Bridging the Barriers to Effective Life Cycle Management Uptake:

A Framework for Primary Industry Sectors

By

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ABSTRACT

There is a rising global awareness of environmental problems and wider sustainability issues in business and society. Examples of environmental issues that are particularly topical include carbon emissions and climate change, waste and pollution, water consumption and impacts on biodiversity.

One approach to incorporate environmental sustainability in organisations is the implementation of Life Cycle Management (LCM). LCM is a comprehensive and integrated approach towards measuring and managing environmental impacts. LCM involves sharing responsibility for addressing environmental impacts across the entire supply chain of products and services, extending from raw material extraction to end-of-life.

In New Zealand, the environmental performance of products is particularly important as export markets are geographically distant and additional environmental impacts occur due to extensive transport to deliver products to end users. Additionally, New Zealand has an image of being "green and clean" which needs to be justified, particularly in discerning export markets such as Europe and Japan. Governments in those export markets often have stringent legislation in place to encourage the uptake of environmental improvement projects and ecologically responsible behaviour. Likewise, customers increasingly use environmental factors to guide their purchasing decisions. Therefore, it is important for New Zealand organisations to comply with legislation and align with customer expectations about the environmental performance of their products and services.

The New Zealand economy relies heavily on primary exports with around 70% of the country's export revenue being generated by primary industries (Ministry for Primary Industries, 2016; Trade, 2019). Successful sector-wide uptake of LCM has the potential to facilitate effective measurement and management of the environmental impacts caused by the New Zealand primary industries. Thus, New Zealand can strengthen its competitiveness in the global marketplace by maintaining and reinforcing the country's "green and clean" image and being able to respond to threats such as the "food miles" concept.

A large number of organisations in primary industry supply chains are Small and Medium Sized Enterprises (SMEs). Compared to large companies, SMEs face particular challenges when it comes to uptake of environmental initiatives. These include limited resources, lack of knowledge around market requirements, and lack of expertise in the environmental area.

The aim of this PhD research was therefore to develop an approach that supports primary industry sectors to effectively evaluate, monitor and demonstrate their LCM

practices based on globally relevant criteria. In particular, this research examined and tested the use of a sector-based, as opposed to individual organisation-based, approach to the implementation of LCM as an effective means of driving change amongst primary industry SMEs and overcoming the barriers they face during LCM uptake. Thus far, the focus of research into the enablers and barriers to uptake of LCM in SMEs has been on individual companies. However, a sector-based approach may allow more effective measurement and management of environmental impacts associated with supply chains.

The research design involved four elements and triangulated a mix of methods, including literature-based research, face-to-face interviews, and an online survey. The New Zealand kiwifruit and aquaculture industry sectors were used as case studies to inform development of a framework for evaluating, monitoring and demonstrating LCM in primary industry sectors that are comprised largely of SMEs.

The thesis has been written using a paper style with four main chapters that cover each of the four elements. Chapter 3 documents the theoretical foundation by synthesizing the literature related to enablers and barriers to uptake of LCM in organisations, related literature on supply chain management (SCM), and on the characteristics of SMEs that influence their ability to engage in change management. This led to the identification of eight factors that affect successful LCM uptake within industry sectors. On this basis it was identified that a sector-based approach could facilitate the implementation of LCM in primary industry sectors and support the large number of SMEs in those industry sectors efficiently. The academic contribution of this research phase includes the synthesis of barriers and enablers to successful sector-wide LCM uptake, as well as identification of a sector-based approach for effective implementation of LCM in supply chains.

Chapter 4 summarises a study of LCM in the New Zealand kiwifruit sector. An online survey was undertaken of kiwifruit growers from various regions in New Zealand. The academic contributions of this element include the identification of the specific barriers and enablers to successful LCM uptake in the New Zealand kiwifruit sector. During this research, it was identified that knowledge management using technology is a key research area that should be considered to ensure that knowledge and information relating to LCM are effectively transferred between supply chain partners in order to facilitate the successful implementation of a sector wide sustainability strategy.

Chapter 5 describes the development of a prototype LCM Uptake Evaluation Framework (LUEF) based on the literature review (Chapter 1) and the kiwifruit case study (Chapter 4). The LUEF is a capability maturity model designed to enable both individual companies and industry sectors to assess themselves against the factors that affect the uptake of LCM. The LUEF provides a methodological contribution to academic knowledge in the area of LCM and a practical tool to support companies and industry sectors to evaluate their maturity with respect to LCM.

Chapter 6 describes the development of an Information Technology (IT) platform to support the effective management of an LCM programme using a sector-based approach. The IT platform aims to address the shortcomings of the LUEF developed in the previous chapter. In order to use it at a larger scale and support individual organisations as well as industry sectors in their decision-making processes to improve their environmental performance on an ongoing basis, an online platform is suggested. The platform was designed to allow individual organisations to input their data at the time of their convenience, and for industry stakeholders to access the aggregated and industry-average data. The New Zealand aquaculture industry was used as a case study to inform development of the IT platform, and industry stakeholders particularly highlighted the ease of communication and collaboration, which was identified as a key enabler of successful LCM uptake on a sector-wide basis. Key contributions during this research phase involved the development and refinement of an online software platform to facilitate the implementation of a sector-based LCM strategy, including setting industry targets, developing best practice guidelines, and identifying improvement projects.

Future research should focus on wider dissemination of the LUEF, facilitated by IT platforms, across other primary industry sectors with different structures compared to the kiwifruit and aquaculture sectors in New Zealand.

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ABBREVIATIONS

EPD	Environmental Product Declaration
GSCM	Green Supply Chain Management
ISO	International Standards Organisation
IT	Information Technology
LCA	Life Cycle Assessment
LCM	Life Cycle Management
LCT	Life Cycle Thinking
LUEF	LCM Uptake Evaluation Framework
NGO	Non-Government Organisation
Psa	*Pseudomonas syringae pv. actinidiae* (bacterial kiwifruit vine disease)
SCM	Supply Chain Management
SME	Small and Medium Sized Enterprise
SWNZ	Sustainable Winegrowing New Zealand

1 INTRODUCTION

This PhD research had the overall goal of supporting the uptake of Life Cycle Management (LCM) in the New Zealand primary industry. The aim was to develop a framework that helped individual companies and industry sectors to identify their barriers and enablers to successful LCM uptake and, based on these findings, develop strategies and programmes to enhance their capability and maturity with respect to LCM implementation.

Chapter 1 provides the foundation and justification for the research. This begins with the background context (Section 1.1) followed by a summary of LCM and related topics including sustainable development, environmental management systems and Life Cycle Assessment (Section 1.2). The relevance of LCM implementation for New Zealand primary industry sectors is discussed in Section 1.3. This provides context for the problem identification and research aim (Section 1.4).

1.1 Background

There is a rising awareness of environmental problems and wider sustainability issues amongst governments, industries and consumers (Le, Engel, & Macht, 2016; McLaren, 2008; Ministry for Environment, 2019a, 2019b, 2019c, 2019d; Rajeev, Pati, Padhi, & Govindan, 2017; Wright, 2011).

Due to the growing relevance of the topic, there are increasing drivers for companies to integrate sustainability into their business practices. Over the two last decades, an increasing number of organisations have started to integrate environmental initiatives in their business strategies and activities (Da Silva, Jabbour, & Santos, 2009; Das & Rangarajan, 2017; Esty & Winston, 2009; Gast, Gundolf, & Cesinger, 2017; Johansson & Winroth, 2010; Michaelis, 2003; Sarkis, 2001). This trend is particularly apparent in Europe where it is driven by strict environmental legislation and an understanding in industry of the financial cost of waste and energy.

One approach to incorporate sustainability in business is the implementation of LCM. LCM seeks to improve the environmental sustainability of products and services (Sonnemann, Gemechu, Remmen, Frydendal, & Jensen, 2015). It involves the systematic application of life cycle thinking (LCT) by integrating environmental issues into decision-making to support the development of more sustainable products and production systems (McLaren, McLaren, King, & Frame, 2008).

New Zealand has a reputation and image for being “clean and green”. In order to maintain and reinforce this reputation in global markets, there is a need to improve performance and implement effective approaches to demonstrate environmental credentials (Brown & Stone, 2007; Gnoth, 2002; Jones & Mowatt, 2016; Sterzik, McLaren, Hume, Garnevska, & McDevitt, 2013). So far, only a small number of New

Zealand companies have actually integrated a life cycle approach into their business operations and decision-making processes (Collins, Dickie, & Weber, 2011; Collins, Roper, & Lawrence, 2010). New Zealand is an exporting country and the economy relies heavily on primary products. This highlights the importance of environmental management in the primary industry and the need to anticipate trends in overseas markets to be able to respond appropriately (De Silva & Forbes, 2016; Foote, Joy, & Death, 2015; Jones & Mowatt, 2016). Concepts such as ‘‘food miles’’ can threaten New Zealand’s economy if the industry sectors in question cannot demonstrate that the environmental performance of New Zealand products is still superior to competitors’ products, despite the long distance to the markets (Coley, Howard, & Winter, 2009; Kemp, Insch, Holdsworth, & Knight, 2010; Saunders, Barber, & Taylor, 2006)

However, even though there are an increasing number of drivers for companies to incorporate environmental aspects into their operations, many organisations are not active in this area – and many of these organisations are SMEs (Aiyub, Arifin, Awang, & Jahi, 2009; Borga, Citterio, Noci, & Pizzurno, 2009; Collins, Lawrence, Pavlovich, & Ryan, 2007; Williamson, Lynch-Wood, & Ramsay, 2006). SMEs find it particularly difficult to develop and implement environmental sustainability strategies due to their specific characteristics, e.g. limited financial and human resources, lack of expertise in sustainability (Hillary, 2000; Seidel, 2011), and lack of awareness amongst SMEs of their own sustainability impacts.

On the other hand, some companies that have successfully implemented LCM have experienced benefits that outweigh the efforts associated with changes in processes and culture (Leonidou, Christodoulides, & Thwaites, 2016). For example, significant commercial benefits can be achieved through improved communication and cooperation with supply chain partners (Barreto, Anderson, Anglin, & Tomovic, 2010; Gecevska, Chiabert, Anisic, Lombardi, & Cus, 2010; Srinivasan, 2011; Yeheyis, Hewage, Alam, Eskicioglu, & Sadiq, 2013). That leads to mutual benefits such as shared learning and experiences in LCM implementation and subsequently improved environmental performance and reputation of the final product (Barreto et al., 2010; Manda et al., 2016; Srinivasan, 2011). Moreover, companies and industry sectors may find it easier to stay competitive in markets such as Europe and Japan where consumers are increasingly concerned about environmental sustainability.

The focus of this PhD research was therefore on implementation of LCM in the primary industry sectors in New Zealand, and particularly amongst SMEs, given they constitute the majority of companies in the industry. Current approaches to LCM in the New Zealand primary industry are to a large extent ad hoc and limited to individual companies (De Silva & Forbes, 2016). In contrast, this research focused on developing and testing a sector-based approach.

1.2 Life Cycle Management

LCM comprises a wide range of tools and paradigms that facilitate the integration of sustainability into decision-making. This section introduces LCM by providing an overview of the concept and exploring different definitions of the term. The section continues with a description of the interconnected LCM processes, concepts and tools that support companies to implement change.

LCM seeks to improve the environmental sustainability of products and services. It is the systematic application of LCT in business practice in order to integrate consideration of environmental issues into decision-making and support the development of more sustainable products and production systems (Sonnemann et al., 2015).

From an LCM perspective, the environmental responsibilities of companies include not only their own production sites, but also up- and downstream entities in the supply chain throughout the entire life cycle (Figure 1-1) from raw material extraction to end-of-life of a product (Jüttner & Ziegenbein, 2009; Sonnemann et al., 2015; UNEP/ SETAC Life Cycle Initiative, 2005).

