ducts (machines) are identified as root causes of excessive PM_{10} generation in the coal-fired boiler. Once the root causes were determined, they proposed corrective actions for reducing PM_{10} generation by feeding the optimal particle size of coal in the feed bunker and providing essential training to the boiler operators for managing the primary and secondary air ducts. Data collected after implementing the corrective actions from root cause analysis on PM_{10} indicated a rapid decrease (approximately 35 $\mu\text{g}/\text{m}^3$), which contributed to achieving the environmental targets. By implementing corrective actions, handling of coal and providing training help to minimise PM_{10} 's adverse health impacts, improve ambient air quality and meet the compliance parameters for PM_{10} generation.

Excessive generation of particulate matter adversely impact the environmental performance during the generation of electricity and steam in the boiler house. New Zealand and World Health Organisation have strict limits to meet the guidelines on particulate matter for maintaining the environmental targets. An investigation team evaluated the data on air emission through fishbone diagram for identification of the main causes of excessive PM_{10} generation and proposed the mitigation strategies. Measurement, material, personnel and machine type of parameters under fishbone diagram have been used to identify the main causes of excessive PM_{10} generation. Boiler engineer and supervisors suggested to improve the coal feed size and educate our colleagues for managing better air circulation to minimise the excessive PM_{10} generation in the boiler house' air stack and ash pits. (group environmental manager)

The environmental manager further noted the non-conformity occurrences (excessive CO, NO_x and SO_x generation) during the analysis of KPI worksheets (boiler operations data). According to the World Health Organisation (WHO) guidelines, the recommended compliance limits of CO, NO_x and SO_x are 7 $\mu\text{g}/\text{m}^3$, 25 $\mu\text{g}/\text{m}^3$ and 40 $\mu\text{g}/\text{m}^3$ respectively for coal-based boilers. However,

VSM data indicated irregularities in air emission parameters of the coal-fired boiler in the Alpha. The management decided to analyse the value stream data on air emissions by using A3 thinking for evaluating the reasons for environmental non-conformities and proposing mitigation solutions. The problem statement of this A3 thinking investigation was to determine the causes of excessive air emission parameters in Alpha's boiler house. Reports on fuel feed (composition of coal and biomass feed) and air emission parameters were generated for analysis to identify non-conformities. They concluded that the composition of sulphur (coal) and volatile matter content (blend of coal and biomass) were higher than the recommended limit of fuel (A3 thinking assessment). They proposed to improve the composition of fuel by blending coal with biomass properly for achieving desired composition of fuel (recommended percentage of carbon, sulphur and nitrogen content) to improve the environmental performance. Optimised CO, NO_x and SO_x parameters in the coal-fired boiler helped to improve the ambient air quality, reduce the potential erosion of boiler equipment and minimise greenhouse gas generation during the electricity and steam generation for the meat processing activities. Further, the environmental manager elaborated the application of KPIs and A3 thinking as follows:

I think, there is an expectation for operational and environmental targets during a project execution. We are using our KPI datasheets to understand what are the essential parameters for monitoring and reporting against the compliance requirements, what are we delivering to our loyal customers and how we set and improve our future targets by overcoming the non-conformities through the application of basic lean tools. (environmental manager)

Informants from Alpha indicated the application of KPI benchmarks for setting targets, analysing data and proposing future recommendations to achieve better operational and environmental performance. The manufacturing excellence lead explained that KPI benchmarks around decarbonisation, water and electricity consumption with operational limits are generally set in slaughterhouse, refrigeration and boiler house operations. The manufacturing excellence lead reported that one of their meat processing facilities consumes a higher volume of water than the ideal limits set in KPI benchmarking. Operational reports based on KPI benchmark datasheets were generated to determine the causes of non-conformities of water usage under the current state assessment of benchmarking. The relevant managers suggested improving monitoring of floor

washing activities, washing angles and spray nozzles for optimising water consumption after a comparative analysis of KPI benchmark datasheets.

Further, the manufacturing excellence lead suggested that wastewater generated from pre-trim and boning room steriliser processes could be reused for cleaning the floor and equipment. Wastewater from the boning room is considered feasible for reuse and recycling processes due to its high temperature (approximately 82 Celsius ($^{\circ}\text{C}$)) which kills micro-bacteria. The manufacturing excellence lead further recommended that the usage of high temperature water (potentially causing burns) requires precautionary measures (wearing rubber gloves for protection). KPIs benchmarking data on water consumption and wastewater generation helped to compare and identify the causes of extra consumption in slaughtering and evisceration processes. Reuse and recycling processes of wastewater helped to achieve the KPIs targets around wastewater reduction and waste to landfill. Wastewater reclamation is considered to have a significant impact on water management. Usage of boning room wastewater for cleaning purposes reduced the consumption of energy and fresh water in the floor cleaning processes which contributed to improving environmental performance.

We have maintained data on raw carcasses, water usage and electricity consumption since 2012. We used operational datasheets of slaughterhouse and boning room processes as KPIs benchmarking for assessment of water consumption within our group. The lean and environmental manager suggested to improve floor washing activities by optimising washing angles and spraying nozzles under the concept of benchmarking strategic prognosis. They further recommended to reuse or recycle the boning room wastewater for cleaning purposes due to its high temperature and favorable chemical composition. (manufacturing excellence lead)

The research and development manager revealed that their local customers of red meat (beef and lamb) placed few sudden orders in the peak export period during the Covid-19 pandemic. The production planning manager and group production manager faced difficulty to plan for meeting the customer demand. The research and development manager stated that VSM is used to analyse the current status and propose future recommendations for effective utilisation of raw carcasses, water and packaging material from when the carcasses arrive in the meat facility to delivering the meat products to customers. In the same vein, the manufacturing excellence lead emphasised that

the application of VSM is considered critical for mapping the material (livestock level, raw carcasses, water, chemicals, packaging material and consumption of electricity) and information flow that signal and control the meat processing activities. Different sources of waste generation are identified by VSM in the meat processing activities such as (a) handling of livestock, (b) slaughtering process (wastewater, handling of blood in hoisting, dressing of carcasses and offal separation), (c) boning room (organic waste and wastewater) and (d) electricity losses in chilling and freezing.

The research and development manager and his team identified bottlenecks and potential production enhancement opportunities by analysing VSM data. They proposed in the future VSM work plan that unexpected orders can be managed by optimising raw carcasses, water and electricity consumption in the slaughterhouse, boning room and packing procedures. Further, they suggested that holding additional animals as buffer stock at the lairage facility mainly contributes positively to meeting the demands during peak processing periods. They explained that holding extra livestock in the lairage facility helps to maintain JIT with a 4 to 12 hours' buffer setting for ensuring the continuous supply of the livestock and managing the unexpected demand. Additionally, holding the animals at the lairage facility helped to rest the animals after transportation for maintaining higher ante-mortem glycogen levels (due to stress-free animals). VSM is applied to identify the value-added activities (such as maximum meat extraction from carcasses and optimum consumption of steam) and non-value-added activities (for instance, mishandling of carcasses and wastewater generation) to process the environmentally friendly meat products. The environmental benefit of the VSM application is to identify the opportunities for efficient utilisation of raw carcasses, energy and water. JIT with buffer setting is used to improve inventory management to meet the customer demand.

Unexpected orders were placed by local customers in the peak export period few months back. Our management initially faced difficulties to meet the new meat orders; however, VSM data helped us to identify the potential production enhancement opportunities. We evaluated current utilisation status of raw carcasses, water and packaging material by analysing the VSM data. Outcomes of current VSM helped us to develop a future map for improving meat processing procedures. Our production planning manager proposed to increase the livestock holding period by placing JIT buffer at the lairage facility to meet the current and future unexpected customer orders. (research and development manager)

The general manager reported frequent spillage and environmental safety issues due to mishandling of chemicals during slaughtering and evisceration processes. The general manager suggested that a clear chemical handling policy, management procedures and the role of the employees are crucial elements in handling chemicals. The general manager explained that 5S, standardised work and visual controls were implemented to ensure effective chemical management for reducing the workplace incidents. 5S is considered as powerful tool in sustaining clean (shine) and orderly (set-in-order) chemical storage areas to provide a safe environment. Further, 5S workplace assessments, audits and checklists are effectively maintained to ensure that workers regularly perform routine checks (chemical ID, maintenance sheets and warning signs), label chemicals properly and remove chemicals from the site (if needed due to expiry or spoilage). Putting chemicals in assigned areas (the set-in-order pillar of 5S) helped to avoid potential chemical spills and ensure obstruction-free spaces for conducting the meat processing activities. Revised chemical management practices (handling, storage and disposal) updated the previous standardised work instructions to identify appropriate places for storing of chemicals, maintaining chemical safety data sheets and incorporating these practices as part of daily routine work. They introduced laminated standardised work procedures (chemical management practices) and prominently placed these instructions in the hazardous material storage station for easy reference. Further, visual management is used to implement the chemical management initiative effectively by displaying clear floor marking and digital cards for identifying point of chemical storage. Digital screens are used to display chemical safety data sheets (specific chemical identity and physical and chemical properties) to improve the workforce's understanding of handling chemicals. Lean tools helped Alpha to store the chemical materials efficiently, handle hazardous chemicals and avoid spillage to reduce the risk of injury and create an accident-free workplace. 5S is applied to remove the obstacles and reduce the associated hazard of chemical mishandling. Regular cleaning processes decreased the possibility for accumulation of chemical substances on the floors of the slaughterhouse, boning room and chillers system that can reduce the chances of meat contamination and processing defects. Regular defects reduction by the application of 5S has significant environmental benefits such as effective utilisation of raw carcasses and consumption of electricity to produce meat products with a long shelf-life. Visual management and revised standardised work instructions helped to improve information sharing with the workforce and

ensure better understanding in order to implement the chemical management procedures and guarantee environmental safety.

Mishandling of chemical materials can cause spills, safety accidents and non-compliance risks which hindered the process flow in the meat processing facilities. We have implemented 5S, standardised work instruction and visual control to achieve the targets of chemical management policy. By using 5S, chemical materials are effectively maintained through regular workplace assessment and 5S audits to provide safe environment and improve production flow. Chemical management practices are included in standardised work to encompass these guidelines as daily routine work instructions for better hazardous material handling. Visual management is used to guide the workforce in identifying point of chemical storage and chemical properties of the hazardous material. (general manager)

The technical compliance manager further explained that visual management is employed for managing information sharing within the different departments in the meat processing facilities. They highlighted the application of this effective tool for communication. Visual management (visual management board) is employed to display KPI targets around quality meat products, environmental parameters and environmental safety to educate the employees and raise their awareness in producing high grade meat products. Further, these parameters are updated on digital and white boards on a regular basis for achieving compliance or removing non-conformities in meat processing.

The environmental manager revealed that the slaughterhouse and boning room operators frequently reported interruptions of raw carcasses processing due to musculoskeletal disorders (MSD) among staff in the previous few months. The top management of Alpha helped staff members to file their accident compensation corporation claims (if MSD occurred). They further introduced 5-Whys to investigate the reasons for occurrence of MSD during the meat processing activities. A team of manufacturing excellence lead, operations manager and operators are involved in conducting 5-Whys brainstorming sessions to determine the causes of MSD in the meat processing activities. Operators of slaughterhouse, boning and packaging processes identified that MSD are caused by manual lifting, repetitive movements and awkward positions for extended periods. The investigation team further concluded that the operators do not (1) follow the standardised work instructions, (2) promptly report discomfort or injury and (3) have access to

documented work instructions. The environmental manager explained that the existing standardised work instructions such as for lifting heavy carcasses and handling wastes (organic and inorganic) are modified based on the analysis of previous data on documented work instructions. These updated documented work instructions and charts are taught to the workforce in the induction and regular training programmes. The environmental manager further elaborated that a series of standardised work procedures including environmental, quality and safety considerations are called safety operating procedures. Environmental safety (reduction of injuries and MSD) and SOPs are maintained during handling carcasses by implementing standardised work instructions.

Our meat processing facilities were facing interruptions in process flow and delays in delivering environmentally friendly meat products to our loyal customers. We have used 5-Whys to identify the main causes of these interruptions during peak hours of meat processing activities. Our investigation team reported that our operators suffer musculoskeletal disorders during peak hours. Main reasons of sprains and strains in our operators were reported as deviation to follow work instruction and unrecorded injury in handling heavy carcasses. Standardised work instructions provide guidelines to handle wastes in slaughterhouse and evisceration processes and handling of heavy carcasses in boning room. (environmental manager)

The manufacturing excellence lead reported workplace accidents (health and safety issues) and extra water consumption caused by mismanagement of cleaning and sanitising procedures in their meat processing facility. 5-Whys was used to identify the potential causes of accidents and extra water consumption during cleaning procedures. Operators from the slaughterhouse and boning room were interviewed to explore the main causes of these non-conformities. They described the root causes as follows: (1) consumption of hot water (approximately 84⁰C) which can cause safety issues (hot water burns), (2) usage of chemicals to dissolve the fat and (3) utilisation of extra hot water for sanitisation procedures to kill the bacteria. The manufacturing excellence lead highlighted that 5S is implemented as a tool for cleanliness management (cleaning and disinfection of floors by using bleach and other chemicals) and optimal storage (handling of raw carcasses and finished meat products) in the waste-intensive meat industry. 5S is crucial for standardising of handling and processing meat products to improve their shelf life. Workplace accidents and safety hazards are minimised by reducing the spillage of liquids and organic waste on the meat processing

floor by adopting the culture of 6S (5S+safety). Further, safety of the workforce should be ensured during the usage of hot water, chemicals and detergent by wearing full length waterproof aprons, gloves and gumboots. Moreover, the manufacturing excellence lead added that water consumption can be reduced by replacing hot water with the latest ultraviolet (UV) steriliser for cleaning knives, saws and meat slicers to improve equipment hygiene in the slaughterhouse and boning room processes.

Our data on water consumption suggested high-volume water usage in cleaning and sanitising processes. Further, our team leaders also reported water spillage and mishandling of hot water in slaughterhouse and boning room processes. Primarily, 5S is used for cleanliness management in the waste-intensive meat industry. Further, spillage of water and hot water usage can be minimised by adopting 5S with safety culture and introducing latest ultraviolet steriliser. (manufacturing excellence lead)

The group environmental manager and his team observed functional irregularities in meat slicer after cleaning of cutters. Assembling of heavy equipment such as meat slicers (cutter and guards) carefully inspected before starting routine processing of the meat. Equipment safety is crucial to avoid the potential safety hazards (strains and falls) of heavy meat processing machinery (cutter and guards). The group environmental manager suggested that TPM is considered as an integral part of their processing activities to engage the workforce for effective maintenance of equipment intensive meat facilities. Preventive maintenance through TPM enabled the operators to maintain a number of heavy meat processing machinery (rails, slicers and cutting saws) that needed regular servicing and maintenance in the slaughter and boning room areas. Their skilled and competent workforce has helped Alpha in maintaining the equipment such as hoisting machines, meat slicers and spray nozzles to avoid breakdown. The group environmental manager further concluded that adopting TPM practices effectively increased the efficiency of the meat slicers upto 15% within two years.

Regular inspections have reduced the malfunctioning of cutters and guards after cleaning process of heavy equipment. We have implemented TPM for effective maintenance of equipment. Further, role of the skilled workforce for implementation of TPM initiatives is vital to ensure regular serving and maintenance of hoisting machines, meat slicers and spray nozzles. (group environmental manager)

A list of lean tools used in the meat manufacturing company Alpha, based on the descending order of the number of informants who cited them, is presented in Table 5.2 (Appendix E).

5.4.6 Implementation awareness, competencies development and training of the workforce

The informants of this case highlighted that the benefits of lean and ISO 14001 strategy implementation can be enriched by having a competent workforce, maintaining the highest awareness levels and conducting internal and external training for achieving the compliance requirements in the energy intensive meat processing industry. The need for conducting training programmes (organisational and employees' perspective) is evaluated on the basis of the existing competence and awareness levels of the workforce to sustain continuous improvement. The group environmental manager explained that the need for training is based on identification of existing knowledge versus desired competencies of the workforce for effective implementation of ISO 14001 and lean or any other improvement initiatives. Informants provided a detailed description of training programmes for newly employed workers to implement environmental, quality and health and safety initiatives in daily routine operations. Further, the newly employed operators are trained to use knives effectively, follow SOPs and instructions in performing hoisting, dressing and offal separation in meat processing operations.

The meat processing workforce are involved in various tasks beyond slaughter and boning. Therefore, the New Zealand Qualification Authority (NZQA) and the Primary Industry Training Organisation (PITO) have developed a variety of training programmes and qualifications that align with best meat processing practices and industry expectations. These well-organised training programmes and courses include knowledge management in areas such as sustainable environmental practices, competent manufacturing skills (lean and clean-in-place skills), knife skills and halal slaughter training and hazard identification and risk assessment. Research and development manager concluded that both NZQA and PITO programmes help to (a) follow compliance requirements and (b) enhance effective communication and monitoring procedures. Additionally, the manufacturing excellence lead explained that induction training is conducted (a few slides about environmental management, health and safety instructions and operational activities) for contractors during their visits to meat processing facilities.

We have got an onboarding programme that we built to promote implementation awareness and provide training which meets the New Zealand standards for improving

existing competencies and qualification of the workforce. The newly hired employees go through an induction training, then they are entitled to qualify for a New Zealand certificate, for example, NZQA level 2 or 3. NZQA certifications include a comprehensive understanding of our environmental, quality and health and safety standards as well as continuous improvement programmes for achieving manufacturing excellence. (manufacturing excellence lead)

The technical compliance manager further provided the details of training by explaining the high-level leadership learning programme for top management to better achieve short and long-term operational objectives as follows:

We have a leadership programme where we provide an integrated learning programme around manufacturing excellence and lean activities. This programme helps the top management to understand the application of lean tools for achieving operational and environmental objectives that we need for our business. (technical compliance manager)

The manufacturing excellence can be achieved by enhancing the competence and skill levels of the workforce for effective implementation of environmental practices, competitive manufacturing skills (lean tools) and hygiene and food safety initiatives. The environmental manager explained the role of training programme to achieve manufacturing excellence as follows:

We trained all our employees, such as seasonal operators, regular operators, team leaders, supervisors and site managers to implement sustainable environmental practices, hygiene and food safety requirements and lean tools to achieve three pathways – bronze, silver and gold – of manufacturing excellence. (environmental manager)

The research and development manager further explained that the need for training is based on identification of existing knowledge versus desired competence of the workforce for effective implementation of ISO 14001/lean strategy or any other improvement programme.

We are having regular awareness programmes and internal training sessions on what the latest environmental legislation, meat processing plant discharge consent requirements and government pressure for environmental effects are coming on to the meat business. (research and development manager)

The competencies level of the workforce and engagement culture of the organisation are consistently encouraged for improvement to ensure effective implementation of work instructions and procedures for achieving standardised and high-quality meat products.

Only conducting awareness and training programmes might not always guarantee achieving excellence and environmental sustainability, but the performance outcomes can be enhanced by the high level of engagement and competencies of the operators, supervisors and managers. An enthusiastic engagement culture at all our plants across New Zealand can reflect on our performance reports for achieving consistent operational and environmental optimisation. (group environmental manager)

5.4.7 Environmental performance evaluation

The informants of this case suggested that monitoring, auditing and performance review are important to evaluate the objectives and targets of waste elimination in the resource-intensive meat industry. The environmental manager indicated that the operational and environmental performance parameters are effectively monitored and data is collected and analysed for performance evaluation. The research and development manager emphasised that KPI targets are set and communicated with the workforce and top management are assigned roles, responsibilities and authorities for environmental performance evaluation. The research and development manager further explained the monitoring, reviewing and evaluation of the environmental performance as follows:

We have our KPI targets that we monitor and track every month to collect information of different meat processing stages at group level to review and evaluate the operational and environmental performance. This performance evaluation mechanism is used as a benchmark to determine the performance of waste and environmental impact reduction against the targets set in the overall organisational policy. (research and development manager)

External audits are conducted by local councils (samples of wastewater, organic and inorganic waste and air emissions are taken for analysis) to evaluate the consent and compliance requirements against the targets set for operational and environmental performance. Further, auditors from a certification body played a critical role in analysing and reviewing the compliance and statutory requirements to attain ISO 14001 certification. The general manager highlighted that

the external auditors (from the certification body) review a series of procedures for different processes for continuing ISO certification status on at least a three-yearly basis. Additionally, internal auditors, environmental managers and plant managers also review and audit the procedures for identifying compliance or non-conformities. Once compliance or non-conformity (in slaughterhouse, packaging and chilling/freezing zone) is reported, then the relevant people from a specific operational area and internal auditors propose better future compliance targets or removing existing non-conformity.

Further, the research and development manager explained that a member of the internal auditors' team checks and evaluates the compliance requirements from a food safety and environmental quality perspective each day and records the data through a SOP (documentation control). The manufacturing excellence lead explained that different types of audits are conducted to determine the level of conformance in their meat processing plants and shared data from manual documents to explain a few examples of these audits as follows:

We are involved in a series of audits in our meat sector: audits for ISO systems, British Retail Consortium, Meat Industry Association carcass trim standard auditing and high-quality beef audits for producing environmentally friendly meat products. (manufacturing excellence lead)

5.4.8 Environmental management review

The informants of this case study explained that the management review is crucial to analyse and review the explicit operational and environmental aspects and targets and propose future recommendations for achieving better compliance or overcoming the non-conformities. Informants from Alpha explained that the consumption of major resources (raw carcasses, water and electricity) is measured for collecting accurate and detailed information on these relevant aspects and targets. Detailed data is analysed for determining the compliance level/non-conformity of a system and based on the outcome of the performance evaluation new objectives and targets are set for upcoming years in the annual management review. The group environmental manager explained the annual management review as follows:

We do have an annual management review. We reviewed operational and environmental aspects and impacts and we evaluated our objectives and targets for the year. New

objectives and targets are set for the next year after evaluation of conformance and non-conformances of our systems. (group environmental manager)

The technical compliance manager emphasised the need for better managing the communication with the workforce to share the appropriate information and evaluation of the existing performance and future targets set in the management review. The research and development manager suggested that the management review is used to determine the weaknesses and gaps for capturing a bigger picture in evaluating the meat processing operations on a yearly basis. Further, the input and output of the management review provides a complete understanding for the top management to allocate utility, financial and human resources to achieve objectives and targets set for next year's operational and environmental performance. The general manager highlighted that the role of the management reviews is to examine the current performance to identify gaps and propose solutions for removing the non-conformities and assign the right people to share information in improving future performance.

Management reviews are not a place to go and solve the identified performance gaps, but they are about having a structural system in identifying existing gaps, reviewing the performance data and proposing future improvement initiatives for environmental performance. Top management is responsible for assigning the right people, e.g., plant managers, processing and quality specialists and maintenance managers, allocating resources, for example, mainly financial, human and technical and maintaining communication activities for achieving future targets after the annual management review meeting. (general manager)

5.5 Critical success factors for implementing lean and ISO 14001 as a combined approach

Leading from the top played a crucial role in establishing waste and environmental policy and managing information sharing with the workforce for achieving waste reduction targets. Further, top management participation and willingness to maintain awareness and training of the workforce is a prominent factor. Availability of financial resources through top management commitment is required for conducting the awareness and training programmes to enhance the competencies of the workforce in attaining sustainable operational and environmental performance. Informants from Alpha explained the key role of top management in communicating the organisation's targets, policy, waste and environmental reduction plans and projects and the outcomes of improvement

initiatives with the workforce. The general manager emphasised that the top management must be actively supportive in managing financial investments for the introduction of new technologies (introduction of software such as Information Leader) and equipment (upgradation of water metering) to achieve a manufacturing excellence programme.

Having a leadership that wants to set priorities and happy to spend money for improving operational/environmental performance is critical. If they are not interested and motivated for achieving manufacturing excellence, then you are not going anywhere in implementing operational and environmental improvement initiatives. (general manager)

The technical compliance manager explained that a strong culture (shared beliefs and values) for implementing lean and ISO 14001 or other improvement initiatives fosters the manufacturing excellence strategy. The environmental manager further elaborated that an environmental sustainability culture helps for developing richer environmental policy and defining roles, responsibilities and authorities to achieve utility KPIs and performance excellence. Adaptation of an EMS framework and the application of lean tools enable the resource intensive meat sector to overcome the non-conformities and meet the compliance and consent requirements against performance outcomes due to the organisational culture for continual improvement.

The research and development manager revealed that the high turnover rate of staff is reported every year due to dissatisfaction, lack of appraisal initiatives and empowerment of the workforce. Therefore, the environmental manager suggested that the involvement and motivation of the employees plays a critical role for retention of the competent workforce (i.e., operators, supervisors and team leaders). The group environmental manager mentioned a get-together party (involving drinks, pizzas and sausages) for the staff to reward their efforts in achieving no recordable injuries and effective environmental conformance for a month. Furthermore, the environmental manager suggested that implementation awareness and training programmes help the workforce to enhance their knowledge for implementation of ISO 14001 procedures and lean tools in meeting operational and environmental targets. The technical compliance manager explained that NZQA qualifications (level 2-6) and Primary Industry's training programmes helped the different hierarchical levels of the workforce (seasonal workers, supervisors, team leads and managers) to perform the best meat processing practices.

I believe, technical expertise of the workforce should increase through training and awareness programmes because the employees are being exposed to adequate information for ISO systems and lean tools implementation to achieve better operational and environmental sustainability. (technical compliance manager)

The manufacturing excellence lead emphasised the importance of implementation awareness programmes for understanding the environmental procedures and lean tools for achieving the sustainability targets. The awareness programme is managed through effective communication (visual management), conducting training (implementation of EMS and consumption of utilities (water, energy and packaging) and promoting knowledge sharing for lean tools implementation. Further, the external consultants also contributed to enhance the competencies of the workers through training programmes on the environmental, quality and safety aspects of meat processing.

To me, universal awareness is critical for understanding the operational and environmental sustainability in the utility intensive meat sector. It is really important to promote awareness for implementation of requirements and procedures for ISO 14001 and lean tools. Further, management of information sharing with relevant internal stakeholders through visual/white board, for instance, by displaying environmental, quality and safety targets in a single matrix helps to improve awareness. (research and development manager)

The research and development manager emphasised that introduction of emerging technologies and installation of the latest equipment are considered critical for optimising utility consumption in meat processing. Manufacturing excellence lead specifically mentioned the importance of Information Leader software for managing the records and documentation of targets in the Alpha across NZ. The group environmental manager further highlighted that a software programme (Information Leader) reduces the idle time of the workforce by replacing a paper-based documentation system with digitally generated spreadsheets. The research and development manager explained that installation of the latest measurement equipment for waste management of ponds helps to achieve targets set and compliance requirement for water utilisation. Interestingly, the general manager further described the importance of installing the latest pressure sensors to collect the data on wastewater generation against treatment targets. Digital pressure sensors linked

with the computer system are utilised to measure compliance objectives and targets for wastewater discharge and provide data for existing and future wastewater treatment initiatives.

The environmental manager emphasised the importance of attaining external financial grants from the Government Investment in Decarbonising Industry (GIDI) fund for implementing environmental and waste reduction programmes to reduce carbon footprint. This funding can be consumed in installing the latest equipment and software for optimising operational and environmental performance. The group environmental manager further emphasised an acute need for installing the latest equipment such as UV sterilizers, hot and cold-water metering to meet the KPI targets set for water consumption in the overall organisational policy and consent requirements against the performance outcomes.

Investment in new technologies for existing meat processes in improving decarbonisation (introduction of UV sterilizers and installation of heat recovery unit), enhancing water consumption, e.g., upgradation of cold and hot water metering and reducing of waste, for instance, by recycling capabilities is critical. Otherwise, you are just taking small steps rather than quantum leaps for achieving manufacturing excellence. (group environmental manager)

A list of the critical success factors for executing an integrated lean and ISO 14001 strategy in the Alpha, based on the descending order of the number of informants who cited them, is presented in Table 5.3.

Table 5.3: Critical success factors for implementation of lean and ISO 14001 in Alpha

SN	Critical success factors	Informants
1	Top management commitment	All informants
2	Introduction of emerging technologies and installation of the latest equipment	General manager, manufacturing excellence lead, group environmental manager, and environmental manager
3	Implementation awareness and training (industrial and NZQA qualification) of workforce	Research and development manager, environmental manager, manufacturing excellence lead, and technical compliance manager
4	Engagement of workforce (reward and recognition)	Research and development manager, environmental manager and group environmental manager
5	Documentation management by software (Information Leader)	Manufacturing excellence lead and group environmental manager
6	Organisational objectives, targets and policy	Manufacturing excellence lead and group environmental manager
7	Communication	Manufacturing excellence lead and research and development manager
8	Financial resource and government grants	Group environmental manager and environmental manager
9	Environmental sustainability culture	Technical compliance manager and environmental manager

5.6 Conclusion

This chapter presented the conduct of the first case study and its findings. The study investigated the contribution of lean and ISO 14001 implementation for reducing undesirable wastes in the meat industry. This case study also explained how lean tools and ISO 14001 processes could be implemented together in the meat industry for improving environmental performance and the synergies between these strategies. The CSFs for sustaining lean and ISO 14001 implementation were also assessed in this case study. Chapter 6 presents the second case of the main study.

Chapter 6 – Case Study Findings from Beta

This chapter presents the data collected from the second case study. This chapter addresses the empirical findings from an Irish meat company that will be called Beta (a pseudonym) for the purposes of this thesis. Beta has implemented lean practices and ISO 14001 certification for more than fifteen years in their facilities. While this company is amongst the first Irish meat processing organisations to receive an ISO 14001 certification to demonstrate their commitment towards environmental sustainability, the lean strategy is also effectively deployed to enhance operational efficiencies, improve meat product quality, and achieve environmental sustainability targets. This chapter aims to empirically investigate the environmental performance in Beta through the implementation of lean and ISO 14001 as a combined approach and how these approaches together assist in reducing undesirable wastes and improving environmental performance. Further, the potential synergies between these strategies are also evaluated and the CSFs for their implementation are analysed in the context of the Irish meat industry. This chapter is organised into the following sub-sections.

First, the case study setting for Beta along with details of the informants are presented in section 6.1. Next, the Beta is introduced with a background on its operations. The constructs of the NRBV model for lean and ISO 14001 implementation (Figure 2.4) are utilised to investigate the environmental performance in the meat industry. Further, the empirical findings for successful lean and ISO 14001 implementation in processing environmentally friendly meat products are presented.

6.1 Beta case study setting

A series of semi-structured interviews with the informants from Beta were held between February 2022 and June 2022. An initial contact was made in February 2022 with the group environmental manager of Beta and correspondence was initiated through LinkedIn™ for conducting an interview to investigate the impact of lean and ISO 14001 implementation on environmental performance. The introductory emails providing the information sheet and questions were sent after receiving the group environmental manager's consent. Further, at our request, the group environmental manager shared the information of the study with the relevant staff to obtain their consent to participate in this study. Further six informants agreed to participate in the investigation. These six informants included a group lean programme manager, group environmental officer,

resource efficiency and sustainability manager, environmental and sustainability officer, head of continuous improvement, and lean programme manager. The positions of these informants and role descriptions are presented in Table 6.1. Seven interviews were conducted via Zoom because of unavailability of the informants for face-to-face meetings due to travelling restrictions during the Covid-19 pandemic. These interviews lasted 45 to 90 minutes and were conducted based on pre-selected questions and recorded digitally for data analysis.

In addition to Zoom meetings, access was obtained to their environmental management manual and organisational reports on environmental performance. Further, promotional material, data on environmental performance and websites of the organisation were reviewed to gain in-depth insight into Beta’s operational and environmental performance. The summary of positions and role descriptions of the informants are depicted in Table 6.1.

Table 6.1: Positions and role descriptions of the informants

SN	Position	Role description
1	Group environmental manager	Implementing and sustaining environmental and lean programme across multiple sites throughout Ireland for over fifteen years.
2	Group lean programme manager	Managing lean scheduling, performance management and implementing quality initiatives at Beta for over eight years.
3	Group environmental officer	Worked at different environmental management roles to implement environmental management system, waste management initiatives and circular economy paradigm for over twenty years.
4	Resource efficiency and sustainability manager	Implementing resource efficiency, environmental and waste management projects across Ireland for over nine years.
5	Environmental and sustainability officer	Implementing environmental problem-solving projects and managing EMS at Beta for over three years.
6	Head of continuous improvement	Planning, implementing and evaluating the operational and environmental performance initiatives for over seven years.
7	Lean programme manager	Facilitating lean implementation for continuous improvement initiatives at Beta for over seven years.

6.2 Company overview

Beta has been delivering good quality, environmentally friendly and flavoured meat (beef and lamb) products and pet food (by-products) since 1956. The vision of Beta, as a market leader in Ireland, is to provide high quality meat products to customers through innovative operations and processes. Beta has operations in 51 facilities across Ireland, the UK and another 7 countries in Europe. The company operates six beef manufacturing facilities in Clones, Waterford, Cahir, Nenagh, Rathkeale and Bandon as the leading exporter of Irish beef. Further, Beta has 100% grass fed lamb processing in two sites (Yetminster and Lurgan) with approximately 1 million lambs annually. Beta has 12,400 employees for processing environmentally friendly meat products across

the 9 European countries. The company's total annual revenue was €4 billion across the 51 meat processing facilities in 2022.

Beta is the founding member of the Origin Green Programme (focuses on reduction of greenhouse gases, optimisation of energy consumption and improvement in grass-fed criteria), the Plastics Action Alliance initiative and the European Water Stewardship programme for achieving operational and environmental sustainability. The company has won a number of awards such as green awards (sustainable water and energy achievement), the Irish Export Association award and the Green Large Organisation of the Year award to recognise their successful implementation of sustainability initiatives. Beta has adopted a circular approach to ensure 100% by-product recovery (i.e., pet food, tallow and kidney). Tallow is converted into biodiesel, while solid waste (bones, legs and fat) are utilised in pet food.

Beta's Nenagh site is currently using innovative solutions powered by EscoPod to reduce CO₂ by approximately 20%, energy consumption by 40% and water consumption by 50%. Beta's Cahir site and two northern sites have become the founding facilities to join the European Water Stewardship and Catchment Group Scheme by consuming 43% less water overall, 80% less water in knife sterilisers and 40% less electricity for treatment of wastewater. The company's Clones site has introduced durable packaging and overhauled the meat packaging process by training their staff to efficiently operate the packaging machines. This innovative and successful initiative has enabled reducing packaging waste by 70%.

6.3 Environmental and waste reduction outcomes by implementing lean and ISO 14001

The informants of this study revealed that an integrated lean and ISO 14001 implementation helps to minimise all kinds of operational and environmental wastes. The environmental and sustainability officer explained that lean and ISO 14001 as a combined approach helps in the identification of operational and environmental non-conformities in the processing of meat products. Corrective action plans are introduced with an integrated lean and ISO 14001 approach to mitigate the root causes of current non-compliances and prevent future problems. Benefits of an integrated approach as identified by the informants in Beta include reduction of operational waste, air emissions and utility consumption.

Lean and ISO 14001 would be paramount essential in minimising waste and air emissions in our company. We have robust lean practices and an environmental management system

to reduce waste, manage utility consumption and minimise air emissions throughout all areas of our factories. We use both approaches in conjunction for identifying fault lines due to inefficient usage of raw carcasses, water and electricity, proposing corrective actions to overcome the occurrence of these non-conformities in meat processing activities and meet the compliance requirements set in the operational and environmental targets. (environmental and sustainability officer)

The lean programme manager suggested that an integrated lean and ISO 14001 is considered an important approach for managing resources (raw carcasses, water and electricity) in different phases of meat processing. A combined operational and environmental policy was formulated to achieve the goals of continuous improvement projects. Operational and environmental wastes are reported through the monitoring procedure of an EMS, while lean tools are implemented to identify opportunities to mitigate these wastes in different phases of meat processing.

Implementing lean and ISO 14001 together is an important paradigm in managing resources, organic and inorganic waste such as efficient raw carcasses processing and mishandling of wastewater in different phases of meat processing across all our processing sites. An integrated approach helps our group in bringing all the relevant information such as organisational goals around raw carcasses, water usage and energy consumption to formulate a policy for operational and environmental performance into one source to initiate continuous improvement projects. ISO 14001 procedures enhance the monitoring capability of a system to report KPI benchmarks around operational and environmental wastes such as wastewater sludge, energy consumption and GHG emissions. Meanwhile, lean provides structural tools for identifying the opportunities in reducing waste. By implementing both these strategies together helps us mitigate all kinds of wastes such as excessive wastewater generation, packaging waste and CO₂ emission in meat processing units and maintain our stance that green is lean. (lean programme manager)

The group environmental manager reported that lean tools and the format of ISO 14001 together permits Beta to effectively identify and mitigate wastes to achieve their sustainability targets (e.g., zero landfill). The group environmental manager further emphasised that increasing recycling of wastewater, composting of solid waste and maximising heat recovery from solid fuel helped to achieve zero waste to landfill target.

We used lean tools such as VSM and root cause analysis to identify the reasons for massive wastewater sludge generation. The structural operational controls of ISO 14001 such as preventive and corrective actions are used to improve the existing recycling capacity for mitigating the excessive wastewater sludge. A combined implementation of lean tools and ISO 14001 operational controls helped our group in achieving the zero waste to landfill sustainability goal across our all-meat processing facilities. (group environmental manager)

The head of continuous improvement explained the benefits of an integrated lean and ISO 14001 strategy through sharing the secondary data on reduction of air emissions, energy consumption and wastes (inorganic and organic). Further, data on implementation of continuous initiatives (ISO management systems and lean) helped to market their commitment towards achieving environmental goals. Moreover, benchmarking data suggested that Beta performed better than their competitors in reducing air emissions, wastes (water and heat losses) and utilisation of by-products from animal carcasses.

Lean and ISO 14001 must be integrated. We implemented both strategies together and have achieved 50% reduction in toxic greenhouse emissions and 40% reduction in energy consumption over the last 14 years across our 51 sites. Lean programme and ISO management system helped save 15 million euros by improving resource efficiency, reducing 40% of carbon footprints and 20% organic and inorganic waste over the last decade. Having ISO management systems and lean programme in place help us in telling our story to the customers and benchmark our competitors in producing environmentally friendly meat products. We are performing better than our competitors in reducing carbon footprints, wastewater and heat losses in meat processing. Further, governmental regulatory requirements permit our facilities to utilise the stomach content of the animals as fertiliser, red meat tallow for biodiesel and bones with meat for pet foods. (head of continuous improvement)

6.4 Implementation of lean and ISO 14001 as a combined approach

The findings of this case study highlighted eight themes that emerged based on the constructs of the theoretical model (Figure 2.4) through the coding of interview transcripts, revealing a strong

relationship between lean and ISO 14001 implementation as a combined approach for sustaining environmental performance in the meat industry.

6.4.1 Integrated lean and ISO 14001 environmental policy

The resource efficiency and sustainability manager explained the process of establishing overall organisational policy once the consent of top management has been obtained. Organisational policy is the proximal component for active involvement of top management to motivate the workforce to exceed the customers' expectations and meet the compliance requirements to produce sustainable meat products. Beta has articulated their organisational policy by incorporating the transparent environmental and waste minimisation objectives and targets in an integrated approach. Three types of targets are included in the policy scope of Beta: (1) reduction of GHG emissions, (2) consumption of electricity and fossil fuels and (3) utilisation of raw material and water. Strategic environmental and waste minimisation targets are defined to fulfil the requirements of the organisational scope of sustainability. Quantifiable strategic targets are set around three dimensions of the organisational policy to become the industry leader in responding to the climate change phenomenon.

ISO 14001 is a good starting point by putting procedures for identifying environmental objectives and targets during the development of our organisational policy to fulfil the meat processing legislation and regulation requirements. Meanwhile, lean actively helped us to reduce operational and environmental waste by measuring and reducing all kinds of waste. In our meat processing facilities, we divided operational and environmental waste targets into three types of scope for achieving our policy. Greenhouse gas reduction targets, electricity and fossil targets and wastewater reduction and raw material utilisation targets are categorised into scope one, two and three targets respectively in our policy. We delivered 50% reduction in wastewater and improved utilisation of our raw material in the previous decade through implementation of ISO management systems and continuous improvement projects. Further, our strategic planning team analysed the previous data on compliance status of environmental and operational targets across Beta. They proposed to include new strategic targets under the above mentioned three categories of 27%, 17% and 10% respectively in future environmental performance and process optimisation initiatives

from 2020 to 2030 showing our commitment as industry leader in Irish meat sector towards climate change. (resource efficiency and sustainability manager)

The group lean programme manager elaborated that tight regulatory control from the Department of Agriculture, Fisheries and Food (DAFF) Ireland and Bord Bia Irish Food Board (BBIFB) are adhered to in an integrated policy for pollution prevention, and reduced consumption of utilities and energy to achieve sustainability goals. Beta has maintained a zero waste to landfill target for the last six years in their meat processing facilities, however they still promote ISO standards and continual improvement initiatives as a company policy to achieve green strategy and meet customer expectations. The group lean programme manager further explained that ISO 14001 environmental audits and assessment uncover operational and environmental waste management opportunities. Assessment activities helped to identify numerous waste (water and solid) streams in their meat processing facilities and highlighted recycling, composting and energy saving opportunities in contributing to achieve zero waste to landfill goal.

We developed our policy benchmarking on operational and environmental targets based on regulatory requirements of pollution prevention, control license and direct participant agreement scheme for mitigating air emissions, inorganic and organic wastes. An integrated policy is stipulated by setting KPIs on wastewater treatment, discharge limits of sludge, release of odour or volatile organic compounds from waste storage and recycling plant. Further, consumption of heat and electricity in kWh/animal is also an important parameter for environmental sustainability. We went zero waste to landfill about six years ago, however we are still tracking waste and recycling of packaging material through meat waste incinerator and sludge treatment. Our organisational policy is aggressively pursuing ISO standards and continual improvement initiative programmes to assure our customers that we follow and promote green philosophy. (group lean programme manager)

The group environmental manager emphasised that operational and environmental performance targets around ISO management systems and optimisation projects provides a foundation for the resource efficiency programme. Production and environmental performance targets are included in the policy aspects to improve the yield of environmentally friendly meat products.

Integrated objectives and targets around lean and ISO management systems provide the backbone to build a resource efficiency programme across our meat and pet food processing facilities. KPI benchmarks are developed by the integrated ISO 14001 environmental management and waste elimination targets in our combined organisational policy. Our environmental and lean teams have implemented a number of projects around efficient usage of raw carcasses, water and energy. Yield of meat percentage, boiler losses, GHG emissions, wastewater and packaging material's KPIs as benchmarking targets are critical aspects in developing our environmental policy. To improve yield of meat products, lean metrics such as takt time, lead time and cycle time are used for maintaining production flow. KPIs for yielding meat products, for instance, steak, roasts, ribs, brisket by utilising hot and chilled carcass as raw material are benchmarked to evaluate the operational performance with the data collected in the last fifteen years. (group environmental manager)

The lean programme manager explained that overall organisational policy is a tangible and auditable document within the context of process optimisation and ISO management systems. Guidelines to implement process improvement projects are closely aligned with the organisational policy to fulfil the meat processing and statutory regulations. The top management communicates the organisational policy to the workforce to highlight and convey the short and long-term strategic operational and environmental goals of Beta.