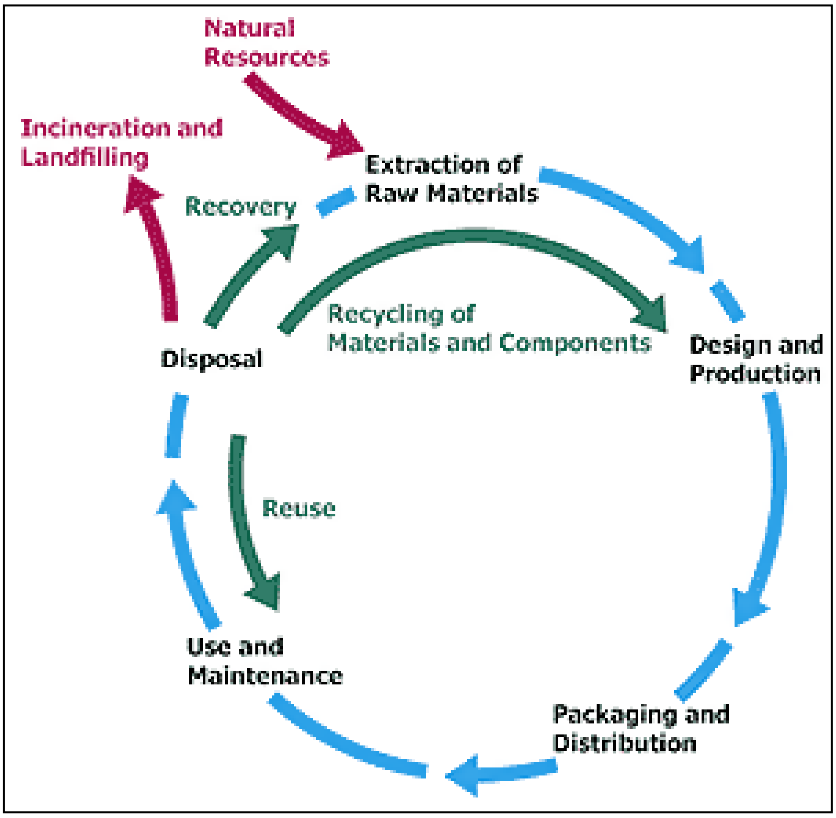

Figure 1-1: Life cycle of a product (UNEP/ SETAC Life Cycle Initiative, 2005)

The role of LCM can be described in three different ways according to different people's perspectives (Linnanen, Bostrom, & Meittinen, 1995):

- Management view: LCM is a way to integrate environmental issues into the decision-making process of a company.

- Engineering view: LCM supports companies in reducing the environmental impact caused by the product system during its life cycle.
- Leadership view: LCM leads to change in organisational culture to support the decision-making process.

According to the definition provided by the Society of Environmental Toxicology and Chemistry (SETAC) Working Group, the overall goal of LCM is closely related to the sustainability concept:

"LCM is a flexible integrated framework of concepts, techniques and procedures to address environmental, economic, technological and social aspects of products and organisations to achieve continuous environmental improvement from a life cycle perspective." (Saur et al., 2003)

The definition by Weidema (2001) relates LCM to the evolution of a new management paradigm:

"LCM as a management paradigm has the potential to provide a synthesis of the modern management theories and practices due to its global throughput- thinking approach and its integration of concepts such as life cycle costing, business process re-engineering, product benchmarking, supply chain management, quality function deployment, core competence, learning organisation and empowerment.

This quote indicates that the change of management styles, structures and procedures are important factors to be considered when implementing LCM approaches in companies. The definition also highlights that LCM is a holistic concept that does not rely on one single strategy or tool.

The following statements by KPMG (2005) also highlight the importance of cooperation and involvement of parties in LCM initiatives:

"Life cycle approaches avoid problem shifting from one life cycle stage to another, from one geographic area to another and from one environmental medium to another. Human needs should be met by providing functions of products and services, such as food, shelter and mobility, through optimised consumption and production systems that are contained within the capacity of the ecosystem." (KPMG, 2005)

Table 1.1 provides a summary of the definitions of LCM from the existing literature.

Table 1.1: Definitions of LCM

Reference	LCM definitions
(Linnanen, 1995)	Life cycle management consists of three views: (1) the management view – integrating environmental issues into the decision making of the company; (2) the engineering view – optimizing the environmental impact caused by the product during its life cycle; and (3) the leadership view – creating a new organizational culture.
(Fava, 1997)	Life cycle management is the linkage between life cycle environmental criteria and an organization's strategies and plans to achieve business benefits.
(Sonnemann et al., 2015)	Life Cycle Management (LCM) is a management concept applied in industrial and service sectors to improve products and services while enhancing the overall sustainability performance of business and its value chains. In this regard, Life Cycle Management is an opportunity to differentiate through sustainability performance on the market place, working with all departments of a company such as research and development, procurement, and marketing, and enhance the collaboration with stakeholders along a company's value chain. LCM is used beyond short term business success and aims at long-term achievements minimizing environmental and socioeconomic burden while maximizing economic and social value.
(Finkbeiner, Wiedemann, & Saur, 1998)	A comprehensive approach towards product and origination related environmental management tools that follow a life cycle perspective.
(Heiskanen, 2002)	LCA-based ideas and tools can be viewed as emerging institutional logics of their own. While LCA makes use of many scientific models and principles, it is more a form of accounting than an empirical, observational science. Thus, the life cycle approach implies a kind of "social planner's view' on environmental issues, rather than the minimization of a company's direct environmental liabilities".
(Hunkeler et al., 2003)	Life cycle management (LCM) is an integrated framework of concepts and techniques to address environmental, economic, technological and social aspects of products, services and organizations. LCM, as any other management pattern, is applied on a voluntary basis and can be adapted to the specific needs and characteristics of individual organizations.

Reference	LCM definitions
(Baumann & Tillman, 2004)	LCM is "the managerial practices and organizational arrangements that apply life cycle thinking. This means that environmental concerns and work are coordinated in the whole life cycle instead of being independent concerns in each company".
(Remmen, Jensen, & Frydendal, 2007)	LCM is a product management system aiming to minimize environmental and socioeconomic burdens associated with an organization's product or product portfolio during its entire life cycle and value chain.
(UNEP/SETAC, 2009)	"… a business management approach that can be used by all types of businesses (and other organizations) to improve their products and thus the sustainability performance of the companies and associated value chains". "It can be used to target, organize, analyze and manage product-related information and activities towards continuous improvement along the life cycle".
(Jensen, 2012)	"… a systematic integration of life cycle thinking in modern business practice with the aim to provide the societies with more sustainable goods and services and to manage the total lifecycles of an organizations product portfolio towards more sustainable production and consumption."

In summary, it can be said that LCM aims to facilitate the reduction of environmental burdens throughout the entire life cycle of a product/service. It is an integrated management framework of different interconnected operational strategies, processes, concepts and tools that allow organisations to systematically incorporate environmental, social and economic aspects into product and process life cycles (Figure 1-2). Generally, concepts describe ideas about how to achieve sustainability whereas tools provide specific guidelines how to assess and improve the environmental performance of products/services and processes (Baumann & Cowell, 1999). Concepts are, for example, industrial ecology, producer responsibility and life cycle thinking (Borchardt, Wendt, Pereira, & Sellitto, 2011). Those concepts can be implemented by companies through processes and tools such as Environmental Management Systems (EMS), LCA, risk assessments, audits and checklists.

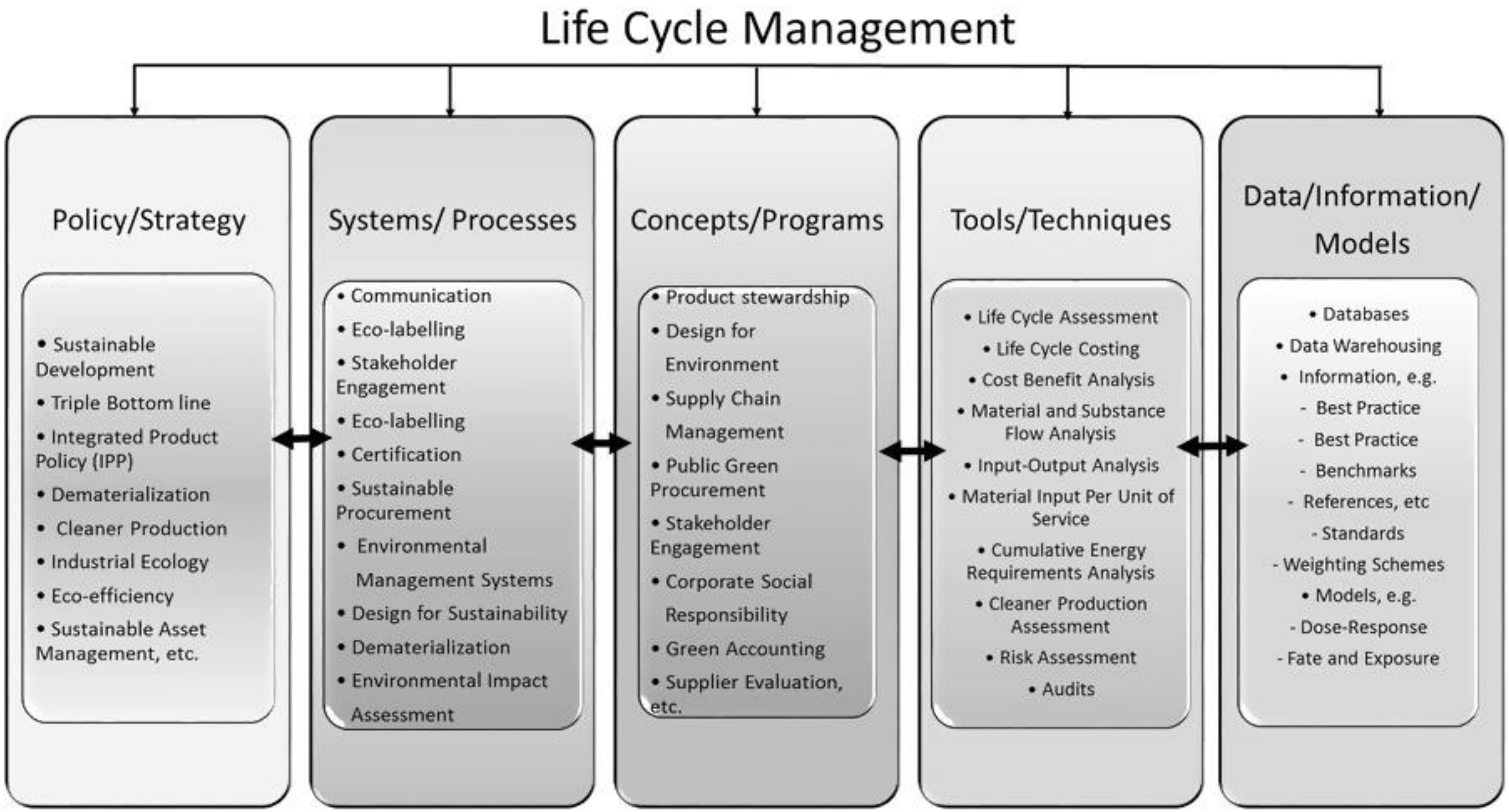

Figure 1-2: Relationship between the various strategies, processes, concepts, tools and models in the context of LCM (Remmen et al., 2007; Sonnemann et al., 2015)

The following sections provide a high-level overview of several key aspects that are fundamental to implementation of LCM: sustainable development (Section 1.2.1), EMS (Section 1.2.2) and LCA (Section 1.2.3).

1.2.1 Sustainability and Sustainable Development

Sustainable development is a concept adopted by companies to guide their environmental, social and economic performance. Sustainable development is most commonly defined as United Nations - Sustainable Development Knowledge Platform (1987):

"Development that meets the needs of the present, without compromising the ability of future generations to meet their own needs."

This definition is from the Rio Earth Summit in 1987 and it has provided the basis for many other definitions and concepts (Holden, Linnerud, & Banister, 2017). In essence, sustainability is the capacity for continuance of an entity more or less indefinitely into the future. In addition, most definitions include statements that sustainability requires us to find integrated solutions that serve the economy, environment and society (Elkington, 1997; Gallo & Christensen, 2011). The economic dimension represents businesses' concerns about their financial situation; it deals with optimisation of the financial performance of a process or a company. The environmental dimension covers health of the biosphere, maintenance of biodiversity and management of renewable and non-renewable resources. The social dimension of sustainability embeds values such as fair and equal distribution of resources between present and future generations, but also integrates maintenance of satisfying lifestyles and availability of rewarding employment. The integration of all three dimensions in decision-making leads to sustainable development (Gallo & Christensen, 2011).

To foster sustainable development, it is critical that policy makers as well as companies engage and commit to environmental, social and economic health. In order to mitigate the adverse consequences on the environment and reach a consensus on targets for the future, a number of government institutions have been created involving multiple countries. For example, the United Nations Framework Convention on Climate Change (UNFCCC) was founded in 1992 to provide a framework for policy making to mitigate atmospheric greenhouse gases and prevent climate change (Ministry for Environment, 2012). In 1997, the Kyoto Protocol was developed in Japan and came into force in February 2005. It is an international agreement linked to the UNFCCC. The Kyoto Protocol includes targets for 37 industrialised countries and the European community for reducing greenhouse gas emissions (Almer & Winkler, 2017).

National governments have the power to put pressure on companies by passing environmental laws and regulations that require more sustainable business practices (Diabat & Govindan, 2011). Thereby they set the platform on which producers and suppliers have to base their decisions. In the European Union (EU), the introduction of stringent environmental legislation forced companies to proactively analyse their operations and associated environmental impacts and implement improvement actions to reduce these effects. Examples include the Regulation, Evaluation and Authorisation of Chemicals (REACH) and the End of Life Vehicles (ELV) Directive, as well as the WEEE (Waste Electrical and Electronic Equipment) Directive and the Eco-design Directive for Energy-using Products (EuP) (Pigosso, Ferraz, Teixeira, & Rozenfeld, 2016). These directives forced businesses to develop an understanding of their life-cycle based environmental impacts and how their business can contribute to national/regional sustainable development (Pigosso et al., 2016). Moreover, they led to an increase in awareness and demand for environmentally friendly products by consumers (Biondi, Iraldo, & Meredith, 2002), and sustainable practices became a point of competitive advantage and in some regions even an order qualifier.

The European steel and plastics industries set up committees to develop sustainability frameworks for their industry sectors. The requirements of the frameworks are third-party-certified. The increase in awareness and environmental performance of European companies has subsequently let to importers from other parts of the world having to adopt similar practices to comply. Otherwise they cannot be part of the tendering process in this market (PlasticsEurope, 2015).

Consumers also have the power to influence businesses by choosing products that have a reduced impact on the environment in comparison to products with the same functions and features (Cronin, Smith, Gleim, Ramirez, & Martinez, 2011; Diabat & Govindan, 2011; Hornibrook, May, & Fearne, 2015; Yalabik & Fairchild, 2011). Based on that, companies need to adapt their products and services and incorporate environmental decisions into their processes, in order to appeal to consumers that consider environmental factors into their decision-making processes. As the number of consumers grows that include environmental consideration in their purchasing decisions, the businesses need to adjust in order to stay competitive.

1.2.2 Environmental Management System (EMS)

An EMS can be used by businesses to facilitate environmental improvement through a continual cycle of planning, implementing, reviewing and improving (Tibor & Feldman, 1996). An effective EMS ensures continual improvement of a company's environmental performance (Netherwood, 1998). The implementation of an EMS requires management support and is built around long-term objectives and visions of the company that are broken down into short-term targets (Melnyk, Sroufe, & Calantone, 2003). The EMS provides a framework for companies to develop organisational structures, processes and procedures to make sure that the achieved standards can be maintained and further environmental improvements can be put in place (Melnyk et al., 2003; Netherwood, 1998).

There are five core elements of EMS (Figure 1-3) which are based on the Plan-Do-Check-Act (Deming) cycle (Markland, 2010):

- Management commitment and development of environmental policy
- Identification of environmental aspects and impacts (Plan)
- Implementation of procedures to manage identified aspects and improvement of processes (Do)
- Checking and monitoring of progress through internal audits, management review and external audit (Check)
- Improvement of processes based on the results from audits (Act).

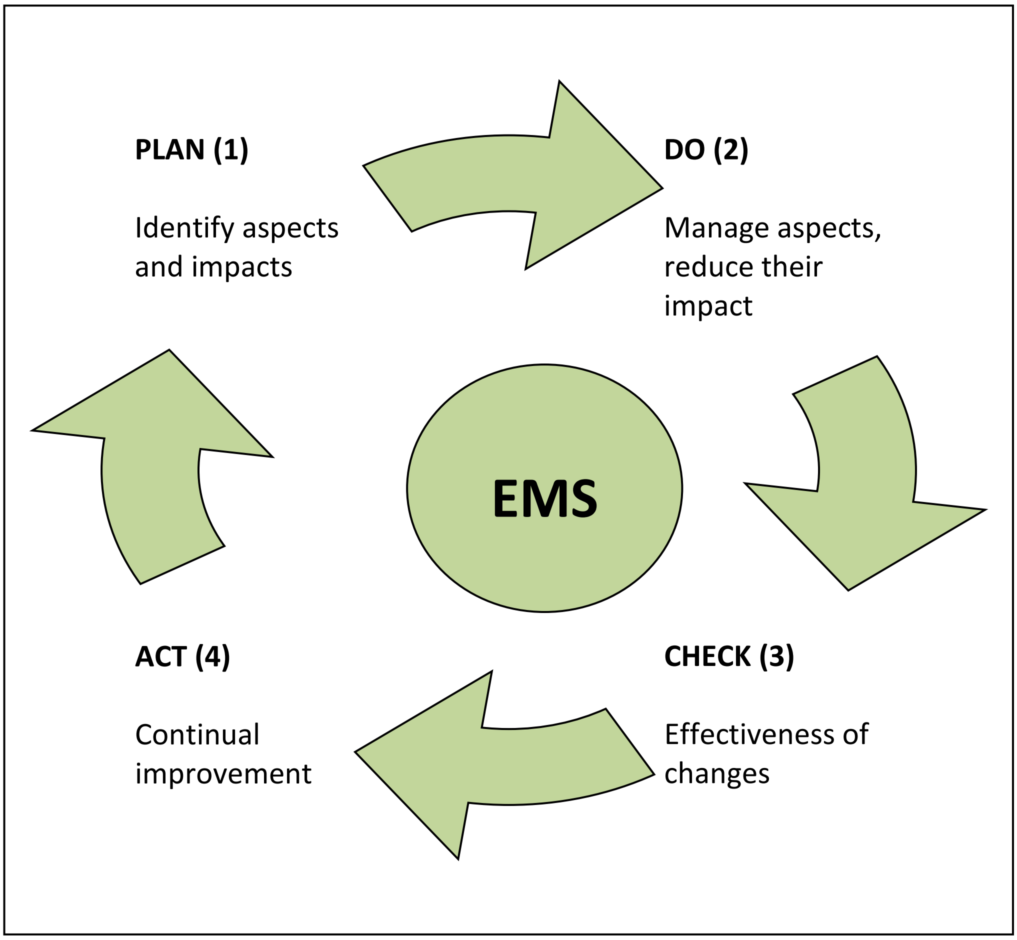

Figure 1-3: Plan-Do-Check-Act Cycle (Deming Cycle)

There are several standards available for companies that want to implement an EMS. ISO 14001 is the best-known international standard for EMS. In order to become ISO 14001 certified the following requirements need to be fulfilled (Da Fonseca, 2015).

→ *Environmental Policy* – An environmental policy is a written statement outlining the company's mission and driving force behind the objectives, targets and management programmes of its EMS. It contains the environmental aims and objectives and builds the basis for an EMS. Furthermore, it needs to be supported and signed by senior management and accepted by all staff members. Developing an environmental policy facilitates communicating the aims and objectives to employees and interested parties, for example customers, suppliers and other stakeholders (Envirowise, 2000).

→ *Legal requirements* – it is required that companies identify laws and regulations relevant for their products and processes. It is pivotal to put processes in place to ensure compliance with applicable legislation.

→ *Environmental programme* – Companies need to identify and allocate resources to achieve their environmental objectives and targets. This includes establishment of responsibilities and dedication of financial and technological resources to the programme.

→ *Procedures and training* – To manage the identified environmental impacts, companies have to develop procedures and implement training programmes.

→ *System audit* – Regular internal auditing and review of the EMS by top management is necessary to ensure the effectiveness and continual improvement of the system.

→ *External audit* – An audit carried out by a third party confirms whether the requirements outlined in the ISO 14001 standard are met.

→ *Life cycle approach* – It is required to look beyond the business boundaries and work together with supplies and customers along the supply chain to reduce environmental impacts.

The European Union introduced the Eco-Management and Audit Scheme (EMAS) EMS standard which is similar to ISO 14001 with the additional requirement for external reporting (EMAS, 2009). Companies within the European Union can get voluntarily certified against the EMAS standard and thereby show their commitment to sustainability. It requires companies to regularly produce a report including the company's policy, objectives and targets, and if possible, performance indicators for each site together with conclusions and improvement actions. Those reports are audited by a third-party auditor. All companies complying with the EMAS requirements are then published in the Gazette of the European Union and are allowed to use the EMAS-label (EMAS, 2009).

A certified EMS can demonstrate to stakeholders that a company is proactively engaged in improving products and processes to manage and minimize their impact on the environment. However, the implementation of EMS does not always have the intended outcomes as some practitioners argue that systems are often created for the purposes of achieving certification to gain competitive advantage with few tangible environmental benefits (Martín-Peña, Díaz-Garrido, & Sánchez-López, 2014; Prajogo, Castka, Yiu, Yeung, & Lai, 2016). Other criticisms of EMS include the general focus of companies on documentation, 'box ticking' and compliance as well as the typically limited scope of the systems to individual business operations without considering the life cycle impact in the wider supply chain (Boiral, Guillaumie, Heras-Saizarbitoria, & Tayo Tene, 2018).

In response to the identified weaknesses in the historic implementation of EMS, the ISO 14001 standard was revised, and a new version released in 2015 (Lewandowska & Matuszak-Flejszman, 2014). The revised standard includes many direct and indirect references to LCT and in particular the need to consider the wider supply chain in the scope of EMS. Additionally, the new standard encourages the use of eco-design in the context of the EMS which is understood to mean the integration of environmental aspects into product design and development to improve the environmental performance of products across the life cycle (Witczak et al., 2014).

It is too early to determine categorically whether the changes to the international standard will have a substantial impact on the benefits of implementing an EMS, as most certified organisations are still adapting their systems to align with the 2015 version of ISO 14001. The changes have however provided needed clarity around the relationship between LCM, sustainability, EMS, and other tools and concepts such as LCA and eco-design (Da Fonseca, 2015).

1.2.3 Life Cycle Assessment (LCA)

LCA is a methodological tool to investigate and evaluate the environmental impacts of a product or service throughout its entire life cycle (Baumann & Tillman, 2004; Hauschild, Jeswiet, & Alting, 2005). According to The Society of Environmental Toxicology and Chemistry (SETAC) LCA can be defined as (SETAC, 1991):

> *"... an objective process to evaluate the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and materials used and waste and emissions released to the environment, to assess the impact of the energy and materials use as the releases to the environment, and to evaluate and implement opportunities to affect environmental improvements. The assessment includes the entire life cycle of the product, process, or activity, encompassing extraction and processing of raw material, manufacturing, transportation and distribution, use/ re-use/ maintenance, recycling, and final disposal".*

According to the ISO 14040 and ISO 14044 standards (International Organisation for Standardisation (ISO), 2006a, 2006b), LCA consists of four phases (Figure 1-4):

1. Goal and scope
2. Life Cycle Inventory (LCI)
3. Life Cycle Impact Assessment (LCIA)
4. Interpretation

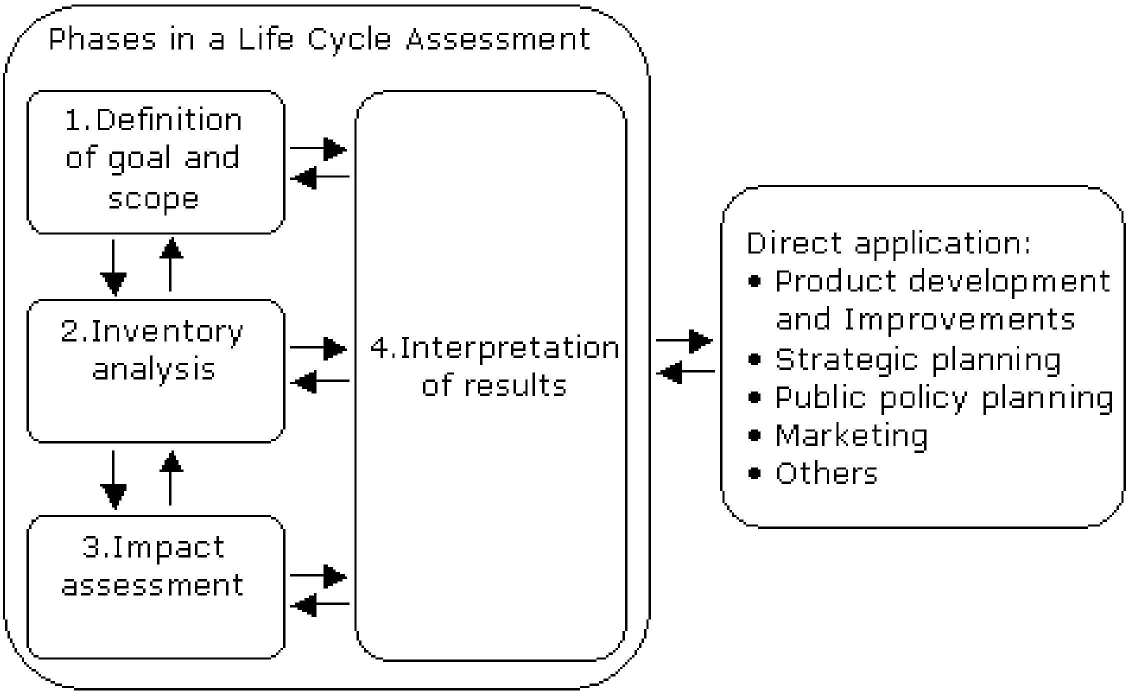

Figure 1-4: LCA Methodology (International Organisation for Standardisation (ISO), 2006)

LCA is a useful tool that is based on LCT in a quantitative way (Baumann & Tillman, 2004). It is applied by companies to evaluate the potential impacts of a product or service. It can be used to identify hotspots of a product or service during the life cycle (stand-alone LCA) and identify priorities for improvement programmes, but also to benchmark and compare products or services and evaluate different material and process options (comparative LCA) (Baumann & Tillman, 2004). LCA can be used as a marketing tool to inform consumers about the environmental performance of a product, but also for developing green procurement policies and as a tool to support strategic planning. Industry also uses LCA to defend products against claims made by competitors or non-government organisations (NGO), to improve strategic planning and to evaluate their environmental performance (Baumann & Tillman, 2004; Grotz & Scholl, 1996; Molina-Murillo & Smith, 2009; Rex, 2005).