6.4.2 Integrated plan and projects of ISO 14001 and lean implementation

The informants of this case study suggested that an integrated plan with improvement projects permits Beta to achieve operational and environmental goals by implementing lean and ISO 14001 as a combined approach. These plans and projects are based on lean and ISO 14001 processes for achieving targets around utilisation of raw carcasses, water and energy consumption, usage of packaging materials and optimised boiler operations in the meat facilities. The group lean programme manager explained that plans and projects help compliance with the prevention and control of environmental pollution license to achieve sustainability goals. In the planning phase of a project, ISO 14001 is implemented to identify non-conformities and lean tools mitigate operational and environmental compliance requirements.

We built our environmental management system to comply with the prevention and control of environmental pollution license and then laid down lean practices to achieve sustainability goals. We developed an integrated environmental plan. We came in with ISO 14001 system for identification of our environmental compliance to identify sustainability gaps, and to bridge the sustainability gaps we introduced lean practices in our optimisation projects. (group lean programme manager)

In the same vein, the resource efficiency and sustainability manager reported that ISO management systems enable them to determine the non-conformities (packaging materials, organic waste and air emissions) and the lean approach reduces the impact of operational and environmental irregularities. Reduction of wastewater is a key environmental impact that resulted from washing of carcasses and floor cleaning activities in meat processing. The wastewater reduction commitment is included in Beta's ISO 14001 environmental policy. Recycling of wastewater enabled Beta to achieve better ISO 14001 environmental policy targets and reduce energy consumption. Electricity consumption in water pump operations was reduced by utilising recycled water in washing equipment and cleaning the floors of slaughterhouse in meat processing. Further, the manager explained that energy consumption was effectively optimised by introducing latest low voltage equipment (blades and cutters) and proactive maintenance of latest machinery by applying TPM. Integrated plans and projects are effectively implemented through sufficient availability of resources (financial and human, i.e., a competent workforce).

We know that our cardboard and plastic is going to recycler, our dirty waste is going to incinerators through licensed contractors and our air emissions are going to treatment plants. To improve our operational and environmental streams, we identified our gaps by analysing VSM and KPI benchmarking data and deescalated non-conformities by introducing corrective and preventive actions through the ISO management system. We are looking at energy management through introduction of latest equipment and promotion of recycling initiatives in our planned optimisation projects. Recently, we replaced our old automotive meat cutting equipment with latest low voltage blades, cutters and saws to achieve low power consumption. While, wastewater recycling project helped our sustainability initiative by promoting an efficient power consumption in water pump operations. An integrated plan based on both strategies along with availability of sufficient

resources and competent individuals is the best methodology to implement sustainability projects. (resource efficiency and sustainability manager)

The head of continuous improvement explained the process of establishing new sustainability plans and projects in achieving continuous optimisation in Beta. Roles and responsibilities of internal (environmental practitioners, group general and environmental managers) and external (government institutions, lean consultants and environmental organisations) stakeholders are identified for defining plans and projects, allocation of resources and implementing optimisation projects.

We asked every site to come up with new sustainability plans and we developed optimisation projects with lean and ISO management systems to achieve operational and environmental performance. Our 51 sites come together in a conference with sustainability leading environmental practitioners to propose resource efficiency plans. These conferences helped our general managers to demonstrate sustainability projects around resources efficiency and provide financial resources to implement ISO management systems and lean. We consulted these optimisation projects with representatives of local councils, lean consultants and environmental non-governmental organisations on a Teams call to discuss the suitability and potential applicability of these projects for achieving organisational sustainability goals. Resources, for example, financial and human are allocated to initiate a sustainability project and results of optimisation project are communicated within our group after receiving the closeout report. (head of continuous improvement)

The group environmental officer reported that a project on wastewater was carried out for reducing wastewater generation and removing organic waste by utilising ISO 14001 procedures (i.e., audit and review mechanism) and lean tools (e.g., VSM, standardised work instruction and automation) in combined optimisation projects.

Essentially ISO 14001 makes the business more accountable, makes the CEO more accountable because of audit and review mechanism to evaluate optimisation projects and lean provides tools to reap immense benefits of these improvement initiatives. For instance, a project on wastewater was initiated for removing organic fats and dirt to consume recycled water in the hose down meat processes. A team of three comprised of research

and development manager along with two graduates was formed to assist in auditing our water consumption impacts on our current outflows of water and wastewater treatment, for instance, recovering, reuse and recycling capacity. VSM was applied to identify the spillage points of water during a pipe leakage or non-conformities in washing angles of the carcass. Application of lean tools, for example, standardised work instructions helped us in evaluating the reasons and proposing the solutions for excessive wastewater generation. Further, wastewater treatment system is used to purify water from slaughterhouses, meat abattoirs and meat processing through biological processes and sludge dewatering. (group environmental officer)

The lean programme manager explained that reduction of carbon footprints and water consumption is achieved through improvement of infrastructure and continuous improvement initiatives. ISO 14001 environmental policy provides directions and guidelines to improve air emissions and reduce wastewater generation.

We go and say we reduced our carbon footprints by 40% and effective water consumption through continuous improvement such as lean and environmental management systems. We are getting halfway there by minimising energy consumption and water consumption in processes such as slaughtering, cleaning and packaging activities and then our group has to invest in infrastructure, for instance, changing boilers, fuel type and introduction of latest equipment for water consumption. Other half is achieved by continuous improvement through ISO 14001 and lean programme. Targets are set around carbon footprints and water consumption in ISO 14001 environmental policy to achieve climate change goals. While AWS EC2 software toolkit is used to produce fishbone diagram to cost the water and energy consumption, amount of water consumption is dependent on the size of the lines, for example, soft, cold and hot water and potential energy consumption in different stages of meat processing. Fishbone diagram or spreadsheets helped our sustainability team to educate our workforce about water and energy consumption, potential non-conformities and solutions to optimise water and energy consumption. (lean programme manager)

The group environmental officer emphasised that integrated lean and ISO 14001 projects are executed as incremental improvement initiatives on an ongoing basis to achieve better environmental performance.

I advocate of a phenomenon of the rolling wave planning for implementing lean and ISO 14001 approach in our facilities; we are constantly focusing to achieve milestones on environmental targets. We start our optimisation projects with limited information on the current status of KPI targets. We evaluated our KPI benchmarking data on operational and environmental targets to determine non-conformities of our meat processing activities. We have placed an investigated system based on root cause analysis to evaluate the occurrence of non-conformities around efficient consumption of raw carcasses, water and energy. After conducting the comprehensive root cause analysis, we revised our standardised work for reducing occurrence of non-conformities to improve operational and environmental performance. (group environmental officer)

6.4.3 Communication and information sharing

The group environmental manager explained that communication management is part of Beta's organisational strategy for operational and environmental sustainability. Sharing the information of events with top management, employees and relevant stakeholders (e.g., DAFF Ireland and BBIFB) enhances the capabilities of communication flow to achieve operational and environmental targets. Most recently a delegation from Beta presented their environmental performance at a conference. This conference allowed Beta to present their story for successful implementation of their operational and environmental initiatives in the recent years. Beta has received several awards such as the Green Large Organisation award and Irish Export Association award. These environmental and export achievements are shared with the employees and customers through newsletters, emails and sustainability reports. Further, awareness of recycling initiatives, energy consumption and utilisation of meat by-products is shared with relevant stakeholders to improve the brand image and shape recognition of producing environmentally friendly products.

Communication is really important, for example, sustainability events on reducing environmental impact are communicated in our fortnightly newsletters to share the information with our employees and relevant stakeholders, for example, customers and suppliers. We share stories of achieving sustainability goals or winning environmental and exports performance awards in our newsletters or news tickers on televisions in the canteen areas of our facilities. Further, we recently presented our environmental performance,

operational sustainability and energy optimisation projects in a European conference. Sharing information on sustainability for producing environmentally friendly meat products is great news to console our customers and consumers. We were wheeled out in front of our customers, for instance, Walmart, Albert Heinz and Sainsbury's, when we disclosed our environmental sustainability initiatives with them. We communicated that we continuously recycled 40% of wastewater into portable water, ran a fully carbon neutral laboratory and consumed tallow as a renewable energy source to generate electricity. (group environmental manager)

The group lean programme manager stated that engagement with employees by undertaking awareness initiatives to educate them in environmental and quality compliance parameters plays a crucial role in producing sustainable meat products. The findings of the internal audits of ISO 14001 and application of lean tools are shared with the workforce to evaluate the current status of conformance and assign responsibilities in achieving future targets around carbon footprints, electricity consumption and utilisation of hot and cold water in different phases of the meat processing. KPI boards are maintained on a regular basis to provide meaningful data to the workforce in achieving environmental targets.

Communication is about getting buy-in and engagement with the relevant people, e.g., workforce, customers and suppliers to understand our commitment to meet statutory requirements in producing prime quality meat. We shared the internal audit findings of lean and ISO systems and assigned responsibilities to implement these initiatives for sustaining our group as an environmentally compliant organisation. We regularly maintained KPI boards to provide our people meaningful data on different KPI targets, for example, carbon footprints, hot water for cleaning the animals and electricity usage in refrigeration. (group lean programme manager)

The head of continuous improvement revealed that information sharing with the relevant internal (top management, middle management and operators) and external (suppliers and contractors) stakeholders is of paramount importance to explain sustainability targets. Current and future environmental targets are communicated through information posters to present sustainability targets status.

Integrated internal and external communication is important for explaining our operational and environmental sustainability strategy to our management, floor staff and suppliers. We communicated our operational and environmental targets, their conformity status and future potential optimisation on posters and pictures to determine operational and environmental performance. (head of continuous improvement)

6.4.4 ISO 14001 procedures

The informants of this case study explained that a dedicated and competent team is crucial in implementing an EMS for achieving environmental goals. The group environmental manager explained that involvement of competent and knowledgeable personnel is of critical importance as such a workforce can help the top management to develop a sound environmental policy (environmental objectives and targets), monitor the performance of ISO 14001 deployment and ensure the compliance obligations. Further, external environmental consultants are hired to improve knowledge and skill levels of the current workforce to achieve targets of optimisation projects. Beta has invested in training their workforce (internally and externally) to acquire the necessary competencies for identifying better pollution prevention opportunities (environmental objectives and targets) and improving the environmental performance. Moreover, ISO 14001 documentation is utilised to maintain records around the environmental aspects of meat processing from carcasses entering and meat products leaving the site. Further, records are documented on performance monitoring, measurement and compliance evaluation to achieve environmental targets in utilisation of raw carcasses, water and energy consumption.

Involvement of right personnel is important to implement lean or ISO 14001 or any other system approach for achieving sustainability goals. In the absence of competent in-house practitioners, external consultants have to be brought in to help getting things up and running optimisation projects. An environmental management system is implemented for monitoring of waste, setting up a control mechanism and promoting documentation to record materials coming to and going off-site. We utilise the ISO 14001 environmental management system to identify potential opportunities, document inventory, and monitor environmental records for performance review. (group environmental manager)

The general manager explained the application of operational controls and procedures of ISO 14001 for achieving an effective environmental performance in Beta. ISO 14001 operational

controls guarantee allocation of resources (financial such as registration of ISO 14001, assigning roles and responsibility of an environmental team and introduction of latest equipment to mitigate non-conformities). Further, operational controls aim to ensure an effective utilisation of raw carcasses, water, electricity and packaging materials in different phases of meat processing. He further elaborated the three steps of operational controls as follows; (1) setting KPIs around environmental parameters, (2) measurement of actual performance on utility consumption and boiler operations and (3) introduction of corrective actions (if any deviations reported). The environmental manager explained the roles of the relevant personnel for evaluating and optimisation of environmental performance and maintenance of documentation control for reporting non-conformities and corrective action plans as follows:

Typically, once non-conformities in terms of wastes are reported or deviations in achieving environmental parameters are observed, our environmental team assigned roles to the relevant responsible individuals for mitigation of these environmental irregularities. Environmental non-conformities and corrective action plans are reported to the top management through documentation control as environmental performance indicators for conducting internal audits and annual management reviews. (environmental manager)

The group lean programme manager explained that the AWS EC2 software toolkit is applied to maintain the documentation and records on KPI targets (water, energy and packaging), audit records and monitoring performance information for conducting annual management reviews. Corrective and preventive actions are introduced and incorporated as new KPI targets in the AWS EC2 software toolkit to achieve better performance for the next fiscal year. The environmental and sustainability officer emphasised that operational control of ISO 14001 is effectively maintained by a competent team. This team is led by the environmental sustainability manager to assign roles and responsibilities to the workforce to maintain documentation control and communicate current environmental performance to the relevant authorities. Further, another role of this team is to evaluate and communicate environmental performance with the relevant stakeholders (top management, government institutions and local councils) and to seek funding for environmental improvement initiatives.

Our group is ISO 14001 compliant; we have a dedicated manager for managing environmental documentation at the centre under head office. Environmental sustainability

manager is responsible to develop a team and assign roles for controlling documentation across all facilities of our group. This competent team is responsible for maintaining documentation per ISO 14001 standard across Beta. Our group environment manager and environmental and sustainability officer are constantly reviewing the environmental compliance status with industry bodies. This team is solely responsible to monitor any trail of environmental optimisation projects or upcoming projects on continuous initiatives. They are actively involved in seeking funding from top management and government institutions to assist our improvement initiatives. (environmental and sustainability officer)

6.4.5 Lean tools

The informants of this case study explained the process of choosing the appropriate lean tools for analysing the current status of overall performance (operational and environmental) and proposing future lean optimisation projects. The resource efficiency and sustainability manager explained that data on all wastes (organic and inorganic), energy consumption and packaging materials usage are collected and conveyed to a multi-skilled lean implementation team. The resource efficiency and sustainability manager reported that a red signal was illuminated in the X-ray as an Andon system during the final inspection of meat products before storing the meat products in the finished goods freezer. This visual feedback allowed the operator to stop the inspection and packaging lines due to the potential presence of foreign particles in the meat product. Before the inspection system, meat products were handled manually by the operators and put into separate meat freezers for the later final inspection. The lean implementation team, which is competent in lean implementation, analyses the information and data from the X-ray inspection system using root cause analysis (such as A3 thinking) to identify causes of process non-conformity in the X-ray inspection system. They concluded that small fragments of broken needles or knives or blades enter the meat products during slaughtering, cutting and marinating processes. They recommended developing a master plan for managing TPM activities with a comprehensive productive maintenance system to avoid the breakage of processing equipment during slaughtering, cutting and portioning procedures. Further, regular inspections of the equipment by the supervisors and operators helps to reduce the possibility of meat contamination.

The group environmental manager reported that the operators monitor excessive GHG emissions (through Green Feed bins – a US system to measure CH₄) at the lairage facility. Furthermore, they

also reported that extra volume of organic waste is generated from the gastrointestinal tract during the evisceration process. Reduction of waste (CH₄ gas and organic substances) is a critical parameter for improving operational and environmental performance. Root cause analysis through A3 thinking is carried out to identify the main cause of excessive CH₄ emission and organic waste generation. The investigation team concluded in an A3 thinking report that the operators feed both food and water simultaneously by deviating from the standard norms (only water is made available) in case of not holding animals beyond 12 hours at the lairage facility. Excessive availability of food and water to the livestock can cause extra CH₄ generation (due to burping and flatulence) at the lairage facility and holding extra organic substances in the gastrointestinal tract. A3 thinking is applied to identify the main causes of waste (CH₄ and organic substances) generation and process solutions (A3 thinking countermeasures) based on the analysis of previous standardised work instructions. Their management shared a comprehensive revised standardised work instruction (A3 thinking implementation plan) with the lairage operators for feeding water and food together (if the holding time of livestock is longer than 12 hours). The reduction of CH₄ and organic waste generation after implementation of A3 thinking and revised standardised work instructions contributed to improving the environmental targets at the lairage facility and evisceration process.

Our operators reported high methane generation at lairage facility and presence of excessive organic waste in the gastrointestinal tract during the evisceration process. Feeding of both food and water to the livestock at lairage facility is the main cause of excessive methane and organic waste generation. Standard guidelines for feeding at lairage facility are shared with the operators to minimise this waste generation. (group environmental manager)

The lean programme manager explained the sequence of a lean project execution in a generic way without giving any specific example of meat processing. The lean programme manager, who leads the implementation team, identifies the potential waste reduction opportunities based on the comprehensive data analysis and initiates a single lean project at a time. Once a lean project is completed, the next waste reduction lean activity is started and so on. Lean tools are applied to reduce waste in generic operational processes as well as very specific and small areas within the meat production processes to achieve incremental improvements in operational and environmental performance. Standardised work instructions are revised to update the existing processes from the

outcomes of lean projects in the processes of meat production. Standardised work is properly documented and circulated to people on the shop floor for ensuring the safest and easiest way to handle carcasses and processing environmentally friendly meat products. Further, the group lean programme manager explained the application of standardised work instructions as follows:

We essentially have standardised work instructions for our core meat processes to handle the carcass effectively, treat wastewater efficiently, operate boiler with minimum effluents and implement packaging regulations. We have displayed these instructions through visual cues or laminated hard printouts in different areas of meat processing for educating our workforce to perform their duties in an effective, accurate and standardised manner.
(group lean programme manager)

Sustainable product packaging has enhanced the meat quality, shelf life and protection, allowing Beta to remain competitive in the meat sector. The group environmental officer suggested that standardised work instructions are mostly used for improving the flow of meat products during the packaging stage. Correct size of packaging material, competencies of the operators and implementation of standard work instructions are the most prominent factors for effective consumption of packaging materials, optimisation of cycle time and managing packaging machines. In the same vein, the group environmental officer reported regular incident reports and malfunctioning of equipment in the slaughterhouse and boning room operations. 5-Whys is applied to determine the root causes of incidents and occurrence of faults in equipment in slaughterhouse and evisceration processes. Interviews were conducted to collect the data for exploring the potential reasons of non-conformities. Interview findings and incident reports were analysed to identify the causes of incidents and faulty equipment in the meat processing activities. The group environmental officer concluded that lack of sharp equipment handling skills (such as circular saws, band saws and sharp knives) and regular maintenance are considered as root causes of incidents and malfunctioning of equipment. The interruptions caused by mishandling of knives and non-functional equipment adversely affect the meat processing activities.

The group environmental officer suggested that environmental safety instructions, personal protection equipment (PPE) and regular maintenance of equipment can mitigate the interruptions and occurrence of incidents during the processing activities. Further, the group environmental officer outlined three types of maintenance (scheduled, on-going and emergency maintenance

activities). TPM is the main lean tool applied in maintenance for smooth running of the meat processing activities. Proactive maintenance activities (regular scheduled and on-going maintenance) are important to avoid unexpected breakdowns of sharp equipment (knives and saws) which can cause lost revenue and make it difficult to fulfil the demand for meat products by customers. Further, wearing of PPE is mandatory as a company policy to avoid the occurrence of workplace accidents. Further, the implementation of lean tools (standard work instruction, 5-Whys and TPM) helped to reduce the occurrence of incidents and interruptions in processing raw carcasses. Further, these tools contributed to improving the raw carcasses' shelf life and reducing the meat contamination due to abnormal interruptions and occurrence of incidents.

Circular saws, band saws and sharp knives are intensively used, for instance, in opening of animal skins, trimming of carcass and cutting of bones in our meat facilities. Safety instructions for utilisation of sharp cutting equipment and wearing of cut-protection PPE are strictly implemented during our boning and trimming phases to ensure occupational health and safety of the workforce. (group environmental officer)

A large water footprint is associated with meat cleaning and sanitation of carcasses during slaughtering and washing of animals in the meat processing procedures. The lean programme manager reported that the intensive water consumption occurs in washing of carcasses surfaces, cleaning of different saws (splitting, circular and band) and carcasses pre-evisceration washing in meat processing. The lean programme manager explained that VSM and root cause analysis are applied for identification of potential wastewater improvements, while 5S, Kaizen events and TPM are employed to improve water use in various stages of meat processing. Data on water consumption is extracted from analysis of VSM for developing an action plan for water consumption in Beta. Data on water usage from the slaughterhouse and boning room (equipment cleaning, blood drainage and sanitising) are analysed to determine the possible opportunities to reduce the usage of water. Interviews with operators, supervisors and plant manager were conducted by asking the question “Why?” successively to analyse the main causes of excessive water consumption in different stages of meat processing. Root cause analysis is intensively used in finding the underlying reasons for wastewater generation and cascading information for process improvements.

On the other hand, Gemba walks, Kaizen events, 5S and TPM are implemented to create a culture of effective water consumption in meat processing. Gemba walks are conducted to motivate the operators to report inefficient utilisation of water in slaughtering of animals, removing of hides and cleaning of the shop floors. Key components of these regular Gemba walks are to get input from the operators and supervisors to identify the causes of wastewater and introduce water optimisation initiatives. Outcomes of VSM and root causes analysis provides the information on what actions are needed in Kaizen events for effective water consumption. Solutions for reducing wastewater by pursuing quick water optimisation opportunities such as adjusting angles for washing carcasses, reuse of boning room water and waterless sanitation of meat processing areas in a “just-do-it” or “quick wins” project are examples of optimisation under Kaizen. Wastewater management activities are incorporated into 5S housekeeping targets for cleaning and inspection activities to engage the workforce to identify and reduce excess wastewater. Further, 5S is implemented to consume less water by creating clean slaughterhouse and boning room processes, maintaining standardised cleaning procedures and sustaining continuous clean processing areas. Brooms and brushes are utilised to remove material debris (by the application of ‘clean and shine’, a pillar of 5S) in slaughtering and boning rooms, meat rails and saws in dry cleaning before consuming water for secondary cleaning. Furthermore, TPM is applied for identifying operational problems, fixing water leakages and ensuring maintenance of automatic carcass washing machines in meat processing. The regular inspections of cold and hot water lines through proactive TPM maintenance are used to identify potential issues and propose water-saving initiatives.

We set targets on optimising water usage; however, excessive water consumption was indicated during washing carcasses activities, cleaning equipment and shop floor. Our investigation team have implemented VSM and 5-Whys initiatives for analysing the operational data to identify the main causes of excessive consumption of water and generation of wastewater. A combination of lean tools such as Gemba walks, Kaizen events, 5S and TPM have also been implemented to execute the wastewater management activities in slaughterhouse and boning room. (lean programme manager)

The group environmental officer elucidated that benchmarking data on raw carcass, wastewater and energy consumption is available from the last decade. Emergent current data from non-conformity and operational performance reports are analysed against the data of benchmarking. Root cause analysis is carried out if the data indicated non-conformities and operational issues

against the benchmark of environmental consent limits. Root cause analysis identifies the problems of a specific meat processing area and the mitigation solutions are proposed to improve the meat production.

Our database have a reliable input-output reports on carcasses consumption utilisation, water and energy consumption and packaging material usage for the last one decade. This precise data is used for benchmarking in regular and annual management review meetings to sustain our short- and long-term environmental objectives and targets. We applied root analysis for majority of non-conformity reports or issues that are identified within our meat processing system. We adopted precautionary measures based on analysis of benchmarking and root cause analysis to perform better in consuming raw materials, water and energy in our meat processing sites. (group environmental officer)

The group lean programme manager mentioned that one of their meat processing facilities is facing foodborne contamination issues and delays in the product delivery. Meat processing is considered a highly safety regulated sector to avoid foodborne contamination; however, E. coli infections are caused due to mishandling of the meat products. The group lean programme manager explained that 5S was implemented to reduce food safety problems and JIT with buffer setting is utilised to improve the delivery of meat products. The application of 5S has fundamental importance for the safety of the workforce by avoiding exposure to chemicals and mishandling of raw carcasses during curing, smoking and preservation of the meat products. Further, the group lean programme manager explained that the scope of JIT application is very limited in the meat industry. JIT with buffer setting is the most suitable approach to estimate a consistent cattle's batch for meeting the demands of the customers. 5S is a widely applied lean tool in their processing and storage areas to ensure precautionary measures for improving the meat safety and shelf life.

We maintained maturation of meat with prime quality, tenderness and flavour in our meat products: however, we were constantly facing foodborne contamination issues. We implemented 5S to ensure reduction exposure with chemicals and mishandling of raw carcasses in meat processing activities. Just-in-time with 48 to 72 hours buffer is applied to avoid aging of our meat products after slaughtering process. Just-in-time with buffer setting helps our organisation to slaughter an appropriate number of cattle for meeting high demands of our customers. Consistent weight of cattle's batch coming into

slaughterhouse and exact date of delivery help us to estimate the required number of animals and establish the sufficient buffer level to meet the customer's demand effectively.
(group lean programme manager)

Coal boilers are the main source of electricity, steam and hot water generation for producing meat products in different process activities such as slaughterhouse, boning and packaging. Further, rendering of animal by-products require intensive heating for producing protein, tallow and lard meals. The environmental and sustainability officer reported that the boiler furnace generates low heating value to produce electricity and steam. Current VSM was drawn based on data from the boiler furnace (heating value, air circulation and particle size of coal) and steam turbine to determine the potential reasons for inefficient operations. Feedback from operators, supervisors and the boiler engineer played an important role in investigating the reasons and developing the current state of VSM for identifying potential reasons for heat losses and low heating values. The outcomes of the current VSM and feedback suggested the future VSM enhance heat value of the furnace by managing the coal feed size, circulation of air in ducts (primary and secondary) and flow of water in the furnace tubes respectively. The environmental and sustainability officer explained that 5S is widely implemented in smooth cleaning of boilers and removal of particulate matter to operate boilers efficiently. Further, the 5S programme helped to minimise unscheduled boiler breakdowns, efficient usage of fuel and improve the generation of optimised steam and electricity.

Currently, the electricity and steam for meat processing such as slaughterhouse activities, chilling system and rendering procedures are generated by coal-fired boilers. Our boiler team have noted repeatedly about the low heating value in the heating processes of the boilers. The investigation team have implemented VSM to analyse the data on coal feed, boiler furnace and steam turbine for identification of the causes in producing low heating values. They have recommended to improve the coal particle size, air circulation and water circulation in the furnace tubes. Moreover, 5S is also an effective tool for cleaning of boiler and removing sticky coal particles during the shutdown period of coal-based boiler.
(environmental and sustainability officer)

The resource efficiency and sustainability manager narrated that the operators and team leader most recently report the microbial spoilage of meat due to clogging issues in the chiller system.

The resource efficiency and sustainability manager initiated an investigation to determine the main reasons for spoilage bacteria impact due to fluctuation of the chilling system by asking the operators and team leader ‘why’ questions a few times. They shared their experiences with the group lean programme manager to determine the root causes of clogging in the chiller (ice blockage, oil and dirt clogging). Ice blockage occurred in the chiller system because of the presence of excessive moisture content in the throttle outlet. Ice is gradually concentrated due to the lowest temperature, blockage of capillary tubes and low air circulation at the throttle outlet. The chiller system contains a higher refrigerant oil quantity which caused oil clogging. Additionally, high viscosity of refrigerant oil caused filter desiccant blockage and air circulation reduction in the chiller system. Moreover, dirt clogging is caused by impurities in refrigerant oil and improper cleaning (inner and outer surfaces) of the chiller system.

The group lean programme manager further suggested that the application of TPM and 5S help in maintaining of equipment and cleaning of dirt in the chiller system. TPM is an essential tool to promote proactive maintenance and avoid blockage of equipment such as chillers and ventilation systems during the meat products handling before the packaging process. Further, effective maintenance of equipment in meat processing plant is vital to avoid the occurrence of non-conformities. Moreover, the workforce plays a role in maintaining the chiller system on a daily basis for achieving TPM goals. Furthermore, 5S is generally applied to maintain cleanliness and removal of dirt in the internal/external surfaces, throttle outlet and capillary tubes of the chiller system on a regular basis. Nitrogen segmentation is also used to flush the dirt as well as remove refrigeration oil in the chillers. The application of 5-Whys, 5S and TPM helped Beta to maintain the temperature of the chillers at 4⁰C or below to avoid the rapid growth of harmful microbes. Efficient management of the chiller system improved the shelf life of meat products, reduced contamination and enhanced preservation.

Clogging issue in initial chilling was reported which caused deterioration in shelf-life and quality of the meat. We have conducted 5-Whys methodology to identify the causes of the clogging phenomenon. Ice blockage, oil leakage and presence of dirt particles were determined as main causes of clogging in chillers. We have further implemented lean tools such as 5S and TPM to mitigate the reasons of ice blockage, oil leakage and dust formation in the internal and external surfaces of the chiller. Nitrogen segmentation process is used

to flush the oil contents and dust particles for improving the air circulation in the chillers. (resource efficiency and sustainability manager)

A list of lean tools in the meat manufacturing company Beta, based on the descending order of the number of informants who cited them, is presented in Table 6.2 (Appendix F).

6.4.6 Implementation awareness, competencies development and training of the workforce

The resource efficiency and sustainability manager elucidated that induction activity helps in introducing newly hired operators to handling carcasses, and effective utilisation of water and packaging materials. Fundamentals on operational and environmental procedures are cascaded to the operators and supervisors for avoiding wastewater generation, water spillage and unnecessary packaging waste. Further, new compliance requirements in operational and environmental targets are updated and shared with the workforce in post-induction training.

Awareness of environmental performance is considered as an essential part of our induction programme. For example, we educate our new employees to handle waste materials by putting edible meat contents such as stomach, spleen and gizzard and non-edible contents for instance gastrointestinal tract content, fetus and trimming in the right bins to avoid mismanagement during our waste removal activities. We provide systematic training to our workforce in using water nozzles, cutting knives and saws effectively to perform their daily meat processing. Induction training programme also motivates our trainees to report the non-conformities in meat processing to the relevant authorities. As far as packaging consumption, we make sure to avoid dropping too many bags on the floor before our internal audit walks. We roll messages through TV-tickers to update our staff about water consumption, packaging materials and waste management around all our facilities. (resource efficiency and sustainability manager).

The group environmental manager explained that a training programme for implementation of ISO management systems and continuous improvement initiatives helps the top and middle management to achieve the benefits of sustainability. Potential application of environmental procedures and lean tools are conveyed in in-house training programmes to enhance the skill sets and competencies development of the workforce. A risk assessment of different stages of meat processing is carried out to develop a health and safety awareness initiative to avoid the fatal impact of water spillage, occurrence of accidental injuries and mishandling of large carcasses.

Further, training on the application of lean tools helps Beta to minimise the operational waste and environmental impact of meat processing facilities.

Training is really important to help the workforce in implementing ISO management systems and continuous optimisation initiatives to reap the immense sustainability rewards. I started training initiatives to educate our top to middle management on environmental management procedures and lean tools for achieving environmental performance fifteen years ago. I am a tough cookie and preferred to go with the trainees to the coalface for providing them with required information to implement ISO management systems and lean toolkit for performing crucial activities in different phases of meat processing. We developed a health and safety training along with ISO 14001 programme based on the findings of the risk assessment for occurrence of potential accidents due to spillage of wastewater and mishandling of large carcasses. (group environmental manager)

The lean programme manager explained that development of an in-house training module is based on evaluation of the workforce's competencies development to implement meat processing procedures, ISO management systems and continuous improvement initiatives for achieving environmentally friendly products in Beta. The environmental, lean programme and sustainability managers are responsible for developing and conducting in-house training to boost the knowledge and skill levels of the workforce. Utilisation of knives, saws and maintenance of equipment following the guidelines of the WHO during the Covid-19 pandemic are taught through internal training. On the other hand, external training sessions are provided to the middle and top management for improving skill levels in implementing meat processing procedures and optimisation projects to achieve sustainability goals.

A skills matrix is developed to identify the gaps between desired and required knowledge and competency of our workforce to implement meat processing procedures and improvement initiatives for continual sustainability. Once the gaps are identified, we customise in-house training programmes to enhance competencies of our workforce by a training team of environmental, lean programme and sustainability managers on a quarterly basis. Most recently, we have conducted a number of internal trainings for maintaining protocols around knives utilisation, managing procedures for proactive

equipment maintenance and educating our people to manage risks of Covid-19 according to the World Health Organisation's guidelines. We promote in-house training initiatives to engage our employees at coalface during their regular working hours and provide them opportunities to build a team for achieving sustainability targets in our group. While based on the outcomes of skills matrix of our middle and senior management, external consultants help them to enhance their skills in performing daily routine meat processes. (lean programme manager).

The head of continuous improvement reported a unique experience of external training from experts at Toyota's European headquarters for implementing lean tools in the meat processing context to achieve potential sustainability rewards. Trainers from Toyota's headquarters also visited different meat processing facilities of Beta to evaluate the implementation of initial training on lean strategy for reduction of operational and environmental impact.

We facilitated our employees to get external training on site Toyota's European headquarter in Birmingham for learning the key concepts of lean and their application in achieving operational and environmental sustainability. On the other hand, Toyota trainers visited our meat facilities to see how our workforce has implemented lean strategy to achieve operational efficiency. Further, they accessed the current status of continual improvement initiatives and further trained our relevant people to boost operational sustainability. (head of continuous improvement)

The environmental and sustainability officer further elaborated that external training provides essential knowledge to the workforce for better understanding of quality and environmental compliance concepts. Beta provides a number of scholarships to their workforce for undertaking external training with certifications or diplomas from reputable Irish institutions to implement meat standards effectively. Further, a competent workforce equipped with knowledge of environmental sciences, lean implementation and circular economy concepts enabled Beta's meat processing facilities to produce quality meat products.

We have internal training capabilities. However, we provide advanced training to our people for producing quality meat-products, generating environmentally friendly electricity and steam in coal-fired boilers and implementing efficient waste reduction procedures by external organisations and consultancy firms. We have provided financial

support to our employees for attaining certification or diploma in environmental sciences, circular economy and lean six sigma from renowned public or private Irish institutes to improve their skill levels. We have recruited operators holding environmental diplomas and people with twenty years' experience on site to conduct internal environmental audits during the implementation of continuous improvement projects. (environmental and sustainability officer).

6.4.7 Environmental performance evaluation

The performance evaluation process facilitates decision makers to collect and analyse KPI data to estimate the current performance status and propose future optimisation opportunities periodically. The group environmental manager explained that the main KPIs on emissions, energy consumption, all kinds of wastes (organic, inorganic and packaging) are hampering parameters in performance evaluation. For example, non-conformities on air emissions and ash discharge were reported in current boiler operations. A comprehensive evaluation of data and collected information was conducted to propose an action plan for mitigation of non-compliance against the consent requirements.

Reducing greenhouse emissions, wastewater, organic and inorganic waste and effective consumption of energy and packaging material are considered as main parameters in environmental performance evaluation. Our boiler engineer monitored and reported poor air quality and high ash discharge to senior management. We analysed the boiler data and suggested a continuous corrective action plan to mitigate the current high level of effluent discharges and potential future incidents. Further, we reviewed our current corrective and preventive action plans for meeting the environmental compliance parameters against the consent regulatory requirements. (group environmental manager)

Performance evaluation is entirely based on reliable data for measuring the meat processing targets. The lean programme manager suggested that operational and environmental performance is measured by using the KPI data on utilities to evaluate the set targets in Beta. Data from the outcome of lean tool (root cause analysis) and findings from ISO 14001 audits are considered as performance evaluation input. Root cause analysis is employed to determine the reasons for occurrence of non-conformities in utilisation of resource utilities, while regular internal and third-party ISO 14001 audits are used for evaluation of environmental targets.

We are firm believers of “only what gets measured gets managed and the devil is in the details”. If we want to remain an operational and environmentally sustainable meat group, we have KPIs for measuring our targets and goals around resource utility, energy consumption and packaging materials that allow our people to measure and document compliance requirements. In case of non-conformity occurrence, we apply root cause analysis for setting targets and assigning responsibilities to achieve future optimisations. Further, our ISO management systems are internally and externally audited for better surveillance biannually and annually. (lean programme manager).

In a similar vein, the resource efficiency and sustainability manager explained that performance measurement and evaluation is determined by analysing KPI targets on operational and environmental optimisation. It helps to evaluate the fulfillment of minimal requirements objectively for continuous project implementation. Once an improvement project is initiated, permanent monitoring and reviews are conducted to evaluate the performance of processes and determine improvement opportunities. Further, internal and external performance audits are also critical for conducting performance evaluation findings of ISO 14001 audit reports and a lean tool (VSM) is employed for identification of gaps and optimisation opportunities in pursuing continual improvement projects.

Within our ISO management systems, we have proposed an assessment mechanism for evaluation of environmental conformance level through internal audits and third-party verification for attaining ISO 14001 accreditation. Internal surveillance audits are also conducted for evaluating the KPIs targets by analysing the data on input and output parameters of value stream mapping to identify process gaps and optimisation opportunities in our continuous improvement projects. Findings from mandatory audits of ISO management systems and value stream mapping are effectively used for performance evaluation in our group. (resource efficiency and sustainability manager).

The group environmental officer explained that assessment for conformance levels of operational and environmental performance is reported on a regular basis (monthly, quarterly and annually). Frequency of performance evaluation is set in documented action plans for implementing and analysing effective consumption of utility parameters in Beta.

We have daily environmental walks to analyse the utilisation of carcass, consumption of electricity and water usage in different phases of meat processing to generate operational and environmental compliance reports in our group. Further, we conduct management meetings to evaluate the environmental impact or regulatory compliance on a monthly, quarterly and annual basis. (group environmental officer)

6.4.8 Environmental management review

Management review for continuous improvement (operational and environmental) projects is an essential activity for evaluating the organisational policy, objectives and targets of optimisation initiatives. The top management is responsible for conducting a six monthly or annual management review during the execution of projects. Intervals or frequency of formal reviews are well-defined in documented operational and environmental procedures. The top management of Beta conducts review meetings to evaluate current performance in all stages of meat processing, and the need for change and improvements (if required) to determine the suitability of sustainability targets set in the policy. The environmental and sustainability officer explained that a quarterly management review helps to identify the potential optimisation areas in operational and environmental performance initiatives. Outcomes of audits, compliance levels of KPIs and noncompliance reports are analysed to evaluate the status of performance in defining possible needs for change in targets for future projects.

Management reviews help to identify additional relevant parameters for improvement that we may not have identified previously. We carry out quarterly management reviews on operational and environmental sustainability projects across Ireland, UK and Poland. It is a great way to share findings of operational and environmental audits, compliance status of KPIs and non-conformity reports across all sites. Outcomes of management reviews are used as inputs to set new targets for managing biodiversity, optimising energy consumption and reducing plastic waste in our meat processing facilities. (environmental and sustainability officer)

The group lean programme manager explained that findings of the environmental and lean audits, conformity or non-conformity reports, process performance and outcomes of corrective actions are considered as agenda items for evaluating operational and environmental performance targets.

Recommendations of opportunities and corrective actions for environmental non-conformities and potential applications of lean tools are included in action plans as outputs of management reviews.

Management review is a fundamental process to evaluate our previous operational and environmental targets set in the last management review meeting and propose targets for the next fiscal year. We use the findings of internal and external environmental audits, and surveillance audits on lean projects, non-conformity reports and corrective actions, which are taken as inputs for management reviews. We identify mitigation opportunities for environmental non-conformities and future application of lean tools for effective usage of utility resources as outputs of management reviews. (group lean programme manager)

The group environmental manager revealed that management reviews are critical for evaluation of overall performance on a yearly basis. Audit reviews on action plans from the last review meeting are considered a type of input for management reviews and changes in targets are recommended (if needed) in future plans after evaluation of operational and environmental performance. The top management is primarily responsible for conducting management reviews, setting future optimisation targets, allocation of financial resources and assigning roles and responsibility for accomplishing optimisation projects.

Management review is key to us. We have a full management review on a yearly basis to evaluate our current operational and environmental systems for every site across Ireland. Findings of the audits reflect the current compliance status of our operational and environmental targets during management review meetings. Corrective and preventive actions are proposed based on non-conformity reports on operational and environmental performance by the top management and the sustainability and environmental lead managers of our company. Further, top management is responsible to set future targets, allocate resources and assign responsibilities to achieve the next year targets set in the management review. (group environmental manager)

6.5 Critical success factors for implementing lean and ISO 14001 as a combined approach

Critical success factors are the main focus areas for implementing a lean and ISO 14001 approach to achieve better operational and environmental sustainability. Top management commitment is critical for creating a culture of implementing continual management initiatives to achieve sustainability goals. The findings of this case suggested that senior management plays a critical

role in establishing targets, engaging workforce and allocating financial resources for implementing lean and ISO 14001. Further, allocation of resources (financial and technical) from top management to improve skill levels of the workforce through in-house and external training fostered continuous improvement initiatives. The environmental and sustainability officer revealed that top management commitment in engaging employees, setting ambitious targets and providing consistent financial support for training programmes helps enable successful lean and ISO 14001 implementation.

Implementation of lean and ISO management systems are driven from top management commitment. Senior management is responsible to ensure engagement of all employees and clearly communicate about sustainability as a top priority to the relevant people. Further, I would say setting appropriate targets is really important for us to drive continuous improvement initiatives. We found more parameters of success, for example, communication, training and introduction of latest technologies which are critical aspects for implementing operational and environmental performance initiatives. (environmental and sustainability officer)

Allocation of financial resources from the top management is a pivotal aspect to support continuous improvement projects for meeting regulatory compliance requirements and achieving process optimisation targets. The group lean programme manager found that financial capacity is critical for initiating training of lean and EMS management (in-house and external consultants), installing new compact equipment and managing expenditures of ISO accreditation in Beta.

Role of top management in providing the capital is key for reducing our environmental footprints, meeting the regulatory objectives through our environmental management system and supporting our efforts for continuous management initiatives. (group lean programme manager)

Similarly, the resource efficiency and sustainability manager highlighted that continuous sustainability projects are carried out by a group comprising competent top management, skilful supervisors and well-trained operators. A competent steering committee conducted fortnightly internal walks for effective evaluation of optimisation projects and possible needs for change in setting future sustainability goals.

At the top, we have a steering committee comprised of group lean programme manager and group environmental manager who are committed to implement lean and ISO management systems and underneath that we have properly trained supervisors. Steering group conducts meetings and visits different areas of meat processing for evaluating the progress of the lean and environmental sustainability projects. So, paramount importance is given to top management engagement and knowledgeable workforce for conducting sustainability projects in our meat processing facilities. (resource efficiency and sustainability manager).

The group lean programme manager noted that implementation of lean and ISO 14001 is not an easy task without allocation of financial resources from the top management. Further, availability of funds is considered the biggest requirement for attaining ISO 14001 accreditation and conducting training to implement lean and ISO 14001 in meat processing.

If we do not have sufficient funds, then we are going to fight an uphill battle in implementing operational and environmental substantiality programme. Therefore, allocation of financial resource by senior management is the single biggest reason for a successful implementation of a lean programme and achieving ISO 14001 accreditation. (group lean programme manager)

The environmental and sustainability officer suggested that eagerness to become the best in the business motivates Beta to produce environmentally friendly meat products. The Plastic Action Alliance and Origin Green stewardship were achieved by Beta as an elite meat producer in Ireland for maintaining zero carbon footprints and efficient handling of packaging material in different stages of meat processing.

Ambition to become the best in sustaining overall meat processing from entering the carcass till packaging of the end meat products is the most important factor. Our company attained stewardship of Plastic Action Alliance for efficient utilisation of packaging material and Origin Green programme for zero carbon footprints as a founding member from Ireland to provide environmentally friendly meat products to their loyal customers. Successful implementation of lean tools and ISO14001 procedures are supportive methods for reducing the continual generation of operational and environmental wastes to produce prime meat-products. For example, standardised work instructions and environmental

KPIs are maintained for efficient usage of packaging material during processes such as store wrap, modified atmospheric packaging and vacuum packaging. (environmental and sustainability officer)

The lean programme manager suggested that information sharing at all the levels vertically and horizontally is essential to share the performance parameters on operational and environmental waste reduction for achieving sustainability targets.

I would say, effective communication is highly important. Information sharing is a crucial aspect to cascade the organisation's waste minimisation policy and targets on handling of carcass, energy consumption and boiler operations among the workforce for raising awareness in achieving sustainability targets. So yeah, definitely, communication would probably be the top factor. (lean programme manager)

The group environmental manager said that effective implementation of environmental and continual improvement initiatives is considered a critical factor to satisfy the customer by taking actions and assign responsibilities to the workforce for better achieving operational and environmental targets to process environmental-friendly meat products, which contributes to enhancing the image and credibility of Beta. Details of optimisation programmes for consumption of electricity and reduction of air emissions created a firmer base for Beta to satisfy the European retailers about environmentally stable meat products.

Effective management of operational and environmental performance provides an opportunity for creating an image as an environmentally sustainable organisation to our big retailers in Europe. Our sustainability team has enlightened our immediate retailers such as Walmart, Albert Heinz and Sainsbury's about our lean and environmental management programmes for minimisation of carbon footprints and managing biodiversity. (group environmental manager)

The environmental and sustainability officer asserted that introduction of renewable sources of fuel or the latest technologies in boiler operations is considered a key aspect in optimising the electricity generation in meat processing.

New fuel sources or introduction of latest technologies is key for optimising boiler efficiency in our meat facilities. Replacement of current coal-based boilers with solar

system or wind energy system or introduction of renewable energy sources would enhance the environmental sustainability of our boiler operations. (environmental and sustainability officer)

On the same issue, the head of continuous improvement further emphasised that investment by the top management and fundings from the European Union (EU) in installation of the latest equipment and continual adoption of initiatives helps Beta to save money after a payback period of the initial investment. Allocation of funds for the operational optimisation programme and introduction of the latest technology showed the intention to create an organisational culture of promoting operational and environmental performance.

We have saved approximately fifteen million dollars over the last decade by implementing sustainable improvement initiatives and introducing latest equipment to improve resource utility in our meat processing facilities. We spent five million on latest meat grinders, another million on a 40% recycling portable plant and a couple of million on heat recovery. The payback periods of these financial investments are between three to five years. We allocated and spent money on these initiatives to demonstrate to our retailers and loyal customers that we are going an extra mile to ensure operational and environmental sustainability. (head of continuous improvement)

Similarly, the group environmental officer elaborated that a culture of introducing continuous improvement initiatives, the latest equipment and technologies fosters the ability of Beta to achieve environmental goals. Further, government regulatory authorities have helped the meat processing facilities to achieve the compliance requirements and provide financial support to introduce the latest technologies.

Our meat group has followed the culture of operational and environmental sustainability by implementing continuous improvement initiatives and ISO management systems. Government environmental institutions and local community bodies played an important role to provide partial funding for introducing the latest technologies and state-of-art equipment to achieve better environmental performance. The application of new modernised tools and installation of innovative equipment and latest technologies have been introduced in our meat processing facilities for achieving our organisational goals. Our research and development manager has worked closely with the regulatory authorities

to introduce ultraviolet technology for reducing water consumption and promoting recyclable packaging material to achieve sustainable development in processing meat products. (group environmental officer)

The group environmental officer emphasised that quality of data is a top-level critical factor for evaluation of lean and ISO 14001. Data from VSM helped to evaluate operational and environmental performance in annual management reviews. Furthermore, the documented evidence is utilised to make action plans for meat process optimisation.

Correct data is a key factor for an effective evaluation of lean and ISO 14001. A comprehensive analysis of value stream mapping helps our research and development team to produce correct data for generating performance reports on wastewater, biofilters and energy consumption. These documented non-conformance reports are critical to make decisions on achieving environmental strategic planning and introducing corrective actions to improve meat processing activities. Further, accurate data on operational and environmental KPIs has helped our group to conduct annual performance audits, assess the environmental protection losses and evaluate the status of regulatory environmental compliance during management reviews. (group environmental officer)

The group lean programme manager explained that training on an EMS programme and lean strategy helps to build capability for these initiatives. External training on environmental audits (as an ISO 14001 lead auditor) is an important aspect in managing the team of internal auditors to improve environmental audits and enhance understanding of the concepts and requirements of ISO 14001 in Beta. On the other hand, lean training from the external consultants at operational level helps to better perform the environmental practices and improve competencies of the employees.

We arranged ISO 14001 lead auditor and lean six sigma green belt, black belt and master black belt courses for our workforce and senior managers to implement lean and environment improvement projects. The ISO 14001 lead auditor training helps our workforce to understand the concepts and requirements of ISO 14001 EMS in identifying and controlling the meat environmental impact. While lean training improves staff productivity for minimising utility wastage and increases shelf life of prime meat products. (group lean programme manager)

A list of the critical success factors for executing an integrated lean and ISO 14001 strategy in Beta, based on the descending order of the number of informants who cited them, is presented in Table 6.3.

Table 6.3: Critical success factors for implementation of lean and ISO 14001 in Beta

SN	Critical success factors	Informants
1	Top management commitment, engagement and support for workforce	Environmental and sustainability officer, group lean programme manager and resource efficiency and sustainability manager
2	Installation of latest equipment/introduction of technology	Group lean programme manager, head of continuous improvement and group environmental officer
3	In-house and external training programmes	Environmental and sustainability officer, lean programme manager and group lean programme manager
4	Engagement of workforce	Environmental and sustainability officer, group lean programme manager and resource efficiency and sustainability manager
5	Availability of resources (financial and human)	Environmental and sustainability officer, group lean programme manager and environmental and sustainability officer
6	Organisational culture	Group environmental manager and group environmental officer
7	Communication	Environmental and sustainability officer and lean programme manager
8	Availability of data for performance evaluation	Group environmental officer

6.6 Conclusion

This chapter presented the findings on the contribution of lean and ISO 14001 implementation strategies as a combined approach for improving environmental performance in the Beta. Further, this case study also explained the application of lean tools and ISO 14001 procedures in Beta (meat processes) to improve environmental performance and the synergies between these strategies. An assessment of the CSFs for implementing lean and ISO 14001 as a combined approach were also discussed. Chapter 7 discusses the key findings of the third case study presented next.

Chapter 7 – Case Study Findings from Gamma

This chapter presents the data collected from the third case study. This chapter addresses the empirical findings from an NZ meat company that will be called Gamma (a pseudonym) for the purposes of this thesis. Gamma have practiced lean tools and are compliant with ISO 14001 for more than a decade in their facilities. Gamma is amongst the prominent meat processing companies to achieve ISO 14001 compliance, a prestigious indication of sustaining environmental performance. A digital lean programme is effectively implemented in Gamma for predicting offal yield from cattle, achieving better production targets and providing value-added meat products to their customers. This chapter aims to empirically investigate the environmental performance in the meat industry through the implementation of lean and ISO 14001 as a combined approach and how these approaches are used to mitigate the waste and achieve environmental improvements. Further, the synergies between these initiatives are explored and the CSFs for their joint implementation are also identified in the context of the NZ based meat industry. The chapter is organised into subsections as follows.

First, the case study setting for Gamma along with details of the informants are presented in section 7.1. The next section introduces Gamma and provides a background on its operations. This chapter aims to examine the empirical findings utilising the constructs of the NRBV model for lean and ISO 14001 implementation (Figure 2.4) to achieve environmental performance in the NZ-based meat company Gamma. Further, an analytical description is presented to demonstrate the main factors that impact the meat industry to implement lean and ISO 14001 successfully.

7.1 Gamma case study setting

A series of semi-structured interviews with the informants from Gamma were held between July and September 2022. An initial contact was made in July 2022 with the innovation manager of Gamma and correspondence was initiated through LinkedInTM for conducting an interview to investigate the impact of lean and ISO 14001 implementation on environmental performance. The introductory emails providing the information sheet and questions were sent after receiving the innovation environmental manager's consent. Further, at our request, the innovation manager shared the information about the study with the relevant people in the company to obtain their consent to participate in this study. Five informants further agreed to participate in the investigation. The other five informants included a group environmental manager, streamline lead

programme manager, regional operations manager, environmental advisor and streamline specialist. The positions of the informants and role descriptions are presented in Table 7.1. Six interviews were conducted via Zoom because of unavailability of the informants for face-to-face meetings due to travelling restrictions during the Covid-19 pandemic. These interviews lasted 45 to 90 minutes and were conducted based on pre-selected questions and recorded digitally for data analysis.

In addition to Zoom meetings, access was obtained to their environmental management manual and organisational reports on environmental sustainability. Further, promotional material, data on environmental performance and web sites of the organisation were reviewed to gain in-depth insight into Gamma’s operational and environmental performance. The summary of positions and role descriptions of the informants are presented in Table 7.1.

Table 7.1: Positions and role descriptions of the informants

SN	Position	Role description
1	Group environmental manager	Implementing environmental management system across multiple sites throughout NZ for over fifteen years.
2	Streamline lead programme manager	Managing food safety, quality and environmental continuous improvement projects for over nine years.
3	Regional operations manager	Implementing a number of continuous improvements for waste reduction, environmental performance and wastewater management across Gamma for over four years.
4	Innovation manager	Implementing a number of cross-functional improvement projects for over ten years.
5	Environmental advisor	Worked at different environmental management roles for over twenty years.
6	Streamline specialist	Implementing continuous improvement initiatives across NZ’s North Island for over eleven years.

7.2 Company overview

Gamma is a NZ based meat manufacturing company which has been providing sustainable meat (lamb, beef and venison) products with a vision of “inspirational food created by passionate people” since 1948. Further, the mission of Gamma is to produce delicious meat products with sustainability in mind and “care at heart”. Gamma is an extensive network with 14 processing plants from north to south NZ, producing 30% of all NZ lamb, beef and venison. A team of 7000 employees works towards achieving operational and environmental performance in Gamma. Further, Gamma generates revenue of over NZ\$3273.7 million and earns a net profit of NZ\$189.3 million after tax from sales to over 60 destinations around the world including the US, UK, Germany and China in 2022.

The company processes 100% grass fed red meat which is leaner (less saturated fat with fewer calories) with a higher level of omega-3 fatty acids and more antioxidants (vitamin A and E).

Gamma is currently pursuing the Sustainability Action Plan 2030 to optimise water utilisation, energy saving and carbon reduction across their 14 sites in NZ. Gamma is committed to reduce scope 1 and 2 emissions by approximately 42% to achieve the targets of the International Science-Based Targets initiative (SBTi) by 2030. A 30% and 9.2% reduction in water and energy utilisation per kilo of meat product produced respectively has been reported for achieving sustainability targets since 2016. Further, a 20% reduction in processing emissions, more than 100 tonnes of plastic waste reduction and a reduction of 14,500 tons of CO₂ have been achieved since 2018.

Gamma received the Market Leader award in the Beef + Lamb NZ award category to acknowledge the best local meat company for promoting innovative ideas in meat processing. Further, Gamma conducts an annual conference on the theme Plate-to-Pasture strategy to share their operational and environmental sustainability vision with internal and external stakeholders (such as farmers, suppliers and contractors). Gamma has been recognised as providing market-leading net carbon zero meat products among NZ meat producing organisations by maintaining low emissions and climate resilient meat processes. In addition, Gamma has committed to several initiatives (such as elimination of coal by 2030 and net carbon zero stewardship) for becoming the world's most sustainable red meat company. Moreover, Gamma has received funding for two projects on decarbonisation for installation of heat pumps to reduce approximately 14,000 tonnes of CO₂ from the Ministry of Energy and Resources.

7.3 Environmental and waste reduction outcomes by implementing lean and ISO 14001

The informants of this study revealed that lean and ISO 14001 implementation as a combined approach helps to minimise all kinds of operational and environmental wastes. The environmental advisor explained that a combined lean and ISO 14001 approach is considered a prime strategy for providing an appropriate direction for achieving sustainability targets. Gamma is currently implementing lean tools under the umbrella of a streamline system. Operational and environmental targets (e.g., water usage, electricity consumption and air emission generation) are combined in an organisational policy to identify improvement opportunities and enhance the operational and environmental performance.

In my experience, an integrated lean and ISO 14001 approach is a superior strategy because everyone's pulling in the coextending direction for achieving waste and environmental reduction targets. An integrated lean and ISO 14001 initiative enabled us

to have a combined system which primarily focused on improving operational and environmental performance. We identified significant environmental targets such as waste consumption, energy usage and air emission reduction in our overall organisational policy. We incorporated environmental aspects into lean through what our company calls a streamlined strategy. A streamlined system helps us to establish combined organisational targets, identify improvement opportunities and provide an integrated structure of lean tools and environmental management procedures for achieving sustainability targets. (environmental advisor)

The streamline specialist explained that lean philosophy provides a culture of improving operational and environmental performance. An ISO 14001 based EMS framework helps to identify non-compliance, while lean tools are utilised to identify causes and opportunities for achieving environmental targets. An integrated lean and ISO 14001 approach contributes to creating a culture of continuous improvement by increasing involvement and awareness of the employees. Items brought to the employees' awareness include parameters such as the organisation's vision for environmental performance, identification of operational and environmental non-conformities and a combined implementation of lean tools and ISO 14001 procedures for improving current performance.

Lean is a culture of making improvements around all aspects of the business, not just operational improvements but definitely including environmental sustainability. We want to improve as a leading meat processing entity from an environmental standpoint through our ISO 14001 certification along with lean initiative. ISO 14001 is providing us a framework for identifying non-conformities from our standard, while lean is utilised for identifying causes and opportunities to overcome operational and environmental deviations. (streamline specialist)

Similarly, the streamline lead programme manager further explained that ISO 14001 provides a framework and lean strategy helps to reduce environmental impact and operational waste. Benefits of an integrated lean and ISO 14001 approach include optimising utility consumption and environmental sustainability in different phases of meat production.

ISO 14001 provides a framework for achieving environmental performance, while lean is about reduction of wastes in the various stages of meat processing. We achieved better

outcomes of air emissions, ash handling and particulate matter along with efficient utility consumption in our meat processing line by putting lean and EMS together. (streamline lead programme manager)

In the same vein, the group environmental manager further elaborated that operational and environmental benefits include reduction in wastewater, decarbonisation and plastic utilisation for implementing the streamline (lean) system and ISO 14001 as a combined strategy. The benefits of an integrated lean and ISO 14001 approach are in reduction of landfill waste, carbon footprints and plastic consumption.

We currently have an integrated system, we implement lean and ISO 14001 side by side through a plan, do, check and act cycle. We found the most benefit is where we can take procedures of ISO 14001 and merge them into the lean system for pursuing operational and environmental projects. Outcomes of streamlined projects achieved are reduction of 7.7% landfill wastewater, 30% gross carbon minimisation and 100 tonnes of plastic waste reduction since 2020 in our 14 sites. (group environmental manager)

7.4 Implementation of lean and ISO 14001 as a combined approach

The findings of this case study highlighted eight themes that emerged based on the constructs of theoretical model (Figure 2.4) through the coding of interview transcripts, revealing a strong relationship between lean and ISO 14001 implementation strategy as a combined approach for sustaining environmental performance in the meat industry.

7.4.1 Integrated lean and ISO 14001 environmental policy

The streamline lead programme manager explained that reduction targets focus on such aspects as decarbonisation, heat losses and wastewater to formulate a comprehensive documented policy. Gamma established targets around minimising coal utilisation, introduction of heat pumps and reduction of water utilisation. Operational and environmental targets based on minimisation of waste and environmental impacts are complimentary to each other in reducing the causes of non-conformities in meat processing. Coal based boiler houses are a main source of solid waste generation (ash content and particulate matter) and environmental air emissions non-conformities (e.g., generation of abundant CO₂, NO_x and SO_x). Therefore, Gamma set a target to replace coal as a source of energy and steam generation with the latest technologies (introduction of heat pumps and renewable energy source/s) by 2030. High consumption of water in meat processing such as

in the slaughterhouse and boning room (for washing carcasses, sanitising and cleaning the floor) caused inefficient resource consumption. Setting targets for fuel replacement and efficient water usage helps their meat facilities to identify and minimise non-value-added activities (solid waste from boiler operations and inefficient utility use) and reduce environmental impacts (generation of greenhouse gases).

We basically renewed our operational and environmental targets in our policy each year. Our overall organisational policy is built upon our reduction targets around greenhouse gas especially CO₂, heat efficiency and wastewater and so on. Reduction of CO₂ generation and replacement of coal as fuel source are our environmental targets. Introduction of automated heat pumps along with alternative fuel sources help to reduce the consumption of highly expensive and non-environmentally friendly coal. Minimum wastewater generation with an accurate quantity of biological and chemical oxygen demand is a prominent target around water in our processing facilities. Lean and environmental targets are complementary aspects to work together towards operational sustainability and environmental performance. (streamline lead programme manager)

In the same thread, the regional operations manager outlined the process for setting operational and environmental targets around lean and ISO 14001. An integrated policy is developed after comprehensive analysis of organisational vision, reports on all kind of meat processing wastes (i.e., water, organic and energy) and minutes of previous management review meetings for improving operational and environmental performance. Gamma encouraged their meat facilities to set targets around GHG emissions in accordance with the SBTi to meet the reduction goals of the Paris agreement. A number of governmental funded projects (e.g., decarbonisation through introduction of heat pumps and renewable fuels) are currently pursued for achieving the reduction of CO₂ targets.

We've developed operational and environmental targets by analysing the reports generated from our streamline and environmental management systems. We established our policy around wastewater reduction, organic waste, energy reduction, CO₂ minimisation, cutting coal consumption for achieving Science-Based Targets Initiative by 2030. We are currently involved in Capex projects funded by the government and local councils to achieve our streamline and environmental policy parameters around

wastewater, CO₂ reduction and replacing coal-fired boilers over the next 10 years. (regional operations manager)

Along similar lines, the group environmental manager further elaborated that the policy provides a foundation to develop targets around water consumption (for instance, slaughterhouse, boning room and cleaning of floor), solid waste (e.g., slaughtering, trimming and portioning of meat) and packaging material (such as biodegradable containers and cardboards). The sustainability action plan helped their streamline and environmental practices to meet compliance requirements and implement their waste reduction policy.

Our operational and environmental policy is considered as baseline in analysing data for reducing waste to landfill parameter. Waste to landfill philosophy also includes parameters such as minimum wastewater sludge generation and reduction of inorganic waste during the execution of streamline and environmental projects. Our group has a sustainability action plan which includes streamline and environmental targets to meet the statutory requirements of operational and environmental performance for achieving our waste reduction policy. We implement continuous improvement projects around our streamline system and environmental practices to mitigate significant impacts on operational and environmental performance. (group environmental manager)

The streamline specialist explained that the role of the workforce is important for setting environmental waste reduction targets and providing guidelines for continuous improvement (lean and ISO 14001) initiatives. Documented policy for operational and environmental performance is established based on data analysis of projects around lean and environmental management practices.

I think people on the floor are quite conscientious to set environmental waste reduction targets for making incremental changes through operational and environmental practices. Data analysis of the streamline system and environmental projects provide a structural system to identify the relevant targets around water consumption, electricity usage and air emissions for developing a documented policy. (streamline specialist)

7.4.2 Integrated plan and projects of ISO 14001 and lean implementation

The environmental advisor provided a generic description for development of an integrated waste and environmental impact reduction plan based on analysis of usage of raw carcasses, water and electricity as well as generation of wastes (organic and inorganic). Further, waste to landfill and compost material data are also evaluated for developing a comprehensive plan to execute optimisation projects in Gamma. Furthermore, the regional operations manager explained that a comprehensive integrated management plan is developed by incorporating operational and environmental aspects such as usage of water, consumption of electricity and reduction of GHG emissions (CO₂, CH₄ and N₂O). These KPI benchmarks are effectively monitored and managed by their environmental and sustainability team to achieve targets around operational and environmental performance. They developed a culture to monitor targets, measure KPI benchmarks and identify future opportunities through lean tools for improving operational and environmental performance. Additionally, ISO 14001 provides a framework to set goals by combining the operational and environmental targets, transforming information about their action plans in the annual review meeting and proposing proactive actions to achieve the organisational policy targets.

In the same thread, the group environmental manager described an annual plan for waste and environmental damage reduction to achieve the operational and environmental aspects, such as, greenhouse gas emissions, waste (organic and inorganic) and resource efficiency. Additionally, KPI benchmarks are established around operational parameters (for instance, raw carcasses processing, water usage and electricity consumption) after a comprehensive analysis of previous optimisation projects. Operational and environmental gaps are identified by analysing current and previous KPI benchmarking to establish future optimisation plans during the management review meeting. The KPIs' input aspects are reflected on smart dashboards to depict the set objectives for the annual optimisation plan. The outputs on KPIs indicate the performance level of Gamma and helped to identify gaps for future optimisation cycles.

Our group have developed a comprehensive annual plan for improving raw carcasses, energy and water consumption after a comprehensive evaluation of the previous KPIs benchmark against the current performance. This comprehensive analysis is used to determine the performance gaps and these gaps are included in the next cycle of

optimisation. The inputs of KPIs benchmark around for instance, raw carcasses processing, water and electricity consumption are included in future performance dashboards. (group environmental manager)

The environmental advisor reported that production of excessive wastewater sludge causes constant handling issues in one of their meat processing facilities. Top management of Gamma comprised a team of environmental advisor, operations and streamline managers to conduct detail investigation. The roles, responsibility and authorities were established and documented according to ISO procedures for identifying the main causes of non-conformity and corrective actions to mitigate excessive sludge generation. They conducted a series of brainstorming sessions by analysing the VSM data and findings of root cause analysis to determine the causes and opportunities for better utilising wastewater sludge as landfill or other alternative mitigation options. The investigation team concluded that this wastewater sludge could be used as an alternative fuel after drying processes for producing electricity and steam in coal-fired boiler. Wastewater sludge is considered as an environmentally friendly alternative fuel with less sulphur content as compared to lignite/sub-bituminous coal. The investigation team further emphasised that the potential usage of wastewater sludge as an alternative fuel option helps their group to meet the environmental targets such as reduction of GHG emissions and efficient handling of the wastewater. The investigation team formulated a comprehensive report which was communicated to the top management for developing a pilot project to use dry sludge as a fuel source. Further, they also recommended assessing these findings during the quarterly management review to improve conformity status of wastewater sludge.

We have faced excessive generation and handling of wastewater sludge. The causes of wastewater sludge non-conformity and opportunities for mitigation were identified. The investigation team suggested to replace the coal as fuel with usage wastewater sludge due to the environmentally friendly composition of dry sludge. We further recommended to use dry sludge in coal-fired boiler in a pilot project. The recommendations of the investigation and outcomes of the pilot project were documented and communicated for further analysis in the management review meeting. (environmental advisor)

The group environmental manager explained that a project was initiated for maximising the meat yield to avoid the rendering process. Their processing department set yield targets in the overall

Gamma policy for reducing the waste. The group environmental manager further explained that one of Gamma's site had limited rendering capacity. Therefore, excessive solid waste is outsourced to waste contractors for rendering and landfill purposes. The streamline lead programme manager further explained that the efficient rendering procedures help Gamma in handling the biological organic waste such as stomach content. However, the rendering and tanning processes have limited scope for handling of sheep skin and beef face pieces. Currently, approximately 16,000 tonnes of sheep skin and beef face pieces waste per year are produced in Gamma which causes waste management issues.

The streamline lead programme manager and his team conducted the root cause analysis to determine the causes and potential opportunities to handle large organic waste. They proposed a project to shred the sheep skin and beef face pieces to meet the regulatory compliance limits around handling and reducing solid waste. They suggested to initiate a pilot project by making skin and face pieces as compost ribbons through the shredding procedure. The ribbons of sheep skin and beef face pieces are converted into small chips of approximately 3-5 centimetres. These small sized chips are efficiently used in composting and rendering processes for mitigating the solid waste. Standardised work instructions are developed and communicated around the shredding project for further extension across Gamma.

We handled biological organic waste effectively through composting and rendering processes. However, the application of rendering procedure have limited scope to handle large size of organic components such as sheep skin and beef face pieces. Gamma introduced a shredding pilot project for making small ribbons and chips to treat the small sized compost for the rendering procedure. (streamline lead programme manager)

The innovation manager explained that removal of coal as fuel source and extraction of heat from air exhaust are integral targets of the environmental and waste reduction policy. The environmental and lean managers conducted a series of meetings to analyse the potential possibilities for replacing coal with other existing environmentally friendly systems (solar system, biomass boilers or heat recovery options) to produce electricity and steam. The innovation manager emphasised that the complete removal of coal as a source of electricity and steam needs a few more years. However, the heat recovery from energy-rich air exhaust by glycol run around a loop system. Glycol liquid is circulated (through two coil system) between the exhaust and outdoor airstream

to recover maximum thermal heating. The investigation team prepared recommendation to further analyse the fuel replacement of coal with alternative options in the six-monthly review meeting. They also communicated the findings of a pilot project for the application of glycol liquid for extracting maximum heat from the boiler tubes.

We have plans to get rid of coal with alternative fuel sources across our group by 2030. Therefore, we are using a business strategy to remove coal. We are also focusing on heat recovery from air exhaust. Our group recently introduced glycol liquid circulation system to recover heat from the energy rich exhaust. (innovation manager)

The regional operations manager explained that they conduct a large number of small operational and environmental improvement projects to achieve targets set in their overall organisational policy. Gamma developed individual initiatives for a site by introducing waste and environmental targets into a PDCA cycle according to the lean and ISO 14001 based EMS framework for continual improvement. The regional operations manager explained that a project was initiated for efficient usage of water across multiple sites throughout NZ. They used the ISO 14001 framework to set targets around efficient water consumption during the different meat processing activities. The implementation team suggested that standardised work instructions were revised and communicated at the coalface to educate their workforce for minimising excessive water consumption. The environment and streamline managers introduced a new set of standardised work instructions for water usage. The reduction of wastewater initiatives included (a) minimisation of water consumption during hand washing and hygiene maintenance, (b) introduction of latest sensors for better maintenance of waterflow during processing and cleaning procedures and (c) contribution of the workforce for reducing water usage during the meat processing activities. KPI benchmarks and water usage targets were continuously monitored and incremental improvements were also reported on effective water consumption.

Our group have introduced a continual improvement cycle by introducing the lean and ISO 14001 based EMS framework together. For instance, our group introduced optimisation project around water usage across multiple sites throughout NZ. Water consumption minimisation targets were set and communicated under the EMS framework. Our environmental and streamline team introduced revised standardised work instructions for effective water usage in meat processing. These reduction initiatives were based on water

consumption during hand washing, introduction of efficient sensors and role of the workforce. (regional operations manager)

7.4.3 Communication and information sharing

The regional operations manager explained that maintenance of communication flow is considered a critical element to inform their workforce about operational and environmental initiatives. Daily meetings are a part of communication for generating data, identifying non-conformities (if they occurred) and welcoming potential corrective actions on quality, operational and safety aspects. Further, external communication is maintained with relevant external stakeholders (customers, government institutions and suppliers) by sharing information on updated operational and environmental parameters. Internal communication is effectively pursued by team leaders, meanwhile external information sharing is effectively conducted by risk managers in Gamma.

Communication as our foundational tool is an integral part of our streamlined strategy and ISO 14001 communication procedure to share information for achieving operational and environmental performance. We set daily meetings to evaluate our production and environmental performance after receiving feedback, capturing optimisation ideas and evaluating ongoing sustainability targets from different departments of a meat processing facility. We have team leaders who are responsible to write up all reported non-conformities, potential solutions and outcomes of corrective actions on health and safety, quality, production yield and environmental compliance parameters from the floor shop to the senior management. We also share quick notes with clear information on environmental targets such as carbon footprints, organic and inorganic wastes with our customers, local councils and government institutions as a part of our external communication initiative. We assign responsibility to our risk managers to cascade information with external bodies. Risk managers are accountable to manage resource consents with local councils, environmental groups and government institutions. (regional operations manager)

The group environmental manager explained that the brand image of Gamma is improved by sharing their commitment to processing zero-carbon meat products for the NZ and US food markets. Operational and environmental parameters were communicated with their stakeholders to manifest their efforts for producing environmentally friendly meat products. In addition, the

group environmental manager explained that the net carbon zero initiative in the farms and meat processing facilities across Gamma is recognised by the British Standards Institution (certification of PAS 2050).

External communication helped us to improve our brand value in NZ and across the globe. We've recently launched our zero-carbon based meat products into the US market. It's not something where we've gone and offset carbon inputs but actually ensured the whole processing of red meat have a zero-carbon footprint. We communicated this environmental sustainability initiative with the business community in the US and NZ to improve our brand integrity. We cascade information about our claims to become environmentally friendly meat processing group with our relevant suppliers, loyal customers and contractors. This external communication is comprised around our environmental optimisation projects, outcomes of these initiatives and future proactive actions to become best-in-class meat processing group. (group environmental manager)

The streamline lead programme manager explained the internal communication plan to manage error-proof information flow for managing operational, environmental and safety parameters. They described key activities (operational, environmental and safety), main goals, information channels, resources allocation and role definition in the internal communication plan. Internal communication empowered their workforce to share their ideas in identifying non-conformities and proposing mitigation actions.

We have an internal communication plan for effective information sharing. We conduct daily meetings on operational, safety and environmental aspects with our shop floor level workers and senior management to cascade the information. We provide proper opportunity to our shop floor workers to share their concern regarding the existing processing procedures and take on-board their ideas for potential improvement prospects. (streamline lead programme manager)

The environmental advisor explained the impact of communication of their goal to become the world's best meat company by highlighting the sustainability projects (lean and environmental practices). Environmental sustainability projects are communicated with their workforce and relevant external stakeholders (for instance, repeat customers, suppliers and contractors) to reveal their commitment towards producing environmentally friendly meat products.

A lot of external communication has been made regarding our green projects, our lean tools implementation and ISO 14001 to depict our credence to become the world's most sustainable meat group. We've put a stake in the ground by saying "we want to be the best", this communication slogan helps us to move in the right direction for achieving operational and environmental sustainability targets. (environmental advisor)

The streamline specialist explained that internal communication (charts, whiteboards and posters) is used to educate their workforce about the current status, statutory and compliance requirements in the different phases of meat processing. Further, custom-made dry erase traditional whiteboards are an efficient tool for scheduling, planning and achieving continuous operational and environmental improvements.

Each site has one streamline room which has a series of charts, maps and whiteboards to show our people about operational, environmental and safety projects, their compliance status and corrective actions. We also depict our company commitment towards environmental strategy, customer expectations and statutory requirements through one or two big posters. (streamline specialist)

7.4.4 ISO 14001 procedures

Informants of this case suggested that operational controls provide assurance to reduce the risk in achieving environmental objectives around utilisation of raw carcasses, water and electricity. The group environmental manager explained that a four-member team records the data manually around quality and environmental management procedures. Further, data of audit and annual management review reports are analysed to determine the non-conformity level of environmental impacts and propose the corrective and preventive actions for achieving the set environmental objectives. A job description chart developed in the Gamma clearly communicate the roles, responsibilities and authorities for maintaining the reporting structure on audits, inspections and EMS performance. A qualified team is responsible for maintaining manual documentation on the set targets (for example, utilisation of raw carcasses, water usage and electricity consumption) and updating targets based on the outcomes of the analysis.

We controlled our ISO 14001 documentation procedure by manually managing the quality and environmental system to maintain data for audit, review and annual management review. Roles, responsibilities and authorities are laid down, and communicated to our

relevant qualified team in our environmental management plan for better environmental targets. Qualified environmental team members are responsible for maintaining the documentation, making amendments in set targets and updating new parameters on overall organisational performance initiatives. (group environmental manager)

The environmental advisor explained that the management of an efficient ISO 14001 based EMS helps to achieve organisational objectives, legal and statutory obligations as well as customers' requirements. Further, he elaborated that a robust ISO 14001 framework helps to improve continuous environmental performance by controlling the conditions, for instance, utilities (water consumption, electricity usage and chemical usage).

Effective functioning of our ISO 14001 through managing the compliance requirements takes us beyond the set targets of regional councils. Management of environmental compliance requirements ensured to improve our environmental performance progressively and continuously. Robust implementation of EMS framework helped us in renewing environmental consent and trade waste agreements with government institutions and regional councils. (environmental advisor)

Operational planning and control are critical procedures for implementing environmental activities and meeting compliance requirements. The streamline lead programme manager reported that the life of freshwater habitat is disturbed due discharge of ammonia into a river. They developed a risk management plan for corrective actions and emergency preparedness to mitigate the nonconformity of effluents generation and meet the consent requirements on GHG emissions. The emergency response procedures not only ensure the occupational health and safety of the workforce but also achieve environmental objectives of Gamma. The innovation manager explained that Gamma maintain a number of documents under the operational procedures of an EMS. A few examples of these mandatory documents are: (1) scope of the ISO 14001 based environmental policy, (2) environmental policy for efficient usage of raw carcasses, water and chemicals and (3) emergency preparedness and response (for avoiding wastewater spillage, efficient utilisation of chemicals and enhancing environmental safety).

7.4.5 Lean tools

The regional operations manager explained a number of basic lean tools such as problem solving at the coalface, cascading information and quick changeover of equipment for streamlining and

improving meat processing. The regional operations manager further elaborated that standardisation work plays a pivotal role in consistent processing of raw carcasses by implementing best practices and maintaining standard operations. Leader standard work helped to manage inspections, identify non-conformities and propose corrective actions. Further, standardised meat processing areas, sets of PPE gear and standardised meat processing procedures helped to meet compliance requirements.

We have used the standardisation lean tool a lot, as is used across other processing industries, as we go back to Toyota Production System, which is the blueprint for lean strategy. We're also using tools such as problem-solving initiatives and communication, where our daily focus is on operational and environmental aspects, and quick changeover to reduce operational waste by streamlining and improving processes. We maintained standardisation in the NZ meat industry since 1970s. We already have done a lot on standardised work instruction in red meat processing chain to implement best practices, maintaining similar processes and following defined roles of the workforce continuously. We have our leader standard work who manages our processing checks, identifies process non-conformities and implements corrective actions effectively for improving our problem-solving methods. We've got a distinct layout of our meat processing areas, a very standard set of PPE that people wear and a well-documented set of procedures for meat processing to meet hygiene requirements of our industry. (regional operations manager)

The streamline lead programme manager reported that Gamma faces constant demand management issues due to erroneous forecasting during strategic process planning. The forecasting process leads to creating some wastes, however; traditional performance metrics for meat processing provides no evidence of operational waste or prediction of offal yield (raw carcasses, liver and heart). The streamline lead programme manager introduced the lean tool Hoshin Kanri for connecting day-to-day meat processing activities with a data driven forecasting approach for better predicting offal yield per cattle. Data is collected automatically on edible meat and non-edible items (e.g., hide, bones and insulin) to analyse the opportunities for better extraction of protein content through statistical prediction. This data driven combination of Hoshin Kanri and the forecasting system provides visual representations for tracking meat processing activities.

Further, Hoshin Kanri along with the data driven forecasting system helps to systematically track the effective utilisation of raw carcasses through analysis of day-to-day meat processing activities for supporting the culture of continuous improvement. The data driven lean programme has helped the staff to incorporate value added activities in meat processing, provide insights for mitigating the process non-conformities and save up to 90 minutes of processing time per week for an operations manager. Further, a 5% recovery of meat (approximate profit increase of NZ\$33,000 per annum) is reported from lower value cuts attached with offal after the introduction of the lean based forecasting system. Furthermore, the efficient utilisation of raw carcasses helps to minimise air emissions during livestock farming operations and transportation processing which contributes for better environmental performance.

I remember; our group was facing difficulties to meet the customer demand due to faulty offal yield prediction in the strategic planning phase. Traditionally, we have applied Hoshin Kanri for strategic planning to fulfil the meat-product demand for our loyal customers. We introduced latest forecasting data driven system with Hoshin Kanri for analysing and tracking offal yield per cattle to promote the culture of continuous improvement. (streamline lead programme manager)

The streamline specialist indicated that exceptionally high chemical oxygen demand (COD), biochemical oxygen demand (BOD) and total suspended solids (TSS) has been reported in the wastewater sludge. The streamline specialist explained that a suite of tools (3C and 5-Whys) was implemented under a problem-solving initiative for identification of wastewater non-conformities. The concern, cause and countermeasure (3C) tool is predominantly utilised in identifying reasons for concern (high quantity of disposal of slaughterhouse waste), root causes (presence of high volume of undesirable waste sludge) and corrective actions (reuse and recycling them under the circular economy framework). The combination of 3C with 5-Whys further enabled them to investigate in-depth root causes of wastewater and sludge of solid waste.

Our processing operators reported an unusual waste generation in slaughterhouse to one of our team leaders. They made a non-conformity report on high chemical oxygen demand, biochemical oxygen demand and total suspended solids for investigation of the reasons and identifying solutions as corrective actions. We utilised 3C and 5-Whys as practical problem-solving tools for handling waste sludge in meat processing. A 3C sheet was used

to identify inorganic and organic waste concerns, causes of non-conformities in disposing waste sludge and propose action plans for reusing and recycling to mitigate non-compliance on waste disposal. 4-Ws and 1H were further used to deep dig into, for identification of extensive sludge generation in the carcasses washing at harvest floor. Our team leader, streamline specialist and manager suggested countermeasures such as promoting reuse and recycling of organic waste and training of our workforce for determining the causes of high volume of sludge generation during our meat processing activities. (streamline specialist)

Similarly, the group environmental manager noted that the total generation of wastewater was approximately 22,000 m³/d which suggested non-conformity and bottleneck in the wastewater discharge. The resource consent for the wastewater permitted Gamma to discharge up to 20,000 m³/d effluents into the river. A formal root cause investigation was carried out by the senior leadership (the group environmental manager, regional operations manager and streamline lead programme manager) to examine the excessive drainage of non-treated wastewater into the river stream. Concern (the first pillar of the 3C philosophy) was established as an excessive effluents discharge. The cause of the concern was determined as the low capacity of the chemical treatment plant i.e., 15,000 m³/d of wastewater (from the integrated sheep and beef meat processing and rendering plant). A non-conformity report was generated and communicated to the top management for proposing corrective actions (countermeasures being the third pillar of 3C). Further, a bottleneck analysis was carried out to determine the reasons for excessive effluents generation. The investigation team concluded that inadequate capacity for wastewater treatment and an outdated effluent plant contributed to producing excessive effluents discharge in the treatment process.

Three countermeasures (a pillar of 3C philosophy) for wastewater were suggested by the engineering department to minimise waste in discharging effluents to the surface water. The first two options were based on biological treatment and the third option was based on physicochemical treatment. The investigation team proposed comprehensive wastewater treatment plan as corrective action, allocation of funds (NZ\$12 million) and establishment of standardised work instructions to implement the physicochemical treatment. Standardised work instructions indicated that the physicochemical treatment process was based on a double pH-adjustment method utilising dissolved air flotation with upstream and downstream flow equalisation units along with UV

disinfection treatment. This treatment process enhanced the treatment capacity up to 33,000 m³/d effluents to meet the compliance requirements and improve waste management performance.

We were facing wastewater discharge non-conformity a few years back. Our environmental team reported deviation posed by exceptionally high wastewater than the standard value according to resource consent for wastewater discharge. A competent team comprised of group environmental manager, regional operations manager and streamline lead programme manager was developed to investigate the main causes of deviation from resource consent requirements. They adopted a simple lean tool 3C to determine the cause of current concern and propose countermeasure to mitigate this non-conformity. Team of senior leadership concluded that limited capacity of chemical treatment plant causes the high volume of effluents drainage to the riverside. Three countermeasures were suggested to reduce waste for discharging effluents. These corrective actions were based on biological and physicochemical treatments. Our investigation team adopted physicochemical treatment, allocated funds and established comprehensive standardised work instructions. Outcomes of this countermeasure suggested that our group follows the compliance requirements of resource consent for wastewater discharge to the surface water. (group environmental manager)

The streamline lead programme manager reported that an Andon signal (red) starts beeping in the boning room due to failure and small-scale damage of the belt conveyor. An automatic red signal alarm is the main component of Jidoka that permits the workforce at the shopfloor to stop the boning room process after detection of non-conformity in the belt conveyor. Small-scale damage to the belt conveyor was reported to the top management due to thermal expansion of belt conveyor sprockets. The whole process line remained non-operational for a few hours; however, the required demand for meat supplies were managed through JIT with a 48 hours' buffer initiative. A team comprising the streamline lead programme manager, safety manager and operations manager was created to determine potential reasons for the belt conveyor failure. A comprehensive investigation was carried out to explore the potential reasons for the non-conformity through root cause analysis (fishbone diagram). Irregularities of conveyor sprockets (improper placement, incorrect locking and thermal expansion), spillage of small meat particles (build up on belt and pulleys), poorly installed lagging and tearing of the conveyor belt were pointed out as potential reasons in the fishbone diagram.

The streamline lead programme manager and operations manager suggested a limited application of 5S (eliminate spillage of meat particles on belt conveyor, standardise and sustain handling of meat-products during raw carcasses movement on pulleys and belt conveyors) to improve movement of the meat from receiving to the shipment dock. Further, TPM provides the essential support to the workforce for reducing downtime losses (breakdown of belt conveyor sprockets), speed losses (stoppage of operations in the boning room) and reducing malfunction error by maximising effective operations of the belt conveyor. Moreover, TPM was implemented for autonomous maintenance of the main conveyor belt, bone conveyor belt and full crate transportation belts for effective management of meat movement in the slaughtering, cutting and packaging lines.