LCA can be also used to support the development of government environmental policy and legislation (Baumann & Tillman, 2004; Hemming, 1994). And NGOs use it to make industry more accountable and for monitoring changes in the environmental performance of products (Miettinen & Hämäläinen, 1997).

1.2.4 Benefits of LCM

The previous sections presented sustainable development, EMS and LCA in the context of LCM. This section discusses benefits companies experience through the integration of LCM into their operations, focusing on competitive advantage, financial benefits, risk management and staff retention.

1.2.4.1 Competitive Advantage

Due to the growing awareness of sustainability worldwide amongst consumers, governments and businesses, environmentally sensitive markets expect businesses to meet certain standards. Companies that are seen to be reducing their environmental impact may gain a competitive advantage (Delmas, Hoffmann, & Kuss, 2011; Laszlo & Zhexembayeva, 2011; Willard, 2012).

In the European Union and Japan in particular, basic environmental requirements are an order qualifier (KPMG, 2005). That means certain environmental standards have to be met for customers to even consider the product in their buying decision. Companies operating in those markets need to implement processes and strategies that support improvement of their environmental performance. LCM is one of the approaches that can be used to meet the requirements in a specific market, but additionally allows a company to go further and use LCM as a differentiator.

The development of strategies to become more sustainable leads to innovation in terms of new technologies and processes but also new marketing strategies.

1.2.4.2 Financial benefits

Individual companies implementing sustainability improvements can experience financial benefits through cost reductions and access to new markets (Carter & Dresner, 2001; Gil, Jiménez, & Lorente, 2001; KPMG, 2005; Linnanen, 1995; Seidel et al., 2009).

Companies implementing sustainable business practices are often prepared when governments introduce stricter environmental legislation. Preparedness prevents them from having to pay fines for non-compliance, whereas companies that only focus on day-to-day business without taking the environmental impacts into consideration might face difficulties complying with the introduced laws.

Financial benefits may also be realised when internal processes and structures are changed. Examples are reduced energy consumption (Blengini & Di Carlo, 2010; Bribián, Usón, & Scarpellini, 2009; Dornburg, Lewandowski, & Patel, 2003) and reduced office and manufacturing waste leading to cost savings for waste disposal (Berry & Rondinelli, 1998; Cherubini, Bargigli, & Ulgiati, 2009; Hilaly & Sikdar, 1994; Lu & Yuan, 2013; Nessi, Rigamonti, & Grosso, 2013). The primary industry may realise financial benefits through more efficient irrigation, reduced fertilizer application or more efficient cooling processes (Gunady, Biswas, Solah, & James, 2012; Núñez et al., 2013; Tendall & Gaillard, 2015; van der Werf et al., 2014). Cost reduction can also be achieved by improvement of packaging leading to reduction of packaging materials (Albrecht et al., 2013; Holland, 2013; Yam & Lee, 2012).

Optimisation of logistics is a result of working with up- and downstream suppliers. If travel routes, location of distribution centres and truck sizes are optimized major reduction of environmental impacts can be achieved. These improvements also lead to cost reductions through efficient use of fuel as well as time savings (Dekker, Bloemhof, & Mallidis, 2012).

1.2.4.3 Risk Management

According to KPMG (2005) companies implementing sustainable business practices are likely to identify and manage risks more effectively and efficiently compared with other companies. LCM can be used as a risk management tool since it allows companies to identify and manage environmental liabilities and thereby mitigate the risk of future penalties (Environment Canada, 2009).

1.2.4.4 Attract and retain talent

Research suggests that companies that implement environmental initiatives are more likely to attract and retain excellent employees. Sharfman, Ellington, and Meo (1997) support this statement since sustainable development is not only a topic concerning governments and businesses but also individuals. In order to reduce staff turnover it is important that employees can identify with company values, and alignment of personal values with company values leads to a better work environment, thereby higher motivation and reduction of staff turnover (McShane, Olekalns, & Travaglione, 2009).

McShane et al. (2009) that the culture of companies that implement LCM concepts is characterized by involvement of staff members in particular decision-making processes, and by open and honest communication. These attributes are important for a company that goes with the trend and wants to set examples in a fast-changing environment. These companies usually encourage learning and are open for changes.

1.2.5 Summary

To conclude this section, it can be said that EMS implementation supports companies to continually improve their environmental performance. However, this approach has historically mainly focused on the environmental performance of one company/site. However, assessment of the environmental impact of products involves all life cycle stages; it allows identification of improvement areas for the respective supply chain and can be used to define environmental performance criteria for suppliers to manage impacts on the environment throughout the entire life cycle of a product. LCA and EMS are therefore complementary because the identification of environmental hotspots of processes and products can be used as the basis for setting the priorities for EMS targets and objectives for a company.

1.3 The Relevance of Life Cycle Management for New Zealand Primary Industry Sectors

New Zealand's "clean and green" image is due in part to its low population density and its beautiful natural environment (Brown & Stone, 2007; Frame & Newton, 2007; Gnoth, 2002). To maintain this positive reputation there is a need to proactively improve processes and systems and reduce impacts on the environment (Sterzik, McLaren, Garnevska, & Hume, 2014).

New Zealand has an export-oriented economy: 26% of New Zealand's GDP was earned from exported goods and services in 201, compared to its key trading partners Australia (21.3%), United States (13%) and China (19.8%) (NZTE, 2017). These exports are dominated by resource-based goods; according to Statistics New Zealand, in 2014 72% of all export products were primary products (Dalziel et al., 2018; Saunders, Dalziel, Guenther, Saunders, & Rutherford, 2016).

Due to the New Zealand economy's dependency on exports it is important to anticipate trends in overseas markets and respond appropriately. Compliance with overseas standards, laws and customer requirements is vital in order to maintain and strengthen competitiveness and reputation in the global market place (Sterzik et al., 2014). However, there has not been a significant increase in the uptake of voluntary environmental improvement practices by New Zealand export industries (Brown & Stone, 2007; Collins et al., 2010). A survey conducted by Collins et al. (2007) showed that nearly 50% of the surveyed companies felt no external pressure to adopt environmental practices.

An example of trends in overseas markets that can create significant threats for the New Zealand export economy, is the "food miles" debate, which came up in the 1990s in the United Kingdom. The "food miles" debate is a result of the increasing awareness of environmental performance of products and services. The term "food miles" refers to the distance the food is transported from the grower to various stages of production till it reaches the consumer (Smith et al., 2005). It promotes the use of locally produced products instead of products that had to be transported long distances (Engelhaupt, 2008). However, the "food miles" concept provides a limited view of the actual environment impacts of a product (Saunders et al., 2006). It only takes into consideration one life cycle stage (transport), but there are many other aspects that contribute to the environmental footprint of a product. For example, different regions use different amounts and types of energy to grow their agricultural products and might therefore result in fewer overall emissions than goods produced locally, as shown in the report "Food miles – Comparative Energy/Emissions Performance of New Zealand Agriculture Industry" by Lincoln University (Saunders et al., 2006). Instead, analytical tools such as LCA (Section 1.2.3) provide a more holistic view of the potential impacts of a product throughout its entire supply chain. Calculations are not only based on travelled distance and are thus a much more valid comparison. It is therefore important for New Zealand companies to apply these types of concepts and tools in order to demonstrate the low impact on the environment of their products (Smith, Stancu, & McKenzie, 2006).

The New Zealand Government can also play an important role to foster sustainable development of businesses. The development of environmental laws and industry standards can strengthen the country's "clean and green" image (PricewaterhouseCoopers, 2009). They can be seen as a tool to reinforce the perception of New Zealand being environmentally friendly and sustainable. Examples are the Resource Management Act, the Waste Minimisation Act, the Emissions Trading Scheme, the New Zealand Packaging Accord, the Packaging Product Stewardship Scheme and the New Zealand Water Efficiency Labelling Scheme:

- In 1991, the *Resource Management Act* was put in place with the purpose to sustainably *"manage the use, development and protection of natural and physical resources"* (Ministry for Environment, 2011c).
- In 2008, *the Waste Minimisation Act* came into force in New Zealand and since 1st of July 2009 it puts a levy on waste disposed in landfill ($10 per tonne). The Waste Minimisation Act encourages waste reduction and decrease in waste disposal in order to protect the environment and provides environmental and economic benefits. Part 2 of the Waste Minimisation Act includes information about product stewardship. The purpose is to encourage people and organisations involved in a product's life cycle to share responsibility for the impact on the environment caused by their products. The implementation of a product stewardship scheme is mandatory for priority products and voluntary for all other products. Priority products are to be declared by Ministers in the Gazette and are those that "will or may cause significant environmental harm when it becomes waste, or there are significant benefits from reduction, reuse, recycling, recovery, or treatment of the product" and also products that "can be effectively treated under a product stewardship scheme" (Ministry for Environment, 2011a).
- In 2008, the *Emissions Trading Scheme* was enacted to reduce/limit emissions by industry. It allows companies producing high amounts of emissions to buy emission units from other industries in order to offset emissions (Ministry for Environment, 2011b).
- The *New Zealand Packaging Accord* is another example of a voluntary initiative. It ran for five years, from 2004 till 2009, aiming to make producers responsible for their packaging products at the end of the useful life and encourage them "to waste less and be more efficient when making, using and recovering packaging materials" (Ministry for Environment, 2004).

- Based on the success of the Packaging Accord and the product stewardship requirements set out in the Waste Minimisation Act, the *Packaging Product Stewardship Scheme* was released in 2010. Again, this is a voluntary initiative aiming to reduce packaging waste, increase reuse of packaging, increase the recycled content of packaging and also to increase consumer awareness and understanding of sustainable packaging (Packaging Council of New Zealand, n.d.).
- The *New Zealand Water Efficiency Labelling Scheme* was introduced in April 2010. Labels on products that use water will provide the consumer with information about the water consumption and facilitate comparison between products (Ministry for Environment, 2010).
- The *ZeroCarbon Bill* is an amendment to the existing Climate Change Response Act 2002 and represents the efforts to combat climate change by limiting the global average temperature increase to 1.5 degrees Celsius above pre-industrial levels. The bill would set greenhouse gas reduction target into law and require future governments to continue those efforts (New Zealand Parliament, 2019).
- The *ban of single-use plastic shopping bags in New Zealand* was introduced on 1st of July 2019. It means that businesses cannot provide customers with single-use plastic shopping bags that are made of up to 70 microns in thickness in order to reduce the amount of plastic in the environment (Ministry for Environment, 2019e).

To avoid risk of future legislation, customer and competitive requirements, New Zealand companies need to take voluntary approaches and make the most out of the significant opportunities presented by the international sustainability trend. Their actions, and the government's engagement, can enable New Zealand as a country to reinforce its "clean and green" image, improve brand reputation and develop innovations to support sustainable development.

1.4 Problem Identification, Aim and Research Structure

The implementation of LCM has thus far been studied primarily at the level of the individual large organisation. Studies focus on differences between organisations in the structure, culture, control and management of LCM activities (Mandl & Dorr, 2007; Seidel et al., 2009). However, the accumulated environmental impacts of SMEs are at least as significant as the impacts of large organisations (Bos-Brouwers, 2010; Groundwork, 2005). Many SMEs face difficulties when it comes to implementation of LCM. The limited number of studies on implementation of LCM in individual SMEs indicate that this is difficult due to factors such as their limited resources (financial, technical, human), limited knowledge and recognition of environmental impacts, and perceived conflicts between environmentally friendly practices and other business objectives (Mandl & Dorr, 2007; Seidel, Seidel, Sterzik, & Shahbazour, 2012; Seidel et al., 2009).

At present, there is little understanding in LCM as to what the barriers to effective uptake, implementation and continuous improvement are. Additionally, it is important to find out how the hurdles can be overcome.

Based on those findings, the aim and objectives of the research (Section 1.4.1), as well as an outline of the individual chapters of this thesis (Section 1.4.2), are presented below.

1.4.1 Research Aim and Objectives

In contrast to current research that focuses on LCM implementation on a company level, this research focuses on the successful application of LCM at the level of an industry sector. Implementation of LCM at the sector-level means that a larger number of organisations can be targeted and supported on a continuous basis, resulting in potentially more significant reduction of environmental impacts. For organisations, that means a more cost- and time-effective LCM implementation, as the cost will be shared amongst the individual supply chain entities. Also, organisations within an industry sector will be able to benchmark themselves against each other, and where appropriate, share knowledge and processes on best-practice approaches to ensure the industry itself reduces environmental impacts.

As discussed above, there is a gap in the literature when it comes to understanding barriers and enablers to successful sector-wide LCM uptake and how to overcome them.

The aim of the research was therefore to develop and test an approach for practical and efficient LCM implementation in New Zealand primary industry sectors. In order to achieve this, the following objectives were defined:

1. **Objective One:** Development of a theoretical understanding of LCM including identification of factors to successful LCM uptake in organisations and industry sectors
2. **Objective Two:** Identification of enablers and barriers to LCM implementation specific to the New Zealand primary industry.
3. **Objective Three:** Development of a framework to enable industry sectors to evaluate their LCM performance.
4. **Objective Four:** Development of an IT platform to facilitate effective uptake of LCM practices in industry sectors.

1.4.2 Thesis outline

This thesis has been written based on 'PhD Thesis by Publication' style. The thesis comprises of seven chapters and the references. Table 1.2 summarises the chapters of the thesis and the methodologies used in each of them.

Table 1.2: Thesis outline

Chapter 1: Introduction

Objective 1: Development of the theoretical foundation for the research.

Literature review on:

- Sustainability: including terminology, historic development and growing significance.
- Introduction to Life Cycle Assessment (LCA), Life Cycle Management (LCM), and Environmental Management Systems (EMS).
- Benefits of successful LCM implementation.
- Relevance of LCM for the New Zealand primary industry.

Outcomes: Problem identification and definition of research aim and associated objectives.

Chapter 2: Research Methodology

Development of the methodology and philosophical stance for the research.

- Literature review on different theoretical perspectives and research approaches to achieve the research aim/objectives.
- Definition and justification of chosen research approach and methodologies.

Outcomes: Formulation of the research strategy and methodology.

Chapter 3: "*Effective LCM in SMEs: Use of a Sector-Based Approach to Overcome Barriers*" (published: (Seidel-Sterzik, 2018))

Objective 2: Identification of enablers and barriers to LCM implementation specific to the New Zealand primary industry.

- Literature research on SME characteristics.
- Research of SCM approaches and their suitability for SMEs.
- Defining sector-based approaches, including advantages and disadvantages when applying this concept in order to effectively implement LCM on a larger scale.
- Evaluation of existing sector-based approaches as a means to exchange knowledge and ideas between supply chain partners and within organisations.

Contributions:

- Synthesised list of factors affecting the successful uptake of LCM in the SME dominated NZ primary industry.
- Preparation of the foundation for a capability maturity model and the development of the LCM Uptake Evaluation Framework (LUEF).
- Justification for a sector-based approach as a viable solution to implement LCM sector-wide in NZ primary industry sectors.

Chapter 4: "Quantitative study in LCM Experiences in the New Zealand Kiwifruit Industry" (to be submitted to International Food and Agribusiness Management Review)

Objective 2: Verification of the enablers and barriers of LCM implementation in the New Zealand kiwifruit industry.

- In-depth quantitative study of the New Zealand kiwifruit industry through online survey.
- Identification and evaluation of life cycle based environmental initiatives implemented in the New Zealand kiwifruit industry.
- Gaining information about orchard practices, as well as knowledge management, communication within organisations as well as horizontally and vertically in the supply chain.
- Identification of the role of various stakeholders in the New Zealand kiwifruit industry, as well as their relationships to each other with respect to enabling LCM uptake in the industry.

Contributions:

- Insights into the role of the stakeholders of the New Zealand kiwifruit industry.
- Insights into environmental management practices undertaken by New Zealand kiwifruit growers.
- Understanding of communication and knowledge management practices within organisations as well as between supply chain partners
- Identification of areas for improvements in order to make LCM uptake scalable. This provides the foundation for the research on the Information System platform in Chapter 6.

Chapter 5: ***"A Capability Maturity Model for Life Cycle Management at the Industry Sector Level"***

(published: (Seidel-Sterzik, 2018))

Objective 3: Development of a framework to enable industry sectors to evaluate their LCM performance.

- Qualitative study in the New Zealand kiwifruit industry to gain an understanding of environmental practices using a different method compared to the online survey in Chapter 4. That way, findings can be verified or otherwise.
- Additionally, the qualitative study focused on different entities in the supply chain and included growers, post-harvest operators as well as Zespri (industry board).
- Using the findings from the literature review, qualitative and quantitative study, development of the factors to assess organisations' and industry sectors' environmental performance.
- Establishment of maturity scales for each factor, to allow organisations and industry sectors to assess how well they are performing in each of those.

Contributions:

- Development of the LUEF framework which can be used by individual organisations, supply chain partners or industry sectors to evaluate their current environmental performance, decide upon actions and set up improvement tasks, and benchmark their performance on a regular basis.

Chapter 6: "An IT platform to facilitate a sector-based approach for life cycle management in the primary industry" (to be submitted)

Objective 4: Development of an Information System (IS) for the effective ongoing management of sector-based LCM programmes in primary industries.

- Literature review on IT for LCM.
- Review of existing IT for LCM.
- Development of required characteristics for an IT to support LCM implementation in the primary industry from the perspectives of growers, industry sector bodies and third-party verification organisations.
- These characteristics are developed based on a review of previous research into software and information systems for environmental management and Life Cycle Assessment, and a case study of the New Zealand aquaculture industry.
- Evaluation of the effectiveness through a case study in the New Zealand aquaculture industry.

Contributions:

- Establishing the criteria for a successful IT platform to facilitate LCM uptake in New Zealand primary industry sectors.
- Development of an IT platform to implement LCM uptake in organisations and industry sectors on a large scale, to effectively support change and continuous improvement.
- Testing of the IT platform for the New Zealand aquaculture industry.

Chapter 7: Discussions and Conclusions
• This chapter of the thesis summarises how the aim and objectives of the thesis have been met. It provides an overview of the contributions to knowledge.

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2 RESEARCH METHODOLOGY

This chapter deals with the selection of an appropriate methodology and an overview of how it is applied for this research. It begins with a summary on theoretical perspectives that are used in qualitative and quantitative research and the philosophical stance used by the researcher for this PhD (Section 2.1). The chapter goes on to discuss in detail the specific methods used to gather qualitative and quantitative data for this research (Section 2.2) and summarises the research objectives in the context of the structure of the thesis (see Section 1.4.1).

2.1 Theoretical Perspectives

The aim of this PhD research is to support the uptake of LCM in the primary industry. This is an interdisciplinary topic that has interactions with several research areas including in particular sustainability, technology transfer, SME characteristics and Supply Chain Management (SCM). Interdisciplinary topics require the researcher to think beyond traditional boundaries and integrate different approaches and methods to better understand complex problems and create new knowledge (Evely, Fazey, Pinard, & Lambin, 2008; Fahy, 2008; Welford & Casagrande, 1997).

Interdisciplinary research can be carried out using different underlying philosophical perspectives. The spectrum of philosophical perspectives ranges from positivist to interpretive (Evely et al., 2008). The use of a particular philosophical perspective lays the foundation for the choice of research method and is informed by the research aim (Evely et al., 2008).

Evely et al. (2008) describe a continuum of philosophical perspective from extreme positivism to extreme subjectivism. They define five intermediate stances between extreme positivism and extreme subjectivism: structural realism, critical realism, transcendental realism, hermeneutics and nominalism.

Recent articles in the corporate sustainability, environmental management and LCA fields provide robust discussion around the epistemology of research in this area (Dijk et al., 2017; Iofrida, De Luca, Strano, & Gulisano, 2018; Vildåsen, Keitsch, & Fet, 2017). Their two main paradigms, positivism and interpretivism, are briefly described in the following two sections of this chapter (Section 2.1.1 and Section 2.1.2). On this basis, Section 2.1.3 describes the philosophical stance of the research in this PhD.

2.1.1 Positivism

Researchers applying a positivist perspective create new scientific knowledge based on observable facts (Meredith, Raturi, Amoako-Gyampah, & Kaplan, 1989). They assume that results are independent of the researcher's action, human intention and purpose and they see the environment in which the research takes place as external to the researcher (Meredith et al., 1989). Positivists see the reality as external and objective, and subsequently apply a very analytical approach where results are measured through objective methods instead of being interpreted through intuition.

Therefore, positivists use research methods such as controlled experiments, field studies, structured interviewing, prototyping, laboratory experimentation, simulation and physical modelling and surveys (Easterbrook, Singer, Storey, & Damian, 2008). Most researchers in the natural sciences apply this worldview (Bryman & Bell, 2007; Myers & Avison, 1997).

Typically, positivist research has a formal proposition, quantifiable measures, hypothesis testing and draws "inferences about a phenomenon from the sample to a stated population" (Myers & Avison, 1997).

2.1.2 Interpretivism

Interpretivism (also known as subjectivism, relativism or phenomenological approach) is the contrasting philosophical perspective to positivism (Bryman & Bell, 2007). Interpretivism assumes that scientific knowledge is linked to the researcher's environment (Bryman & Bell, 2007; Easterbrook et al., 2008; Myers & Avison, 1997).

Interpretivists consider that new scientific knowledge is created through social constructs, such as language. They study human interaction and how people in an environment make sense of certain phenomenon (Meredith et al., 1989). Therefore, they regard results as being influenced by people's experience and values, beliefs, culture and feelings and also depend on the researcher's individuality. This limitation needs to be considered and can potentially limit replicability of interpretivist research projects.

Interpretivist research is usually less structured than positivist research, as it takes place in close interaction with the environment. It is therefore also more subjective (Meredith et al., 1989). Researchers in this area most commonly use qualitative research methods, ethnography, case studies, action research, Delphi, expert panels, conceptual modelling and hermeneutics (Meredith et al., 1989).

2.1.3 Philosophical perspective for the research

A number of researchers in the sustainability field emphasise that the positivist focus is "oversimple" and criticise the "emphasis on positivism and rationality" in academic as well as industry research (Fahy, 2008; Welford & Casagrande, 1997). Continuing to research sustainability from a positivistic perspective will not lead to much improvement, and a more critical perspective is needed, otherwise the results will not lead to more knowledge creation in this area. Other researchers emphasise that it is important to take into consideration the social and cultural practices of organisations to understand the inherent complexity involved in LCM and corporate sustainability implementation within organisations and industry sectors (Dijk et al., 2017; Fahy, 2008; Iofrida et al., 2018; Vildåsen et al., 2017).

Critical realism is a philosophical worldview that includes humans' assumptions and perceptions of the world (Evely et al., 2008). Like positivism, critical realism values objective realities, but also includes human perceptions and takes those into account (Oliver, 2011). This perspective was considered appropriate for researching LCM uptake in organisations and industry sectors. For example, the uptake of LCM initiatives by kiwifruit growers cannot only be based on arguments around tolerable amounts of fertiliser and pesticides but is also linked to the growers' experience with those chemicals as well as their personal values, education and background. Therefore, a combination of methodologies, including quantitative as well as qualitative data, allows the researcher to take into consideration the human perspectives of the phenomenon under investigation.

In this PhD, the researcher takes the philosophical perspective of the critical realist.

2.2 Research Methodology

As highlighted in Section 2.1 it is appropriate to apply different research methods to investigate a complex topic such as LCM uptake in primary industry sectors. Therefore, this research used a mix of qualitative and quantitative methods. The following sections describe the triangulation approach and the quantitative and qualitative aspects of the PhD research. Further details of the methodologies are summarised in the corresponding chapters of this thesis.