Our operators have reported the failure and damage of belt conveyor during the peak hours of the meat processing activities. This non-conformity was indicated by Andon signal, which permitted the operator to stop the belt for identification of the reasons and proposing solution for future process optimisation. We have maintained the required demand of meat products to satisfy our loyal customers through JIT with buffer setting during the repair works of belt conveyor. Our group initiated comprehensive investigation to analyse the potential reasons of malfunctioning in belt conveyor by fishbone diagram and propose mitigation solutions. We have implemented 5S and TPM as combination for cleaning and reducing malfunctioning errors of belt conveyors in boning and packaging operations. (streamline lead programme manager)

The streamline specialist notified that the operators take extra time to change the broken parts of brisket and band saws, which caused delay in processing the raw carcasses. The streamline specialist suggested that preventive and proactive maintenance through TPM is considered an effective approach to improve reliability of equipment. Furthermore, SMED is applied to reduce the changeover time of broken parts of cutting equipment for processing the raw carcasses. Standardised changeover steps were managed by a competent team to achieve the desired outcomes of the SMED application. The roles and responsibilities of this team during implementation of the SMED tool were (a) observe and record the activities, (b) record the time for each activity, (c) record the number of steps and (d) identify points of improvement in the implementation of setup. The application of TPM and SMED enabled avoidance of broken parts

(efficient maintenance of equipment) and reduction of processing delays of raw carcasses (reducing the possibility of meat contamination).

SMED, a lean tool, is efficiently utilised to manage and change the parts of meat brisket and band saws during the occurrence of mechanical failure of our machinery. We assessed our equipment at our site regularly by looking at their lifecycle, failure rates and type of machines based on their repairing or replacing nature. This lean tool empowered our workforce to take ownership in managing preventive and proactive maintenance of our critical machines in the processing line for improving the efficiency and reliability of our equipment. (streamline specialist)

The lean implementation team conducted a comprehensive analysis through 5-Whys in identifying the root causes for the reported malfunctioning of essential equipment. The main causes were identified as lack of regular cleaning and maintenance of machines. Stoppages and speed losses were also reported due to leakage of chemical substances and breakdown (if it occurred) of hoists and rails. The environmental advisor explained that the chemical spillage of equipment causes the malfunctioning, misalignment and potential breakage of hoist, chutes and meat rails. Portable cradles are used to keep carcasses above the floor surface for avoiding potential food contamination (if hoists and overhead rails are broken). The environmental advisor suggested that 5S and TPM can solve the issues of chemical spillage in equipment and reduce the consumption of lubricants or solvents for removing friction (such as hoists, chutes and meat rails). 5S is used as the fundamental lean tool for systematic inspection and cleaning (shine) of hoists, chutes and meat rails to create a waste-free process flow in slaughtering and evisceration activities. Standardisation, a pillar of 5S, facilitated their group to develop procedures for efficient utilisation of lubricants and solvents to avoid spillage of chemicals and potential breakage of the equipment.

Similarly, TPM is also implemented for chemical management in optimising the meat processing equipment. Team leaders and operators are responsible for proactive maintenance of the hoist, chutes and meat rails. Further, TPM enabled the workforce to identify the root cause of lubricants leakage and provide a solution to mitigate chemical leakages in the meat processing equipment. Autonomous maintenance is a critical aspect of TPM to ensure precision checks, simple repairs and lubrication maintenance on a daily basis. Further, safety management under the TPM tool helped to develop safety checklists, standardisation of operations and communicating non-

repetitive maintenance tasks to avoid chemical leakages and malfunctioning of equipment in meat processing.

We were facing breakage of equipment in the slaughterhouse and boning room on a continuous basis. The lean implementation team conducted 5-Whys to identify the malfunctioning of equipment. Our investigation team analysed and concluded that the chemical spillage and mishandling of equipment were the main reasons for equipment breakdown in slaughterhouse and the boning room. We have implemented 5S as the fundamental lean tool for cleaning of equipment and creating waste-free slaughtering and evisceration processes. In addition to 5S, we have applied TPM for chemical management and maintenance of meat processing equipment to avoid chemical leakages. (environmental advisor)

The streamline lead programme manager reported constant high-pressure fluctuation which caused variations in air flow and cooling generation in the chiller system. Meat chilling helps to maintain the shelf life (by avoiding growth of pathogens and pseudomonads), improving tenderness and meat appearance. Development of a 3C sheet enabled Gamma to identify root causes of reported pressure and cooling variation in the chilling system. Outcomes of the 3C pointed out three reasons for high pressure and air circulation fluctuations as follows: high condensing pressure, inappropriate operating practices and neglected chiller maintenance. Setting of the high-pressure parameter is reported as the main cause of high condensing pressure. They suggested that standardised work provides operating guidelines for producing the required level of air flow and pressure to improve the chiller efficiency during storage of meat products. The investigation team recommended that training of the workforce and updated standardised work instructions are essential elements for better operating and maintenance practices to maximise chiller performance. Ignoring the implementation of efficient maintenance procedures caused the chillers to use more energy. Effective maintenance of the chiller system by the application of TPM was initiated through maintaining an operating log for tracing data to analyse the performance trends. The role of competent maintenance personnel is important in finding the main issues, reporting the outcomes of regular inspections and check-ups to improve the performance of the chiller system. The application of 3C, standardised work and TPM helped to reduce the pressure fluctuation in the chiller system which contributed to improving the shelf-life of the finished meat products.

Pressure readings of cooling in the initial chilling system have shown irregularities which has impacted the shelf life, tenderness and appearance of the meat. We developed 3C datasheets to identify the root causes of malfunctioning in the chilling system. Brainstorming sessions helped us to detect three reasons, for example, high condensing pressure, improper operating practices and disregarded chiller maintenance. We proposed that the application of standardised work can help in setting standard pressure and ensuring to follow proper operating practices. TPM and competent workforce enabled us to carry out regular inspections and check-ups to sustain chiller maintenance. (streamline lead programme manager)

Informants from Gamma faced difficulty in managing the right livestock to meet local and export orders promptly because of mismanagement in arranging the required livestock and delays in meat product deliveries (interruptions in transportation operations) during the Covid-19 pandemic. The regional operations manager explained that JIT is implemented to maintain the inventory levels of animals coming in from farmers and going out from meat facilities according to customers' demand at a certain time. The regional operations manager suggested that the application of JIT is limited in the customer-oriented and utility intensive meat industry; however, JIT with a maximum buffer level of 48 hours' meat stock was applied to maintain the inventory levels of the final meat products during the Covid-19 pandemic. He further elaborated that reduction of lead-time performance can be managed through JIT by increasing standardisation to enhance the shelf-life of the meat products.

We have faced difficulties to meet export orders because of mismanagement in transportation to manage the required livestock during the Covid-19 pandemic period. We introduced a maximum buffer period of 48 hours meat stock level to meet the required quantity of meat inventory. JIT with buffer philosophy helped us to maintain safety stock of meat products. (regional operations manager)

A list of lean tools used at Gamma, based on the descending order of the number of informants who cited them, is presented in Table 7.2 (Appendix G).

7.4.6 Implementation awareness, competencies development and training of the workforce

The group environmental manager explained that new recruits need adequate knowledge and necessary expertise to meet the skill requirements for performing the meat processing activities.

Qualifications of the workforce are role dependent: for example, secondary school graduates with a minimum age limit of 18 years join Gamma as entry-level employees while a tertiary qualification is required for managerial level. Managerial roles also require staff to have extensive experience and professional capabilities for operating the latest technologies and IT systems.

Every role required specific competencies in terms of qualification, experience and skills to meet the job specification for improving productivity in our group. Competency or knowledge or upskilling of an employee is completely role dependent, for instance, one could come in straight out of the school and join us for entry-level processing jobs. Some of the more technical or managerial roles required to have a relevant tertiary education to drive our data-based forecasting system and automated X-ray technology to calculate offal yield of the livestock. (group environmental manager)

The regional operations manager explained that implementation awareness and training programmes (for selected leaders) contribute positively to implementation of lean tools (daily tasks) and environmental practices. Only a team of 60 site leaders are selected from 50,000 people for the training programme to implement advanced lean tools and environmental procedures. Scarcity of financial resources is considered the main constraint limiting the number of employees for training initiatives.

Training and awareness programme had a huge role in educating our people to do daily meat processing tasks in an effective way. We are facing financial constraints to train our 50,000 people across our all-meat processing facilities. So, we are only focusing to train and engage selected leaders from a site to perform lean activities and EMS procedures. After attaining appropriate skill levels, these 60 devoted leaders are assigned prime responsibilities to conduct induction trainings for the new joiners. (regional operations manager)

The environmental advisor reported that lean training provides better understanding for streamline team members in solving non-conformity issues, improving meat quality and maintaining the innovation culture. The in-house training initiative helps the environmental management team and lower workforce to better understand the efficient implementation of lean tools and environmental practices in meat processing. NZQA level 3 and 4 certifications based on competitive systems and practices are an essential external skills development initiative for improving meat processes

through critical thinking, understanding of change management and improving productivity (minimising waste and improving production efficiency).

Site engineer, plant manager and site manager received an onsite high level environmental management induction training. Refresher training programmes are also conducted by the senior management to educate the workforce for effective handling carcasses, managing packing material and reducing wastewater on a yearly basis during shutdown period. Level 3 and 4 NZQA lean courses are provided to selected streamline team members for solving problems, controlling meat quality and managing cultural change. (environmental advisor)

In the same vein, the streamline specialist explained that external consultants provide a pragmatic approach for conducting on-the-job training to implement lean practices and environmental guidelines. Further, identification of environmental safety and risks are also included in the induction programme. The NZQA suite of qualifications on lean strategy assisted their top management to adopt improvement tools for efficient management of the meat processing. Further, internal (induction) and external (NZQA) training assisted the employees to better perform the operational and environmental activities.

We hired external consulting firm to offer their services for providing an initial training under the umbrella of on-the-job training programme. External training initiatives mainly comprise of environmental safety guidelines, handling of equipment such as knives and saws and mitigation solutions of environmental risks associated with the meat processing. Offsite NZQA level 2, 3 and 4 suite of trainings are also provided to familiarise our streamline lead, environmental manager and selected operators with lean and environmental practices. External training programmes helped to adopt the culture of safe handling of equipment and mitigation of environmental risks. (streamline specialist)

The innovation manager explained the induction training to the relevant stakeholders (contractors, environmental group and council representatives) to educate them about the potential hazards and safety guidelines during their visit to Gamma. Further, forklift operators are provided with external training for handling merchandise, moving carcasses and working at different heights. Forklift operators are also provided with regular refresher training for renewing forklift certification and avoiding potential serious damage/injury in the meat processing areas.

Contractors, representatives from environmental groups and councils are frequently visited our sites during shutdown periods. We provided them an induction training around environmental safety guidelines, working at height and identification of hazards in different areas of the meat processing facility. We also organised external training to our forklift operators for loading or unloading of merchandises and moving carcasses from one point to another area and working at heights. (innovation manager)

The streamline lead programme manager admitted that the evaluation of previous training initiatives indicates a number of improvements in their existing upskilling programme a few years ago. They developed a robust training programme based on SOPs for lean and ISO 14001 implementation to promote a culture of operational and environmental optimisation. This modified training initiative helped internal and external stakeholders (contractors and suppliers) to achieve better operational and environmental performance.

We partially failed to develop a mature training system for educating our workforce in the past. However, we are overhauling our training and awareness programmes by incorporating robust standard operating procedures around environmental safety, environmental compliance requirements and operational improvement considerations. We have adopted a holistic training and awareness culture to educate our core workforce, contractors and suppliers for achieving competitive operational and environmental performance. (streamline lead programme manager)

7.4.7 Environmental performance evaluation

The group environmental manager explained that monitoring and measurement of performance provides a clear direction for evaluating and improving operational and environmental targets. Environmental data and audit reports are comprehensively evaluated regarding the current performance parameters such as raw carcasses, water utilisation and energy consumption in various stages of the meat processing. The outcomes of the performance evaluation initiative helped staff to propose corrective, preventive and proactive actions for achieving environmental compliance requirements.

If we are not monitoring and measuring our operational and environmental performance then we don't know where we are going or how we are going to implement improvement projects. So, monitoring, measuring and auditing procedures are an integral part of our

operational and environmental performance evaluation. An integrated evaluation of operational and environmental performance helped to check, review and audit data on set parameters of meat processing such as raw carcasses, water utilisation and energy consumption. Outcomes of performance evaluation data helped our management to propose corrective, preventive and proactive actions for achieving operational targets and meeting environmental compliance requirements across our all-processing plant network. (group environmental manager)

The streamline lead programme manager explained that evaluation of lean and environmental practices through monitoring and reporting procedures provides a foundation for setting future optimisation targets. Performance evaluation based on monitoring, reporting and auditing is used to validate the current optimisation strategy on a quarterly and annual basis. Further, the streamline lead programme manager elaborated that monitoring and reporting procedures for waste reduction and GHG emissions are considered crucial parameters to attain permits from NZ statutory bodies. Comprehensive monitoring plans for waste reduction, GHG emissions and utilisation of packaging material have been introduced in Gamma to meet the compliance requirements set by the EPA and local councils.

Monitoring and reporting procedures are key parameters of our streamline and ISO 14001 evaluation. Outcomes of system evaluation help us to establish the baselines for developing waste reduction and greenhouse emission minimisation targets. Our monitoring and reporting system is used to capture the reality of our current performance. We updated our operational and environmental targets based upon the data analysis and this assessment provides the validation of what we're doing around lean and ISO 14001 implementation. We arranged environmental and quality audits tours persistently for enhancing the credibility of our streamline and EMS implementation for sustaining overall performance. We audited our processes for evaluating the waste and environmental reduction targets on quarterly and annually basis. (streamline lead programme manager)

The regional operations manager reported that data on air emissions, water consumption and raw carcasses are compiled through the readings of equipment such as CO measurement sensors, ultra-flow meters and X-ray technology. Analysis of this data enabled the management to evaluate the current performance and provide guidance for future implementation action plans for continuous

improvement initiatives. Further, operational and environmental reports are provided to the workforce for better understanding of current compliance status and future prospects of optimisation.

We collected raw data on CO measurement from boiler stack and ventilation of meat processing areas, wastewater and offal yield forecasting from slaughterhouse and boning room. Catalytic bead sensor is employed for CO detection, ultrasonic flow meter is used for measuring the wastewater flow and automated X-ray technology is applied for forecasting the offal yield. We split our data into relevant queues of operational and environmental KPIs to analyse current performance and identify the future action plans for achieving organisational targets. Adequate access to operational and environmental data assisted the top management to guide the workforce on proactive management of raw carcasses, water usage and electricity consumption. (regional operations manager)

The innovation manager explained that combined compliance audits by representatives of Gamma and regional councils help to evaluate the compliance requirements set for water usage, air emissions generation and energy consumption. Regional councils ensure that Gamma follows the environmental rules and regulations to achieve the statutory and SBTi parameters. Occasional compliance audits (once every four months) are common in Gamma to evaluate the conformity level of the operational and environmental performance.

We have conducted compliance audits with the collaboration of regional councils to review set statutory requirements on wastewater sludge, consumption of packaging material and environmental parameters of coal fired boiler. Our compliance level is highly credible which makes easier for us to conduct streamline system and environmental performance audits. We talk the talk and walk the walk for achieving the operational and environmental compliance requirements in our processing plants. Operational and environmental compliance audits are critical for validation of organisational policy commitments, current performance status and exploration of future opportunities to implement lean tools and the ISO 14001 based EMS framework. (innovation manager)

7.4.8 Environmental management review

Informants of this case study suggested that management review allows their meat processing facilities to identify non-conformities and opportunities to make an informed decision on

operational and environmental performance. The group environmental manager explained that a management review helps to evaluate the operational and environmental parameters for suggesting future improvement for the next processing cycle. Further, a management review is utilised to measure day-to-day operational and environmental performance for evaluating the continuous improvement initiatives.

A management review is used to evaluate the number of parameters, for instance, operational and environmental KPIs, compliance requirements and outcomes of training programmes. We also review the adequacy of our environmental management system and waste reduction targets on a regular basis to suggest future improvements for the next year. Consistently reviewing the organisation's continuous improvement initiatives such as our ISO 14001 or lean implementation is critical to measure the intended performance in day-to-day meat processing activities and propose new compliance requirements if non-conformities are reported. (group environmental manager)

The streamline specialist reported that operational and environmental parameters are reviewed to identify gaps and propose opportunities by analysing audit reports and the minutes of the last meeting to spur continuous improvements. A management review is an essential element to bind operational and environmental aspects to implement cohesive management improvement initiatives. Effective implementation of previously suggested corrective and preventive actions for improving parameters (i.e., water, air emissions and electricity consumption) are analysed in the management review meetings. Outcomes of these meetings help to identify non-conformity occurrences during utility consumption such as carcasses handling, water and energy sources (such as steam and electricity).

The management review is mainly talking about our performance parameters and environmental KPIs for identifying gaps and challenges through a structural meeting. Audit reports, documented records and minutes of last management review meeting on operational, environmental safety and environmental targets are reviewed as inputs for an annual meeting. These reviews allow our group leaders to make informed decisions to identify gaps and optimisation opportunities for improving meat processing activities. (streamline specialist)

The streamline lead programme manager explained that outcomes of streamline and environmental practices are used as a starting point for setting new continuous improvement targets. Management reviews help to consider new opportunities and additional areas of optimisation and set new targets of operational and environmental performance on a quarterly and annual basis.

A management review is used to establish a baseline for operational, safety and environmental aspects after a comprehensive evaluation of our streamline and environmental practices. A management review is performed to evaluate the potential opportunities which weren't considered previously for evaluation and maintenance of performance. So, we have to go and look for some additional areas of operational and environmental optimisations. We do management reviews quarterly and on an annual basis to track our KPI targets for achieving our organisational overall strategy. (streamline lead programme manager)

7.5 Critical success factors for implementing lean and ISO 14001 as a combined approach

Informants of this case study identified attributes of top management commitment (such as setting policy, availability of resources and managing training initiatives), employee involvement, cultural change, introduction of the latest technologies and IT systems and financial support from the government as prominent factors in successful implementation of lean and ISO 14001 in Gamma. The streamline specialist explained that the top management plays a pivotal role in establishing continuous improvement targets and communicating these aspects to the rest of the workforce. Further, top management provides essential support in allocating the budget for managing operational and environmental training and awareness programmes. The commitment of the top management is essential in assessing the need for external training of the workforce to implement continuous improvement initiatives (lean tools and ISO 14001) and managing the budget to support external training programmes (NZQA qualifications and training from external consultants).

Having upper-level management buy-in for implementing continuous improvement initiatives is critical because everything comes from the top. Top management plays an important role in establishing optimisation targets, cascading these goals down to the floor. They are also responsible in providing financial support for training and

implementation awareness programmes on environmental sustainability. (streamline specialist)

The environmental advisor further elaborated on the commitment of the top management as vital in setting environmental and operational targets for articulating overall policy to enhance their credibility as a sustainable meat producing company. Further, top management is responsible for defining crucial parameters (meat yield and waste reduction) and providing guidelines for implementing lean and ISO 14001 procedures through the organisational policy.

Our environmental credibility helped our group to reach an extra mile as the most sustainable red meat company through signing off an overall policy by considering main operational and environmental aspects. Top level commitment is vitally important to support us in setting an overall organisational policy, enhancing meat yield per hour and achieving waste reduction targets in our group. (environmental advisor)

The group environmental manager explained that setting of attainable organisational goals is considered of vital importance in defining the direction to implement lean tools and environmental improvement initiatives for the workforce to achieve operational and environmental targets. An integrated lean and ISO 14001 approach provides appropriate combined goals, management review and an awareness programme for developing a culture of continuous improvement. Further, lean tools and environmental practices help the workforce to maximise the utility of their knowledge through effective participation in identifying prospects for continuous improvement during the execution of both strategies together.

Setting of operational and environmental goals is critical. If our group doesn't have attainable goals then our people aren't achieving anything and they get burnt out or unengaged. We observed, launching an integrated streamline system with an ISO 14001 based EMS framework helped our group to achieve better process outcomes by efficient engagement of our people in the right direction as lean tools and environmental practices speak common language of continuous improvement. I think, lean and environmental practices together become a powerful tool in breaking people out of their silos to work together for cultural change. Combined management reviews and training programmes are essential for identification of opportunities and understanding deployment of lean tools and ISO 14001 procedures. (group environmental manager)

The innovation manager emphasised that financial capabilities require introducing the latest forecasting system, meat processing equipment and replacing fuel sources for predicting offal yield, enhancing processing capacity and reducing carbon footprints respectively. Further, competent human resources are critical in driving improvement initiatives (lean and ISO 14001) to achieve the Sustainability Action Plan 2030.

Streamlined programme and ISO 14001 require adequate budget to implement data driven forecasting system, introduce the latest meat processing rig and replace coal-fed electricity generation. State-of-the-art data forecasting system helped to predict accurate offal yield, automated X-ray technology enabled our sites to process 600 lambs per hour and replacing coal fired boilers reduced carbon footprints in our processing sites. Competent employees are responsible to drive lean and environmental practices by applying their experience and knowledge to collect, report and analyse data on operational and environmental performance. (innovation manager)

In the same direction, the regional operations manager explained that the introduction of technology such as artificial intelligence and application of Industry 4.0 help in collecting and analysing meat processing data to forecast offal yield and improving utilisation of resources.

We have done some work in introducing latest technologies; artificial intelligence and Industry 4.0 for collecting and interpreting data to forecast and optimise the offal yield. We are looking for operational and environmental trends by deep diving on data to identify variability in raw carcasses processing, water consumption and energy usage across our meat processing plant network. (regional operations manager)

The streamline lead programme manager emphasised the importance of a competent workforce and financial support to overcome barriers in implementing the streamline system and ISO 14001 to achieve environmental targets continuously. Competent and talented employees helped in developing a culture of continuous improvement by utilising the resources (for instance, raw carcasses, water and energy) proactively. Allocation of financial resources is critical for implementing continuous initiatives, providing a blended learning approach (inhouse and external training) and introducing the latest technologies.

Human and financial resources are key things in removing a lot of processing obstacles to create openings and providing training to enhance the competencies of the workforce for

implementing lean and ISO 14001 procedures. We are promoting a harmonised lean and EMS framework approach that is driving a journey of incremental operational and environmental improvements. (streamline lead programme manager)

The regional operations manager explained that change management contributes positively to implement lean and ISO 14001 together for promoting a sustainability-oriented culture through the commitment of leadership to provide resources (financial and human). Attainment of precise organisational goals, executive buy-in and availability of resources (funds and staff) are essential elements to achieve continuous cultural change.

I think, managing and controlling change is one of the biggest factors in implementing lean strategy and ISO 14001 together for achieving the vision of our organisation that is “protect and enhance our natural environment by reducing carbon footprint and optimising biodiversity”. Change management has to come from the top-tier. Upper management has to be involved and supportive to implement continual operational and environmental initiatives. Top management have the authority in providing financial and human resources to promote a culture for reducing environmental impact, using utility effectively and providing foundation to drive continual improvement. (regional operations manager)

The streamline lead programme manager further emphasised that cultural change helps to empower the workforce for implementing lean tools and environmental practices proactively. Furthermore, cultural change provides ownership and accountability to the different hierarchical levels of their processing facilities for achieving operational and environmental targets.

Totally, continuous improvement initiatives such as lean processes and environmental management system are dependent to cultural change of an organisation. Traditionally, it is believed that improvement came down from above; however, this philosophy sometimes does work and sometime doesn't. Cultural change is coming from a proactive management by empowering the workforce at all levels for making improvements in their own workspace. It provides ownership with accountability to our leadership and shop floor workforce for improving operational and environmental performance. (streamline lead programme manager)

The group environmental manager explained the importance of information sharing, documentation and training initiatives for implementation of lean and environmental practices to achieve sustainability targets. Further, lean and environmental management initiatives as a combined approach help in enhancing the knowledge of the workforce by conducting training sessions on achieving set optimisation targets.

Effective communication, documentation management and training programmes are part and parcel of our streamline and environmental management initiatives. Streamlined system along with ISO 14001 provides a framework to have documented roles and responsibilities for the workforce, maintain a regular information flow at various hierarchical levels and equip our workforce with appropriate knowledge and education through training programmes. (group environmental manager)

The environmental advisor suggested that internal induction training is considered a crucial element to educate their workforce over a three days' workshop for achieving the organisational vision of operational and environmental performance. Further, induction and refresher training initiatives for lean and ISO 14001 implementation are essential factors for better understanding of fundamental procedures to process environmentally friendly meat products.

We've done internal training by initiating three days' workshop for newly recruited employees to educate them and provide fundamental understanding about the vision of our group. Internal training is critical for the workforce to understand the core areas and identify processing optimisation opportunities during the implementation of lean tools and environmental practices. (environmental advisor)

The innovation manager explained that introduction of the latest technologies helps their group to become the best in the business. Financial support from GIDI fund administered by the Energy Efficiency and Conservation Authority helped Gamma to replace coal-fired boilers and introduce the latest automated processing systems for improving environmental performance and production yield capability.

Our meat processing group made a commitment to introduce latest technologies to become the world's best sustainable grass-fed red meat supplier. We recently received decarbonising fund for a NZ\$2.6 million to phase out an existing coal boiler with high temperature heat pump to minimise our carbon footprint. We further invested NZ\$11.2 to

introduce custom-built automated meat processing system to make robust carcasses processing capability. (innovation manager)

A list of the critical success factors for executing an integrated lean and ISO 14001 strategy in Gamma, based on the descending order of the number of informants who cited them, is presented in Table 7.3.

Table 7.3: Critical success factors for implementation of lean and ISO 14001 in Gamma

SN	Critical success factors	Informants
1	Top management commitment, engagement and support for workforce	Regional operations manager, streamline specialist and environmental advisor
2	Engagement of workforce	Group environmental manager, streamline lead programme manager and streamline specialist
3	Installation of latest equipment/introduction of technology	Innovation manager and regional operations manager
4	Organisational culture	Regional operations manager and group environmental manager
5	Communication	Streamline specialist and group environmental manager
6	Availability of resources (financial and human)	Innovation manager and environmental advisor
7	Organisational objectives, targets and policy	Streamline specialist and environmental advisor
8	Internal training programmes	Environmental advisor
9	Availability of data for performance evaluation	Environmental advisor

7.6 Conclusion

This chapter presented the findings on the contribution of lean and ISO 14001 implementation as a combined approach for improving environmental performance in Gamma. This case study also explained the application of lean tools and ISO 14001 procedures in Gamma (meat processes) for environmental performance and the synergies between these strategies. An assessment of the CSFs for sustaining lean and ISO 14001 implementation was also presented. The next chapter 8 presents the cross-case analysis and discussion of the case study findings.

Chapter 8 – Cross-Case Analysis and Discussion

8.1 Introduction

Chapter 8 discusses the empirical findings, cross-case comparison of the three case studies and the findings in detail, drawing on the NRBV theory. This chapter combines the findings from the cases with the conceptual model proposed in Chapter 2. Furthermore, this chapter presents an analysis of lean and ISO 14001 implementation for environmental performance and CSFs for the implementation of lean and ISO 14001 in the meat industry. First, the environmental and waste reduction outcomes by implementing lean and ISO 14001 are discussed. Next, a discussion on the findings of the cases by using the constructs of the NRBV model for lean and ISO 14001 implementation (Figure 2.4) is presented in section 8.3. Further, the CSFs for lean and ISO 14001 implementation as a combined approach in the meat facilities are discussed in section 8.4. Furthermore, summary of environmental and waste reduction outcomes, implementation of lean and ISO 14001 and the CSFs for implementing both strategies together from the cases are presented (sections 8.5, 8.6 and 8.7). Next, the comparison of case study with the preliminary study is explained. Further, summary of research questions and units of analysis is presented in section 8.9. Further, models of lean and ISO 14001 implementation jointly for improving environmental performance are revised in 8.10. Finally, conclusion is presented in section 8.11.

8.2 Environmental and waste reduction outcomes by implementing lean and ISO 14001

The findings from this study in the meat manufacturing industry revealed that an integrated lean and ISO 14001 approach helps to define operational and environmental targets, allocate resources and implement strategies to achieve better utility consumption, energy usage and GHG emissions minimisation. For instance, in the case of Alpha, the lean tools and an ISO 14001 framework helped to attain the vision of the environmental strategy 2035 by identification of non-conformities, optimisation of improvement opportunities and implementation of proactive actions. Further, the combined approach of lean and ISO 14001 using fundamental operational and environmental processes in identifying gaps (non-conformities) and corrective action plans for mitigating the main causes, achieved compliance requirements proactively as evidenced at Beta. This aspect is in line with the findings of the previous literature (e.g., Souza & Alves, 2018; Wiesmeth & Hackl, 2017).

The findings from the cases indicated mechanisms for implementing lean and ISO 14001 as a combined approach to attain environmental and waste reduction waste targets. For example, in the case of Alpha, lean tools such as standardised work (producing standard products), visual management (for communication) and root cause analysis (to solve issues) are implemented along with ISO 14001 procedures (performance evaluation, corrective actions and continuous improvements) to conduct KPI-based projects. Further, the findings from Alpha indicated that procedural similarities and synergies (i.e., integrated policy, communication and training initiatives) of lean strategy and ISO 14001 help to provide clear environmental targets, enhancing information sharing and implementing projects for better improving environmental performance. Furthermore, the implementation of both these strategies also helps in achieving compliance status under strict directives of federal government agencies and exceeding the customer expectations to produce environmentally friendly meat products. The findings from Alpha further revealed that strict compliance and consent requirements (i.e., quality and environmental assurance, hygiene, and sanitation) drive them to explore process optimisation opportunities for utilising energy and resources.

The findings from all the three organisations indicated that lean and ISO 14001 implementation together helps in improving environmental impacts such as reducing wastewater, packaging waste, sludge, GHG emissions, waste to landfill, health and safety issues, heat losses, chemical handling, and solid waste. The findings from all cases revealed that lean and ISO 14001 implementation as a combined approach concerted helps to reduce wastewater. For instance, at Alpha, data analyses of internal audit of ISO 14001 and root cause analysis are used to identify the reasons for excessive wastewater generation. Corrective actions (ISO 14001 procedure) are proposed to reduce wastewater in the different meat processing activities. Furthermore, the top management of Alpha also suggested utilising hot wastewater from the boning room for cleaning purposes (e.g., dirty areas) due to its high temperature which kills micro-bacteria. In the same vein, data analyses of VSM and KPI benchmarks are used to identify the potential causes of wastewater at Beta. The application of ISO 14001 procedures (corrective and preventive actions) and lean tools (e.g., VSM and standardised work instructions) as a combined approach is used to reduce the excessive wastewater. Furthermore, wastewater reduction target is included as a prominent goal in the ISO 14001 environmental policy at Gamma. 3C are predominantly implemented to identify the bottlenecks of wastewater and propose the optimisation opportunities. The application of lean and

ISO 14001 implementation jointly for reducing wastewater is a new finding, which is lacking in the previous literature.

All the three cases revealed that implementation of lean tools and ISO 14001 procedures together helps in reducing packaging waste. For instance, the packaging waste target is included as a high potential risk in the integrated lean and ISO 14001 environmental policy. This KPI target is communicated with the internal stakeholders (e.g., top management and the employees) through visual boards. Data analysis of VSM and internal audits (ISO 14001 procedure) on a daily basis helped Alpha to evaluate the status of potential packaging irregularities. The top management defined the roles and responsibilities (ISO 14001 procedure) of internal auditors for conducting environmental audits to identify the causes of packaging waste. Innovative packaging (i.e., barrier vacuum shrink bags) and right sizing of packaging material (as a future VSM target) are introduced as solutions to reduce plastic waste. At Beta, the documented records of packaging material are maintained by the AWS EC2 software toolkit. The root cause analysis is employed to identify potential causes of packaging waste. After identifying the causes of non-conformities, standardised work instructions are revised, which are as follows: (a) correct size of packaging material and (b) management of packaging machines to improve the smooth flow of meat products. 70% of packaging waste is minimised by rigorously following these optimisation initiatives at Beta. On the other hand, a comprehensive monitoring plan around packaging material is followed to evaluate the causes of packaging non-conformities at Gamma. The application of 5S and TPM helped Gamma to ensure cleaning and reduce the malfunctioning errors of the packaging machines. These optimisation initiatives and introduction of biodegradable packaging material helped to avoid 100 tonnes of plastic waste in recent years, as evidenced at Gamma. Packaging waste reduction by implementing lean and ISO management system resonates with the findings of Duarte and Cruz Machado (2017), who pointed out that maintenance of standardised packaging helps to better achieve environmental targets.

The potential causes of high sludge content (due to excessive *E. coli* and listeria) are identified by using A3 thinking format at Alpha. An ISO 14001 procedure (i.e., corrective actions) and lean tools (i.e., Kaizen events and A3 thinking) helped Alpha to introduce solutions such as coagulating sludge with aluminium sulphate and organic polymer for minimising excessive *E. coli* component. Further, ISO 14001 procedure (i.e., monitoring performance) and lean tools (i.e., VSM and root cause analysis) helped Beta to identify the causes and opportunities to reduce extra sludge

formation. In the same vein, data analysis of VSM and records of ISO 14001 are used to determine the reasons for excessive sludge (i.e., COD, BOD and TSS) and propose solutions for mitigation at Gamma. Furthermore, top management recommended to implement a suite of tools (3C and 5-Whys) to reduce the sludge content. They also proposed using dry sludge as an alternative fuel for producing electricity and steam. The analysis of the three cases revealed that a joint lean and ISO 14001 implementation largely reduces sludge content, which is lacking in the previous literature on this topic.

All three organisations emphasised reducing GHG emissions, minimising PM₁₀ and enhancing air quality by implementing lean tools and ISO 14001 together. For instance, 5-Whys and A3 thinking are used to identify the reasons for GHG emissions and other effluents which limit Alpha's ability to follow the guidelines of the WHO around air emissions. Further, fishbone diagram is used to reduce PM₁₀ generation, improve ambient air quality and meet the compliance parameters of air emissions. On the other hand, GHG emissions target is included as a critical aspect in the lean and ISO 14001 environmental policy at Beta. A3 thinking is used to identify the reasons and propose solutions for excessive CH₄ generation at the lairage facility. Reduction of particulate matter and gross carbon are considered prime SBTi parameters in achieving better environmental performance, as evidenced at Gamma. The analysis of the three cases revealed that lean and ISO 14001 implementation as a combined approach reduces air emissions efficiently, which are also addressed in research studies such as Duarte and Cruz Machado (2017) and Vasconcelos et al. (2019).

All the three cases have confirmed that lean and ISO 14001 as a combined approach is used to reduce waste to landfill. For instance, the findings from Alpha suggested implementing root cause analysis to evaluate the reasons for excessive wastes (i.e., sheepskin, face bones and sludge). The top management at Alpha revealed that lean tools (i.e., A3 thinking and Kaizen events) and ISO 14001 procedures (i.e., corrective and preventive actions) helped to mitigate waste to landfill. In the same vein, at Beta, lean tools (i.e., VSM and root cause analysis) and ISO 14001 procedures (i.e., preventive and corrective actions) improved environmental goals including reducing waste to landfill. In the case of Gamma, lean tools (i.e., KPI benchmarks and VSM) and ISO 14001 were implemented alongside each other to develop a culture of waste to landfill reduction through the PDCA cycle by identifying non-conformities and proposing opportunities for improvement. These findings from this study reveal that lean and ISO 14001 implementation as a combined approach

helps to reduce waste to landfill; however, these aspects are not mentioned in the previous literature.

The analysis of the three cases suggested that lean and ISO 14001 implementation together helps in reducing environmental safety issues. For example, at Alpha, risk assessment of different processes is carried out according to ISO 14001 procedure to identify potential causes of safety issues. Further, induction training is conducted to help the stakeholders (e.g., the workforce and contractors) to promote health and safety culture. A fishbone diagram is used to reduce PM₁₀ in order to minimise the fatal effects of particulate matter on the workforce's health. Further, other lean tools such as 6S, 5-Whys and TPM are also implemented to reduce wastewater spillage, minimise chemical handling problems and decrease MSD issues. At Beta, environmental safety instructions, wearing PPE and regular maintenance of equipment are implemented to reduce the occurrence of accidents. 5-Whys is implemented to identify the root causes of equipment breakdown. Furthermore, TPM maintenance activities and standardised work instructions help to avoid the workplace accidents due to unexpected breakdowns of sharp equipment. On the other hand, an information sharing plan is followed to identify potential non-conformities and propose corrective actions around safety issues (i.e., wastewater spillage and chemical mishandling) at Gamma. A combination of lean tools (i.e., 5-Whys, 5S and TPM) is implemented to ensure safety is managed by mitigating chemical leakages and equipment malfunctions. ISO 14001 procedures (i.e., risk assessment, communication and corrective actions) and lean tools (5-Whys, 6S and TPM) are implemented together for mitigating environmental safety issues, which is lacking in the previous literature.

The findings from all cases reveal that heat losses (i.e., boiler, chilling and freezing processes) are minimised by deploying lean and ISO 14001 together. For instance, continuous improvement projects (application of ISO 14001 and lean tools) are executed to reduce heat losses in the coal-fired boiler at Alpha. Further, data analysis of VSM is used to evaluate the target around heat losses at Beta. Their top management suggested reducing coal feed size, improving air circulation in ducts and enhancing water flow in the boiler tubes. Furthermore, 5S is implemented to ensure smooth cleaning of boilers by removing particulate matter and reducing heat losses. The findings from Gamma though presented limited evidence of reducing heat losses. For instance, the glycol liquid circulation is proposed as a corrective action (ISO 14001 procedure) to extract heat from energy-rich air.

Chemical handling is a critical activity in the organisational environmental policy at Alpha. For instance, data analysis of VSM is used to identify the causes of chemical spillage. 5S, standardised work instructions and visual management are implemented for cleaning the floors, handling the hazardous material and identifying the chemical storage points. In the same vein, the findings from Beta revealed a limited application of 5S to improve chemical handling. Further, spillage of chemical substances caused the malfunctioning of meat processing equipment at Gamma. 5S and TPM are used to solve the spillage issues and improve the efficiency of processing equipment to ensure smooth processing. This aspect is consistent with the previous studies such as Duarte and Cruz Machado (2017) who pointed out that implementation of lean and ISO 14001 jointly helps in developing a culture of efficient handling of hazardous chemical materials.

Solid waste minimisation is better achieved through the joint implementation of lean and ISO 14001 according to the analysis of the three cases. At Alpha, for instance, root cause analysis is implemented to identify the reasons for excessive solid waste generation (i.e., sheepskin and bones). Corrective actions (i.e., ISO 14001 procedure) are proposed to mitigate the excessive solid waste (by converting sheepskin into small pellets). The solid waste minimisation aspect is included in the integrated lean and ISO 14001 environmental policy at Beta. Further, ISO 14001 procedures (i.e., audit and management review) and lean tools (e.g., VSM, standardised work instructions and automation) as a combined approach is used to reduce solid waste. Furthermore, solid waste from meat processing activities (i.e., slaughtering, trimming and portioning meat) and solid waste from the coal-based boiler (i.e., ash content and particulate matter) are considered critical aspects of policy benchmark at Gamma. Root cause analysis was conducted to explain 16,000 tonnes per year of solid waste and determine potential opportunities to handle this large amount. An ISO 14001 procedure (corrective actions) was used to initiate a pilot project (by converting sheepskin and face pieces into small chips). Standardised work instructions are revised and the findings of pilot project are communicated across Gamma to better mitigate solid waste. A summarised illustration of environmental and waste reduction outcomes by implementing lean and ISO 14001, based on the descending order of the number of informants who cited them, is presented in Table 8.1.

Table 8.1: Environmental and waste reduction outcomes by implementing lean and ISO 14001 from the main study

Benefits achieved from joint implementation	Evidence from Lean	Evidence from ISO 14001
<p>Environmental benefits</p> <ul style="list-style-type: none"> - Reduce waste to landfill, heat losses, chemical handling, wastewater, packaging waste, utility consumption, energy usage and GHG emissions. - Procedural similarities and synergies (i.e., integrated policy, communication and training initiatives) of lean strategy and ISO 14001 helped to provide clear environmental targets, enhancing information sharing and implementing projects for better improving environmental performance. - Joint lean and ISO 14001 implementation largely helped to reduce sludge content, etc. 	<ul style="list-style-type: none"> - At Alpha, lean tools such as standardised work (producing standard products), visual management (for communication) and root cause analysis (to solve issues) helped in waste reduction. - At Beta, data analyses of VSM and KPI benchmarks are used to identify the potential causes of wastewater. - At Beta, lean tools (e.g., VSM and standardised work instructions) helped in reducing excessive wastewater. - KPI targets are communicated with internal stakeholders (e.g., top management and the employees) through visual boards. - At Gamma, application of 5S and TPM helped to ensure cleaning and reduce the malfunctioning errors of packaging machines. - Potential causes of high sludge content (due to excessive E. coli and listeria) are identified by using A3 thinking format and Kaizen events. - At Gamma, waste to landfill was reduced through the PDCA cycle by identifying non-conformities and proposing improvement. - At Gamma, 5-Whys, 5S and TPM ensured safety management by mitigating chemical leakages and equipment malfunctions. 	<ul style="list-style-type: none"> - At Alpha, identification of non-conformities, optimisation of improvement opportunities and implementation of proactive actions. - At Alpha, ISO 14001 procedures (performance evaluation, corrective actions and continuous improvements) helped to conduct KPI-based projects. - At Alpha, data analyses of internal audit of ISO 14001 and root cause analysis are used to identify the reasons for excessive wastewater generation. Corrective actions (ISO 14001 procedure) are proposed to reduce wastewater in the different meat processing activities. - At Beta, fundamental operational and environmental processes helped in identifying gaps (non-conformities) and corrective action plans for mitigating the main causes. Achieved compliance requirements proactively. - At Beta and Gamma, ISO 14001 procedures (i.e., monitoring performance and corrective actions) helped to identify the causes and opportunities to reduce extra sludge formation and reduce content. - At Gamma, ISO 14001 procedures (i.e., risk assessment, communication and corrective actions) helped in mitigating environmental safety issues.

8.3 Implementation of lean and ISO 14001 as a combined approach

8.3.1 Integrated lean and ISO 14001 environmental policy

The empirical findings from all the three meat processing companies highlighted that an integrated lean and ISO 14001 environmental policy is formulated to achieve short-term and long-term objectives and targets around operational and environmental performance. These objectives and targets are mainly based on decarbonisation, wastewater elimination, electricity saving and packaging waste reduction parameters. This aspect is linked with the pollution prevention capability and strategic planning competence (i.e., planning for reduction of GHG emissions, wastewater and packaging waste) under the NRBV and current literature on waste and environmental policy (e.g., Adelegan, 2018). Further, all the three organisations have emphasised on reduction of GHG emissions, efficient usage of carcasses and consumption of energy as essential elements in their documented policy for better achieving environmental performance.

The findings from all the cases included a zero waste to landfill target; meanwhile, the Irish group at Beta achieved this policy benchmark six years ago through efficient implementation of their ISO management system and continual improvement initiatives. However, Alpha and Gamma have not been able to achieve zero waste to landfill target in their organisations. Attainment of zero waste to landfill target indicated the commitment of Beta in fulfilling their policy parameters around resource conservation, recycling of waste (water and packaging), and rendering of solid waste. This finding is consistent with the study outcomes of Al-Rawi, Farid, Jones, and Louie (2022) and Song, Li, and Zeng (2015) who emphasised promotion of recycling and rendering procedures for achieving the policy benchmarks around zero waste to landfill. On the other hand, in the cases of Alpha and Gamma, both organisations particularly included the reduction targets around solid waste and packaging materials to reduce their waste to landfill footprints.

In the cases of Beta and Gamma, optimisation targets are set to pursue specific international action plans for achieving environmental performance. For instance, DAFF and BBIFB based targets – pollution prevention minimisation targets, efficient consumption of raw carcasses and energy consumption – are included in a comprehensive policy at Beta. On the other hand, the SBTi (the Paris agreement) are used to focus on reduction of GHG generation, electricity and fossil fuels usage and efficient utilisation of raw material and water at Gamma. These objectives and targets of an integrated policy are linked with both pollution prevention and product stewardship capabilities. Further, this finding from Gamma is also addressed in prior studies by Bjørn, Tilsted, Addas, and Lloyd (2022) and Moshrefi, Kara, and Hauschild (2022) who pointed out the importance of environmental parameters (e.g., GHG emissions, decarbonisation and raw material consumption) under the SBTi to achieve operational and environmental performance.

Interestingly, in the case of Alpha, a comprehensive odour management plan is also included as an integral parameter in their documented policy to meet the core commitment of their pollution prevention targets. This aspect is not included in the integrated lean and ISO 14001 environmental policy of Beta and Gamma. Meanwhile, the findings from the cases also revealed that inputs for an integrated policy are articulated based on evaluation of KPI benchmarks, analysis of ongoing improvement projects and findings of the previous management review on the operational and environmental targets. These findings are consistent with the previous literature (e.g., Souza & Alves, 2018; Vasconcelos et al., 2019). On the other hand, in the case of Gamma, analysis of vision statements, reports on all kinds of meat processing wastes and minutes of the last management

review meeting are also included as the main inputs for an overall policy to improve operational and environmental performance, which is in line with previous literature (e.g., Chiarini, 2011; Souza & Alves, 2018).

The empirical findings from Beta highlighted a number of Capex projects (introduction of heat pumps, renewable fuels, biodegradable packaging material and recycling of wastewater sludge), which were conducted to reduce GHG emissions, packaging waste and wastewater sludge. These findings are in line with the conventional competencies (promotion of recycling technology) and capabilities of the NRBV, for instance, product stewardship (e.g., introduction of recycling process and renewable fuels) for achieving the ecological targets. A summarised illustration of an integrated lean and ISO 14001 environmental policy from the main study is presented in Table 8.2.

Table 8.2: Integrated lean and ISO 14001 environmental policy from the main study

Case	Integrated lean and ISO 14001 environmental policy
Alpha	<ul style="list-style-type: none"> • Team for developing policy – group manager, environmental manager and plant manager. • Policy manual development around reduction of effluents – carbon footprints, NO_x, SO_x, and PM₁₀. • Wastewater reduction – nitrogen content, E. coli and suspended particles. • Electricity saving (refrigeration, air compressor and motor operations), reduction of packaging waste and minimisation of coal consumption. • Reduced odour of contamination from wastewater lagoons and untreated wastes.
Beta	<ul style="list-style-type: none"> • Reduction of GHG emissions and efficient usage of resources (raw material, electricity and fossil fuel). • DAFF and Bord Bia Irish Food Board based targets for reduction of – zero waste to landfill, utilities consumption and energy usage. • Capex projects for reducing heat losses, wastewater and packaging material (introduction of biodegradable packaging).
Gamma	<ul style="list-style-type: none"> • Inputs for policy based on reduction of – GHG emissions, solid waste, packaging waste, energy usage and water consumption. • Inputs for policy are developed by analysing the vision, minutes of previous management reviews and environmental reports. • Updating policy targets based on analysis of improvement projects around lean and environmental management practices.

8.3.2 Integrated plan and projects of lean and ISO 14001 implementation

The findings of all the three cases revealed that integrated plans and projects of lean and ISO 14001 help to reduce (waste and air emissions) undesirable by-products and use (water packaging material and energy) resources efficiently. For instance, continuous improvement projects based on risk management plans (ISO 14001 risk assessment procedures and lean) helped to plan, organise and control resources in achieving operational and environmental targets at Alpha. Further, in the case of Alpha, the findings revealed that risk-based thinking helps to implement continuous improvement initiatives by identifying and mitigating the operational and

environmental risks through the systematic application of policies, monitoring and controlling tasks, which is also emphasised in a prior study by Martins, Sanches da Silva, Sampaio, and Catalani Gabriel (2022). The findings from all the three companies highlight that integrated waste and environmental impact reduction plans are set and projects are executed to achieve short and long-term targets around water usage, electricity consumption and wastewater reduction. These aspects are in alignment with literature to maximise resource conservation, improve pollution prevention and enhance competitive advantage (e.g., Bellisario & Pavlov, 2018; Farrukh et al., 2022).

The analysis of Alpha and Beta emphasised that accurate data on utility parameters, VSM information and outputs of management review meetings are considered as inputs to set KPI targets in the planning phase for developing continuous improvement projects. For instance, in the case of Alpha, analysis of VSM data is used to identify operational and environmental risks and indicate opportunities for continuous improvement, while ISO 14001 operational controls and communication procedures helped the workforce to better understand the planning phase of a project. These aspects are also aligned with the previous literature (e.g., Kruse et al., 2019; Souza & Alves, 2018). The findings from Alpha and Beta explained that documentation control (project management, Information Leader and the AWS EC2 software toolkits) around KPI benchmarks are used for cascading documented information around operational and environmental targets and outcomes of these initiatives in the planning and post-implementation phases of the continuous improvement projects.

The analysis of this study indicated that NZ-based groups (Alpha and Gamma) initiated a continuous improvement project to use sheepskin and beef face pieces by introducing shredding equipment to convert large pieces into small ribbons and chips of solid compost for further processing (rendering process) for landfill or using as renewable material for fertilisers and biogas. Lean tool such as root cause analysis is used to identify reasons and propose solutions to mitigate landfill issues (sheepskin and beef face handling). On the other hand, standardised work is also used to update and communicate the work instructions around the shredding project extension. Meanwhile, ISO 14001 procedures (operational and communication) are maintained to identify the reasons for non-conformities and propose and communicate corrective actions. This aspect is aligned with pollution prevention (minimise solid waste by handling of sheepskins and beef face pieces) capability of the NRBV.

The findings from Gamma revealed that reduction of GHG emissions and maximum extraction of heat from air exhaust is maintained by implementing lean tools and ISO 14001 procedures. Combined implementation of lean tool (root cause analysis) and ISO 14001 performance evaluation (monitoring procedure) is used to explore the reasons for the excessive generation of air emissions and low value of heat generation. ISO 14001 operational controls (corrective actions) and EMS support procedures (usage of baghouse filters/electrostatic precipitators and replacing renewable fuel) are used for improving environmental KPI targets. These aspects are aligned with pollution prevention (i.e., reduction of GHG emissions and heat losses) and stewardship (e.g., renewable fuels).

The findings from Alpha emphasised that efficient water usage and reduction of wastewater are achieved through efficient lean and ISO 14001 implementation. Top managements have proposed wastewater optimisation projects by evaluating non-conformities through audit and review mechanisms and analysis of VSM data to achieve environmental targets. The potential improvements (biogenic material for compost, recycling by coagulating with aluminium sulphate and ultrafiltration process) are proposed in corrective action plans. Further, wastewater (sludge containing material) is proposed as a source of energy generation, converting these materials into small compost pellets to meet the compliance requirement. Standard work instructions are revised to identify reasons for wastewater generation and the mitigation opportunities are updated to attain compliance requirements (Alpha and Beta cases). For instance, the findings from Beta revealed that roles and responsibilities according to the ISO 14001 procedure are defined for evaluating and optimising wastewater sludge. Root cause analysis by analysing VSM data on excessive wastewater sludge and electricity is applied to evaluate the reasons for non-conformities. A comprehensive plan was developed by the management teams for usage of dry wastewater sludge as a pilot project and was evaluated during the management review to improve the conformance level of the sludge and the use of electricity. Electricity consumption is optimised by installing lower voltage equipment and introducing proactive maintenance (TPM). A summarised illustration of integrated plan and projects for lean and ISO 14001 implementation from the main study is presented in Table 8.3.

Table 8.3: Integrated plan and projects of lean and ISO 14001 implementation from the main study

SN	Attributes	Similarities	Differences	Lean and ISO 14001 procedures
1	Integrated plan and projects of lean and ISO 14001	Integrated plans for lean and ISO 14001 implementation are developed on risk-based thinking, VSM data, and management review meetings.		<ul style="list-style-type: none"> • VSM data, KPI benchmarks • Procedures of ISO 14001 such as policy, documentation, communication, monitoring, controlling procedures, and management review meetings.
2	Waste minimisation (sheepskin and beef face pieces)		Waste minimisation helps to achieve better waste to landfill targets. Sheepskin and beef face pieces are converted to small pellets using lean tools and ISO 14001 procedures at Alpha and Gamma.	<ul style="list-style-type: none"> • Root cause analysis, VSM and KPI benchmarks data and standardised work. • Operational controls (non-conformities and corrective actions) and communication procedures.
3	Reduction of GHG emissions and deviation of heating value	GHG emissions and heat losses are mitigated by the application of lean tools and ISO 14001 procedures.		<ul style="list-style-type: none"> • Root cause analysis • Performance evaluation, operational controls and support procedures of ISO 14001.
4	Wastewater reduction projects	Wastewater optimisation projects are developed by following comprehensive plans through lean tools and ISO 14001 framework.		<ul style="list-style-type: none"> • VSM, root cause analysis and standardised work • ISO 14001 procedures such as performance evaluation (audit, review and management review), and improvement (corrective and preventive actions).
5	Efficient energy usage		Electricity consumption is optimised by the installation of latest equipment and TPM (proactive maintenance) tools.	<ul style="list-style-type: none"> • VSM, KPI benchmarks and TPM (proactive maintenance) • ISO 14001 procedures

8.3.3 Communication and information sharing

Informants from all cases supported the importance of communication and information sharing around operational and environmental targets through daily interactions within the different departments and with the relevant external stakeholders (customers, suppliers and contractors), which is consistent with the organisational competence of the NRBV and previous literature (e.g., Poksinska, Swartling, & Drotz, 2013; Tayo Tene, Boiral, & Heras-Saizarbitoria, 2021). All three companies emphasise that internal and external communication is critical to promote culture, sustain brand image and enhance competitive advantage by implementing continuous operational and environmental improvement initiatives for processing environmentally friendly meat products. In the case of Gamma, team leaders are responsible for managing internal communications while risk managers cascade information to external bodies to implement sustainability projects (lean and environmental practices). This finding is in alignment with a previous study by Tayo Tene et al. (2021) who emphasised the importance of internal and external information sharing that leads to improving environmental performance.

All the three companies have reported that internal systematic communication programmes (posters, digital visual and white boards) are developed by displaying, monitoring and updating set targets around wastewater, GHG emissions and packaging waste. This aspect of information sharing is consistent with the findings of previous studies (Kruse et al., 2019; Souza & Alves, 2018). Meanwhile, inputs (e.g., operational and environmental targets) and outputs (e.g., targets achieved or missed) are displayed through light-emitting diode screens at Alpha. On the other hand, in the case of Beta, KPI boards are used for displaying internal audit outcomes of lean and ISO 14001 systems in providing meaningful data to the workforce on carbon footprints, hot water for washing the animals and electricity usage in refrigeration. Further, the findings from Gamma explain that an error-proof internal communication plan is reflected through charts, whiteboards and posters for managing key activities (operational, environmental and safety), defining clear roles of the workforce and making financial resources available to become a best-in-class organisation.

The findings from all the three organisations indicate that outline for internal communication is an essential element for managing information sharing to improve resource usage (raw carcasses, water and packaging material) and reduce wastes (GHG emissions, solid and hazardous material). These aspects are aligned with pollution prevention capability (e.g., reducing hazardous material and reducing waste), sustainable development capability (e.g., efficient usage of resources) and the previous literature (e.g., Dieste et al., 2020; Kruse et al., 2019; Souza & Alves, 2018). The findings from the cases revealed that efficient external communication with overseas customers and government institutions helps to create a culture of environmental sustenance and promote the brand image by processing environmentally sustainable meat products. For instance, the NZ based meat processing groups (Alpha and Gamma) shared their commitment with their repeat customers from NZ, the UK and the USA for processing high grade meat products and zero-carbon meat products (recognised by the British Standards Institution through certification of PAS 2050). Meanwhile, the Irish group (Beta) disclosed their environmental sustainability and carbon neutral laboratory initiatives to Walmart, Albert Heinz and Sainsbury's. These aspects are aligned with previous literature (e.g., Eaidgah et al., 2016; Tayo Tene et al., 2021).

The findings from Alpha reported a series of communication between broader multi-stakeholders (meat industry, local council, and public and environmental institutions) for mitigating noise pollution and odour of wastewater. This unique aspect of external communication has only been

described at Alpha. Canterbury Regional Council conducted a series of interactions (face-to-face meetings and email correspondence) to communicate the concern of the public and environmental institutions regarding noise pollution and the unbearable odour of wastewater in the Alpha case. ANZECC guidelines were implemented to mitigate these non-conformities on the recommendation of Canterbury Regional Council. Alpha shared and communicated the results of corrective and proactive actions through detailed email correspondence with Canterbury Regional Council and relevant stakeholders (environmental groups and end-consumers) (e.g., Mazzi, Spagnolo, & Toniolo, 2020; Poksinska et al., 2013).

Meanwhile, the Irish meat processing group presented their success story at a European conference (a prime example of external communication) for implementation of operational and environmental initiatives. Further, they shared their achievements (e.g., the Green Large Organisation award and Irish Export Association award) with the workforce and customers via newsletters, emails and sustainability reports. This aspect is in line with product stewardship (environmental seminar and programme) for enhancing the organisational competence to share information with the relevant stakeholders. Providing environmental communication through websites and sustainability reports is considered a prime source of information disclosure within the organisation and with relevant external stakeholders (e.g., Ramya, Shereen, & Baral, 2020; Tayo Tene et al., 2021). A summarised illustration of communication and information sharing for lean and ISO 14001 implementation from the main study is presented in Table 8.4.

Table 8.4: Communication and information sharing from the main study

Case	Communication and information sharing
Alpha	<ul style="list-style-type: none"> • Structural internal communication around environmental and waste minimisation through light emitting diodes. • Regular monthly meetings for analysing previous targets to set new targets. • Communication with relevant external customers (NZ and UK customers). • External information sharing with public and environmental groups, and local government to report and minimise noise pollution and unbearable odour.
Beta	<ul style="list-style-type: none"> • External communication at conferences to present their environmental performance. • Stewardship (Green Large Organisation and Irish Export Association) awards are communicated through newsletters and sustainability reports. • Internal audits of ISO 14001 and application of lean tools are internally communicated for evaluating carbon footprints, electricity consumption and water usage. • Current and future environmental targets are shared via information posters. • Communication with relevant external customers (Walmart, Albert Heinz and Sainsbury's).
Gamma	<ul style="list-style-type: none"> • Daily regular meetings (analysing data, identifying non-conformities and proposing corrective actions). • Internal communication by team leader and external communication by risk manager. • Development of internal communication plan and methods of internal communication (charts, whiteboard and posters). • Interaction with NZ and US food markets to produce zero-carbon meat products.

8.3.4 ISO 14001 procedures

The findings from all the cases revealed that assigning the roles, responsibilities and authorities to competent and knowledgeable workforce is considered as a critical aspect in implementing ISO 14001 procedures. Further, in the cases of Alpha and Beta, roles, responsibilities and authorities of the competent personnel are defined as essential elements for developing an EMS framework, maintaining records and documents of ISO 14001 procedures and proposing corrective actions after environmental performance evaluation. On the other hand, in Gamma, documented roles, responsibilities and authorities are communicated to the workforce through a job description chart for developing policy, evaluating environmental performance and suggesting continuous improvement actions. Development of ISO 14001 environmental policy, evaluating environmental performance and proposing corrective actions are maintained due to well defined roles of top management and environmental teams, which is aligned with strategic and organisational competencies of the NRBV and recent literature (e.g., Chiarini, 2019; Kruse et al., 2019).

Informants from all the cases suggested that having a competent team is fundamental in implementing ISO 14001 procedures. A team comprised of the group environmental manager, environmental manager and environmental officers at Alpha, a team led by the environmental sustainability manager at Beta and a four-member team at Gamma are responsible for managing their respective EMS frameworks. Further, at Beta, the top management received documented reports on environmental non-conformities and corrective action plans for conducting internal audits and management reviews.

The findings of all the three cases emphasised that documentation (manual and digital) of operational and environmental procedures is considered a critical element in implementing the ISO 14001 framework. For instance, in the cases of Alpha and Beta, document management systems (the application of Information Leader and the AWS EC2 software toolkits) are used to maintain significant environmental aspects with high environmental risks (e.g., GHG emissions, organic and inorganic wastes, and energy consumption). The findings from Alpha and Betas emphasised the application of software for maintaining KPI benchmarks, audit checklists and corrective actions, which is lacking in the current ISO 14001 literature. However, in the case of Gamma, manual documentation control (for collecting and analysing data) is used to maintain the records around the scope of the ISO 14001 environmental policy, records of internal and external audits

and emergency preparedness procedures for implementation of ISO 14001 procedures. A summarised illustration of ISO 14001 procedures from the main study is presented in Table 8.5.

Table 8.5: ISO 14001 procedures from the main study

Case	ISO 14001 procedures
Alpha	<ul style="list-style-type: none"> • Roles, responsibilities and authorities are set for the workforce to implement ISO 14001 procedures. • Significant environmental aspects, such as air pollution, wastes (organic and inorganic) and efficient consumption (packaging material and energy) are maintained through documentation procedure. • Role of environmental team is critical in developing environmental targets, reviewing performance and introducing corrective actions. • Information Leader software is used to maintain the document management system in collecting KPI targets for evaluating environmental performance. • Authorised individuals are responsible for updating existing targets and compliance status around food safety, operational and environmental perspectives in Information Leader software.
Beta	<ul style="list-style-type: none"> • The role of the competent personnel is critical for developing environmental policy, monitoring the performance and managing the environmental compliance obligations. • Documents and records are maintained for identification of pollution prevention opportunities and improving environmental performance. • Resources are allocated (i.e., financial support for ISO 14001 registration and training for the environmental team to implement ISO 14001 procedures). • KPIs are set around environmental parameters, measurement of environmental performance and introduction of corrective actions to maintain operational control. • The AWS EC2 software toolkit is used to maintain records on KPI targets, audit and monitoring records, and corrective actions for conducting annual management reviews.
Gamma	<ul style="list-style-type: none"> • A job description chart describes the roles, responsibilities and authorities for conducting structural audits and evaluating environmental performance. • A four-member team maintains manual documentation around quality and environmental management procedures. • Key documents are listed which include (1) environmental policy, (2) results of internal audit and management reviews and (3) results of corrective action are maintained. • Three steps of operational control (setting KPI benchmarks, measurement of performance and corrective actions) are implemented to improve environmental performance.

The analysis of the findings from Alpha and Beta cases highlighted that operational control procedures measure the effectiveness of EMS implementation, review the environmental performance parameters and propose corrective actions to mitigate the gaps in environmental performance. For example, in Beta, operational controls are guaranteed allocation of financial resources for attaining ISO 14001 certification and introduction of state-of-the-art equipment to overcome environmental non-conformities. Further, three steps of operational controls are elaborated by setting environmental KPI benchmarks, measurement of environmental performance and suggesting corrective actions at Beta and Gamma. This aspect is aligned with strategic planning competence (setting of environmental targets) and procedural competence (evaluation of environmental performance and corrective actions) under the NRBV lens.

8.3.5 Lean tools

The application of lean tools is used for reduction of GHG emissions, low heating values, reduction of excessive water usage, minimisation of wastewater, meeting unexpected meat demands,

reduction of interruptions, reduction of chemical spillage, improving shelf-life and environmental safety. Lean tools such as root cause analysis (fishbone diagram, A3 thinking, 3C, 5-Whys), 5S, VSM, KPI benchmarks, visual management, standardised work, JIT, Gemba walks, Kaizen events, TPM, SMED, Hoshin Kanri, and 6S (5S+safety) were found implemented in the case studies to achieve operational and environmental targets.

The findings from the Alpha and Beta cases revealed that excessive PM₁₀, GHG (i.e., CO₂, CH₄ and N₂O) and low heating value issues are minimised by the application of lean tools such as fishbone diagram, VSM data, A3 thinking, standardised work and 5S. For instance, non-conformity was reported due to excessive PM₁₀ generation at Alpha. Root cause analysis based on fishbone diagram (quantity, measurement, material and machines) is used to determine the main causes of excessive PM₁₀ generation. The investigation team analysed the fishbone diagram to suggest the corrective actions (optimal particle size, management of primary and secondary ducts, and training of the employees) to mitigate excessive PM₁₀ generation. This aspect is in line with pollution prevention (efficient usage of fuel for reduction of PM₁₀), sustainable development (maintenance of air ducts) capabilities and human resource competence (knowledge enhancement through training). Similarly, in the case of Alpha, analysis of the KPI datasheets and value stream data indicated excessive GHG (i.e., CO₂, CH₄ and N₂O) emissions, which are exceeding the recommended compliance limits of WHO guidelines for GHG emissions. The management analysed the value stream data by applying A3 thinking to identify the root causes (recommended percentage of carbon, sulphur and nitrogen content) and propose the solution (blending coal with biomass) for reduction of GHG emissions.

Meanwhile, at Beta, operators monitored and reported the excessive CH₄ and organic waste generation at the lairage facility and evisceration process. Root cause analysis through A3 thinking concluded that providing excessive food and water to the livestock is the main cause of excessive CH₄ and organic substances in the gastrointestinal tract. A3 thinking countermeasures helped to update the standardised work instructions for giving water and food to reduce environmental non-conformities at the lairage and evisceration process. Furthermore, in the case of Beta, boiler operators from this study indicated that the boiler furnaces produced low heating values for generating electricity and steam. Data analysis (current VSM) on heating value, air circulation and size particle of fuel are analysed for identification of reasons for heat losses and low heating values. The outcomes of VSM analysis recommended improving coal size, air circulation and water flow

to generate high heating values. Further, heat efficiency is also enhanced by cleaning tube surfaces and removal of sticky particles by the application of 5S. The implementation of these lean tools is aligned with pollution prevention (reduction of GHG emissions especially CH₄ at the lairage facility) and product stewardship capability (introduction of renewable fuels) under the lens of the NRBV. This aspect is also in line with the findings of previous studies (e.g., Barth & Melin, 2018; Garza-Reyes, et al., 2018a; Kumar & Rodrigues, 2020).

The findings from the cases indicated that excessive water consumption, wastewater sludge formation and wastewater treatment (reuse and recycling) are addressed by the application of lean tools such as KPI benchmarks, VSM, 5-Whys, Gemba walks, 5S, Kaizen events, TPM, 3C and standardised work. For example, in the case of Alpha, comparative analysis of KPI benchmark datasheets is used to identify the excessive water consumption and propose corrective actions (such as efficient monitoring of floor cleaning activities, optimising washing and spray angles) to optimise water usage. Further, the reclamation of wastewater (due to the high temperature of 82⁰C) from the boning room through reusing and recycling processes helped to achieve KPI benchmarking targets around wastewater reduction and waste to landfill. These findings are consistent with pollution prevention (e.g., reduction of wastewater and waste to landfill) and product stewardship (e.g., recycling and reuse of water) under the NRBV capabilities.

The findings from Beta revealed that the Irish organisation was facing issues to minimise water footprints during cleaning of carcasses, the pre-evisceration washing process and cleaning of cutting equipment. The causes of excessive water consumption were identified through analysis of VSM, and interviews for 5-Whys brainstorming data helped to develop an action plan for efficient water consumption at Beta. Improvement of water usage is better achieved by the application of Gemba walks, 5S (by implementing ‘clean and shine’, a pillar of 5S), Kaizen events (just-do-it and quick wins projects) and TPM (fixing water leakages and maintenance of automated carcass washing machines) in different meat processing activities. The analysis of findings from Gamma revealed that exceptionally high COD, BOD and TSS compositions were reported in wastewater sludge which affected the quality of drain water. The application of 3C is used to identify the concern (high quantity of disposal of wastewater sludge), main causes (presence of high volume of undesirable sludge composition) and countermeasure (reuse and recycling of wastewater sludge).

In the same vein, the high volume of wastewater is reported against the compliance level at Gamma. Root cause analysis based on 3C is used to identify causes (inadequate capacity for wastewater treatment) and propose solutions (biological and physical recycling systems). The investigating team adapted physicochemical treatment as a countermeasure for recycling wastewater and standardised work instructions were revised to enhance the treatment capacity. These aspects of lean tools are in line with pollution prevention (reduction of wastewater sludge) and product stewardship capability/conventional competence (reuse and recycling of wastewater) under the NRBV. The findings from Alpha and Gamma suggested that unexpected demands for meat products are managed through process optimisation and application of lean tools. This study reported the difficulty of planning for sudden orders placed during the peak period of export in the Covid-19 pandemic at Alpha and Gamma. For instance, in the case of Alpha, VSM is implemented to identify the gaps and propose process optimisation opportunities for meeting the emergency customer demand. Meanwhile JIT with buffer solution is maintained at the lairage facility to meet the demand of unexpected orders. Mapping of material (e.g., raw carcasses, water and packaging) and sources of waste generation (e.g., slaughtering process, boning room procedures, chilling and freezing processes) is analysed through VSM data to identify bottlenecks and potential process enhancement opportunities. Future, VSM work plans are developed by optimising the usage of material (e.g., maximum meat extraction from carcasses and optimum consumption of water) and reducing the sources of waste (e.g., mishandling of carcasses and wastewater generation). Further, holding additional livestock as buffer stock (e.g., JIT with a 4 to 12 hours' buffer setting) in the lairage facility also helped to ensure the on-going supply of environmentally friendly meat products. The application of VSM is used to identify the operational and environmental gaps and opportunities to meet the customer demand which is linked with the previous literature (e.g., Barth & Melin, 2018; Garza-Reyes et al., 2018b), while the concept of JIT with buffer setting is addressed in limited research studies such as that of Choi, Netland, Sanders, Sodhi, and Wagner (2023).

Further, at Gamma, constant non-conformities in demand management are reported by the top management due to a faulty manual forecasting system which affected the strategic process planning. A combination of lean tool Hoshin Kanri with the latest data driven forecasting system helped in predicting accurate offal yield per cattle through visual presentation of meat processing activities. Hoshin Kanri with statistical prediction system is used to support the culture of

continuous improvement by promoting value added activities in meat processing facilities. Similarly, delivery delays were reported due to mismanagement of inventory levels and interruptions in transportation operations during the Covid-19 pandemic. JIT with a maximum buffer level of 48 hours' meat inventory was maintained to meet the required stock levels during the Covid-19 pandemic. The concept of Hoshin Kanri with a data-driven forecasting system is lacking in the lean tools implementation literature, while JIT with buffer solution is discussed to a limited extent in the current literature by Choi et al. (2023). The application of Hoshin Kanri is consistent with the strategic planning competence of the NRBV lens for efficient forecasting to process environmentally friendly meat products.

The findings of all the three cases reported meat processing interruptions due to MSD and functional equipment irregularities (malfunctioning and broken parts of cutting equipment). These non-conformities are mitigated through lean tools such as 5-Whys, standardised work, TPM and SMED. For instance, in the case of Alpha, delays in raw carcasses processing are reported due to MSD among the workforce. The application of 5-Whys brainstorming sessions helped to determine the reasons for MSD (manual lifting, repetitive movements and awkward positions for extended periods). Injuries and MSD issues are reduced by following the updated standardised work instructions (for handling of raw carcasses) and providing training (induction and regular programmes) to the workforce. In the same vein, functional irregularities in meat cutting equipment caused processing delays during cleaning and assembling procedures. TPM is considered a pivotal lean tool for ensuring preventive maintenance, providing regular service (rails, slicers and cutting saws) and conducting training in handling heavy meat processing machinery. The application of lean tools (5-Whys and TPM) helped with pollution prevention (reduction of safety issues) and sustainable development (environmental safety and efficient resource usage) and is in line with recent research studies (Barth & Melin, 2018; Dieste et al., 2020; Garza-Reyes et al., 2018a).

In the case of Beta, the Andon signal indicated potential meat contamination during their final inspection due to cutting tool breakage in the meat processing (as suggested in the findings of A3 thinking). A master plan was developed for managing the TPM activities to reduce the potential meat contamination due to small fragments of broken needles or knives or blades. In another example from Beta, accidents of the workforce and malfunctioning of equipment were reported in the slaughterhouse and boning room operations. 5-Whys is implemented for exploring the reasons

for the main causes (lack of sharp equipment handling skills and mismanagement of regular maintenance). Environmental safety instructions, wearing PPE and proactive maintenance under TPM (regular scheduled and on-going maintenance) helped to avoid accidents and malfunctioning of equipment. On the other hand, at Gamma, delay in raw carcasses processing was reported due to extra time to replace broken parts of meat processing machinery. The finding from Gamma revealed that the application of TPM (preventive and proactive maintenance) and SMED (standardised changeover steps) help to avoid the breakage of parts, reduce replacement time of equipment and improve environmental safety of the workforce.

The findings from Alpha and Gamma further revealed that mishandling and spillage of chemicals cause malfunctioning of the equipment and production delays. The application of lean tools such as 5-Whys, 5S, standardised work, visual management and TPM are implemented to handle chemicals and optimise meat processing as evidenced at Alpha and Gamma. For instance, frequent spillage of chemicals and safety issues reported in slaughtering and evisceration processes at Alpha. A comprehensive chemical handling policy is developed for efficient management of chemical substances. 5S is used to provide clean areas, sustain orderly chemical storage stations and put chemicals in assigned areas to avoid chemical spills and ensure obstruction-free areas. Standardised work instructions are updated by revising the documented chemical handling procedures (allocation of spaces for chemical storage, maintenance of chemical safety datasheets and management of instructions for hazardous material storage). Further, visual management (digital screens) is also applied to demonstrate clear floor marking for identification of appropriate chemical storage areas and displaying chemical safety data sheets. The findings revealed that the application of lean tools (e.g., 5S and standardised work) helps to achieve capabilities such as pollution prevention (avoidance of chemical spillage) and sustainable development (environmental safety and risk reduction).

Meanwhile, in the case of Gamma, leakage of chemical substances, lack of regular cleaning and maintenance of equipment caused malfunctioning of essential equipment. Root cause analysis (5-Whys) is conducted to identify the causes of stoppages, leakage of chemicals and breakdown of equipment. 5S (systematic inspection, cleaning and standardisation) and TPM (proactive maintenance, autonomous maintenance and safety management) are implemented to reduce and mitigate lubricant and chemical leakages in the meat processing equipment. Such benefits of 5S and TPM are highlighted in literature (e.g., Caldera, Desha, & Dawes, 2017; Cherrafi et al., 2017).

The analysis of the findings from Beta and Gamma reported that meat processing faces issues in maintaining the shelf-life and reducing food contamination due to mismanagement of packaging and microbial spillage (clogging issues to generate pathogens and pseudomonads). Lean tools such as standardised work instructions, 5S, JIT, root cause analysis (5-Whys and 3C) and TPM are implemented to improve packaging of meat products, shelf-life, and air circulation in the meat processing activities. For instance, in the case of Beta, improvement of shelf-life of meat products is maintained through implementation of standardised work instructions (usage of packaging material, improvement of cycle time and maintenance of packaging machines). Further, applications of 5S and JIT are implemented to reduce foodborne contamination (reduction of E. coli infections and mitigation of mishandling of the meat products) and delays in meat delivery. For instance, 5S is implemented to reduce mishandling of chemicals and raw carcasses during curing, smoking and preservation processes. Meanwhile JIT with buffer setting helped to meet the demand of the customers during the mitigation of foodborne contamination. This aspect of lean tools implementation helps to enhance the organisational capabilities such as pollution prevention (i.e., reduction of package waste, product contamination and equipment usage) and sustainable development (improved environmental safety) under the lens of the NRBV.

In the case of Gamma, microbial spoilage of meat is also reported due to clogging problems in the chiller system. 3C philosophy is used to determine the causes of clogging issues (ice blockage, oil and dirt clogging). TPM (proactive maintenance) helps to avoid clogging (chillers and ventilation systems) and occurrence of equipment non-conformities on a daily basis for attaining maintenance goals. 5S is used as a fundamental tool for removing the dirt from internal/external surfaces, capillary tubes and throttle outlets of the chiller system. However, the application of 3C, TPM and 5S for reducing the causes of clogging issues in the chiller system is lacking in the lean implementation literature. The analysis of the findings from Alpha and Gamma cases revealed that workplace accidents and damage to the belt conveyors is reduced through lean tools such as 5-Whys, 6S (5S+safety), Andon signal, JIT with buffer setting, fishbone diagram and TPM to achieve environmental safety targets. For instance, in the case of Alpha, health and safety issues of the workforce are reported due to mismanagement of cleaning procedures and water spillage in meat processing activities. Safety issues (hot water burn), mismanagement of chemical handling and extra hot water consumption to kill bacteria were identified by the analysis of 5-Whys data. 5S is implemented for cleaning and disinfection of floors (bleach and chemicals) and optimal

handling of resources (raw carcasses and finished meat). Further, the culture of 6S (5S+safety) is a prime tool to reduce workplace accidents and safety hazards by proactively reducing spillage of liquids and organic waste in meat processing activities.

The findings from Gamma indicated that the damage to the belt conveyor reduces environmental safety and delays meat delivery. The Andon signal indicated failure and minor damage to the belt conveyor due to thermal expansion of belt conveyor sprockets, which allowed the shopfloor workers to stop the processing activities in the boning room. The demand of the customers is managed through JIT with 48 hours' buffer setting during the non-operational state of meat processing activities. Further, abnormalities of conveyor sprockets (improper placement, incorrect locking and thermal expansion), spillage of meat fragments (build-up on rails, pulleys and belt) and poorly installed lagging were determined as main issues in the fishbone diagram. 5S is implemented to reduce the causes of non-conformities (spillage of meat fragments on the belt conveyor and standardising the movement of raw carcasses on the belt). Meanwhile, TPM (autonomous maintenance) is used for minimising downtime losses, speed losses and malfunctioning irregularities during optimal operations of the belt conveyor. A summarised illustration of lean tools implementation from the main study is presented in Table 8.6.

Table 8.6: Lean tools implementation from the main study

Environmental aspect	Area of application	Lean tools
Emission control	PM ₁₀	Fishbone diagram
	CO, NO _x and SO _x at the boiler house	KPIs and A3 thinking
	GHG emissions at the lairage facility	A3 thinking and standardised work
	Heat losses	VSM and 5S
Waste management and resource conservation	Water usage and wastewater sludge	KPIs benchmarking
	Chemical management (handling and spillage)	5S, standardised work and visual management
	Water usage	VSM, root cause analysis (5-Whys), 5S, Kaizen events, Gemba walks and TPM
	Potential food contamination due to breakage of processing equipment	Andon signal, JIT with buffer setting, A3 thinking and TPM
	Shelf-life (packaging, food contamination and microbial spillage)	5-Whys, TPM, 5S and JIT with buffer
	Wastewater sludge (reduction of BOD, COD and TSS)	Combined application of 3C and 5-Whys
	Reduction of chemical spillage	5-Whys, 5S and TPM
Environmental safety and technology	Efficient demand management	JIT with buffer solution
	Wastewater treatment	3C philosophy and standardised work
	Unexpected demands for meat products	VSM and JIT with buffer solution
	Unexpected demands for meat products	Hoshin Kanri with data-driven forecasting system
	Irregularities and malfunctioning of equipment due to MSD	5-Whys and standardised work
	Workplace accidents	5-Whys and 6S (5S+safety)
	Maintenance of equipment (i.e., rails, slicers and cutting saws)	TPM
	Malfunctioning of belt conveyor	Andon signal, JIT with buffer, fishbone diagram, 5S and TPM
	Reduction of broken parts	TPM and SMED
High fluctuation of pressure in the chiller system	3C philosophy, standardised work and TPM	

8.3.6 Implementation awareness, competencies development and training of the workforce

The findings of this study highlighted that effective lean and ISO 14001 implementation is ensured by a competent workforce, awareness levels for sustaining continuous improvement and appropriate training (if needed) in the meat processing facilities. Alpha and Gamma have emphasised the critical role of a competent workforce for developing a culture of environmental sustainability. The informants from Gamma explained the relevant qualification and expertise levels of the workforce for performing various roles (e.g., seasonal workers, supervisors and top management). For instance, a school graduate with a minimum age limit of 18 years could perform entry-level processing jobs. Meanwhile, top managerial roles required tertiary qualifications along with professional capabilities to drive a data-based forecasting system, automated X-ray technology and continuous improvement initiatives. These aspects are consistent with human competence to achieve environmental sustainability under the NRBV capabilities.

Appropriate qualifications and skill levels of the workforce (entry level and top management) are critical for implementing continuous improvement initiatives and installation of new technologies. Beta and Gamma have developed designated training teams for conducting training programmes for internal staff (i.e., new recruits and existing workforce) and external stakeholders (e.g., suppliers and contractors) to improve environmental performance. For example, a team comprised of environmental, lean programme and sustainability managers at Beta and about sixty devoted leaders at Gamma are responsible to enhance the knowledge and skill levels of their workforce internally. Alpha and Gamma focused on evaluating the skill matrix of their workforce to initiate training programmes for enhancing their competencies to improve environmental performance. For instance, Alpha conducted an evaluation of their need for training initiatives by comparing the current knowledge base versus the competencies required of the workforce for implementing lean and ISO 14001 together. On the other hand, in the case of Beta, the training need assessment is initiated at the organisational level for determining the gaps between desired and required competencies of the workforce for adopting lean and ISO management systems. This assessment also evaluated the previous training initiatives to create capability in implementing the best meat processing procedures and environmental practices. This aspect also aligns with previous literature (El-Khalil, 2022). Assessment of previous training initiatives has also helped the Gamma to overhaul their holistic training and implementation awareness initiatives by developing robust SOPs around environmental safety and environmental compliance requirements.

All the three cases have emphasised to conduct induction training for enhancing the existing knowledge of the newly employed workforce in implementing lean and ISO 14001 or any other improvement initiatives. Further, introductory training initiatives have helped the relevant stakeholders (e.g., suppliers and contractors) to enhance their awareness in areas such as safety hazards, chemical deposit and potential spillage by acknowledging the induction instructions at the start of their visit. The findings from Alpha revealed that orientation training is provided to newly employed workers on efficient usage of knives, SOPs and performing activities such as hoisting before slaughter, dressing the carcass and offal separation. Meanwhile, in the case of Beta, awareness parameters such as methods for separation of edible and non-edible meat, usage of water nozzles and cutting (knives and saws) are included in the induction programme. On the other hand, a team for internal foundation training have helped the newly hired employees to become familiar with mitigation strategies for overcoming the environmental risks and safety issues at Gamma. Further, Alpha and Gamma have also initiated special orientation awareness programme for relevant external stakeholders (e.g., contractors and suppliers) to provide guidelines around potential hazards such as chemical storage areas and environmental safety protocols. These findings are consistent with human competence under the NRBV lens.

Additionally, all the three cases explained that in-house training also helps in enhancing competencies and awareness in implementing continuous improvement initiatives for improving environmental performance. For instance, the competencies of the top management is enhanced through leadership programmes for better understanding in achieving environmental targets with three pathways – bronze, silver and gold – of manufacturing excellence as seen at Alpha. Most interestingly, the Irish group also conducted comprehensive in-house training to promote the WHO's guidelines during the Covid-19 pandemic for usage and maintenance of cutting equipment (knives and saws) to meet the compliance requirements of the main food safety and hygiene standards. At Gamma, on-the-job training helped the workforce in solving environmental non-conformities, mitigating environmental risks and implementing the lean strategy. These aspects of internal training programmes helped to create awareness amongst the workforce for implementing continuous improvement initiatives and are aligned with the human resource competence, strategic capabilities (pollution prevention) under the NRBV.

The findings of the three cases emphasised the importance of external training (from external consultants and educational institutions) for efficient implementation of lean and ISO 14001. The

findings explained that NZ-based groups (Alpha and Gamma) provide a NZQA suite of qualification (level 2, 3 and 4) programmes to their top management and selected operators for updating the knowledge and skill levels (lean and environmental practices implementation). A summarised illustration of implementation awareness, competencies development and training of the workforce for lean and ISO 14001 implementation from the main study is presented in Table 8.7.

Table 8.7: Implementation awareness, competencies development and training of the workforce from the main study.

Case	Implementation awareness, competencies development and training of the workforce
Alpha	<ul style="list-style-type: none"> • Need for training programmes helped to evaluate competence and implementation awareness (existing knowledge versus awareness level) to sustain lean and ISO 14001 implementation. • Newly employed operators are inducted to utilise knives and provide SOPs for processing raw carcasses. • Well-organised external training programmes (NZQA and Primary Industry Training Organisation) are conducted for processing meat products. • Induction training is initiated for contractors around environmental management, and health and safety instructions. • High-level leadership learning programme helped to achieve operational and environmental targets. • Role of training programme is critical to implement environmental practices, lean tools and food safety initiatives. • An enthusiastic engagement culture and competent workforce is critical for achieving excellence in environmental sustainability.
Beta	<ul style="list-style-type: none"> • Induction programme helped new hired workforce for handling waste (edible and non-edible) and processing equipment (i.e., cutting knives and saws). • Internal training is conducted to enhance competence of the workforce, develop health and safety awareness, and follow WHO guidelines during Covid-19 pandemic. • Findings of skill matrix suggested to enhance the competence of middle management and senior management through external training initiatives. • External training at Toyota’s European headquarters facilitated the workforce to implement lean tools for enhancing operational sustainability. • A number of scholarships provided to the workforce for undertaking certifications and diploma from Irish institutions to enhance the concepts of environmental sciences, lean implementation and circular economy.
Gamma	<ul style="list-style-type: none"> • Qualification of the workforce (new entrants to management cadre) is role dependent (school graduate for new entrants and tertiary qualification for managerial roles). • A team of about sixty devoted leaders is responsible of conducting internal training for efficient implementation of lean tools and environmental practices. • Internal lean training is used to solve non-conformity issues, improve quality and promote innovation culture. • External qualifications such as NZQA level 3 and 4 certifications helped the workforce for improving critical thinking, ensuring change management and improving productivity. • Internal training (induction and on-the-job) and external training (NZQA qualifications) assisted the workforce to mitigate environmental risks and safety issues. • External training helped the forklift operators for handling merchandise and carcasses to avoid potential damage/injury. • Robust training initiatives based on lean and ISO 14001 implementation helped the workforce and relevant stakeholders to adopt a culture of operational and environmental optimisation.