2.2.1 Triangulation

A number of sustainability researchers recommend the benefits of triangulation in sustainability research. For example, Welford and Casagrande (1997, p. 230) suggest that, "Sustainable development requires much more systemic thinking and interdisciplinary approaches", and that the researcher should ideally "immerse him or herself in the subject" and integrate results from both quantitative and qualitative methodologies to develop new knowledge (Molina-Azorín & López-Gamero, 2016; Reinecke, Arnold, & Palazzo, 2016).

A methodological triangulation approach was therefore adopted in this research in order to strengthen the applicability of the findings and to provide a means of comparing the outcomes of the different research methods (Collis and Hussey, 2013). Triangulation allows counterbalancing weaknesses of different research methods, assuming that the different methods do not have the same weaknesses in common (Bouchard Jr, 1976; Rohner, 1977; Welford & Casagrande, 1997). Jick (1979) highlights that triangulation allows the research to take a holistic view of the phenomenon being researched. However, the research focus remains the same in all methods used. If the different methods lead to the same conclusion, then it is likely that the approach adopted has delivered a reliable insight into the studied problem.

Quantitative research is associated primarily with research methods such as surveys, experiments, and questionnaires (closed-ended questions), measurements from experiments, official statistics and documents (e.g. business data or company reports) and observations (Denscombe, 2010).

Qualitative data take the form of words (spoken or written) and visual images (observed or creatively produced). This type of data is usually collected through case studies or grounded theory, ethnography and phenomenology using methods such as interviews (semi-structured or unstructured) as well as open-ended questions in surveys, documents and observations.

This PhD research makes use of both quantitative and qualitative research techniques. Elements of the triangulation research methodology include literature research (Chapter 3), an online survey to collect quantitative data (Chapter 4) and semi-structured face-to-face interviews to collect qualitative data (Chapter 5).

The following sections describe the main research methods that have been used in this PhD research: an online survey and semi structured interviews supported by observations on site.

2.2.2 Quantitative Study - Online Survey

Online surveys were chosen as a method to verify whether the barriers and enablers to successful LCM uptake identified in the literature were applicable in the New Zealand kiwifruit sector.

An advantage of this method is the fact that respondents can fill in the survey in their own time and it is less intrusive than a telephone or face-to-face interview (Denscombe, 2010). Online surveys reduce bias as the researcher is not in the same room and answers are all confidential. Therefore, the participants of the online survey do not feel pressured to answer the questions in a certain way and the researcher's own opinions do not influence the respondents. There are no verbal or visual cues to influence the respondent (Denscombe, 2010) as gestures and other body language are not applicable with written questionnaires.

To get representative insights into practices and perceptions around LCM it was important to include kiwifruit growers from across different regions of New Zealand. Online surveys were a useful tool to accomplish that in an effective manner within the time and resource constraints of the PhD.

Given that Zespri, the industry body for the kiwifruit sector, provides an online portal with information and tools for growers, it was assumed that the vast majority of kiwifruit growers have access to the internet. Furthermore, most people are familiar with online surveys, and therefore this method does not make people apprehensive towards it (Denscombe, 2010).

The online survey was undertaken by using a survey software tool called Qualtrics. It allows the researcher to enter questions of different types (e.g. yes/no questions, multiple choice questions, open ended questions, Likert scales, etc.) and send the link to survey participants. Survey participants can then open the survey and answer the questions at their time of convenience.

The researcher used a statistics software tool called SPSS to process the survey responses. It was important to clean the data first and delete surveys that were submitted without any response to any of the questions. Furthermore, the categorical variables were checked to make sure that only possible responses appeared in SPSS. Where this was not the case, the researcher consulted the original questionnaire to confirm what the response for that particular question was.

Additionally, it was important to check for missing cases. If there are a lot of missing cases it needs to be checked if there are errors in entering the data (e.g. in the wrong columns).

Continuous variables also need checking. For example, it is crucial to check maximum and minimum values to see if they are realistic and make sense. One question, for example, asked participants to enter the number of years that they have been working in the New Zealand kiwifruit sector. People can accidentally add another zero to their numbers and it is unrealistic that someone worked 150 years in the industry so far. That shows that it is crucial to check that numbers are realistic and exclude numbers that ruin the average of the results.

2.2.3 Qualitative Study - Semi-Structured Interviews

In this PhD research, semi-structured interviews were used as a research method to gather qualitative data relating to the implementation of LCM initiatives in the New Zealand kiwifruit sector. Organic and contemporary growers, and staff at post-harvest operations, as well as Zespri were interviewed for the pilot study and for the development of the LUEF framework (Chapter 5).

Interviews, especially unstructured or semi-structured interviews, offer considerable researcher flexibility. By directly questioning and talking to relevant stakeholders of the industry, large amounts of relevant information about the different experiences could be acquired. Qualitative research through in-depth interviews results in more detailed data than what is available through other data collection methods such as online surveys.

The use of semi-structured interviews was appropriate to supplement and extend knowledge about the culture, structure and technology transfer processes within the

New Zealand kiwifruit sector as well as enablers and barriers to LCM uptake. Moreover, it may provide a more relaxed atmosphere in which to collect information and people often feel more comfortable having a conversation as opposed to filling out a survey (Woods, 2011).

Interviews can be carried out in a structured, semi-structured or unstructured way. For the research reported in Chapter 5, the development of semi-structured interviews was an appropriate method to ensure that all important topics were addressed while providing enough flexibility to encourage the interviewee to raise and discuss issues that would otherwise be neglected. The method enables the researcher to ask spontaneous questions and allow the participants to express themselves. This method also allows questions to flow naturally, based on information provided by the participants. The partial pre-planning of the questions still allows for replication of the interview with others.

A limitation of this method is that interviewers could be biased and consequently leads to inaccurate results (Woods, 2011). That can be reduced by avoiding judgement of their answers. In addition, the researcher is from a university and is not a stakeholder of the kiwifruit sector who has the power to make or influence decisions. Moreover, yes/no-questions and leading questions were avoided to allow the respondent to provide the information that reflects and justifies his or her opinion.

The language and terms used during the interviews was supposed to be easily understood by participants, and complicated or confusing questions were avoided.

There are different means of analysing semi-structured interviews. One way is to record and then transcribe the interviews. However, Denscombe (2010) highlights that “[t]he amount of the raw data that needs to be transcribed will depend on the use to which the data is being put. If the contents of an interview are being used for the factual information they provide, for example, as part of a “descriptive account” then the researcher can be quite selective; transcription might only be needed for the purpose of small extracts that can be used as “quotes” to illustrate particular points when writing up the findings” (Denscombe, 2010).

Denscombe (2010) explains that “[i]f the researcher is looking for the underlying structure of the talk or the implied meanings of a discussion, the audio recordings will need to be transcribed quite extensively […]” (Denscombe, 2010). However, the interviews were conducted to find out what different stakeholders do with regards to LCM uptake, what experiences they had and what projects they might take up in the future. The structure of the interviews, as well as the specific use of words did not matter. The interviews were about facts and not about underlying assumptions or gut feelings.

For this PhD research, it was not deemed necessary to transcribe the interviews. However, the interviews were recorded, and audio records were kept. Rather, it was more important to get quotes to highlight what the stakeholders are doing in LCM uptake and their opinions about specific issues. The researcher also made use of the insights from on-site visits and studied available industry documents.

The interviews were analysed in relation to a construct (LUEF) that was created as a result of the literature review. The researcher had an overview of barriers and enablers to successful LCM uptake due to the extensive review of the literature related to the LCM, characteristics of SMEs and supply chain management (SCM). The LUEF construct was used to guide design of the questionnaire and structure as well as analysis of the interviews.

Ethical considerations are a major issue in qualitative research but also crucial for quantitative studies. As mentioned above, the adopted research methods required face-to-face interviews and interaction as well as online surveys with industry participants in order to collect data on existing processes and activities regarding environmental management in their organisations and industry sectors.

Before getting in touch with potential interview partners, a human ethics approval was obtained from Massey University. That process involves a brief description of the study, including purpose and methods being used. The Human Ethics Committee from Massey University categorized the study as a low risk study and the researcher was allowed to continue the project.

The participants of the study had the chance to quit at all times and were not pressured to answer particular questions. Questions were asked in an unbiased way so that participants were able to choose responses that matched their personal opinions.

To ensure ethical treatment of all participants in this research, participants' answers have been anonymised. All participants had insights into the reason for the interview/online survey before agreeing to take part in the interview/online survey. When the interviews were recorded, the respondents were asked for their consent. Participants were ensured that confidentiality would be carefully maintained throughout the study.

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3 EFFECTIVE LIFE CYCLE MANAGEMENT IN SMES: USE OF A SECTOR-BASED APPROACH TO OVERCOME BARRIERS

This chapter evaluates relevant literature in the field of SME characteristics and SCM to understand existing knowledge and to determine how and where the PhD research can make a valuable contribution. In addition, the goal of this element of the research was to develop the theoretical foundation for subsequent research phases.

As described in Chapter 1.2, the concept of LCM involves the identification and systematic reduction of environmental impacts at each life cycle stage. Given the prevalence of SMEs in the primary industry sectors, Chapter 3.2 summarises their specific characteristics and evaluates what barriers and enablers they face when it comes to LCM uptake. Chapter 3.3 presents a summary of the relevant literature on SME characteristics that influence LCM uptake.

Chapter 3.4 subsequently presents and assesses the literature about SCM, including Green Supply Chain Management (GSCM). The concept of SCM relates closely to the concept of LCT when implementing sustainable business practices. The synthesis of the literature reviews in these three areas (LCM and sustainability, SME characteristics and SCM) led to definition of a number of critical factors for successful implementation of LCM in businesses and supply chains (Chapter 3.4).

Some of the barriers towards LCM uptake include lack of resources as well as lack of experience in environmental projects. A sector-based approach was identified as a potential way of overcoming the identified hurdles to successful LCM uptake in an industry sector, given that resources, knowledge and experience can be shared amongst the industry sector on horizontal and/or vertical levels between the supply chain partners. The final section of this Chapter (Chapter 3.5) thus discusses the sector-based approach to overcome the barriers identified in the preceding sections, presenting examples and benefits.

The following sections have been published as a journal paper "Seidel-Sterzik, H., McLaren, J.S., and Garnevska., E. Effective Life Cycle Management In SMEs: Use of a Sector-Based Approach To Overcome Barriers. Sustainability 2018; doi:10.3390/su10020359.

My contribution to the publication was as the main author. I conducted an extensive literature review in the area of LCM, SMEs and SCM. I also conducted the research around sector-based approaches and defined the term for this research project. My supervisors provided support via proofreading and feedback on the writing and structure of paper leading to iterative changes culminating in the final version.

Abstract

One approach to incorporate sustainability in organisations is the implementation of Life Cycle Management (LCM). LCM involves sharing responsibility for addressing environmental impacts across the entire supply chain of products and services, extending from raw material extraction to end-of-life of the product.

The New Zealand primary sector relies heavily on natural resources and provides about 70% of the country's export revenue. Most companies in primary industry sectors in New Zealand are Small and Medium Sized Enterprises (SMEs). Successful sector-wide uptake of LCM can potentially facilitate effective measurement and management of environmental impacts caused by this sector.

The aim of this research was to identify the barriers and enablers to successful LCM uptake by New Zealand primary sector SMEs within a sector-based context. An extensive review of the literature was undertaken in the areas of change management for SMEs and SCM. The main factors influencing successful LCM uptake include: owner/manager influence, environmental culture, resource availability, future orientation, knowledge of environmental issues, market requirements, geographical separation of production and consumption, awareness of own environmental issues and communication/information sharing.

This paper forms the basis for future research and development of tools for the effective implementation of sector-based approaches to LCM in the primary industry. The results of this research include a capability maturity model and the development of a cloud-based platform for collaboration and communication around LCM.

Keywords: Life Cycle Management (LCM), Sector-Based Approach (SBA), Sustainability, Agriculture, Small and Medium Sized Enterprise (SME), Supply Chain Management (SCM).

3.1 Introduction

There is a rising awareness of environmental problems and wider sustainability issues amongst governments, industries and consumers both in New Zealand and elsewhere (Green Growth Advisory Group, 2011; McLaren et al., 2008; Pure Advantage, 2014; UNEP, 2012, 2016; WBCSD, 2016a, 2016b, 2016c). As a result, many companies have implemented environmental sustainability initiatives in their business activities (Da Silva, Jabbour, & Santos, 2009; Esty & Winston, 2009; Johansson & Winroth, 2010; McLaren & Garnevska, 2014; Michaelis, 2003; Sarkis, 2001). This trend is particularly apparent in Europe where it has been driven by strict environmental legislation and financial instruments to encourage more efficient management of energy and other resources, and waste, in companies (European Commission Environment, 2010, 2011a, 2011b, 2011c; Gmelin & Seuring, 2014).

However, many organisations are still not active in this area – and many of these organisations are SMEs (Aiyub, Jahi, Arifin, & Awang, 2009; Borga, Citterio, Noci, & Pizzurno, 2009; Bourlakis, Maglaras, Aktas, Gallear, & Fotopoulos, 2014; Collins, Lawrence, Pavlovich, & Ryan, 2007; Henriques & Catarino, 2015; Hörisch, Johnson, & Schaltegger, 2015; Johnson & Schaltegger, 2016; Klewitz & Hansen, 2014; Williamson, Lynch-Wood, & Ramsay, 2006). SMEs find it particularly challenging to develop and implement environmental sustainability initiatives due to their specific characteristics e.g. limited financial and human resources, lack of expertise in sustainability, and lack of awareness about their own sustainability impacts (Hillary, 2000; Seidel, 2011).

New Zealand has a reputation for being "clean and green" and this is often used as a marketing attribute by New Zealand-based companies. However, in order to maintain and reinforce this reputation in global markets, companies need to be able to demonstrate their environmental sustainability credentials (Brown & Stone, 2007; Gnoth, 2002; Jones & Mowatt, 2016; Stern, 2012; Sterzik, McLaren, Hume, Garnevska, & McDevitt, 2013; Sustainable Business Council, 2017). In particular, the New Zealand economy relies heavily on export of primary products with over 70% of New Zealand's merchandise exports coming from primary industries (Ministry for Primary Industries, 2016). The New Zealand primary industry sector is largely run by SMEs (Whitman, Seville, Wilson. T., & Vargo, 2012). Therefore, demonstration of environmental sustainability credentials is particularly relevant in this sector.

One approach to implementing environmental sustainability is the use of Life Cycle Management (LCM). LCM is the application of life cycle thinking (LCT) to business practice, with the aim of managing the total life cycle of an organisation's products and services in order to move towards more sustainable consumption and production systems. According to UNEP, "LCM has been defined as the application of LCT in modern business practice" (UNEP, 2006). However, so far, only a small number of New Zealand companies have actually integrated a life cycle approach into their environmental sustainability initiatives (Collins, Dickie, & Weber, 2011; Collins, Roper, & Lawrence, 2010). This raises the question of why so many NZ SMEs have not engaged with LCM, and what is required to change this situation. This chapter therefore focuses on the underlying factors that can facilitate or impede implementation of LCM in SMEs in New Zealand, and particularly in the primary sector given its importance to New Zealand's economy.

The first part of this chapter (Sections 3.2 to 3.4) focuses on the use of LCM in SMEs and supply chains. Section 3.2 provides an overview of LCM and its relevance to the New Zealand primary industries, and Section 3.3 identifies the specific characteristics of SMEs that can limit uptake of environmental management practices including LCM more specifically (internal view). Section 3.4 draws on the supply chain management literature to identify enablers and barriers that are relevant to LCM uptake (external view).

The second part of the chapter (Section 3.5) integrates the findings from the literature-based research to provide a compiled overview of enablers and barriers to LCM implementation on a sector-wide level and discusses the idea of the sector-based approach as a mean of supporting sectors with large numbers of SMEs. The chapter concludes with a summary of how these results can be used in future empirical research on LCM uptake in the New Zealand primary sectors (Section 3.6).

3.2 Life Cycle Management

3.2.1 The Relevance of Life Cycle Management for the New Zealand Primary Industry Sectors

The purpose of LCM is to improve the overall sustainability of products and services. It is the systematic application of LCT in business practice to integrate considerations of environmental (as well as social and economic) issues into decision-making and support the development of more sustainable products and production systems. From an LCM perspective, the environmental responsibilities of companies include not only their own production sites, but also up- and downstream entities in the supply chain throughout the entire life cycle (Figure 3-1) from raw material extraction to end-of-life of a product (Jüttner & Ziegenbein, 2009).

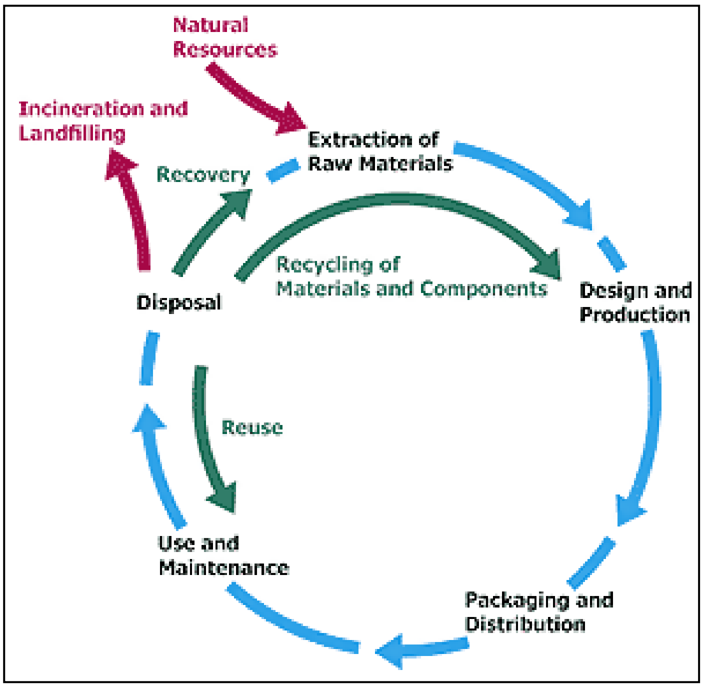

Figure 3-1: Life cycle of a product (UNEP/SETAC, 2007)

This concept was summarised in the definition provided by the Society of Environmental Toxicology and Chemistry (SETAC) Working Group which stated that the goal of LCM is to address environmental, economic, technological and social aspects of products and organisations to achieve continuous environmental improvement from a life cycle perspective (Saur et al., 2003). Sonnemann et al. (2015) further note that LCM is the systematic application of LCT in business practice in order to integrate environmental issues into decision-making and support the development of more sustainable products and production systems (Sonnemann et al., 2015).

In summary, it can be said that the purpose of LCM is to facilitate the reduction of environmental (and social and economic) impacts by addressing the entire life cycle of a product/service. To achieve this, it is important to consider management aspects as well as quantifying flows of materials and products – with their associated environmental impacts - along supply chains.

New Zealand has an image of being "clean and green" due in part to its low population density and its beautiful natural environment (Brown & Stone, 2007; Frame & Newton, 2007; Gnoth, 2002). To maintain this positive reputation, there is a need to proactively – and continuously – manage and improve economic activities in order to minimise their impacts on the environment (Stern, 2012; Sterzik, McLaren, Garnevska, & Hume, 2014).

Due to New Zealand economy's dependence on exports (27.9% of GDP is derived from exports (Bank, 2016), it is important to anticipate trends in overseas markets that may affect the sales of New Zealand exports, and pro-actively prepare for these trends in case they become "the new normal". A past example of a trend in overseas markets that created a significant challenge for New Zealand exports was the food miles concept which was first articulated in the 1990s in the United Kingdom (Paxton, 1994). The term 'food miles' refers to the distance the food is transported from the producer through the various stages of production, processing, packaging and distribution until it reaches the consumer (Smith et al., 2005). It had previously been suggested that the environmental impacts of food products, as well as other negative social impacts, are linked to the distances travelled by these products to markets (Alliance, 1994). The potential risk for New Zealand exports associated with the food miles concept was significant given the country is located a long way away from its main export markets (Saunders, Barber, & Taylor, 2006; Smith, Stancu, & McKenzie, 2006). The issue particularly affected New Zealand between 2007 and 2010 (McLaren, 2009). However, during that same period and subsequently, various environmental life cycle-based assessment studies were undertaken to quantify the environmental impacts of products (e.g. carbon, water and biodiversity footprints as well as the complementary and more comprehensive Life Cycle Assessment (LCA) studies). Many of these studies provided evidence that counteracted the proposed link between distances travelled and environmental impacts (McLaren, 2009; Nemecek, Jungbluth, i Canals, & Schenck, 2016; Notarnicola et al., 2017) .

Therefore, it is important that New Zealand exporters frame their environmental management activities using a life cycle perspective, in order to proactively prepare for future trends. LCM provides the approach and set of analytical tools to make this a reality.

3.2.2 Guidance on Uptake of Life Cycle Management

Three guides have been produced on LCM uptake to date: the first one was produced in 2003 (Remmen, 2003) and was followed by another guide published by the UNEP-SETAC Life Cycle Initiative in 2007 (Remmen et al., 2007).

The Remmen (2003) guide was aligned with the approach taken in ISO 14001 (International Organisation for Standardisation (ISO), 2004) on how to measure, manage and improve the environmental performance in a business. Although the guide took a life cycle perspective and highlighted the focus on other supply chain activities outside the core activities of an organisation, it did not suggest specific initiatives to enable wide uptake of LCM-oriented improvement projects.

The second guide by Remmen and co-authors, "Life Cycle Management – A business guide to sustainability" (Remmen, Jensen, & Frydendal, 2007), provided detailed information of what sustainability, LCM and LCT are, and why those topics are relevant to organisations. The first part of the guide provided examples of LCM implementation for typical supply chain stages (production and distribution, product development and design, economy and finance, purchasing, sales and marketing and stakeholder relations). It then went on to provide guidance on how to implement LCM initiatives in those different areas. The guide provided generic ideas, almost a checklist approach, on how to expand the focus of environmental management outside an organisation's core operations.

The third guide, "Life Cycle Management – how business uses it to decrease footprint, create opportunities and make value chains more sustainable" (Power, 2009; UNEP. & SETAC, 2009), presented a capability maturity model consisting of five maturity levels for organisations. The different maturity levels were related to the extent of control the organisation had over the various levels of supply chain activities. These were identified as extending from the individual, to the project, organisation, supply chain and society levels. The guide also presented case studies and examples of LCM implementation in different organisations. In a similar way to Remmen et al. (2007), this guide provided the user with a checklist approach of considerations in order to improve the life cycle-based environmental performance of an organisation (UNEP. & SETAC, 2009).

As well as these guides, the ISO Technical Specification on Organisational LCA (ISO/TS 14072) has more recently been published (ISO, 2014). It provides additional requirements and guidance for applying LCA to organisations.

3.3 Challenges for Uptake of Environmental Management Amongst Small and Medium Sized Enterprises

3.3.1 Defining SMEs and their Relevance for Environmental Management Research

Definitions and criteria for what constitutes an "SME" vary widely around the world. They are often based on the number of employees, industry classification or the turnover of an organisation. Many definitions use the number of employees as the most important criterion to distinguish between SMEs and large enterprises:

- In the European Union, enterprises up to 10 employees are called micro, up to 50 employees small and up to 250 employees medium sized enterprises (Commission, 2016)
- In the United States, SMEs are characterised as organisations having less than 500 employees (Commission, 2010).
- The Ministry of Economic Development (MED) of New Zealand defines SMEs as having less than 20 employees (MED, 2011).

Alternatively, Massey and Cameron (1999) provided a definition that does not refer to the number of employees but to differences in decision-making compared with large companies (Cameron et al. 1999):

"A small business can be defined as a business that is independently managed by the owners, who own most of the shares, provide most of the finance and make most of the principal decisions."

Using the New Zealand definition provided by the MED, 97% of all New Zealand companies are SMEs (Ministry of Business, Innovation and Employment, 2014). SMEs accounts for approximately 30% of New Zealand's GDP and employ 584,000 people (Ministry of Business, Innovation and Employment, 2014).

It is usually true that the environmental impacts of large companies are higher (in absolute terms) than those of smaller companies in any given industry sector. However, on the other hand, the cumulative environmental impacts of all SMEs may be greater than those of the larger companies in that sector. Indeed, in the UK it has been estimated that SMEs contribute up to 70% of all industrial pollution (Agan, Acar, & Borodin, 2013; Arvizu-Piña & Burgos, 2017; Groundwork, 2005; Halila & Tell, 2013;

Parker, Redmond, & Simpson, 2009). This suggests that research should focus on implementation of environmental management in these smaller companies as well as in the larger companies (Al Zaabi, Al Dhaheri, & Diabat, 2013; ECOTEC Research & Consulting Ltd., 2000; Johnson & Schaltegger, 2016; Schaper, 2002).

3.3.2 Enablers and Barriers for SMEs to Implement Environmental Management

SMEs face several difficulties in the implementation of environmental management (and LCM more specifically) in their business practices, and these barriers are often closely related to the specific characteristics of SMEs. These characteristics have been investigated by a number of researchers and it is recognised that they should not be treated as smaller versions of large companies (O'Regan & Ghobadian, 1998), Mandl et al. 2007; Seidel et al. 2009, Seidel et al. 2012).