Level 2, 3 and 4 NZQA certifications helped the meat processing facilities create a culture of environmental improvements, enhancing critical thinking and improving productivity (minimising waste and improving production efficiency). Meanwhile, Alpha also conducted a PITO initiative along with a NZQA programme for fulfilling environmental compliance requirements, implementing best meat processing practices and enhancing the skill levels of the

workforce. On the other hand, the Irish group provided financial assistance to their workforce for undertaking certifications or diplomas in environmental sciences, circular economy and lean six sigma from Irish institutes to boost their skill levels in executing lean and environmental practices. Further, top management staff were provided with offsite training at Toyota's European headquarters in Birmingham for lean tools implementation in the context of meat processing. Toyota trainers also visited meat processing facilities across Beta for examining the improvements in operational and environmental performance. On the other hand, Gamma provided external training to their forklift operators to avoid potential damage/injury in the meat processing areas.

8.3.7 Environmental performance evaluation

The findings from the main study indicated that monitoring, measurement and audits are important to evaluate objectives and targets around reduction of waste (organic, inorganic and packaging) and environmental (GHG emissions) parameters. All the three cases highlighted the input parameters for proposing action plan and evaluating environmental performance to achieve operational and environmental targets. At Alpha and Beta, the proposed action plan is based on the analysis of environmental data, audit reports and KPI benchmark targets around utilisation of raw carcasses, water and energy, and provided performance evaluation and clear direction for better achieving environmental performance. The inputs of environmental performance are further explained as evidenced at Beta, which more interestingly, suggest that the outcomes of root cause analysis data (for occurrence of non-conformities) and ISO 14001 audits (for evaluation of the environmental targets) are considered as inputs for performance evaluation.

On the other hand, at Gamma, the outcomes of performance evaluation are used to propose process optimisation actions (corrective, preventive and proactive) for achieving operational and environmental targets. Further, an environmental action plan is proposed for boiler operations by evaluating air emissions and ash discharge to optimise environmental performance. Furthermore, the findings from Gamma revealed that data from CO measurement sensors, ultra-flow meters and automated X-rays (forecasting the offal yield) are used to measure and monitor performance for evaluating the SBTi. These aspects are in line with procedural competence (environmental performance evaluation) and capabilities (pollution prevention by achieving operational and environmental KPI benchmark targets) under the NRBV lens.

A series of external audits (as evidenced in all the cases) were conducted by local councils and ISO certification third party auditors to meet the consent requirements to reduce all kinds of wastes and attain ISO 14001 certification. For instance, at Alpha, external auditors from local councils analysed the samples of wastewater sludge, GHG emissions and inorganic waste for evaluation of compliance requirements against the set targets for operational and environmental performance. On the other hand, at Gamma, combined environmental audits (Gamma and regional council representatives) were conducted to evaluate the parameters of the SBTi. In the cases of Alpha and Beta, third party ISO 14001 audits helped to attain and maintain the ISO 14001 certification status. All the three cases described the frequency of internal and external environmental monitoring, reviews and audits for a clear picture of the overall environmental performance evaluation. External audits are conducted by the ISO certification body to review environmental procedures for continuing ISO 14001 certification status on at least a three-yearly basis (as noted in the Alpha case). Further, frequency of performance evaluation is reported on a monthly, quarterly and annual basis for meeting the requirement of documented action plans (as seen in Beta). In the same vein, quarterly and annual monitoring, reporting and auditing helped to attain the compliance requirements of the SBTi parameters (as evidenced at Gamma) (e.g., Bjørn et al., 2022; Moshrefi et al., 2022). A summarised illustration of environmental performance evaluation for lean and ISO 14001 implementation from the main study is presented in Table 8.8.

Table 8.8: Environmental performance evaluation from the main study

Case	Environmental performance evaluation
Alpha	<ul style="list-style-type: none"> • Top management assigned roles, responsibilities and authorities to evaluate environmental targets and objectives. • Local council representatives and third-party auditors conducted external audits to review waste reduction parameters, compliance and statutory requirements around environmental targets. • Certification body conducted external audits to attain ISO 14001 certification. • Daily internal audits are conducted to evaluate compliance requirements around food safety and environmental performance.
Beta	<ul style="list-style-type: none"> • KPIs data on air emission, energy consumption and packaging are evaluated to determine non-conformities and propose action plan to mitigate non-compliance with consent requirements. • Data from root cause analysis and audit of ISO 14001 is used for evaluation of environmental performance. • Continuous monitoring and reviewing is carried out to achieve objectives of continuous improvement projects. • Internal and external audits are used for evaluating VSM and ISO 14001 findings to identify gaps and opportunities in continuous improvement projects. • Environmental performance evaluation is conducted monthly, quarterly and annually.
Gamma	<ul style="list-style-type: none"> • Environmental data and audits around raw carcasses, water usage and energy consumption are used to evaluate performance parameters. • Quarterly and annual performance evaluation is based on monitoring, reporting and auditing data of waste and GHG emissions to achieve consent permits from NZ statutory bodies. • Comprehensive action plans for continuous improvement projects are developed by reviewing the data on CO measurement sensors, ultra-flow meters and automated X-ray (forecasting the offal yield). • Regular compliance audits (once every four months) are conducted to evaluate the compliance requirements of SBTi parameters.

8.3.8 Environmental management review

The findings of the main study explained that environmental management reviews permit the meat processing facilities to evaluate the current operational and environmental targets and identify future opportunities to make an informed decision on successful on-going initiatives. All the cases comprehensively described the inputs for conducting environmental management review. For example, in the case of Alpha, data on the current status of resources (e.g., raw carcasses, water, chemicals and energy) is used as the starting point for the environmental management review. On the other hand, outcomes of audits and KPI reports are considered as the inputs for conducting the environmental management review as evidenced at Beta. Further, at Gamma, the inputs for the environmental management review are included in the environmental audit reports, surveillance audits on lean projects, and minutes of the last review meeting, which are analysed to identify non-conformities and propose improvements (if required) for the next processing cycle. These findings are consistent with the NRBV's procedural competence (management review), capabilities (pollution prevention, product stewardship and environmental sustainability) and previous studies (Heras-Saizarbitoria, Boiral, García, & Allur, 2020).

The findings of this study suggested that there is a consensus between three case study companies to conduct management reviews on a quarterly and annual basis to determine the status of current resources, include additional areas of optimisation and set new targets around operational and environmental performance. Outcomes of management review meetings are used as a starting point for setting new targets around biodiversity management, efficient energy usage and reduction of plastic waste as evidenced at Beta and Gamma, which is line with the procedural competence and pollution prevention capability under the NRBV. In the cases of Alpha and Beta, the top management is responsible for allocating resources for conducting management review to evaluate the current environmental performance and propose future optimisation. The role of the top management is pivotal in assigning the right people and allocating funds and human resources for future operational and environmental performance targets after the annual management review meeting (as seen at Alpha and Beta). A summarised illustration of environmental management review for lean and ISO 14001 implementation from the main study is presented in Table 8.9.

Table 8.9: Environmental management review from the main study

Case	Environmental management review
Alpha	<ul style="list-style-type: none"> • Analysis and review of major resources (raw carcasses, water and electricity) consumption for identifying non-conformities and proposing future compliance opportunities in the annual management review. • Efficient management of information sharing for evaluation of current performance and setting future targets. • Yearly environmental management review is conducted to determine the weaknesses of meat processing operations and proposing future performance. • Top management is responsible for allocating financial and human resources to set and achieve objectives and targets for the next year after the review meeting.
Beta	<ul style="list-style-type: none"> • Top management conducts a management review based on the current performance of meat processing operations and proposes corrective actions (six monthly or annual). • Inputs for environmental management review are based on outcomes of audits and KPIs reports (compliance and non-compliance). • Top management is responsible for conducting management reviews, allocating financial resources and assigning responsibilities to pursue optimisation projects.
Gamma	<ul style="list-style-type: none"> • Environmental review is conducted to evaluate operational and environmental performance based on environmental audit reports, organisational documents and minutes of the last review meeting. • Outcomes of lean and environmental practices are the starting point for evaluation of the recent environmental performance and proposing future optimisation opportunities.

8.4 Critical success factors for implementing lean and ISO 14001 as a combined approach

The findings from all cases suggested that top management commitment is the most critical factor for successful implementation of lean and ISO 14001. This study described the role of senior management for developing waste and environmental policy to drive continuous improvement by reducing environmental footprint targets and meeting the regulatory objectives in resource-intensive meat processing facilities. The findings of all the three cases explain the vital role of the leadership in providing financial support for introducing the latest technologies, equipment and conducting training (induction, internal and external) programmes. For instance, at Alpha, the role of the top management is critical in providing financial support to introduce software such as Information Leader for maintenance of documents which enabled the Alpha to minimise downtime (reduction of processing time for manual documentation). Further, at Beta, the top management allocated financial resources for installing the latest decarbonisation (heat recovery unit), upgrading the water meter for water usage and enhancing recycling capabilities to sustain manufacturing excellence. Furthermore, in the case of Beta, the role of senior management is a key element in providing funding for reducing environmental footprints by initiating training in lean and ISO 14001 implementation (inhouse and external consultants). In the same vein, at Gamma, the top management also played a critical role in providing financial assistance to support the external training programmes for successful implementation of lean and ISO 14001, which is consistent with literature on lean (e.g., Barclay et al., 2021; Lizarelli et al., 2021) and ISO 14001 (e.g., Ejdys et al., 2016; Sambasivan & Fei, 2008).

All the three case study organisations have suggested the importance of awareness and training programmes for understanding the operational and environmental sustainability. For instance, an awareness programme is managed by cascading information through visual management around utility consumption, environmental parameters and promoting knowledge for lean implementation (as evidenced in the Alpha case). In the case of Beta, the findings suggested that competent and well-trained workforces play a fundamental role in implementing sustainable projects and evaluating environmental performance. The findings from NZ companies (Alpha and Gamma) suggest that external training (NZQA qualifications and Primary Industry's training programmes) plays a crucial role to enhance the competencies of supervisors, team leads and managers for implementing best meat processing practices. This aspect is in alignment with literature on lean (Achanga et al., 2006; Barclay et al., 2021) and ISO 14001 (e.g., Murphy et al., 2020; Sambasivan & Fei, 2008).

On the other hand, the Irish Beta arranged an EMS lead auditor and lean six sigma (green, black and master black belts) courses to enhance the current competencies of the middle and senior managers for better achieving the operational and environmental KPI targets. Further, external consultants conducted training initiatives on the environmental, quality and safety aspects of meat processing to enhance the competence of their employees as seen in the Alpha and Gamma cases. More interestingly, internal induction and refresher training sessions are provided to implement ISO management systems and lean tools. These training initiatives are crucial for better understanding of the organisational vision and core procedures to process environmentally friendly meat products as evidenced at Gamma.

The analysis of this study recognises that introduction of the latest equipment, IT systems and technology are significant factors for implementation of continuous improvement initiatives (i.e., lean and ISO management systems). In the case of Alpha, installation of the latest measurement equipment for wastewater and digital pressure sensors for predicting wastewater treatment help to achieve compliance requirements (for water consumption and wastewater treatment). Meanwhile, the findings from Beta explain that introduction of the latest renewable system by replacing coal-fired boilers with solar or wind energy systems is an important aspect for improving environmental performance. More interestingly, at Gamma, the installation of the latest equipment (e.g., introduction of digital pressure sensors, data driven forecasting system and X-ray technology) is a factor for success for achieving the integrated lean and ISO 14001 environmental policy

parameters (i.e., wastewater reduction and efficient raw carcasses usage), which is lacking in the literature. Further, artificial intelligence and Industry 4.0 are introduced at Gamma to successfully collect and analyse data to predict and optimise the offal yield.

This study reported that financial assistance from the government institutes helps in introducing the latest equipment, software package and meat processing technologies for minimising carbon footprint, better collecting KPI benchmarks data and reducing packaging waste. In the case of Alpha, NZ government provided industrial funding (e.g., GIDI fund) for installing equipment and software to better achieve lean and ISO 14001 environmental target (e.g., reduction of carbon footprint). Further, the EU provided financial assistance to Beta Irish meat processing facilities for decarbonisation (steam and electricity systems) and making carcasses processing more robust (custom-built automated meat processing). The top management initially allocated financial resources and later received funding from the EU for introducing the latest technology (i.e., meat grinders, portable recycling plant and heat recovery plant); however, huge operational cost savings were reported after recouping the costs of the equipment. Furthermore, availability of financial support by EECA was critical, as seen in Gamma, in introducing state-of-the-art data forecasting systems for predicting accurate offal yield, automated X-ray technology to process 600 lambs per hour and replace coal boilers to reduce carbon footprint.

The findings from Alpha and Gamma suggest that a strong sustainability-oriented culture fosters continuous improvement initiatives through lean and ISO 14001 implementation. For instance, at Alpha, a continuous improvement culture helps to develop an efficient waste and environmental impact reduction policy through the application of ISO 14001 framework and lean tools for fulfilling the consent requirements and overcoming the non-conformities. In the same vein, managing the concept of change at Gamma helped to promote a sustainability-oriented culture for successful lean and ISO 14001 implementation to achieve the slogan “protect and enhance our natural environment by reducing carbon footprint and optimising biodiversity. Further, cultural change ensured proactive management to implement lean and environmental practices for improving operational and environmental performance.

In addition to the above CSFs for lean and ISO 14001 implementation, the findings from Alpha emphasises that motivation of the workforce and social events are also crucial factors for lean and ISO 14001 implementation. Employee satisfaction was ensured by offering rewards, providing

financial support and improving their skills (through awareness and training initiatives) as is evident in the case of Alpha, which is in alignment with literature (e.g., Habidin et al., 2018; Puvanasvaran et al., 2014). Further, at Alpha, social events (involving drinks, pizzas and sausages) were arranged to reward the staff for recognition of non-recordable injuries and fulfilling the environmental compliance requirements for a month.

The findings from Beta suggest that communication and maintenance of quality data are considered as critical for improving the environmental performance in achieving the goal to become the business leader. For instance, at Beta, the ambition to become the best in the business is an important factor for processing environmentally friendly meat products and achieving stewardship recognition from organisations such as the Plastic Action Alliance (usage of packaging material) and Origin Green (zero carbon footprints). More interestingly, at Beta, quality data is a top factor for evaluation of lean and ISO 14001 implementation. Data from VSM and KPI benchmarks help to produce performance reports for conducting annual audits, evaluating environmental losses and assessment of regulatory compliance at Beta. A summarised illustration of the critical success factors for lean and ISO 14001 implementation from the main study is presented in Table 8.10 (Appendix H).

8.5 Summary of environmental and waste reduction outcomes by implementing lean and ISO 14001 from the cases

In answering the first research question, the findings from the cases revealed how lean and ISO 14001 implementation strategies as a combined approach contribute to environmental performance. The findings from all three organisations suggested that lean and ISO 14001 as a combined approach helps in developing a comprehensive organisational policy with allocation of financial support to improve the environmental targets and usage of resources. Further, environmental parameters are shared with the relevant stakeholders (i.e., workforce, suppliers and contractors) to enhance the environmental awareness via internal communication (i.e., use of digital and white boards) and external information sharing (i.e., through email correspondence). Furthermore, the findings of the three cases reported that a number of optimisation projects were established based on use of lean tools (i.e., KPI benchmarks, VSM and standardised work instructions) and ISO 14001 procedures (i.e., environmental policy, internal audit and corrective actions) for better improving environmental performance. The competencies of the workforce are

enhanced through implementation awareness and training initiatives for executing lean and ISO 14001 as a combined approach. Additionally, training programmes around lean and ISO 14001 helped to achieve better environmental competitiveness, implement environmental practices and enhance competencies of the workforce. The cases also revealed that lean and ISO 14001 strategies as a combined approach develops a mechanism to evaluate the conformity status and proposes a corrective action plan for improving the environmental performance.

The findings from the three cases also indicated that the meat processing facilities follow strict compliance requirements in implementing lean tools and ISO management systems for improving the environmental performance (e.g., reduction of wastewater and packaging waste). For instance, the findings highlighted that lean tools (i.e., root cause analysis, VSM and standardised work instructions) and ISO 14001 operational control procedures are implemented together to reduce wastewater. Alpha and Beta cases adopted corrective actions (e.g., reduction of wastewater) and proactive actions (e.g., reuse and recycling of wastewater), while Gamma suggested the use of wastewater treatment initiative. Further, lean tools (i.e., A3 thinking, Kaizen events and VSM) and ISO 14001 procedures (i.e., corrective and preventive actions) together helped to achieve the waste to landfill goal. The findings suggest that waste to landfill targets were achieved by Beta six years ago; however, Alpha and Gamma are still working to attain the waste to landfill targets. Furthermore, the cases revealed that lean tools (i.e., 5-Whys, 5S+safety and TPM) and ISO 14001 procedures (i.e., risk assessment, communication and corrective actions) are implemented together for reducing environmental safety issues. The findings suggested that all the three cases depicted a mature safety culture by implementing lean and ISO 14001 jointly for mitigating environmental safety issues. A summary of the environmental and waste reduction outcomes by implementing lean and ISO 14001 jointly from the three cases is presented in Table 8.11 (Appendix I).

8.6 Summary of implementation of lean and ISO 14001 as a combined approach from the cases

In answering the first part of the second question, the findings from all the three organisations indicated that a comprehensive and combined lean and ISO 14001 environmental policy is developed by including parameters such as reducing GHG emission targets, efficient usage of carcasses, water and energy, and achieving waste to landfill. All of the three meat processing organisations implemented a specific long-term continuous operational and environmental policy

to meet their operational and environmental targets. The findings clearly suggest that Beta is a more mature organisation in implementing lean and ISO 14001 environmental policy by achieving zero waste to landfill targets six years ago, efficiently following DAFF and BBIFB based targets and implementing Capex projects for improving environmental performance.

The findings highlighted that integrated plans and projects of lean tools and ISO 14001 help to improve resources (i.e., water usage, energy consumption and carcasses processing) reduce GHG emissions and heat losses recovery. Digitised documents and records highlighted in Alpha and Beta cases are used to communicate the KPI benchmarks during planning and post implementation of continuous improvement projects. Lean tools and ISO 14001 procedures are used to evaluate the conformity status and propose optimisation projects in all the three organisations. For example, analysis of VSM data is performed to identify potential environmental risks and operational controls of ISO 14001 are implemented to execute continuous improvement projects (i.e., utilisation of large sheepskin and water) in the case of Alpha. Similarly, lean tools (root cause analysis, VSM and TPM) and ISO 14001 procedures (conformance status in management reviews) are used to use wastewater sludge at Beta. In the same vein, lean tools (root cause analysis and standardised work instructions) and ISO 14001 procedures (communication and corrective actions) are used in processing sheepskin and face pieces into small compost material and reduction of GHG emissions at Gamma. The findings of this study suggested that Alpha is a more mature organisation due to efficient risk management, management of digitised documentation via Information Leader, and better implementation of lean tools and ISO 14001 procedures for continuous improvement projects.

Light-emitting diodes, newsletters, charts, and whiteboards are used in managing structural internal communication. Further, regular meetings on internal audits of ISO 14001 and application of lean tools are also included in in-house communication for improving environmental performance. On the other hand, the findings from the cases highlighted that efficient external communication helps in showcasing their commitment to processing environmentally friendly meat products to their repeated customers around the globe. Unique information sharing is reported at Alpha: for instance, multiple communications between Alpha and external stakeholders (public and environmental groups, and local government) to minimise noise pollution and unbearable odour. Additionally, internal information sharing around stewardship (Green Large Organisation

and Irish Export Association) awards and external communication (Walmart, Albert Heinz and Sainsbury's) are also highlighted at Beta.

Alpha and Beta have a more digital data-oriented documentation culture as shown by installing Information Leader software and the AWS EC2 software toolkit respectively for implementing ISO 14001 procedures efficiently. On the other hand, Gamma has implemented a manual documentation approach to manage (1) environmental policy, (2) outcomes of internal audits and management reviews, and (3) results of corrective action. Roles, responsibilities and authorities are considered critical procedures by all three companies for implementing ISO 14001 to improve environmental performance. For instance, in the case of Alpha, only authorised personnel are assigned responsibilities to modify or update the existing targets around operational and environmental performance in Information Leader software. On the other hand, a four-member team is responsible for maintaining manual documentation to implement ISO 14001 procedures at Gamma. In the case of Beta, intensive financial resources are allocated for ISO 14001 registration and environmental teams' training initiatives to implement ISO 14001 procedures effectively. These findings clearly indicate that Alpha and Beta are more sophisticated organisations with the latest documentation control systems, sufficient financial support and robust operational control to implement ISO 14001 procedures. On the other hand, Gamma is still weak in adopting a digitised documentation and records management system due to financial constraints and the maturity level of ISO 14001 implementation in their organisation.

All the three organisations have shown their commitment to improving utilisation of water and reduction of wastewater sludge by reducing the generation of BOD, COD and TSS, introducing improved recycling systems and reusing the wastewater through a comprehensive application of lean tools. Further, Alpha and Beta have implemented lean tools such as root cause analysis (fishbone diagram and A3 thinking), KPI benchmarks, standardised work instructions, VSM and 5S for emission control (reducing PM₁₀, GHG emissions, and heat losses) in their organisations. These findings suggest that Alpha and Beta both follow a strong management commitment to generate ecologically safe electricity and steam through coal-based power plants and reduce GHG emissions at the lairage facility (as evidenced at Beta). Further, the findings from Alpha and Gamma indicate that an efficient chemical management system by implementing a combination of lean tools is instrumental in reducing chemical spillage, workforce accidents and efficient usage of chemicals.

In the same vein, Alpha and Gamma also demonstrate a superior lean tools implementation to provide sufficient meat products in fulfilling the required demand of their customers during the Covid-19 pandemic period. On the other hand, in the case of Beta, reduction of potential food contamination and improvement of shelf life were ensured by the application of lean tools. This study reported the application of lean tools for improving environmental safety and efficient usage of meat processing equipment. However, Alpha and Gamma have implemented lean tools more efficiently for improving environmental safety (i.e., reduction of MSD), utilising equipment (rails, slicers and cutting saws) better and maintenance of pressure in the chiller system.

All three organisations have emphasised maintaining competence of the workforce, sustaining awareness of continuous improvement initiatives and providing internal and external training to increase the existing knowledge of the workforce for improving environmental performance. Alpha and Beta have evaluated the current knowledge status of their employees through skill matrix analysis for performing their daily tasks. All three companies have conducted internal (induction and regular) and external training to implement environmental practices and lean tools effectively. The NZ-based meat processing organisations both had a strong external training culture (NZQA and PITO). On the other hand, Beta has also provided external training at Toyota's European headquarters on lean tools and short courses from Irish institutions on environmental practices and the circular economy. The findings from the study clearly suggest that all three organisations are mature companies implementing (internal and external) training programmes to improve environmental awareness and enhance the competencies of the workforce.

This study emphasised conducting regular internal and external audits for evaluating the compliance level and status of current environmental performance to improve environmental objectives and targets. However, the findings of this study reveal that Beta and Gamma both are advanced companies with well-established environmental performance evaluation mechanisms in their organisation. For instance, Beta utilised audit systems such as (a) root cause analysis and ISO 14001 audits and (b) VSM and ISO 14001 audits for efficient evaluation of environmental performance. On the other hand, Gamma demonstrated superior environmental performance evaluation by managing efficient monitoring, reviewing and auditing around GHG emissions, water flow and more accurate forecasting of the offal yield.

The findings from all cases have reported efficient environmental management reviews as a result of their commitment to be an environmentally friendly organisation by managing efficient usage of resources, evaluating findings of audits and allocating financial resources. The findings of this study reveal that Alpha and Beta are stronger in conducting environmental management reviews for evaluating efficient resource usage, analysing reports (KPI targets, operational and environmental performance) and reviewing minutes of the last review meeting on a periodical (six monthly or annual) basis. A summary of implementation of lean and ISO 14001 as a combined approach from the three cases is presented in Table 8.12 (Appendix J).

In answering the second part of the second research question, the findings from the cases reveal how lean and ISO 14001 implementation strategies complement each other for improving environmental performance. Informants of the cases suggested that an integrated lean and ISO 14001 environmental policy works better for improving environmental and minimising waste targets instead of individual/separate lean and ISO 14001 policies. This finding resonates with the findings of Souza and Alves (2018) and Wirkus and Chmielarz (2018) who pointed out the importance of an integrated policy for implementing lean and ISO 14001 together to achieve better environmental performance. Further, an integrated lean and ISO 14001 environmental policy is consistent with the NRBV competencies (e.g., strategic planning competence).

Articulation of operational and environmental policy helps to provide guidelines for achieving short-term and long-term organisational targets. The findings of this study suggest that revised KPI targets around environmental performance are set by incorporating the outcomes of the environmental reports and management review meetings (ISO 14001 procedures). Further, ISO 14001 provides flexibility to the top management for defining environmental policy to enable continuous environmental improvement and comply with the environmental regulations. On the other hand, data analysis of VSM is used to help in evaluating the status of the environmental targets (i.e., wastewater, GHG emissions and solid waste) and proposing revised targets for developing future optimisation cycles. Furthermore, the findings also revealed that Hoshin Kanri with the latest forecasting system helps in setting strategic target around offal extraction to minimise waste. These findings are consistent with the study results of Chiarini (2011) and Souza and Alves (2018) who described the role of lean tools (i.e., Hoshin Kanri and VSM) and ISO 14001 procedures for developing an integrated environmental policy based on both strategies. ISO 14001 procedures provide a framework for better defining environmental objectives, targets and policy.

However, the lean strategy fails to provide a structural framework and contributes little in formulating the integrated lean and ISO 14001 environmental policy. Additionally, ISO 14001 based EMS framework is better at articulating the integrated operational and environmental policy for achieving enhanced environmental performance.

The findings of the main study revealed that lean tools such as visual management (i.e., visual screen, light emitting diodes and white boards) and ISO 14001 procedures such as communication (clause 7.4.1) help in better maintaining the internal communication. For instance, visual management including displaying operational, safety and environmental performance parameters in a single visual/white board arrangement, facilitates in sharing the targets of an organisation internally. Additionally, day-to-day meetings (according to ISO 14001 procedure) around the current status of operational and environmental performance assists an organisation in providing environmental awareness to their workforce. However, there are no lean tools to maintain external communication for cascading the information to the external stakeholders. Conversely, ISO 14001 procedure (i.e., external communication, clause 7.4.2) helps in cascading the information with the relevant external stakeholders (i.e., suppliers and overseas customers) via email correspondence, newsletters, and sustainability reports. Further, the participation of an organisation in conferences helps to convey their achievements around environmental performance. The role of external communication (according to ISO 14001) is consistent with the findings of Savely et al. (2007), who pointed out the pivotal role of information sharing through various means (i.e., newsletters, Internet websites, bulletin boards, and trade journals) under the framework of ISO 14001. The findings revealed that ISO 14001 contributes more to an overall communication paradigm; however, lean plays a limited role around the internal communication aspect only.

The findings of the cases showed that lean tools (e.g., root cause analysis, VSM and 3C) and ISO 14001 operational control (e.g., preventive and corrective actions) are implemented to identify non-conformities (e.g., GHG emissions and wastewater) and propose solutions. For instance, air emissions are monitored on a daily basis according to the ISO 14001 framework to fulfil the consent requirements (e.g., quality and environment assurance). Root cause analysis (i.e., 5-Whys and fishbone diagram) is implemented to measure the conformance status of GHG emissions and propose corrective actions (if non-conformities occurred). Further, A3 thinking is used to determine the reasons for excessive waste (CH₄ gas and organic substances) at the lairage facilities and countermeasures (a pillar of A3 thinking) are proposed (reduction of food and water).

Standardised work instructions are revised based on the findings of A3 thinking to reduce GHG emissions and solid waste.

Additionally, the findings also reveal that a suite of lean tools (i.e., 3C and 5-Whys) is implemented for identifying extra sludge generation and proposing countermeasures (i.e., reuse and recycling programmes) to mitigate the sludge. Further, lean tools (i.e., VSM and root cause analysis) are used to identify the causes of sludge and ISO 14001 operational controls (preventive and corrective actions) are undertaken for better achieving the waste to landfill goal. The above discussion indicates that the main causes of non-conformities are rigorously identified and solutions are proposed (by lean tools and ISO 14001). These findings point out that lean aspects contribute more to measuring and improving, and ISO 14001 procedures suggest solutions for improving environmental performance.

The informants of all the three cases explained that manual and digital (Information Leader and the AWS EC2 software toolkit) documentation control help to maintain environmental records (i.e., environmental policy, environmental audits and outcomes of corrective actions). These documentation management systems are used to collect data on KPI targets (i.e., water use, packaging material and wastewater) for evaluating overall environmental performance. Further, the findings indicated that records of lean tools (i.e., 5S audit reports, revised standardised work instructions and future VSM mapping) are also maintained to improve production flow and provide a safe environment for the workforce. These findings are aligned with the findings of Souza and Alves (2018) who emphasised maintaining documentation records of lean implementation and ISO 14001 procedures in a combined implementation of both strategies. However, the findings of all cases suggest that robust ISO 14001 documentation control contributes more to maintaining efficient organisational environmental documentation procedures (i.e., policy, audits and management reviews) in a joint lean and ISO 14001 implementation.

The findings suggest that environmental performance evaluation (i.e., procedural competence) provides a mechanism to collect and analyse the data for evaluating the current status of KPI targets and propose future opportunities. Further, monitoring, measurement and audits of environmental performance provide a clear direction for conducting environmental management reviews. For instance, this study reveals that data analysis of ISO 14001 mandatory audits and lean tools (i.e., VSM, root cause analysis and 5S) is used to evaluate the non-conformities (e.g., wastewater and

solid waste) and propose solutions for achieving future compliance requirements in combined optimisation projects. Further, 5S audits (i.e., assessment of chemical handling), checklists (i.e., maintenance sheets and warning signs for handling chemicals) and chemical labelling are maintained for reducing chemical spillage and accidents. On the other hand, ISO 14001 environmental audits from internal auditors and external certification bodies are conducted to analyse and review the compliance status around environmental performance targets. Further, procedural competence (i.e., environmental management reviews based on lean and ISO 14001) falls under the NRBV lens.

The findings explain that environmental management reviews are considered as foundational process to evaluate the KPI targets by reviewing the outputs of previous review meetings, non-conformity reports and environmental and lean audits. Recommendations (opportunities and corrective actions) are proposed as outputs of management reviews to implement lean and ISO 14001 jointly. The findings indicate that ISO 14001 procedures (i.e., environmental performance evaluation and management review) provide comprehensive structural monitoring and auditing mechanisms during lean and ISO 14001 implementation as a combined approach. A summary of the lean and ISO 14001 implementation as a combined approach for environment initiatives is presented in Table 8.13.

Table 8.13: Summary of combined approach of lean tools and ISO 14001 procedures for environmental performance

Process aspects	Lean tools	ISO 14001 procedures
Integrated lean and ISO 14001 environmental policy	VSM and Hoshin Kanri	ISO 14001 based EMS framework for setting environmental objectives, targets and policy
Communication	Visual management (internal communication)	Internal and external communication for effectiveness of ISO 14001 (clause 7.4)
Identification of process non-conformities and improvement programme	Root cause analysis (i.e., 5-Whys, fishbone diagram and A3 thinking) Data analysis of VSM	ISO 14001 operational control procedures (i.e., corrective and preventive actions)
Documentation	5S audit reports, revised standardised work instructions and records of VSM (i.e., current and future mapping)	Manual and digital document control (ISO 14001)
Audit process	5S audit reports	Environmental performance evaluation (internal and external environmental audits)
Environmental performance evaluation	VSM, root cause analysis and 5S	ISO 14001 procedures (environmental performance evaluation such as audit and compliance evaluation)
Environmental management review	Lean audit reports	Outputs of previous review meeting, non-conformity reports and environmental audits

8.7 Summary of the CSFs for implementing lean and ISO 14001 as a combined approach from the cases

In answering the third research question – what are the critical success factors for implementing lean and ISO 14001 as a combined approach for improving environmental performance in the meat industry – several critical success factors were identified by the informants of the three organisations as evident in Table 8.14 (Appendix K). Puvanasvaran et al. (2014) have recommended 7 critical success factors for lean and ISO 14001 implementation strategies together in the manufacturing industry. However, the findings from the consultants and three organisations reported unique and new CSFs such as introduction of the latest technological trends to better achieve the lean and ISO 14001 environmental KPI targets (e.g., reduction of wastewater and GHG emissions). The most pronounced CSFs for implementing lean and ISO 14001 as a combined approach for improving environmental performance from this study are as follows:

- Top management’s commitment in developing policy
- Top management support via financial resources (i.e., installation of software, upgradation of equipment and external training)
- Awareness and training programmes (i.e., NZQA qualifications and Primary Industry’s training programmes, ISO 14001 lead auditor training and lean six sigma training)
- Introduction of the latest technological trends (installation of software packages and equipment, and introduction of renewable fuels for reducing wastewater, GHG emissions and optimising water usage)
- Governmental financial support (i.e., installation of software, equipment and adopting recycling packaging materials)
- Sustainability-oriented culture
- Communication
- Engagement of workforce

A summary of the key findings to explain the CSFs for implementing lean and ISO 14001 as a combined approach is presented in Table 8.14 (Appendix K).

8.8 Comparison of case study findings with the preliminary study

The key findings from the three cases are compared with the preliminary study (insights from lean and ISO 14001 consultants who are the experts in these fields) in this section. These comparisons help in establishing triangulation and confirming the validity of the research findings to answer the three research questions. These insights and comparisons are presented next.

8.8.1 Environmental and waste reduction outcomes by implementing lean and ISO 14001 as a combined approach

In answering the first research question, the findings from this study revealed how lean and ISO 14001 implementation as a combined approach contributes to better improving environmental performance. The informants of the cases agreed with the findings of the preliminary study that a joint lean and ISO 14001 implementation substantially helps to achieve the environmental targets (e.g., reduction of wastewater, GHG emissions and environmental safety issues). Further, the findings from the preliminary study revealed that lean and ISO 14001 implementation together also substantially improves environmental parameters (e.g., waste to landfill). For instance, the lean and ISO 14001 consultants conveyed that reduction of sludge and packaging waste are enhanced by implementing both strategies together. These aspects (sludge and packaging waste) indirectly contribute to minimising waste to landfill. The environmental and waste reduction outcomes by implementing lean and ISO 14001 as a combined approach are presented in the Table 8.15.

Table 8.15: Environmental and waste reduction outcomes by implementing lean and ISO 14001 as a combined approach

Environmental aspect	Preliminary study	Main study (multi-case studies in the meat processing companies)		
		Alpha	Beta	Gamma
Reduction of wastewater	☑	☑	☑	☑
Reduction of sludge	☑	☑	☑	☑
Reduction of GHG emissions	☑	☑	☑	☑
Reduction environmental safety issues	☑	☑	☑	☑
Reduction of solid waste	☑	☑	☑	☑
Reduction of packaging waste	☑	☑	☑	☑
Reduction of waste to landfill	●	☑	☑	☑
Reduction of heat losses	☑	☑	☑	☑
Reduction of chemical handling issues	☑	☑	☑	☑

Notes: ☑ = Realised; ● = Partially realised; ☒ = Not realised

8.8.2 Implementation of lean and ISO 14001 as a combined approach

In answering the first part of the second question, the informants of this study revealed how lean and ISO 14001 implementation strategies complement each other for improving environmental performance. For instance, the cases confirm that KPI targets (i.e., wastewater, air emissions and packaging waste) are included in an integrated lean and ISO 14001 environmental policy to better achieve environmental performance. However, the informants of the preliminary study suggested to develop a combined lean and ISO 14001 environmental policy based on SMART objectives and targets. The informants of the preliminary study and the three cases agreed to maintain internal communication by displaying operational, safety and environmental targets in a single digital visual/white board. The study described that a number of projects based on lean and ISO 14001 helps to better improve environmental targets (i.e., reduction of sludge and packaging waste). Further, the findings of the three cases suggested that lean and ISO 14001 implementation also improves some additional KPI targets (i.e., waste to landfill, heat losses and chemical handling). The informants from Alpha and Beta reveal that document control (ISO 14001 procedure) is maintained digitally through Information Leader and the AWS EC2 software toolkit. On the other hand, the informants from the preliminary study and Gamma describe that maintenance of document control is sustained by manual system. This study implemented a number of lean tools (e.g., root cause analysis, 5S and TPM) for better reducing environmental targets (e.g., wastewater, sludge and packaging waste). Additionally, the findings of the preliminary study and Gamma suggest that Hoshin Kanri is also implemented to develop strategic planning for efficient utilising raw materials. These findings highlight that the mechanism of environmental performance and management reviews mentioned by the informants of the three organisations closely match with the findings of the preliminary study. A summary of implementation of lean and ISO 14001 as a combined approach from the three cases is presented in Table 8.16.

Table 8.16: Summary of implementation of lean and ISO 14001 as a combined approach from the three cases and preliminary study

Implementation of lean and ISO 14001	Preliminary study	Main study (multi-case studies in the meat processing companies)		
	Lean and ISO 14001 consultants	Alpha	Beta	Gamma
Integrated lean and ISO 14001 environmental policy	☑	☑	☑	☑
Integrated plan and projects of lean and ISO 14001 implementation	☑	☑	☑	☑
Communication and information sharing	☑	☑	☑	☑
ISO 14001 procedures	☑	☑	☑	☑
Lean tools	☑	☑	☑	☑
Competencies, awareness and training of the workforce	☑	☑	☑	☑
Environmental performance evaluation	☑	☑	☑	☑
Environmental management review	☑	☑	☑	☑

Notes: ☑ = Realised; ● = Partially realised; ☒ = Not realised

In answering the second part of the second research question, the findings from this study reveals how lean and ISO 14001 implementation strategies complement each other for improving environmental performance. Informants of this study suggested that an integrated lean and ISO 14001 environmental policy leads to better results in improving environmental performance instead of individual lean and ISO 14001 policies. Further, this study revealed that ISO 14001 procedures provide a framework for better articulating environmental objectives, targets and policy; where lean contributes little in providing such a structure or defining the integrated lean and ISO 14001 environmental policy. However, lean provides the tools for implementing and executing the environmental policy, therefore both these strategies complement each other in achieving the organizational objectives.

The findings from the preliminary study and the main study also highlighted that much of the internal communication (ISO 14001 procedure) is implemented using the lean tool visual management via visual TV screens for better managing the internal information sharing. However, for external communication (ISO 14001 procedure) there are no lean tools for cascading the information, and mostly email correspondence is used. This again showcases the nature of support these strategies provide each other.

The informants of the cases agreed with the findings of the preliminary study that monitoring, measurement and audits of environmental performance provide clear guidelines for conducting

environmental management reviews (ISO procedure). For instance, the informants of the cases and preliminary study highlighted that ISO 14001 environmental audits may include the review of implementing lean tools such as root cause analysis and 5S audit for determining the causes of non-conformities and proposing solutions to achieve better results. Further, the findings of this study indicate that ISO 14001 procedures provide robust structural monitoring and auditing mechanisms for conducting environmental performance evaluation and management reviews during the joint implementation of lean and ISO 14001.

8.8.3 CSFs for implementing lean and ISO 14001 as a combined approach

In answering the third question, this study identified several CSFs for implementing lean and ISO 14001 as a combined approach in the meat industry. The findings highlight that the CSFs mentioned by the informants of the three cases closely match with the CSFs cited in the preliminary study. For instance, both the main study and preliminary study informants cited CSFs such as top management commitment, awareness programmes and training initiatives, communication, sustainability-oriented culture and engagement of the workforce for a joint lean and ISO 14001 implementation. Further, these factors are consistent with the study results of Habidin et al. (2018) and Puvanasvaran et al. (2014), who also identified these factors for a joint lean and ISO 14001 implementation. A summary of the findings for CSFs for implementing lean and ISO 14001 together in the cases and preliminary study are compared and presented in Table 8.17. Such a comprehensive list of CSFs for implementing lean and ISO 14001 together has not previously been presented based on multiple case study organisations' and consultants' perspective.

Table 8.17: Summary of CSFs for implementing lean and ISO 14001 together in the cases and preliminary study

SN	Critical success factors for implementing lean and ISO 14001 as a combined approach	Preliminary study	Main study (multi-case studies in the meat processing companies)		
		Lean and ISO 14001 consultants	Alpha	Beta	Gamma
1	Top management commitment	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
2	Awareness programmes and training initiatives	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
3	Availability of resources (financial and technical)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4	Introduction of the latest technological trends	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5	Sustainability-oriented culture	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
6	Engagement of the workforce	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
7	Communication	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
8	Availability of data	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
9	Government financial grants	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Notes: = Identified; = Not identified

The findings of all the three cases suggested that government financial grants plays a pivotal role in providing support to better assist these organisations in achieving the environmental targets of continuous improvement projects (i.e., a joint implementation of lean and ISO 14001). However, this aspect was not revealed in the preliminary study. This can be attributed to the limited access of consultants regarding the availability of government grants for aiding the actual implementation of lean and ISO 14001.

8.9 Summary of research questions and units of analysis

The findings of this study established a relationship between units of analysis and research questions to achieve the objectives of the current investigation. For instance, the first unit of analysis (environmental performance and waste reduction outcomes) has guided to answer the first research question. The first research question (how lean and ISO 14001 implementation strategies as a combined approach contribute to environmental performance in the meat industry) is answered through the sections 4.6.1, 8.2 and 8.5. The second unit of analysis has guided this study to answer the first part of the second research question (how can lean and ISO 14001 strategies be implemented together in the meat industry) as is evident in the sections 4.6.2, 8.3.1 to 8.3.8 and 8.6. Further, the findings of this study indicate that lean and ISO 14001 as a combined approach complements each other for improving environmental performance and is answered through the third unit of analysis as indicated in sections 4.6.2 and 8.6. Furthermore, the fourth unit of analysis has guided the researcher to evaluate the CSFs for implementing lean and ISO 14001 as a combined approach in the meat industry (as evidenced in sections 4.6.3, 8.4 and 8.7). A summary of reference headings, units of analysis and research questions are presented in Table 8.18.

Table 8.18: Summary of reference headings, units of analysis and research questions

Reference headings	Units of analysis	Research questions
4.6.1, 8.2 and 8.5	Environmental performance and waste reduction outcomes	Research question 1: How do lean and ISO 14001 implementation strategies as a combined approach contribute to environmental performance in the meat industry?
4.6.2, 8.3.1 to 8.3.8 and 8.6	Lean practices and ISO 14001 procedures implemented as a combined strategy	Research questions 2 (i): How can lean and ISO 14001 strategies be implemented together in the meat industry?
4.6.2 and 8.6	How lean and ISO 14001 complement each other for environmental performance.	Research questions 2 (ii): How do these strategies complement each other for improving environmental performance?
4.6.3, 8.4 and 8.7	CSFs for a combined lean and ISO 14001 approach for environmental performance.	Research questions 3: What are the critical success factors for implementing lean and ISO 14001 as a combined approach in the meat industry?

8.10 Revised models of lean and ISO 14001 implementation strategies as a combined approach for improving environmental performance

A conceptual model and an NRBV-based model of lean and ISO 14001 implementation as a combined approach for improving environmental performance, developed in Chapter 2 (Figures 2.3 and 2.4), have guided this research study. A paucity of literature exists on lean and ISO 14001 implementation as a combined approach for improving environmental performance (e.g., Puvanasvaran et al., 2014; Souza & Alves, 2018; Vasconcelos et al., 2019). Further, none of the previous studies have integrated organisational theories with lean and ISO 14001 implementation jointly for improving environmental performance. The empirical evidence is lacking on lean and ISO 14001 implementation as a combined approach in the previous studies. The empirical findings based on semi-structured interviews from this study are included in a revised model for lean and ISO 14001 implementation for improving environmental performance (shown in Figure 8.1).

Further, the current study presents lean and ISO 14001 implementation as a combined approach based on the competencies (e.g., strategic planning and human) and capabilities (e.g., pollution prevention and sustainable development) under the NRBV lens in a revised model (Figure 8.2). These revised models (Figures 8.1 and 8.2) include the findings of the preliminary study (lean and ISO 14001 consultants) and the main study in the meat industry, which is considered as a highly environmentally polluting sector within the manufacturing industry. Consequently, it can be argued that these revised models of this study are generic in nature exploring novel insights for implementing lean and ISO 14001 as a combined approach for better improving environmental performance. Thus, manufacturing organisations confronting similar environmental issues can take guidance from these revised models for implementing lean and ISO 14001 jointly for improving environmental performance.

8.10.1 Revised model for an integrated lean and ISO 14001 implementation for environmental performance

This study suggested that an integrated policy based on waste minimization and environmental targets helps in achieving better environmental performance and business excellence. Policy, goals and objectives around parameters (i.e., minimisation of wastewater, GHG emissions and packaging waste) provide structural guidelines in implementing lean and ISO 14001 jointly. These aspects of lean of ISO 14001 environmental policy are consistent with the findings of the previous

literature (i.e., Johnson Dana et al., 2007; Souza & Alves, 2018; Vasconcelos et al., 2019). Further, Salleh et al. (2015) have emphasised that a combined lean and ISO 14001 environmental policy provides a driving force to satisfy customers, comply with regulatory requirements and streamline value stream activities, which is consistent with the findings of this study. Moreover, an integrated lean and ISO 14001 environmental policy is derived from environmental and operational targets to enhance the organisational strategic competencies. From a joint lean and ISO 14001 implementation perspective, lean and ISO 14001 environmental policy is depicted separately in Figure 2.3; however, a joint policy deployment of both strategies is included in the revised model (for more details, see Figure 8.1).

This study emphasises that an integrated policy of lean and ISO 14001 implementation must be cascaded down to all levels through an effective communication channel. An outline for internal and external communication between different organisational stakeholders for achieving policy, objectives and targets as an integrated management initiative is developed, which is also emphasised in the findings of a previous study by Kruse et al. (2019). This study revealed that a joint implementation plan provides more clarity in aligning ISO 14001 operational procedures with lean tools for enhanced environmental performance outcomes. The tool provides clear guidelines, continual feedback and information to the teams on their current performance and future improvement initiatives (Eaidgah et al., 2016). This study also revealed that visual management (i.e., digital screens) aligned with ISO 14001 procedures (internal communication, clauses 7.4.1) helps in sharing information more transparently with relevant internal stakeholders for reducing waste and improving resources utilisation. On the other hand, external information is also maintained through ISO 14001 procedure (e.g., external communication) only. These aspects are aligned with the previous literature (e.g., Chiarini, 2011; Souza & Alves, 2018).

Lean tools and ISO 14001 procedures together can holistically assist in implementing, monitoring and evaluating environmental plans and projects. This study has validated the applicability of essential lean tools (i.e., e-VSM, JIT, TPM, Kaizen, standardised work, 5S, SMED, Kanban and automation) for improving operational and environmental performance. These aspects are aligned with the previous literature (e.g., Belekoukias et al., 2014; Cherrafi et al., 2016; Dieste et al., 2020; Farrukh et al., 2022). For instance, the findings of this study revealed that 5S is considered as a basic lean tool in making an organisation neat and standardised for reducing environmental waste (i.e., reduction of chemical spillage and wastewater). Further, it also helps in

reducing workplace issues (e.g., reduction of wastewater and chemical spillage), improving product quality (i.e., reduction of product safety issues) and reduction of air emissions (e.g., removal of PM₁₀ and CH₄). Further, this study also revealed that standardised work enables a processing facility to maintain the best measurable operational practices for mitigating the workplace accidents, improving environmental safety and enhancing wastewater management.

The informants of this study suggested additional lean tools such as Hoshin Kanri, root cause analysis (i.e., A3 thinking, 5-whys and fishbone diagram), Andon signal, KPI benchmark, JIT with buffer, Gemba walk, 5S+safety and visual management for achieving better operational and environmental performance. These additional lean tools are incorporated in the revised model to achieve better environmental performance as depicted in the revised model. For instance, the findings of this study revealed that Hoshin Kanri with data driven forecasting system is considered as a basic lean tool to track and forecast the utilisation of raw material (raw carcasses). Further, the findings of this study reported that root cause analysis, as a structural problem-solving tool, helps to evaluate the reasons (e.g., excessive wastewater and air emissions) and propose solutions to improve the product quality and customer satisfaction. This study described the comprehensive application of lean tools for better improving environmental performance (for more details see sections 4.4.5, 4.6.2, 5.4.5, 6.4.5, 7.4.5, 8.3.5, and 8.6).

This study confirms that training and implementation awareness programmes are necessary for creating the skills and competencies of the workforce for enhancing operational efficiencies and environmental performance. Therefore, this aspect is included in the implementation phase of the revised model. The lack of knowledge in the installation of new technologies, lean tools and environmental practices are improved through employee training programmes, which are also linked with the findings of Alefari et al. (2017). The findings of this study suggested that an integrated performance evaluation of lean and ISO 14001 is used for verifying conformance status and suggested corrective actions. For instance, data analysis of VSM, root cause analysis and A3 thinking are utilised to determine the reasons for excessive waste (i.e., wastewater, sludge and GHG emissions). On the other hand, ISO 14001 operational procedure (e.g., corrective and preventive actions) is used to mitigate non-conformities in the preliminary and case studies. Further, corrective actions and suggestions on the basis of the audit programme are also proposed for improving product quality, lowering operational expenses and increasing customer satisfaction (Lenning & Gremyr, 2017). This study reveals that management reviews are conducted to evaluate

the current performance around integrated policy targets (i.e., wastewater, GHG emissions and energy consumption) and recommends future process improvements for processing environmentally friendly products. The integrated improvement programme can be strengthened by including criteria parameters and procedures for monitoring and measuring through process evaluation in the “act” phase of PDCA. The revised conceptual framework of lean and ISO 14001 implementation as a combined approach for improving environmental performance based on the findings is presented in Figure 8.1.

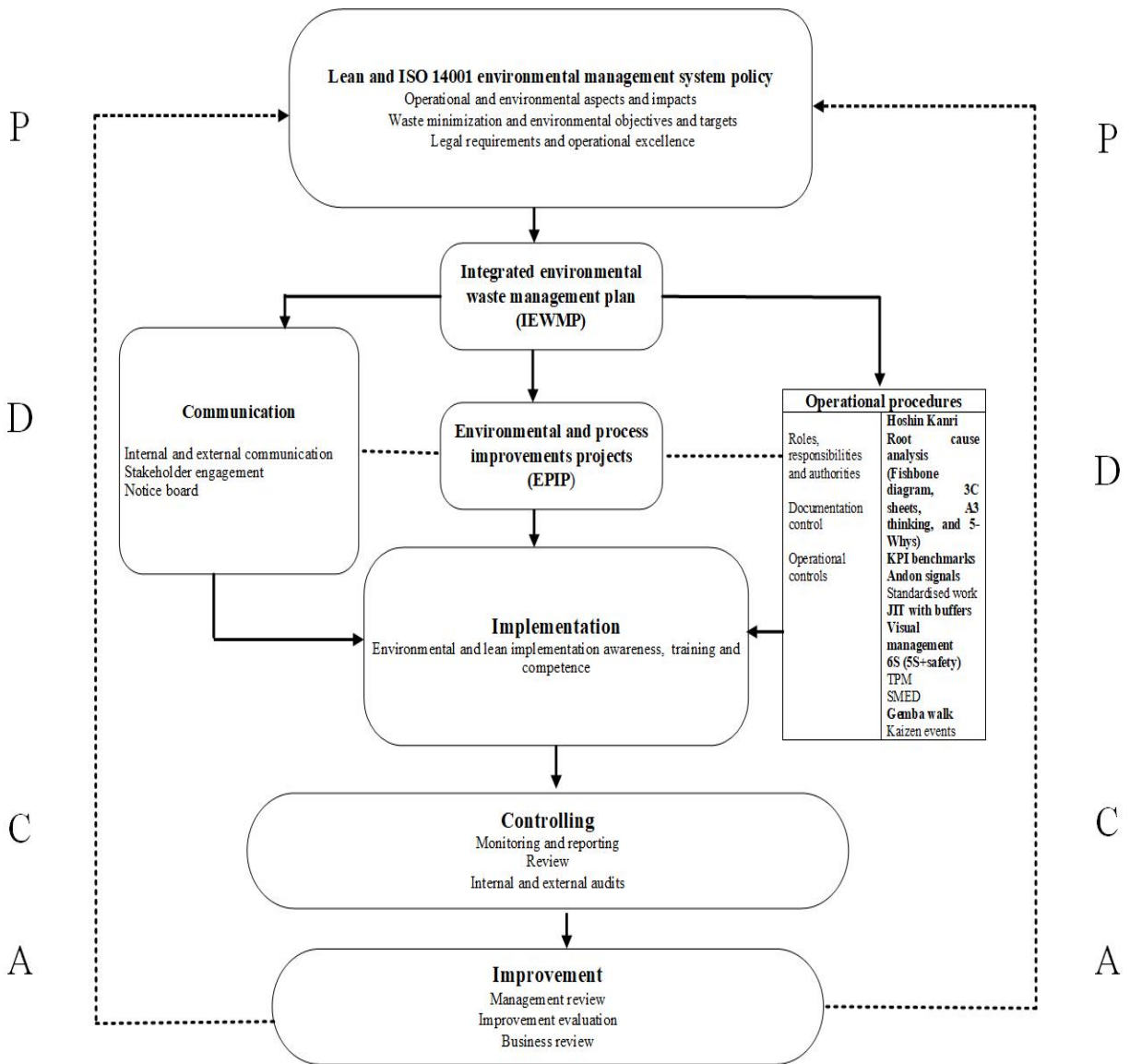


Figure 8.1: Revised model for an integrated lean and ISO 14001 implementation for environmental performance in the manufacturing industry.

8.10.2 Revised NRBV-based model of lean and ISO 14001 implementation strategies for environmental performance

The findings from this study have revealed that based on the improved competencies by implementing lean and ISO 14001 together leads to improvement in the capabilities (i.e., pollution prevention, product stewardship and sustainable development) under the NRBV lens. The following sections provide a discussion on these aspects.

8.10.2.1 Pollution prevention by implementing lean and ISO 14001 as a combined approach

This study has indicated that lean and ISO 14001 implementation together achieves pollution prevention parameters (i.e., reduction of wastewater, GHG emissions, sludge, solid waste, packaging waste, chemical handling issues, heat losses and safety issues) more efficiently. The study reveals that lean tools (e.g., root cause analysis, VSM, Kaizen events) and ISO 14001 procedures (e.g., environmental policy and corrective actions) are implemented together to better achieve waste to landfill KPI target. For instance, lean tools (e.g., root cause analysis, VSM and Kaizen events) and ISO 14001 procedures (e.g., preventive and corrective actions) can jointly identify the causes for excessive waste to landfill (e.g., sludge and bones) and propose solutions for mitigation.

The informants of this study revealed that chemical handling is included as a critical aspect in the lean and ISO 14001 environmental policy. For instance, data analysis of VSM is utilised to determine the reasons for chemical spillage and handling issues. Further, a suite of lean tools (e.g., 5S, visual management and TPM) and ISO 14001 procedures (e.g., environmental policy and corrective actions) are implemented for cleaning the floors, reducing the spillage of chemical substances and identifying chemical storage points. Further, other pollution prevention parameters (i.e., reduction of wastewater, GHG emissions, sludge, solid waste, packaging waste, heat losses and safety issues) are thoroughly explained in the earlier discussions (see details in 8.2, 8.5 and 8.8.1).

8.10.2.2 Product stewardship by implementing lean and ISO 14001 as a combined approach

Building on the capabilities of the NRBV, product stewardship parameters (i.e., efficient water usage, energy consumption and recycling of resources) are achieved by implementing both strategies as evidenced in this study. For instance, the informants identified that data analysis of

management review meetings and VSM is used to set the KPI targets around extra water consumption (development of the strategic planning). Implementation awareness and training programmes (if required) (i.e., human competence under the NRBV) are carried out to enhance the competencies of the workforce for reducing water usage. Further, this study also reveals that procedural competence (i.e., environmental performance evaluation and management review) are used to determine the causes of inefficient water usage and propose future optimisation opportunities (i.e., preventive and corrective actions).

The findings suggested that integrated lean and ISO 14001 environmental policy helps to achieve electricity savings target (i.e., refrigeration, air compression and motors). For instance, efficient electricity usage for cleaning, chilling and freezing of products is critical in the energy and resource intensive processing facilities. Lean tools (e.g., 5S and TPM) and ISO 14001 procedures (i.e., environmental policy, document control and environmental management review) as a joint implementation helps to improve electricity usage in different phases of processing activities. For instance, energy consumption is reduced by introducing low voltage processing equipment and ensuring the proactive maintenance through the application of TPM. Further, the electricity consumption is also reduced by using recycled water for cleaning equipment and washing floors. Lean and ISO 14001 implementation as a combined approach is used to achieve product stewardship by introducing renewable resources. For instance, this study indicated that reduction of air emission targets (a part of lean and ISO 14001 environmental policy as strategic planning competence) are better achieved by introducing renewable sources (i.e., biomass, electrode boilers and latest heat pumps). Further, dry organic sludge is recommended to use as a renewable fuel source for producing high calorific value. Additionally, dry sludge is also used as renewable raw material for fertiliser manufacturing (a proposed solution as corrective action to utilise the solid waste).

8.10.2.3 Sustainable development by implementing lean and ISO 14001 as a combined approach

The informants of this study reported that the sustainable development parameters (i.e., sustained employee health and safety, environmental awareness and consumption of resources) are effectively achieved by implementing lean and ISO 14001 together. For instance, the findings reveal that sustained employee health and safety (i.e., sustainability development under the NRBV capabilities) is achieved by implementing lean and ISO 14001 jointly. KPI targets around health

and safety (e.g., creating an accident-free workplace) are considered critical aspects in an integrated lean and ISO 14001 environmental policy (i.e., strategic planning competence). Efficient information sharing (organisational competence) through visual management is used to enhance the competencies of the workforce for better handling hazardous material, avoiding workplace accidents and implementing safety SOPs. Further, implementation awareness (e.g., handling of raw material and identification of causes for accidents) and conducting training (i.e., health and safety management) programmes are used to help the organisations for mitigating the workplace accidents. Further, this study also reveals that lean tools (i.e., 6S, TPM and standardised work instructions) and ISO 14001 operational control (i.e., emergency preparedness and response) are implemented to better achieve health and safety targets. For instance, 6S is used for identifying the hazards, minimising mishandling issues and enhancing environmental safety (by implementing ‘clean, shine and sustain’, a pillar of 5S). Further, TPM is also implemented to ensure equipment safety by avoiding the safety hazards of heavy processing machinery. Safety of the workforce is further ensured by implementing ISO 14001 emergency preparedness procedures and following the standardised work instructions (i.e., wearing PPE, waterproof aprons and gumboots).

The findings of this study revealed that environmental awareness enhances amongst the workforce and the relevant external stakeholders (i.e., customers, contractors and suppliers) by implementing lean and ISO 14001 as a combined approach. Environmental awareness is considered as parameter of sustainability development under the NRBV lens to implement a combined lean and environmental improvement initiative (Farrukh et al., 2021a). For instance, this study reveals that environmental awareness is maintained by cascading the integrated lean and ISO 14001 environmental policy (e.g., environmental targets via visual boards, KPI records and VSM data). Further, the informants reported that highest environmental awareness level helps the organisations to achieve better compliance status around governmental legislations and consent requirements (e.g., quality and environmental assurance). On the other, the findings also reveal that environmental awareness is improved amongst the external stakeholders (e.g., suppliers and contractors) through external communication (ISO 14001 procedure) and induction training (human competence under the NRBV) to better understand the environmental and safety instructions.

This study revealed that a continuous improvement culture based on lean and ISO 14001 approach helps to develop a combined environmental policy, communication and environmental

management review for better achieving sustainable development parameters. This aspect is consistent with the findings of Farrukh et al. (2021a) and Garza-Reyes et al. (2018), who reported that continuous improvement of processes are linked with the sustainable development. For instance, lean tools (i.e., VSM, benchmarking targets and 5S) and ISO 14001 (i.e., environmental policy, document control and environmental management review) together are implemented to better reduce environmental targets on an ongoing basis. Further, continuous monitoring, reviewing and auditing (e.g., procedural competence) is carried out to identify gaps and opportunities in a lean and ISO 14001 joint implementation. The findings of continuous improvement projects (the application of ISO 14001 framework and lean tools) are suggested to reduce decarbonation, wastewater and sludge in the resource intensive process facilities.

Additionally, the findings of this study revealed that lean and ISO 14001 implementation together helps in sustaining consumption of resources (i.e., raw materials, biodegradable packaging and efficient usage of water). The risk assessment (non-mandatory procedure of ISO 14001) helps in identifying risks associated with consumption of resources (i.e., raw carcasses, packaging materials and water use) and proposing solutions for mitigating the high-risks activities. Moreover, data analysis of VSM is used to determine the current status and propose future mapping for efficient utilisation of resources (i.e., raw carcasses, water and packaging material). For instance, the application of 5S for cleanliness management helped to ensure optimal storage of raw carcasses and finished meat products for improving product sustainability and shelf life. Furthermore, precautionary measures are introduced based on root cause analysis and KPI benchmarks to reduce non-conformities around raw materials, water and packaging material consumption. More interestingly, Hoshin Kanri with the data-driven forecasting is used to better extract the protein content (sustainable raw carcasses usage) through statistical prediction. Records and documentation (i.e., ISO 14001 procedural control) around raw carcasses are maintained to monitor and measure compliance for setting future optimisation targets in the revised policy.

Additionally, non-conformance of water consumption is also determined (by implementing root cause analysis) and improved through preventive and proactive actions (i.e., introduction of latest flow meters, efficient management of water valves and adjustment of washing angles) in the different processing activities. Further, a suite of lean tools (i.e., VSM, 5S, Kaizen events and TPM) are employed as proactive measures for improving water consumption, fixing water leakages and better managing water saving initiatives. Furthermore, water usage is also sustained

by replacing hot water with the state-of-the-art UV steriliser (an optimisation initiative to achieve the KPI target around water use) for cleaning and improving hygiene of the equipment. A revised model for the NRBV capabilities and competencies of lean and ISO 14001 implementation strategies for environmental performance based on all cases is presented in Figure 8.2.

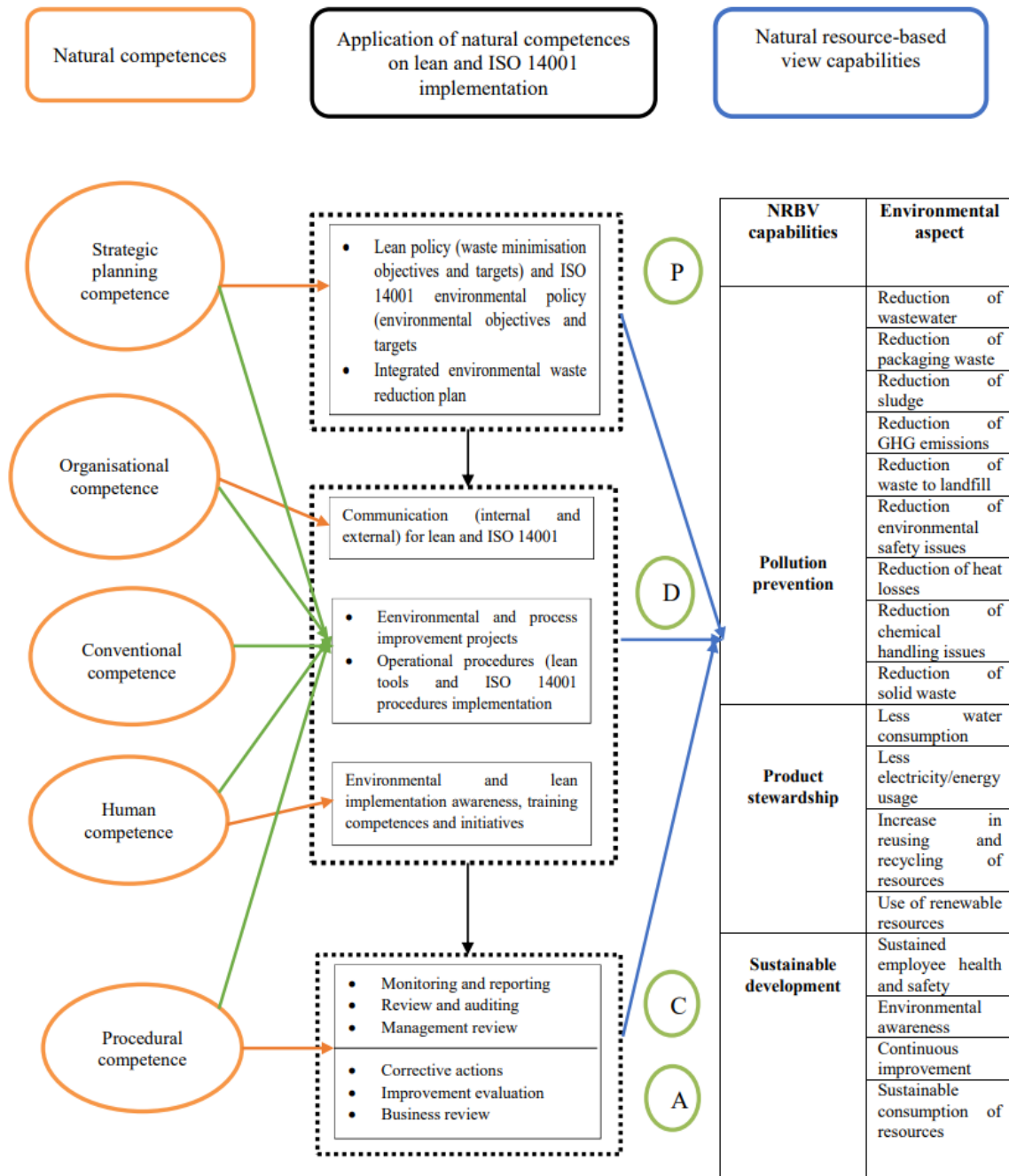


Figure 8.2: Revised NRBV-based model of lean and ISO 14001 implementation strategies for environmental performance in the manufacturing industry

8.11 Conclusion

This chapter discussed the empirical evidence, within and cross-case analyses of the three case studies, and comparison of the cases with the preliminary study on lean and ISO 14001 implementation for improving environmental performance. Further, this study also explained the potential synergies (i.e., integrated lean and ISO 14001 environmental policy, communication and documentation control) for better improving environmental performance. The CSFs for implementing lean and ISO 14001 as a combined approach were determined based on the findings of this study. Furthermore, building on the competencies and capabilities of the NRBV, lean and ISO 14001 implementation strategies for improving environmental performance were presented in this chapter. A revised model for an integrated lean and ISO 14001 implementation and an NRBV-based revised model of lean and ISO 14001 implementation strategies in the manufacturing industry for improving environmental performance were presented. The next chapter 9 presents the conclusion, implications and future research directions of this study.

Chapter 9 – Conclusion, Implications and Future Research Directions

This study explored the implementation of lean and ISO 14001 as a combined approach for improving environmental performance in the meat processing facilities. This chapter is organised as follows. First, an overview of the study is presented. The next section presents the key findings on lean and ISO 14001 implementation as a combined approach for an improved environmental performance and the CSFs for a joint implementation strategy in the meat processing facilities. The theoretical, practical and policy implications are explained. Finally, the limitations and future directions are provided.

9.1 Overview of the study

The purpose of this study was to evaluate the lean and ISO 14001 implementation strategies as a combined approach for improving environmental performance in the meat industry. Further, CSFs were also determined for successful implementation of a combined lean and ISO 14001 approach in the meat industry. To achieve this, the current study attempted to answer the following research questions.

1. How do lean and ISO 14001 implementation strategies as a combined approach contribute to environmental performance in the meat industry?
2. How can lean and ISO 14001 strategies be implemented together in the meat industry and how do these strategies complement each other for improving environmental performance?
3. What are the critical success factors for implementing lean and ISO 14001 as a combined approach in the meat industry?

The exploratory nature of the research questions and scant empirical evidence on lean and ISO 14001 implementation made it appropriate to use qualitative research methodology to address the research questions. A qualitative exploratory case study design (semi-structured interviews) was utilised in the main study to explore the lean and ISO 14001 implementation strategies as a combined approach for improving environmental performance. The sample for this study (two companies in NZ and one in Ireland) includes only those meat processing groups known for their commitment to implementing lean and ISO 14001 for improving environmental performance. Triangulation in this study was achieved through a combination of primary data (semi-structured interviews) and secondary sources of data (environmental management manuals, organisational reports on environmental and sustainability, and websites). The competencies (e.g., strategic

planning and human) and capabilities (e.g., pollution prevention and product stewardship) of the NRBV have been used as an organisational theory to examine the lean and ISO 14001 implementation together for better improving environmental performance. Furthermore, this study also determined the CSFs for efficient implementation of lean and ISO 14001 as a combined approach in the meat industry. The overall key research findings are briefly summarised in section 9.2.

9.2 Overall key research findings

The study revealed that strategic vision of the organisations in the meat industry motivates them to develop continuous improvement projects based on lean and ISO 14001 for better achieving environmental performance by mainly reducing wastewater generation, air emissions, sludge content, packaging waste and health and safety issues. This study suggests that lean tools (e.g., root cause analysis, VSM, 3C, Kaizen events, 5S, TPM and standardised work instructions) and ISO 14001 procedures (e.g., environmental policy, environmental audit, corrective actions and environmental management review) are implemented together to better achieve environmental performance. There are numerous examples in answering the first research question - how lean and ISO 14001 as a combined approach contribute to environmental performance in the meat industry. The findings reveal that optimisation project on wastewater was carried out in all the case companies to reduce excessive wastewater by utilising the ISO 14001 procedures (e.g., environmental audit and/or corrective actions) and lean tools (e.g., root cause analysis and/or VSM). The analyses of internal environmental audits, VSM and root causes helped to identify the causes of wastewater. Further, corrective and preventive actions were implemented for mitigation of excessive wastewater.

This study also highlights that implementation of lean tools (e.g., fishbone diagram and A3 thinking) and ISO 14001 procedures (e.g., environmental policy and corrective actions) are implemented together to reduce air emissions. For instance, fishbone diagram was used to minimise PM10 and improve air quality at Alpha. Furthermore, A3 thinking was implemented to identify and propose solutions for CH₄ generation to achieve prime SBTi targets at Gamma.

The findings highlighted that data analysis of lean tools (e.g., A3 thinking, Kaizen events, VSM, 3C and 5-Whys) and ISO 14001 procedures (e.g., environmental monitoring records and corrective actions) helps to identify and reduce the causes of sludge content (i.e., excessive E. coli, COD and

BOD). For instance, A3 thinking was used to identify the causes of excessive E. coli and listeria generation at Alpha. Lean tools (i.e., Kaizen events and A3 thinking) and ISO 14001 procedure (corrective actions) were implemented jointly for minimising excessive sludge component. Further, analyses of VSM and records of ISO 14001 procedures were utilised to identify the reasons for excessive sludge (i.e., COD, TSS and BOD) at Gamma. Furthermore, a suite of lean tools (e.g., 3C and 5-Whys) was implemented to reduce excessive sludge content. Additionally, top management also proposed to use dry sludge as an alternative fuel source in the coal-fired boilers for generating electricity and steam. This study highlights that lean tools (e.g., VSM, 5S and TPM) and ISO 14001 procedures (e.g., environmental audit and records) are implemented together to identify the bottlenecks of packaging usage and propose solutions for reducing plastic waste. For instance, the findings reveal that packaging waste was included as a major KPI target in the integrated lean and ISO 14001 policy at Alpha. Further, analyses of internal environmental audits and VSM data were used to determine the potential packaging irregularities and propose mitigation. Additionally, causes of packaging waste were evaluated through root cause analysis and minimised 70% of packaging waste at Beta. Furthermore, a suite of lean tools (e.g., 5S and TPM) were implemented to reduce the malfunctioning of packaging machines at Gamma. Additionally, this study has revealed that a combined lean and ISO 14001 implementation helps to develop a safety culture in the resource intensive meat processing facilities. For instance, lean tools (i.e., fishbone diagram, 5S+safety, 5-Whys and TPM) and ISO 14001 procedures (e.g., environmental risk assessment) were implemented together to mitigate wastewater spillage, decrease MSD issues and minimise workplace accidents at Alpha. Further, standardised work instructions (e.g., safety instructions) and training initiatives (e.g., chemical handling and wearing PPE) were also used to promote a safety culture (a workplace free of occupational accidents) at Beta. Furthermore, lean tools (e.g., 5-Whys, 5S and TPM) and ISO 14001 procedure (e.g., corrective actions) were implemented to avoid the workforce accidents, wastewater spillage and chemical mishandling at Gamma.

In answering the first part of the second research question, the findings from this study have highlighted how the application of lean and ISO 14001 implementation strategies together improve environmental performance and potential synergies between these management initiatives. study reveals that an integrated lean and ISO 14001 environmental policy and environmental waste reduction plan help to develop better strategic planning competence for improving environmental

performance. This study suggests that the ISO 14001 framework provides a more robust structure in developing an integrated lean and ISO 14001 environmental policy for achieving environmental targets efficiently. From an organisational competence perspective, this study has highlighted that information sharing internally (e.g., regular meetings and notifications of environmental performance status) is maintained through the lean tool visual management and ISO 14001 procedure internal communication. However, external communication with the external stakeholders (i.e., overseas customers, environmental groups and local community) is maintained by ISO 14001 procedure external communication only. For human competence, the findings highlight that competencies of the workforces, implementation awareness and training initiatives based on both lean and environmental practices help to better implement combined improvement projects. Environmental performance evaluation and management reviews as part of procedural competence help to evaluate the environmental performance and propose future optimisation opportunities for enhancing the capabilities of the organisation (i.e., reduction of wastewater, introduction of recycling and consumption of resources). This study highlights that ISO 14001 procedures (i.e., environmental performance evaluation and management review) provide more structural monitoring and auditing mechanisms in the joint implementation of lean and ISO 14001. In answering the second part of the second research question, this study reveals that articulation of a combined lean and ISO 14001 environmental policy provides guidelines for better achieving environmental targets. For instance, this study highlighted that ISO 14001 provides a structural framework for formulating environmental policy based on the previous environmental reports and outcomes of management review meetings. On the other hand, lean tools (e.g., VSM and Hoshin Kanri with forecasting system) help to evaluate environmental performance parameters, set strategic targets and implement the operational processes. However, the findings suggested that lean strategy fails to provide a structural framework and contributes little in articulating lean and ISO 14001 environmental policy. Therefore, both these strategies complement each other in achieving the organizational environmental goals.

The findings highlight that visual management (a lean tool) and internal communication (ISO 14001 procedure) are implemented together to better cascade the information around operational, safety and environmental performance parameters internally. Conversely, this study also suggests that external communication (ISO 14001 procedure) is only responsible for maintaining external information sharing with the relevant external stakeholders (e.g., suppliers and overseas

customers) during a joint lean and ISO 14001 implementation. The findings highlight that monitoring, measurement and audit mechanisms are used to evaluate the environmental performance (environmental management reviews). Analyses of lean tools (e.g., VSM and 5S audits) and ISO 14001 procedures (e.g., environmental policy and audits) are used to evaluate the non-conformities (e.g., GHG emissions and sludge) and propose recommendations for mitigation. The findings revealed that ISO 14001 procedures provide robust monitoring and auditing mechanisms during a joint lean and ISO 14001 implementation. However, lean provides the tools for achieving the organizational environmental targets based on the outcomes of the environmental management reviews in a combined lean and ISO 14001 implementation. In answering the third research question, the findings of this study have highlighted several CSFs for implementing lean and ISO 14001 as a combined approach for improving environmental performance. The empirical findings indicate that top management commitment is the most pivotal aspect for developing lean and ISO environmental policy (i.e., setting objectives and targets) and providing financial support (i.e., initiating external training for implementing lean and environmental practices). Further, lean and ISO 14001 is successfully implemented through conducting appropriate awareness and training programmes to develop a sustainability-oriented culture. Based on these findings, the external training initiatives are recognised as an important success factor to better implement lean and environmental practices in processing environmentally friendly products. This study further explained the importance of the latest technological trends and governmental financial assistance to adopt the most up-to-date software packages and equipment and introduce renewable fuels for better maintaining the environmental records, reducing resource usage and minimising air emissions. Further, this study also reveals that a comprehensive and combined communication (vertical and horizontal) is an integral factor for successful monitoring operational and environmental targets in a joint lean and ISO 14001 implementation. Furthermore, the findings highlight that engagement of the workforce (competence, empowerment and appraisal) is of immense importance for successful implementation of lean and ISO 14001 as a combined approach.

9.3 Implications of the study

The theoretical, managerial, consultants and policy-makers implications of this study are presented as follows:

9.3.1 Theoretical implications

This study contributes to lean and ISO 14001 implementation as a combined approach for improving environmental performance from a theoretical perspective in several ways. First, it is argued that this study is one of the first evaluations of lean and ISO 14001 implementation as a combined approach for improving environmental performance. The prior studies have focused on individual lean and ISO 14001 implementations for improving operational optimisation in the meat industry and mostly ignored the environmental performance perspective. The current study is timely as it provides an understanding of combining lean and ISO 14001 implementation strategies for improving environmental performance. Second, this study has highlighted the critical success factors for implementing lean and ISO 14001 as a combined approach in the meat industry. These factors provide novel insights and adds significant knowledge regarding the critical aspects to implement lean and ISO 14001 jointly, these CSFs were lacking in the previous literature. Third, this study has highlighted that lean tools such as root cause analysis, JIT with buffer setting, TPM, SMED and visual management are used in addressing environmental performance in the meat industry, which was lacking in the previous studies as most of the prior studies have addressed these tools from operational perspective only. Fourth, this study uses a qualitative research design, hence adding significant in-depth insights and knowledge for lean and ISO 14001 as a combined implementation strategy to achieve greater environmental performance. This study is conducted (via semi-structured interviews) with the consultants and senior managers, who are experts in implementing lean and ISO 14001, to understand their perspective and gain knowledge on a joint implementation of these strategies for better improving environmental performance. The previous studies mostly focused on literature review (Souza & Alves, 2018) and quantitative survey designs (e.g., Habidin et al., 2018; Salleh et al., 2015; Wirkus & Chmielarz, 2018).

Fifth, another key theoretical contribution of this study is to examine the application and development of the competencies and capabilities using the NRBV lens for implementation of lean and ISO 14001 as a combined approach to achieve improved environmental performance. The use of NRBV competencies and capabilities as an organisational theory is limited within the lean and ISO 14001 literature; hence, this study provides an enriched theoretical foundation to implement both strategies together for improving environmental performance. The NRBV helped in better delineating the complex joint lean and ISO 14001 implementation and identifying thematic framing for analysing empirical findings. Combining the application and development of

competencies and capabilities of the NRBV with empirical findings contributes to enhancing the literature and body of knowledge on lean and ISO 14001 implementation for achieving optimal environmental performance. For instance, the competencies perspective of the NRBV has helped to examine the strategic planning (integrated lean and ISO 14001 environmental policy), organisational competence (communication), conventional competence (environmental and process improvement projects, and operational procedures), human competence (competencies, awareness and training) and procedural competence (audits, management reviews and improvement evaluations). Further, the NRBV capabilities such as pollution prevention (e.g., reduction of air emissions), product stewardship (e.g., recycling of wastewater) and sustainable development (e.g., sustainable resources consumption) provide a theoretical perspective and novel insights to overcome the environmental issues in energy intensive meat processing.

Finally, the development of lean and ISO 14001 models (Figures 8.1 and 8.2) for improving environmental performance add significant knowledge to lean and ISO 14001 implementation as a combined approach literature as these models provide a holistic view of this strategy.

9.3.2 Implications for managers, consultants and policymakers

The current study has implications for managers who plan to implement lean and ISO 14001 as a combined approach for improving environmental performance. First, this study provides a roadmap of lean and ISO 14001 strategy as a combined approach (Figures 8.1 and 8.2) for corporate managers to implement in their organisations. For instance, this study assists practitioners to develop a combined lean and ISO 14001 environmental policy, communication, and training programmes for achieving competencies (e.g., strategic, human and organisational competencies) to improve environmental performance. Further, this study provides valuable insight for managers regarding CSFs to implement lean and ISO 14001 together. Second, the findings of this study can highlight the top management's role in adopting lean and ISO 14001 as a combined approach for minimising GHG emissions, reducing wastewater, and introducing reuse and recycling initiatives as well as the latest equipment and technologies for improving organisational strategic capabilities (pollution prevention, product stewardship and sustainable development).

Third, the findings highlight that senior managers could adopt lean tools for improving emission control, waste management and resource conservation, and environmental safety and technology

to achieve organisational competitive advantage. For instance, this study indicates that emission control can be achieved by the application of root cause analysis (fishbone diagram and A3 thinking), VSM, 5S, standardised work and KPI benchmarking. Meanwhile, waste management and resource conservation can be enhanced through lean tools (as identified in the findings) such as root cause analysis (5-Whys), VSM, 5S, standardised work, JIT with buffer, visual control and TPM. Furthermore, environmental safety can be maintained by using root cause analysis (3C philosophy and 5-Whys), 6S (5S+safety), standardised work, JIT with buffer, TPM and Andon signal. Additionally, raw materials can be effectively utilised and productivity maximised in processing facilities by using Hoshin Kanri with a data-driven forecasting system.

Fourth, the results of this study can also help the managers to improve brand image by processing environmentally friendly products (i.e., zero carbon products) and sharing their commitment to promote carbon-neutral initiatives (i.e., developing laboratories to mitigate carbon footprints) with their relevant stakeholders and customers. Further, the managers can promote a culture of achieving environmental product stewardship by analysing the findings of this study to outline and manage an efficient communication system for improving resource consumption (water, energy and packaging material) and reducing GHG emissions, solid and hazardous material.

This study suggests significant implications for consultants of lean and ISO 14001 to implement as a combined approach for improving environmental performance. In the consultancy perspective, lean and ISO 14001 consultants implemented both of these strategies individually. Therefore, there is an acute need to establish a group of lean and ISO 14001 consultants to assist the manufacturing sector in implementing lean and ISO 14001 as a combined approach for environmental performance. The consultants can use lean tools (i.e., root cause analysis, VSM and standardised work) and ISO 14001 procedures (i.e., policy, corrective actions and management reviews) as a combined approach to improve environmental performance. The lean and ISO 14001 consultants can assist industrial managers and policymakers for implementing lean and ISO 14001 together for environmental outcomes.

The findings from this study can be used as a guide for the policymakers to implement lean and ISO 14001 as combined approach for improving environmental performance. The policymakers can develop a framework of lean and ISO 14001 implementation strategies by considering their environmental performance parameters (i.e., usage of resources such as water, energy and

packaging material). Further, this study can use a guide for the policymakers to reduce GHG emissions, mitigate plastic waste and recycle the wastewater sludge. Furthermore, the policymakers can benefit from the application of lean tools to improve environmental performance (i.e., reduction of GHG emissions, improved environmental safety and reduced contamination issues).

9.4 Challenges for implementation of lean and ISO 14001 as a combined approach

This section covers the potential challenges for any new organisation which shows an interest in implementing lean and ISO 14001 as a combined approach for improving environmental performance. Firstly, the informants of this study explained the detailed contribution of ISO 14001 environmental policy for developing a comprehensive integrated lean and ISO 14001 environmental policy. However, the informants indicated the limited application of Hoshin Kanri (a lean tool) as a foundation block for formulating an integrated strategic management initiative. Therefore, an organisation can face a challenge in developing a balanced integrated environmental policy based on lean and ISO 14001 attributes for achieving environmental performance.

Secondly, the findings of this study suggested that the frequency of combined performance evaluation of lean and ISO 14001 plays an important role in monitoring and evaluating environmental performance. However, this study indicated an ambiguity to decide about the suitable frequency of conducting the environmental performance evaluation. For instance, the informants determined three years to conduct an environmental audit for evaluating the compliance status of environmental parameters (as noted in Alpha). On the other hand, the findings from Beta and Gamma suggested a more frequent environmental performance evaluation (e.g., monthly, quarterly and annually) to better monitor, report and audit the compliance requirements of environmental targets. However, the ambiguous time framework for conducting, evaluating and reporting of environmental performance can pose a serious challenge for an organisation to implement lean and ISO 14001 as a combined approach.

Thirdly, this study indicated that manual (e.g., paper-based) and/or digital (e.g., Information Leader) documentation procedures help to collect and analyse the environmental data to implement an integrated lean and ISO 14001 approach. However, manual documentation is considered as waste in the lean manufacturing perceptive. On the other hand, documentation control is a critical procedure for ISO 14001 implementation. The centrally controlled digital

documentation can help an organisation for better managing set targets to implement continuous initiatives (e.g., lean and ISO 14001). However, the cost of a suite of digital infrastructure for digital documentation is high. Therefore, the installation of costly digital documentation infrastructure can be a challenge to maintain digital lean and ISO 14001 documentation control.

Fourthly, the evaluation mechanism to determine the contribution and recognition of the lean and ISO 14001 groups is a challenging factor for an organisation to implement lean and ISO 14001 as a combined approach. For instance, the lean group claimed that their contribution plays a critical role in implementing both strategies. On the other hand, the ISO 14001 lead auditors asserted that they contribute largely for successful implementation of lean and ISO 14001 together. Therefore, this factor can pose a challenge for an organisation to motivate both lean and ISO 14001 teams to establish their role and responsibilities for achieving better environmental outcomes by implementing lean and ISO 14001 as a combined approach.

9.5 Limitations of the study

This study provides valuable contribution and significant knowledge enhancement to implement lean and ISO 14001 together for achieving environmental performance in the meat industry. However, this section presents the limitations of the current study which must be acknowledged.

First, the meat chain involves management of various stages such as livestock farms, meat processing units, and transportation of meat products. The air emissions, wastes (organic and inorganic) and inefficient consumption of resources (e.g., energy and water) are reported in all phases of the meat chain. However, the current study is limited to meat processing facilities only for improving environmental performance by implementing lean and ISO 14001 as a combined approach.

Second, the case study design adopted in this research achieves analytical generalisation; however, this study lacks statistical generalisation for lean and ISO 14001 implementation strategies as a combined approach. Third, this study was conducted within the context of Ireland and NZ-based meat manufacturing industries only. However, the findings on the lean and ISO 14001 implementation could vary in other regions (developed and developing countries) due to the different social values, organisational culture and regulatory requirements.

Fourth, this study was conducted in the energy intensive meat processing facilities only. However, the implementation of lean and ISO 14001 could vary in other energy-based manufacturing facilities (e.g., chemicals, iron and steel, and cement) due to the varied nature of their technology and processes. Fifth, semi-structured interviews were conducted with consultants (lean and ISO 14001) and senior managers in the meat industry. However, the perspectives from policymakers, customers and suppliers were not included in the current study.

9.6 Future research directions

The following imminent guidelines to explore future research avenues are suggested based on the above limitations after analysing the findings of this study. First, since this study was conducted in the meat processing operations only. Therefore, future investigations can be carried out in the whole meat processing chain, and small and medium-sized meat slaughterhouses, which will bring more new insights into the application of lean and ISO 14001 implementation strategies together in overcoming environmental issues.

Second, future research could be conducted in other energy-intensive industries such as chemicals, food and beverages, and cement, which are also facing similar environmental sustainability issues as the meat industry. The future empirical findings of these investigations can help to encompass the validity of the study findings. Third, future research needs to be conducted using mixed-method (qualitative and quantitative) and quantitative research designs to explore the implementation of lean and ISO 14001 as a combined approach for improving environmental performance. These research approaches will assist in achieving statistical generalisability on the combined lean and ISO 14001 implementation strategy for improving environmental performance.

Fourth, cross-country lean and ISO 14001 projects can be initiated in other developed countries (for instance, the UK and USA) and developing countries (such as Turkey, Pakistan and Poland) for further generalisation of this study. Hence, future research could be conducted in other developed and developing countries to validate the findings of this study in diverse geographical contexts. Fifth, future studies could explore the role of stakeholders (i.e., overseas customers, suppliers and policymakers) for implementing lean and ISO 14001 together to improve environmental performance in other large processing and energy-intensive sectors.

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Appendices

Appendix A

Massey University Human Ethics Approval Letter



Date: 14 November 2019

Dear Aqeel Ahmed

Re: Ethics Notification - 4000021971 - **A Framework to Evaluate Effectiveness of ISO 14001 and Lean Implementation on Environmental Benefits in Meat Industry**

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** 06 350 5573; 06 350 5575 **F** 06 355 7973
E humanethics@massey.ac.nz **W** <http://humanethics.massey.ac.nz>

Appendix B



Information Sheet

A model to Evaluate Effectiveness of Lean and ISO 14001 Implementation on Environmental Benefits in the Meat Industry

Researcher: Aqeel Ahmed

Supervisors: Dr. Sanjay Mathrani (main) and Dr. Nihal Jayamaha (secondary)

Project description and invitation

As a PhD candidate at Massey University, Albany campus, New Zealand, I am conducting a research to evaluate the effectiveness of implementing environmental management system and lean on environmental benefits in the meat industry. The study investigates the environmental performance through the application of these two strategies and evaluates whether these strategies help in reducing or eliminating undesirable wastes. The study also identifies the potential synergies between these management initiatives and determines the critical success factors for their effective implementation.

This research contributes in presenting key practitioner and meat industry insights on the implementation of environmental management system and lean strategies for improvement of environmental performance as well as provides factors for their successful implementation in the meat industry. The main questions for this study are: How do lean and ISO 14001 implementation strategies as a combined approach contribute to environmental performance in the meat industry? How can lean and ISO 14001 strategies be implemented together in the meat industry and how do these strategies complement each other for improving environmental performance? and What are the critical success factors for implementing lean and ISO 14001 as a combined approach for environmental performance in the meat industry?

For the advancement of knowledge in implementation of environmental management system and lean in the meat industry and achieving environmental benefits, I request your participation in this study.



Research procedures

Participation in this PhD study is entirely voluntary, although no incentives are offered to the respondents in this study. A copy of the study results, however, would be shared. Interviews are expected to take approximately 45-60 minutes and will be conducted via Zoom®. Interviews will be recorded using digital audio-recorder at the respondent's place of work. The researcher will also get the consent form signed by the respondent before the interview.

Participant's Rights

If you decide to participate, you have the right to decline to answer any question. The personal records (name and organization of the participant) will be kept confidential. The participant has a right to ask for the recorder to be paused or turned off at any time during interview. In case of any concern by participant, he/she can directly contact the Massey University Human Ethics Committee. A comprehensive summary of the study findings will be provided to the participants on the completion of the study.

Project Contacts

If you are interested in participating or have any queries, please contact me (Aqeel Ahmed) directly. I can be contacted at A.Ahmed@massey.ac.nz or on (+64) 224283813.

The principle supervisor for this research is Dr. Sanjay Mathrani S.Mathrani@massey.ac.nz and the secondary supervisor is Dr. Nihal Jayamaha N.P.Jayamaha@massey.ac.nz

Committee approval statement

This research project has been reviewed and approved by the Massey University Human Ethics Committee: Ethics Notification No. 4000021971. If you have any ethical concerns or any queries and wish to raise with someone other than the researcher, you may 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

Appendix C



Consent Form

A Framework to Evaluate Effectiveness of Environmental Management System and Lean Implementation on Environmental Benefits in Meat Industry

I agree to take part in this PhD study, which is being conducted by Aqeel Ahmed, PhD student at Massey University, Auckland, New Zealand.

- 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.

I hereby consent to participate in this study.

Participant's Signature

Date

Researcher's Signature

Date

Appendix D



Interview questions

1. Do you think environmental management system and lean (as a separate or an integrated approach) can be used in improving environmental performance by minimizing wastes in the meat industry?
2. How does an environmental and waste reduction policy help an organization in implementing environmental management system and lean for achieving environmental waste reduction objectives and targets in the meat industry? Can both of these strategies be implemented as an integrated environmental waste management plan?
3. How does internal and external communication assist in the implementation of an integrated environmental management system and lean strategy in the meat industry?
4. How can an environmental waste management plan and environmental process improvements projects effectively be pursued in the meat industry through the implementation of environmental management system and lean as an integrated approach?
5. How do environmental management system procedures and lean tools as an integrated approach help in reducing environmental wastes associated with the meat industry?
6. How do environmental management system procedures and lean tools complement each other in improving meat production processes and environmental performance?
7. How do training and awareness programs for effective implementation of environmental management system and lean help to enhance the competence of the workforce and stakeholders in the meat industry?
8. How does environmental performance evaluation through monitoring and reporting, reviewing and auditing, help in achieving environmental waste reduction objectives and targets in the meat industry?
9. How do management and improvement reviews provide support for future environmental performance improvement initiatives in the meat industry?
10. What are the critical success factors for sustaining a lean and environmental management system, in the meat industry?

Appendix E

Table 5.2: Lean tools for operational and environmental performance in Alpha

SN	Lean tools	Informants	Application of lean tools	Impact of lean tool
1	Root cause analysis (fishbone diagram, A3 thinking and 5-Whys)	Group environmental manager	Fishbone diagram (quantity, measurement, material, personnel and machines) was applied to identify the reasons for PM ₁₀ generation and propose corrective action for mitigating PM ₁₀ .	<ul style="list-style-type: none"> Improved environmental safety Improvement of ambient air quality Achievement of compliance requirements.
		Environmental manager	A3 thinking was utilised to determine the reasons for non-conformities of air emissions and propose recommendations for mitigating GHG emissions.	<ul style="list-style-type: none"> Reduction of air emissions Achievement of compliance requirements.
		Environmental manager	5-Whys brainstorming activity was conducted with operators to identify the causes of MSD.	<ul style="list-style-type: none"> Identification of causes for environmental safety issues
		General manager	5-Whys was used to identify the reasons for excessive consumption of water and increasing spillage accidents.	<ul style="list-style-type: none"> Identification of causes of extra water consumption Identification of causes of increasing spillage accidents
2	VSM	Research and development manager	Value stream data on air emissions was analysed (set compliance requirements against actual parameters) to explore the causes of high air emissions.	<ul style="list-style-type: none"> Identification of irregularities in air emission parameters
		Manufacturing excellence lead	VSM was applied to analyse the material and information flow throughout the meat processing for identification of yield improvement opportunities.	<ul style="list-style-type: none"> Mapping the causes of waste generation Improving the information flow on environmental parameters
		Group environmental manager	VSM data on livestock and carcasses handling was used to identify process bottlenecks and yield enhancement opportunities.	<ul style="list-style-type: none"> Reducing the environmental bottlenecks Enhancing the yield of meat products
3	KPI benchmarks	Environmental manager	Application of KPI benchmarking was presented to evaluate the parameters for environmental performance.	<ul style="list-style-type: none"> Assessment of environmental parameters (compliance requirements against actual performance)
		Manufacturing excellence lead	Datasheets of the KPI benchmarks were analysed to identify the causes of high-volume water consumption and propose mitigation solutions.	<ul style="list-style-type: none"> Identification of extra water consumption causes and proposing the recommendations to mitigate them
4	Standardised work	Group environmental manager	Standardised work implemented for chemical handling to improve storage and management of safety datasheets. The work instructions were shared and laminated at the chemical storage station.	<ul style="list-style-type: none"> Efficient chemical management Improved environmental safety Reduction of chemical spillage
		Environmental manager	Standardised work instructions were applied for effective handling of carcasses and all kinds of wastes to ensure environmental safety.	<ul style="list-style-type: none"> Reduction of accidents caused by handling of carcasses Reduction of waste Improved environmental safety
5	5S	Group environmental manager	Shine and set in order pillars of 5S were applied to maintain safe storage areas for chemicals. Maintenance of 5S workplace assessments, audits and checklist helped to implement chemical handling policy.	<ul style="list-style-type: none"> Reduction of spillage incidents Environmental safety through clean spaces
		Manufacturing excellence lead	Environmental safety and water consumption was minimised by introducing 5S practices. Further 5S and safety (6S) played an essential role in handling of chemical materials and	<ul style="list-style-type: none"> Extending the meat's shelf-life Reduction of workplace accidents Environmental safety

SN	Lean tools	Informants	Application of lean tools	Impact of lean tool
			consumption of water during cleaning procedures in the slaughterhouse and boning room processes.	
6	Visual management	Technical compliance manager	Visual management was employed for displaying KPIs targets on quality, environmental and environmental safety parameters in different phases of the meat processing.	<ul style="list-style-type: none"> • Displaying quality and environmental safety parameters • Raising awareness of environmental performance • Reducing environmental non-conformities
		Group environmental manager	Chemical storage data sheets and handling procedures were displayed through digital screens.	<ul style="list-style-type: none"> • Improved chemical handling • Reduced spillage and workplace incidents
7	TPM	Group environmental manager	TPM and competent employees helped to maintain equipment effectively. Regular preventive maintenance serviced heavy processing machinery (such as rails, slicers and cutting saws).	<ul style="list-style-type: none"> • Improved equipment safety • Reduced workplace accidents • Improved process flow • Increased efficiency for equipment
8	JIT	Research and development manager	JIT with buffer used to meet customer demand. 4 to 12 hours buffer setting helped to improve inventory management for meeting the unexpected demands.	<ul style="list-style-type: none"> • Increased customer satisfaction by meeting their demand on time • Reduced potential wastes due to holding high inventory levels.

Appendix F

Table 6.2: Lean tools for operational and environmental performance in Beta

SN	Lean tools	Informants	Application of lean tool	Impact of lean tool
1	Root cause analysis (5-Whys, A3 thinking and fishbone diagram)	Resource efficiency and sustainability manager	A3 thinking was applied to identify the causes of meat contamination during the X-ray inspection.	<ul style="list-style-type: none"> • Identification of causes of meat contamination to avoid spoilage of meat products.
		Environmental group manager	A3 thinking was implemented to identify the reasons for CH ₄ and excessive organic generation in evisceration. A3 thinking provides countermeasures to reduce air emission and waste generation.	<ul style="list-style-type: none"> • Reduction of organic waste • Minimisation of CH₄ generation
		Group environmental officer	Root cause analysis identified reasons for malfunctioning of equipment (knives, circular and band saws).	<ul style="list-style-type: none"> • Improvement of functioning of equipment • Reduction of incidents
		Lean programme manager	5-Whys was used to identify the causes of excessive water consumption in slaughtering and boning rooms.	<ul style="list-style-type: none"> • Identification of causes of excessive water usage • Exploring opportunities to reduce water consumption
		Resource efficiency and sustainability manager	5-Whys determined causes for clogging in the chiller. Brainstorming with operators and team leaders helped to identify the presence of excessive water, oil and dirt in the chiller system.	<ul style="list-style-type: none"> • Identification of ice blockage, oil and dirt clogging and proposing solution to mitigate them
2	TPM	Resource efficiency and sustainability manager	Proactive maintenance master plan based on TPM could avoid breakage of steel fragments to reduce meat contamination.	<ul style="list-style-type: none"> • Improved maintenance of equipment • Reduced meat contamination by foreign particles
		Group environmental officer	Maintenance based on continuous TPM initiative was used for smooth running of the meat processing activities by managing equipment proactive handling.	<ul style="list-style-type: none"> • Improved environmental safety. • Reduced equipment breakdown • Smooth running of meat processing
		Lean programme manager	TPM was implemented for maintenance of washing machines, fixing water leakages and managing water saving initiatives.	<ul style="list-style-type: none"> • Maintenance of automatic washing equipment • Fixing water leakages • Water saving initiatives
		Resource efficiency and sustainability manager	TPM was applied to promote proactive maintenance for removing ice blockages and improving conformance of handling meat products.	<ul style="list-style-type: none"> • Removal of ice blockage • Maintenance of oil consumption in chiller system
3	Standardised work	Environmental group manager	Standardised work educated the workforce enabling a process to feed and water animals at the lairage facility.	<ul style="list-style-type: none"> • Efficient utilisation of water and food at lairage facility • Reduction of waste generation in gastrointestinal tract
		Lean programme manager	Standardised work instructions were updated after data analysis of previous lean projects to handle carcasses and processing meat products.	<ul style="list-style-type: none"> • Efficient handling of raw carcasses • Processing environmentally friendly meat products
		Group environmental manager	Standardised work instructions were updated to ensure correct size of packaging material and managing efficient packaging machines.	<ul style="list-style-type: none"> • Improved flow of meat products during packaging • Efficient consumption of packaging material
4	5S	Lean programme manager	5S was implemented to identify water usage optimisation opportunities during cleaning in slaughterhouse and boning room process activities. Shine and sustain pillars of 5S were managed to achieve better wastewater management goals.	<ul style="list-style-type: none"> • Identification of potential possibility for wastewater generation • Implementation of wastewater management initiative

SN	Lean tools	Informants	Application of lean tool	Impact of lean tool
				<ul style="list-style-type: none"> • Reduction of water usage in cleaning activities
		Environmental and sustainability officer	5S was implemented to clean the surface and remove the sticky particles of boiler tubes for improving the generation of maximum heating value.	<ul style="list-style-type: none"> • Cleaning of boiler tubes • Efficient utilisation of coal for electricity and steam generation
		Resource efficiency and sustainability manager	5S was utilised to maintain cleanliness and removal of dirt in the chiller system.	<ul style="list-style-type: none"> • Removal of dirt • Removal of oil fragments • Improvement of air circulation of the chiller system
5	VSM	Lean programme manager	VSM identified potential extra water consumption issues by analysing water usage data from slaughterhouse and boning room. A waste reduction plan was formulated based on this analysis.	<ul style="list-style-type: none"> • Analysis of data for identification of extra water consumption • Development of action plan for waste reduction
		Environmental and sustainability officer	VSM analysed coal feed, furnace heat and air circulation data to identify reasons for low heat calorific value.	<ul style="list-style-type: none"> • Efficient usage of coal • Improved heating value of the boiler
6	Visual management	Resource efficiency and sustainability manager	Visual feedback through Andon signal helped to remove presence of foreign particles during slaughtering, cutting and marinating processes.	<ul style="list-style-type: none"> • Indication of foreign particles • Reduction of meat contamination
7	JIT	Lean programme manager	JIT with buffer setting was introduced to estimate consistent batch and meet the required demand of the customers.	<ul style="list-style-type: none"> • Accurate batch size estimation • Improved usage of raw carcasses
8	Benchmarking	Head of continuous improvement	Benchmarking data on raw carcasses, water usage and energy consumption for analysing and comparing with status of processing parameters.	<ul style="list-style-type: none"> • Efficient management of data • Comparison of past performance with current status to the identify root causes
9	Gemba walk	Lean programme manager	Gemba walks were conducted to educate the workforce to report the potential non-conformities of water consumption in the slaughterhouse and boning room.	<ul style="list-style-type: none"> • Improved non-conformities reporting of water consumption • Identification of causes for wastewater generation • Optimised water usage
10	Kaizen events	Lean programme manager	“Just-do-it” or “quick wins” projects under Kaizen events improved water consumption efficiency to promote water reusage and provide wastewater mitigation.	<ul style="list-style-type: none"> • Provided solutions for efficient water consumption • Maintenance of efficient water consumption

Appendix G

Table 7.2: Lean tools for operational and environmental performance in Gamma

S N	Lean tools	Informant	Application of lean tools	Impact of lean tools
1	Root cause analysis (3C, 5-Whys and fishbone diagram)	Streamline specialist	A combination of 3C and 5-Whys was implemented to identify root cause analysis for extra wastewater sludge generation and propose reuse and recycling programme to mitigate the effluent.	<ul style="list-style-type: none"> • Identification of sludge generation • Proposing reuse and recycling programme for effluent minimisation
		Group environmental manager	3C sheet was developed to identify the bottleneck for effluents discharge. An efficient physiochemical treatment as countermeasure helped to meet compliance requirement for resource consent.	<ul style="list-style-type: none"> • Identification of causes for excessive drainage of effluents • Reduction of waste sludge through recycling process • Achieving resource consent requirements
		Streamline lead programme manager	Fishbone diagram was developed to identify the causes of malfunctioning of the belt conveyor and propose solutions to mitigate the reasons.	<ul style="list-style-type: none"> • Identification of irregularities in belt conveyor • Identification of solutions (cleaning and maintenance of belt conveyor)
		Streamline lead programme manager	3C sheet was developed to identify the reasons for pressure fluctuation in the chiller system.	<ul style="list-style-type: none"> • Identification of pressure fluctuation in chilling system
2	TPM	Streamline lead programme manager	TPM provides support for maintaining the belt conveyor sprockets and reducing equipment errors to improve belt conveyor operations.	<ul style="list-style-type: none"> • Reduction of downtime losses • Reduction of malfunctioning equipment errors • Improved meat movement in meat processing activities
		Environmental advisor	TPM was implemented to reduce the chances of chemical stickiness in equipment and improve the usage of lubricants in equipment intensive meat processing.	<ul style="list-style-type: none"> • Reduction of stickiness of chemical material • Maintenance of equipment on daily basis • Effective utilisation of chemical and lubricants
		Streamline specialist	Equipment maintenance (preventive and proactive) based on TPM was implemented to improve the utilisation of equipment.	<ul style="list-style-type: none"> • Improved equipment utilisation • Improved raw carcasses processing
3	5S	Streamline lead programme manager	5S was implemented to reduce spillage of meat particles on conveyor belt and ensure the standardised handling of raw carcasses.	<ul style="list-style-type: none"> • Reduction of meat particles spillage • Optimised movement of raw carcasses from receiving to shipment dock
		Environmental advisor	Limited application of 5S (shine and standardise) was implemented to clean chemical residues on hoists, chutes and meat rails.	<ul style="list-style-type: none"> • Reduced sticking and spillage of chemicals • Efficient consumption of lubricants
4	JIT	Streamline lead programme manager	JIT with buffer setting was applied to meet the meat demand during the malfunctioning of the belt conveyor.	<ul style="list-style-type: none"> • Efficient availability of the meat-products during breakage of belt conveyor
		Regional operations manager	JIT with 48 hours' buffer was implemented to improve the availability of meat products during the Covid-19 pandemic.	<ul style="list-style-type: none"> • Improved meat-products inventory during Covid-19 pandemic
5	Standardised work	Regional operations manager	Standardised work was applied to implement similar processes for identification of non-conformities and implementation of mitigation corrective actions in meat processing activities.	<ul style="list-style-type: none"> • Achieved environmental safety by wearing PPE • Meeting the compliance requirements
		Streamline lead	Standardised work provides guidelines for producing required air flow to improve the	<ul style="list-style-type: none"> • Provided guidelines to enhance chiller efficiency

S N	Lean tools	Informant	Application of lean tools	Impact of lean tools
		programme manager	chiller. Further, updated standardised and training helped in maintaining chiller performance.	<ul style="list-style-type: none"> • Improved chiller performance
6	Hoshin Kanri with data driven forecasting system	Streamline lead programme manager	Hoshin Kanri with data driven forecasting system was implemented for accurate prediction of offal yield per cattle in day-to-day meat processing activities.	<ul style="list-style-type: none"> • Efficient strategic planning for predicting offal yield per cattle • Effective utilisation of raw carcasses which contributes positively to environmental performance
7	Andon	Streamline lead programme manager	Andon signal (red) indicated the malfunctioning of the belt conveyor in the boning room. Automatic red signal alarm was used to stop the belt conveyor and start investigation for determining the root causes of belt conveyor damage.	<ul style="list-style-type: none"> • Indication of the belt conveyor malfunctioning • Reduced damage to the belt conveyor
8	SMED	Streamline specialist	A systematic SMED approach was applied to reduce the changeover time during replacing broken parts of equipment.	<ul style="list-style-type: none"> • Reduction of changeover time for broken equipment

Appendix H

Table 8.10: Critical success factors for lean and ISO 14001 implementation from the main study

Critical success factors	Sub-categories of CSFs	Examples from cases
Top management commitment	Development of policy	<ul style="list-style-type: none"> • It is a top management responsibility to develop well-defined operational and environmental policies at Alpha. • Top management's role is critical for developing policies for achieving environmental performance at Beta. • Top leadership is vital in articulating operational and environmental policies to enhance credibility for processing sustainable meat products at Gamma.
	Availability of financial resources	<ul style="list-style-type: none"> • Allocation of financial resources for introduction of Information Leader software, upgradation of equipment and conducting training at Alpha. • Providing financial support for installing heat recovery units, upgrading the water meter and improving recycling capacity at Beta. • Top leadership commitment is essential for providing financial assistance to conduct lean and ISO 14001 training (inhouse and external) and attaining ISO 14001 certification at Beta. • Top management commitment is critical for evaluating the need for training and allocating financial support to conduct external training at Gamma.
Awareness programme and training initiatives		<ul style="list-style-type: none"> • Awareness programme through communication, conducting training and knowledge sharing for lean and ISO 14001 implementation at Alpha. • Competent top management and well-trained employees are critical for implementing sustainability projects and evaluation (data analysis and financial audits) at Beta. • Inhouse and external training (by consultants) to achieve environmental targets at Alpha and Beta. • ISO 14001 lead auditor and lean six sigma (green, black and master black belts) training courses help to achieve better operational and environmental performance at Beta. • NZQA qualifications and Primary Industry's training helped to improve awareness around environmental targets and enhance lean implementation knowledge at Alpha and Gamma. • Internal induction training (a three-day' workshop) is critical for achieving the operational and environmental performance vision at Gamma.
Introduction of the latest technological trends		<ul style="list-style-type: none"> • Introduction of digital pressure sensors and UV sterilisers for mitigating wastewater problems at Alpha. • Introduction of Information Leader software for managing and documenting records at Alpha. • Introduction of renewable system (solar/wind energy systems) for attaining the compliance requirements around GHG emissions at Beta. • Introduction of artificial intelligence paradigm, Industry 4.0, data forecasting systems, automated X-ray technology and renewable fuels to achieve operational and environmental targets at Gamma.
Government financial grants		<ul style="list-style-type: none"> • Government and local councils provided industrial funding for installing the latest equipment and software to achieve policy and consent requirements at Alpha. • Partial financial support from government, environmental institutions and local community bodies helped to introduce state-of-the-art equipment (i.e., UV sterilisers) and adopt recycling packaging material at Beta. • Decarbonising fund and financial support from government and environmental groups assisted in introducing high temperature heat pumps and a custom-built automated meat processing system at Gamma.
Communication		<ul style="list-style-type: none"> • Communication is maintained through a single board arrangement (by displaying environmental, quality and safety KPI targets) at Alpha. • Structural vertical and horizontal communication is considered as a critical aspect for successful joint implementation of lean and ISO 14001 at Beta.

Critical success factors	Sub-categories of CSFs	Examples from cases
		<ul style="list-style-type: none"> • Regular information sharing with relevant stakeholders (e.g., workforce, contractors and suppliers) is crucial in implementing lean tools and environmental practices at Gamma.
Sustainability-oriented culture		<ul style="list-style-type: none"> • Strong culture is of prime importance for developing overall policy, defining roles and assigning responsibilities to attaining consent requirements (e.g., environmental and quality assurance) at Alpha. • Environmental sustainability culture is critical for successful implementation of lean and ISO management systems at Beta. • Culture development via proactive change management is essential parameter at Gamma.

Appendix I

Table 8.11: Summary of environmental and waste reduction outcomes by implementing lean and ISO 14001 jointly

Environmental aspect	Main study (multi-case studies in the meat processing companies)		
	Alpha	Beta	Gamma
Reduction of wastewater	<ul style="list-style-type: none"> Reduction of wastewater discharge (reducing nitrogen content, E. coli and suspended solids) Hot wastewater of boning room as water reuse 	<ul style="list-style-type: none"> Recovering, reusing and recycling of wastewater Identification of spillage points and non-optimised washing angles 	<ul style="list-style-type: none"> Wastewater treatment
Reduction of packaging waste	<ul style="list-style-type: none"> Analysis of VSM data and ISO 14001 internal audits for evaluating and proposing effective packaging use Introduction of innovative packaging (i.e., barrier vacuum shrink bag) and right size of packaging material 	<ul style="list-style-type: none"> ISO 14001 procedures (documentation and records) and lean tools (i.e., root cause analysis and standardised work) for evaluating causes and identifying opportunities 70% of packaging waste reduction 	<ul style="list-style-type: none"> ISO 14001 procedure (monitoring) and lean tools (i.e., 5S and TPM) are used for reducing errors in packaging machines Reduction of 100 tonnes of plastic waste Introduction of biodegradable packaging material
Reduction of sludge	<ul style="list-style-type: none"> Lean tools (i.e., A3 thinking and Kaizen events) and ISO 14001 procedure (e.g., corrective actions) to identify and propose mitigation solutions for the excessive E. coli and listeria content 	<ul style="list-style-type: none"> Lean tools (i.e., VSM and root cause analysis) and monitoring procedure of ISO 14001 for identifying root causes and opportunities to reduce excessive sludge (i.e., COD, BOD and TSS) 	<ul style="list-style-type: none"> Implementation of lean tools (3C and 5-Whys) to reduce the sludge content Dry sludge as alternative fuel for producing electricity
Reduction of GHG emissions	<ul style="list-style-type: none"> Implementation of 5-Whys and A3 thinking for identify the reasons and solutions of GHG emissions Reduction of PM₁₀ by fishbone diagram 	<ul style="list-style-type: none"> A3 thinking for reducing CH₄ at the lairage facility 	<ul style="list-style-type: none"> Reduction of particulate matter and gross carbon
Reduction of waste to landfill	<ul style="list-style-type: none"> The application of ISO 14001 procedures (i.e., corrective and preventive actions) and lean tools (i.e., A3 thinking and Kaizen events) for mitigating landfill target 	<ul style="list-style-type: none"> VSM along with root cause analysis and ISO 14001 procedures (i.e., preventive and corrective action) for reducing waste to landfill target 	<ul style="list-style-type: none"> Lean tools (i.e., KPI benchmarks and VSM) and procedures of ISO 14001 for developing a culture of landfill waste
Reduction of environmental safety issues	<ul style="list-style-type: none"> Risk assessment (ISO 14001 procedure) for identify potential causes of safety issues Induction training to the workforce and contractors for promoting health and safety culture Fishbone diagram for minimising the fatal effects of PM₁₀ on the workforce's health. 6S, 5-Whys and TPM implementation for reducing wastewater spillage, minimising handling of chemical and decreasing MSD issues. 	<ul style="list-style-type: none"> Environmental safety instructions, wearing of PPE gears and regular maintenance of equipment for reducing the occurrence of incidents 5-Whys for identifying the root causes of equipment breakdown TPM maintenance activities and standardised work instructions for reducing the workplace accidents 	<ul style="list-style-type: none"> Information sharing plan for identifying potential non-conformities and proposing corrective actions around safety issues A combination of lean tools (i.e., 5-Whys, 5S and TPM) for ensuring safety management
Reduction of heat losses	<ul style="list-style-type: none"> Continuous improvement projects (application of ISO 14001 and lean tools) for reducing heat losses 	<ul style="list-style-type: none"> VSM data is used for evaluating the heat losses target Coal feed size reduction, air circulation improvement and water 	<ul style="list-style-type: none"> Glycol liquid circulation as a corrective action for extracting heat from energy-rich air

Environmental aspect	Main study (multi-case studies in the meat processing companies)		
	Alpha	Beta	Gamma
		flow enhancement implemented for reducing heat losses	
Reduction of issues related chemical usage and handling	<ul style="list-style-type: none"> Analysis of VSM data for identifying the causes of ISO 14001 environmental policy parameter 5S, standardised work instructions and visual management implemented for better cleaning floors, handling hazardous material and identifying chemical storage points 	<ul style="list-style-type: none"> A limited application of 5S for reducing chemical mishandling 	<ul style="list-style-type: none"> 5S and TPM for solving the spillage issues and improving the efficiency processing equipment
Reduction of solid waste	<ul style="list-style-type: none"> Root cause analysis and corrective actions are implemented to reduce solid waste. Converted sheepskin into small pellets 	<ul style="list-style-type: none"> Solid waste minimisation aspect Audit and management review (ISO 14001 procedures) and VSM, standardised and automation (lean tools) to reduce solid waste 	<ul style="list-style-type: none"> Solid waste of meat processing and coal boiler residues are included as policy parameters Pilot project (ISO 14001 and lean tools) for converted solid into small chips

Appendix J

Table 8.12: Summary of implementation of lean and ISO 14001 as a combined approach from the three cases

Implementation of lean and ISO 14001	Alpha	Beta	Gamma
Integrated lean and ISO 14001 environmental policy	<ul style="list-style-type: none"> Team for developing policy – group manager, environmental manager and plant manager Targets around effluents, wastewater, electricity saving, and reduction of packaging waste and coal consumption Odour of contamination reduction targets 	<ul style="list-style-type: none"> Reduction of GHG emissions and efficient consumption of electricity, fossil fuel and raw material Zero waste to landfill targets (achieved six years ago) DAFF and BBIFB based targets Capex projects for reducing heat losses, wastewater and packaging material 	<ul style="list-style-type: none"> Inputs for policy – reduction of GHG emissions, solid waste, and consumption of energy, and packaging material Inputs for policy – analysis of vision, minutes of previous meeting and environmental reports
Integrated plan and projects of lean and ISO 14001 implementation	<ul style="list-style-type: none"> Integrated plans and projects lean and ISO 14001 – risk-based thinking Analysis of VSM data to identify environmental risks and ISO 14001 operational controls and communication procedures Information Leader software for cascading information around continuous improvement projects Continuous improvement projects (rendering and shredding) for reducing sheepskin large pieces Water usage and wastewater reduction by lean tools (VSM) and ISO 14001 procedures (audit, review and corrective actions) 	<ul style="list-style-type: none"> The AWS EC2 software toolkit for maintaining documentation control and KPI targets during planning and post implementation phases Wastewater sludge utilisation project through lean tools (root cause analysis, VSM and TPM) and ISO 14001 procedures (conformance status in management review) 	<ul style="list-style-type: none"> Large sheepskins and beef face pieces converted into small ribbons and chips by lean tools (root cause analysis and standardised work instructions) and ISO 14001 procedures (communication and corrective actions) Reduction of GHG emissions and heat extraction by lean tool (root cause analysis) and ISO 14001 operational control
Communication and information sharing	<ul style="list-style-type: none"> Structural internal communication via light-emitting diodes Regular monthly meetings Communication with NZ and UK customers Communication with public and environmental groups, and local government 	<ul style="list-style-type: none"> External information sharing in conference proceedings Stewardship awards are shared internally via newsletters Internal communicated via audits of ISO 14001 and application of lean tools Information posters Communication with Walmart, Albert Heinz and Sainsbury's 	<ul style="list-style-type: none"> Daily regular meetings Internal (by team leader) and external (risk manager) communication Internal communication via charts, whiteboards and posters for Internal communication plan Communication with NZ and US food market
ISO 14001 procedures	<ul style="list-style-type: none"> Roles, responsibilities and authorities for implementing ISO 14001 Documentation procedure of ISO 14001 for maintaining records of environmental aspects Role of environmental team in developing and reviewing environmental targets and proposing corrective actions 	<ul style="list-style-type: none"> Role of the competent personnel for implementing ISO 14001 procedures Maintenance of documentation and records through the AWS EC2 software toolkit Financial support for ISO 14001 registration, training of environmental team and introduction of the latest equipment 	<ul style="list-style-type: none"> A job description chart for the roles, responsibilities and authorities A four-member team for manual documentation and records A list of documents: (1) environmental policy, (2) results of internal audit and management review and (3) results of corrective

Implementation of lean and ISO 14001	Alpha	Beta	Gamma
	<ul style="list-style-type: none"> Information Leader software to maintain ISO 14001 documentation and records Authorised individuals for updating inputs and future outputs targets in Information Leader software 	<ul style="list-style-type: none"> Setting and maintaining the documentation on KPI targets, audit and monitoring records, and corrective actions 	<ul style="list-style-type: none"> actions are maintained manually Three steps of operational control (setting KPI benchmarks, measurement of performance and corrective actions) for evaluating and improving environmental performance
Lean tools	<ul style="list-style-type: none"> Fishbone diagram (reduction of particulate matter 10) KPIs and A3 thinking (reduction of GHG emissions at the boiler house) KPI benchmarks (efficient water usage and reduction of wastewater sludge) VSM and JIT with buffer setting (unexpected demands for meat products) 5S, standardised work and visual controls (chemical management such as handling and spillage) 5-Whys and standardised work (smooth flow and reduction of MSD during raw carcasses processing) 5-Whys, 6S (5S+safety), Andon signal, JIT with buffer, 5S and TPM (reduction of workplace accidents and damage to belt conveyor) TPM to maintain equipment such as rails, slicers and cutting saws 	<ul style="list-style-type: none"> Andon signal, A3 thinking and TPM for reduction of potential food contamination A3 thinking and work instruction (reduction of GHG emissions) VSM and 5S for reduction of heat losses and GHG emissions VSM, root cause analysis (5-Whys), 5S, Kaizen events, Gemba walks and TPM for efficient water usage 5-Whys, TPM, 5S and JIT with buffer for improving food shelf-life VSM and 5S for reducing heat losses 5S and JIT with buffer for reducing foodborne contamination 	<ul style="list-style-type: none"> 3C philosophy and standardised work for wastewater treatment Hoshin Kanri with data-driven forecasting system (unexpected demands for meat products) Andon signal, JIT with buffer setting, fishbone diagram, 5S and TPM for reducing workplace accidents and damage to belt conveyor TPM and SMED for reduction of maintenance issues 5-Whys, 5S and TPM for reduction of chemical spillage 3C philosophy, standardised work and TPM for managing high fluctuation of pressure in the chiller system JIT with buffer solution for efficient demand management
Competencies, awareness and training of the workforce	<ul style="list-style-type: none"> Assessment of need for training to evaluate competence and awareness of the workforce Induction training for newly employed operators and contractors External training programmes such as provided by NZQA and PITO High-level leadership learning programme Role of training for implementation of environmental practices, lean tools and food safety initiatives 	<ul style="list-style-type: none"> Induction programme for new hired workforce Internal training for enhancing the competence of the workforce to follow the WHO guidelines during the Covid-19 pandemic Findings of skill matrix for enhancing the competence of the workforce External training (Toyota's European headquarters) for the workforce to implement lean tools A number of scholarships for attaining certifications and diplomas from Irish institutions External training for enhancement of concepts (i.e., 	<ul style="list-style-type: none"> Qualification (secondary school graduation for entry level and tertiary education for managerial roles) A team of 60 leaders for conducting internal training Internal lean training for promoting innovation culture. NZQA level 3 and 4 certifications for improving critical thinking, change management and productivity Internal training (induction and on-the-job) External training for forklift operators

Implementation of lean and ISO 14001	Alpha	Beta	Gamma
	<ul style="list-style-type: none"> An enthusiastic engagement culture and competent workforce for environmental sustainability 	environmental sciences, lean and circular economy)	<ul style="list-style-type: none"> Robust training on lean and ISO 14001 for adopting a culture of environmental optimisation
Environmental performance evaluation	<ul style="list-style-type: none"> Assigning roles, responsibilities and authorities for evaluating environmental performance External audits conducted by local council representatives and third-party auditors External audits conducted by certification body for attaining or renewing ISO 14001 certification Daily internal audits for evaluating compliance requirements 	<ul style="list-style-type: none"> Evaluation of KPIs data for conformance status to propose future action plan Data from root cause analysis and audit of ISO 14001 for evaluating the environmental performance Monitoring and reviewing mechanism for achieving objectives of improvement projects Internal and external audits for evaluating VSM and ISO 14001 findings in improvement projects Frequency of environmental performance – monthly, quarterly and annually 	<ul style="list-style-type: none"> Analysis of environmental data and audits for evaluating performance parameters Quarterly and annual performance evaluation for attaining consent permits from NZ statutory bodies Comprehensive action plans for improvement projects Regular compliance audits for evaluating the STBi parameters Occasional compliance audits are once every four months
Environmental management review	<ul style="list-style-type: none"> Annual management review for analysing and reviewing of major resources Efficient management of information sharing for evaluation current performance and setting future targets Yearly environmental management review Top management allocating financial and human resources for management review 	<ul style="list-style-type: none"> Responsibility of the top management for conducting management reviews (six monthly or annually) Inputs for environmental management reviews (i.e., outcomes of audits and KPIs reports) Responsibility of the top management for managing financial resources and assigning responsibilities to pursue optimisation projects 	<ul style="list-style-type: none"> Environmental review for evaluating operational and environmental performance Outcomes of lean and environmental practices for evaluation and proposing future optimisation opportunities

Appendix K

Table 8.14: Summary of CSFs for implementing lean and ISO 14001 as a combined approach from the three cases

CSFs for lean and ISO 14001 implementation	Main study (multi-case studies in the meat processing companies)		
	Alpha	Beta	Gamma
Top management commitment in developing policy	<ul style="list-style-type: none"> • Top management's role for developing well-defined operational and environmental policy 	<ul style="list-style-type: none"> • Top management role in developing operational and environmental policy 	<ul style="list-style-type: none"> • Top management role in articulating organisational policy
Top management support in providing financial resources	<ul style="list-style-type: none"> • Installation of software • Upgradation of water metering to improve water usage • Conducting training 	<ul style="list-style-type: none"> • Installation of equipment for environmental process improvement to reduce of energy and water consumption • Inhouse and external training • Attaining ISO 14001 certification 	<ul style="list-style-type: none"> • External training
Awareness programmes and training initiatives	<ul style="list-style-type: none"> • Awareness programme for lean and ISO 14001 implementation • Internal and external (by external consultants) training • NZQA qualifications and PITO programmes 	<ul style="list-style-type: none"> • Competent management and employees for implementing improvement, projects and collecting data • Inhouse and external training • ISO 14001 lead auditor training • Lean six sigma (green, black and master black belts) training courses 	<ul style="list-style-type: none"> • NZQA qualifications and PITO programmes • Internal induction training (a three-day' workshop)
Introduction of the latest technological trends	<ul style="list-style-type: none"> • Installing digital pressure sensors and UV sterilisers for efficient water consumption • Introducing Information Leader software for maintaining environmental documentation 	<ul style="list-style-type: none"> • Introduction of renewable systems (solar/wind energy systems) for reducing GHG emissions 	<ul style="list-style-type: none"> • Introduction of artificial intelligence paradigm • Utilisation of Industry 4.0 • Installation of data forecasting systems and automated X-ray technology • Introduction of renewable fuels
Government financial grants	<ul style="list-style-type: none"> • Installing the latest equipment and software 	<ul style="list-style-type: none"> • Financial support for introduction of state-of-the-art equipment (i.e., UV sterilisers) and adopting recycling packaging material 	<ul style="list-style-type: none"> • Introduction of high temperature heat pumps and custom-built automated meat processing system
Sustainability-oriented culture	<ul style="list-style-type: none"> • Strong culture for developing overall policy, defining roles and assigning responsibilities • Improvement culture for attaining consent requirements and achieving environmental conformities 	<ul style="list-style-type: none"> • Environmental sustainability culture by implementing continuous improvement initiatives and ISO management systems 	<ul style="list-style-type: none"> • Culture development via change management and improvement initiatives • Cultural change via proactive management

CSFs for lean and ISO 14001 implementation	Main study (multi-case studies in the meat processing companies)		
	Alpha	Beta	Gamma
Employee motivation	<ul style="list-style-type: none"> • Social events for motivating and rewarding the workforce • Employee satisfaction, appraisal and empowerment 	<ul style="list-style-type: none"> • Engagement of the workforce for implementing continuous improvement projects 	<ul style="list-style-type: none"> • Empowerment of the workforce for implementing lean tools and environmental practices
Communication	<ul style="list-style-type: none"> • Communication through a single matrix by displaying environmental, quality and safety targets 	<ul style="list-style-type: none"> • Vertical and horizontal communication 	<ul style="list-style-type: none"> • Information sharing for implementing lean tools and environmental practices