Seven characteristics were identified as relevant in relation to uptake of LCM. These characteristics range from the widely recognised influence of the owner/manager, through to less commonly identified aspects such as the geographical distance between production site and markets, and ability to identify emerging trends. Some are relevant to uptake of environmental management more generally and others are more relevant to uptake of LCM specifically. The following paragraphs briefly summarise these characteristics and how they influence uptake of environmental management in SMEs.

3.3.2.1 Owner/manager influence

According to (Papagiannakis & Lioukas, 2012), commitment from senior managers to environmental management is a prerequisite for providing an organisation with a clear direction in this area. In large companies, the power base is usually evenly distributed amongst managers in different departments, so there are several people involved in decision-making processes. This means there is a higher likelihood that environmental issues will be raised for consideration by at least one person. In SMEs, on the other hand, one owner/manager usually controls most strategic decisions; therefore the background, values and education of just this one person will have a significant impact on the strategic direction of the organisation (Mandl & Dorr, 2007; Seidel et al., 2009). The owner/manager of an SME thus has a significant influence on the uptake of environmental management in the organisation.

Some owner/managers see environmental issues as a threat and associate it with financial costs and other negative consequences (Cucchiella, Koh, Walker, & Jones, 2012; Giunipero, Hooker, & Denslow, 2012). They may also have a lack of knowledge of environmental issues and the advantages associated with implementing environmental management (Massoud, Tabcharani, Nakkash, & Jamali, 2012; Muduli, Govindan, Barve, & Geng, 2013). Also, often managers hesitate to invest in environmental practices that may only pay back in the longer term (after five years) (Cucchiella et al., 2012). For this reason, SMEs may not consider LCM as an appropriate environmental management approach.

On the other hand, given the influence of the owner/manager in SMEs, a positive attitude towards the environment and sustainability can result in the decision to implement and integrate approaches such as LCM into the organisation (Johnson, 2015). It has been argued that due to the hierarchy and decision-making characteristics of SMEs, smaller companies may be in a better position than larger organisations to innovate for sustainability (Klewitz & Hansen, 2014).

3.3.2.2 Environmental culture

Culture can be described as "the sum total of the knowledge, attitudes and habitual behaviour patterns shared and transmitted by the members of a particular society" (Linton, 1963). The definition by Altman et al. (1984) also includes "beliefs, perceptions, values and norms […] of a group or society". The specific type of culture that describes how humans treat the natural environment is called environmental culture (Schumacher, 2015) and, according to Schumacher (2015), environmental culture plays an important role in shaping how individuals view, value and subsequently treat trade-offs that affect the environment. If the culture of a company is not based on the beliefs, values, norms and perceptions that support environmental initiatives, then this will hinder uptake of environmental management.

This characteristic is closely related to the "knowledge of environmental issues" characteristic (see below), since people in organisations, supply chains and relevant stakeholders need to be aware about the relevance of environmental topics in order to foster a culture that supports uptake of environmental initiatives (Muduli et al., 2013; Stoica, Florea, & Lukacs, 2016; Thun & Muller, 2010); (Abdelzaher & Abdelzaher, 2015; Boiral, Baron, & Gunnlaugson, 2014; Graafland & Smid, 2015; Sugita & Takahashi, 2015; Uhlaner, Berent-Braun, Jeurissen, & de Wit, 2012). It is also related to the "owner/manager influence" characteristic as the support of senior managers can significantly aid the process of developing an environmental culture.

3.3.2.3 Resource availability

SMEs are characterised by having limited financial, technical and staff resources (Carrillo-Hermosilla, Del Río, & Könnölä, 2010; Cucchiella et al., 2012; Hillary, 2004; Young, 2010). The most critical barrier to any new activity for an SME is cost (Giunipero et al., 2012; Lewis & Cassells, 2010; Parker et al., 2009).

Linnanen et al. (1995) highlighted that reduced costs can be realised by environmental initiatives focused on more efficient use of resources, a reduced need for pollution control equipment, and/or reduced hazardous waste disposal. This finding is shared amongst other researchers (Comas Martí & Seifert, 2013; Nilsson-Lindén, Baumann, Rosén, & Diedrich, 2014). Furthermore, KPMG (2005) noted that reduced energy and resource consumption, associated with improved brand reputation, could lead to an increase in sales and higher profits for companies.

However, there may be a perception that costs for environmental management training, and purchase of software programmes and tools, cannot be outweighed by the benefits (Ageron, Gunasekaran, & Spalanzani, 2012; Cox, Sarkis, & Wells, 1999; Linnanen, Bostrom, & Meittinen, 1995; Min & Galle, 1997b). Consequently, investments need to have significant short-term financial benefits for them to be considered (Condon, 2004).

For environmental management, the cost barrier is also closely related to the availability of technical resources that are necessary in order to achieve improvements. It might be necessary to upgrade technology to reduce emissions, and purchase software products to conduct LCAs or that support the implementation and maintenance of an effective Environmental Management System (EMS). Biondi et al. (2002), Tilley (1999), Singh (2015) and Graafland, et al. (2015) claim that SMEs need strategies, tools and approaches that can easily be implemented into the existing business strategy, incorporated into day-to-day activities, and that are easy to understand and use.

Resource availability is closely related to perceived trade-offs between environmental sustainability and other business objectives. The implementation of environmental management usually requires investment, change of processes, and change of supply chain partners or supplier development. Usually companies prioritise projects according to time, cost and quality. However, prioritisation in terms of environmental issues is often difficult for decision makers in companies, when they do not have the knowledge to evaluate all the implications. Instead, uncertainties in decision-making are usually solved by application of simple rules that are based on the decision maker's interpretation of norms and information (Wu & Pagell, 2011).

3.3.2.4 Strategy

Investments with long-term payback periods are usually not considered by SMEs. This is closely related to the fact that SMEs usually pursue short-term rather than long-term goals (Ageron et al., 2012; Carter & Rogers, 2008; Pérez-Luño, Saparito, & Gopalakrishnan, 2016). Eriksson et al. (2016) conducted a study in Sweden on the uptake of management systems in organisations; the results showed that large organisations were more proactive in that area. They considered potential trends and changes in the future in their decisions and were able to address them earlier than SMEs. Redmond et al. (2016) suggested that SMEs might be less proactive in uptake of voluntary programmes for improving environmental performance due to organisational habits that are hard to break; as a result, SMEs often stayed stuck in a "business as usual" *modus operandi*.

3.3.2.5 Knowledge of environmental issues

Lee et al. (2011) pointed out that a limited awareness of environmental issues might lead to a limited commitment to environmental management in SMEs (Lee & Kim, 2011). Murillo-Luna et al. (2011) conducted a study that concluded that scarcity of information and lack of understanding about environmental legislation presents one of the main barriers for SMEs in the uptake of environmental improvement practices (Murillo-Luna, Garcés-Ayerbe, & Rivera-Torres, 2011). Condon (2004) highlighted that insufficient information on the real costs and potential benefits of environmental initiatives are a key barrier to improving the environmental performance of organisations. Often SME owner/managers believe that national and local government should take a lead on environmental issues and that these issues are more relevant to larger companies (Parker et al., 2009).

Collin et al. (2007) suggested that decision makers in SMEs tend to ignore the environmental impacts associated with their companies' activities. As SMEs are smaller than large companies, they think that the environmental impacts of their own business are negligible compared to the impacts of large companies (Chan, Hon, Okumus, & Chan, 2014). As a result, they do not feel that they have to act to reduce their environmental impacts (Lewis & Cassells, 2010).

3.3.2.6 Market requirements

Market requirements differ significantly between industrial sectors and countries (Sinding, 2000). In some markets, companies are exposed to less market and regulatory pressures to adopt life cycle approaches than others (Sinding, 2000).

Market pressures may arise from stakeholders such as environmental groups, supply chain partners and customers. If the organisation/supply chain providing the product/service does not align with the stakeholders' values and expectations, then this is something that needs to be taken into consideration by the supply chain partners/industry sector (Chan et al., 2014; Chan, Okumus, & Chan, 2015).

Regarding regulatory pressures, as an example the European Parliament has many legislative requirements relating to sustainability. Well-known examples include hazardous substances in electronic and electrical equipment (European Commission Environment, 2017), and REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) (European Chemicals Agency). Since this legislation has come into force, there has been a significant increase in the uptake of environmental initiatives in Europe (Agan et al., 2013; Biondi, Iraldo, & Meredith, 2002; Hernandez-Pardo, Bhamra, & Bhamra, 2013; Rutherfoord, Blackburn, & Spence, 2000; Williamson et al., 2006). Indeed, Salimzadeh et al. (2015) suggest that environmental legislation is one of the most important reasons why SMEs invest in environmental management initiatives.

3.3.2.7 Geographical separation of production and consumption

In the past, SMEs tended to operate within a specific region, and suppliers and consumers were based close to the organisation (Hillary, 2000). Due to globalization, this has changed and not only large companies but also SMEs have suppliers, distributors and customers located all over the world. This leads to a diffused responsibility for the environmental impacts of products. It is more likely that each company in the supply chain will primarily work on improving its own environmental performance rather than communicating and collaborating with supply chain parties all over the globe (Norrman & Jansson, 2004), and it is more of a challenge for supply chain partners to communicate about environmental improvement projects (Accorsi, Manzini, Pini, & Penazzi, 2015; Arzu Akyuz & Erman Erkan, 2010; Kache & Seuring, 2014). Another aspect is the lack of consumer awareness of environmental impacts during the production. This is intensified by larger distances between consumption and production (Lewis, Cassells, & Roxas, 2015).

3.4 Enablers and Barriers in Supply Chain Management

3.4.1 Defining Supply Chain Management

The subject of Supply Chain Management (SCM) is recognised as closely related to both the practice and the theory of LCM (Norrman & Jansson, 2004; Swink, Narasimhan, & Wang, 2007); (Martinsuo & Ahola, 2010; Song & Di Benedetto, 2008).

A *supply chain* can be defined as, "[…] the sum of all activities associated with the flow and transformation of materials starting at the point of original supply and continuing through to the end customer or consumer" (Handfield, Nichols, & Ernest, 1999). In its simplest form, a supply chain comprises at least three entities: an organisation, a supplier and a customer (Gardiner, 2010).

In general, definitions of SCM focus on the management of flows of information, resources and money along supply chains, and place different emphasis upon these flows and upon the management aspects (Christopher, 2016; Fredendall & Hill, 2016; Gilling & Ulmer, 2016; Mangan, Lalwani, & Lalwani, 2016). Two definitions of SCM that are the most relevant in the context of using SCM to support LCM are:

- "… an integrated approach to obtaining, producing and delivering products and services to customers" (Gardiner, 2010)
- "… to synchronise the requirements of the customer with the flow of material from suppliers in order to affect a balance between what are often seen as the conflicting goals of high customer service, low inventory investment and low unit cost" (Stevens, 1989, p.3).

The term Green Supply Chain Management (GSCM) has been developed by those focusing on environmental sustainability in the context of SCM (Carter, Kale, & Grimm, 2000; Green, Morton, & New, 1998; Hamner, 2006; Min & Galle, 1997a; Zsidisin & Siferd, 2001). Some researchers address social as well as environmental sustainability aspects in their work , and in these cases the term "sustainable supply chains" is sometimes used to describe the research area (Hassini, Surti, & Searcy, 2012). Definitions of GSCM include:

- "The management of supply chain operations, resources, information and funds in order to maximize the supply chain profitability while at the same time minimising the environmental impacts and maximising the social well-being" (Hassini et al., 2012).
- "Integrating environmental concerns into the inter-organisational practices of SCM including reverse logistics" (Sarkis et al., 2011, p.3).
- "Integrating environmental thinking into supply-chain, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life" (Srivastava, 2007).
- "…the management of material, information and capital flows as well as cooperation among companies along the supply chain while integrating goals from all three dimensions of sustainable development: economic, environmental and social, which are derived from customer and stakeholder requirements. In sustainable supply chains, environmental and social criteria need to be fulfilled by the members to remain within the supply chain, while it is expected that

> competitiveness would be maintained through meeting customer needs and related economic criteria "(Seuring et al. 2008).

As these definitions show, SCM and GSCM are focused on ensuring (environmental) initiatives are considered throughout the entire life cycle of a product/service. In this respect, they share the same objective as LCM. It is therefore appropriate to identify the enablers and barriers in the literature to uptake of SCM and GSCM.

3.4.2 Enablers and Barriers to Uptake of Supply Chain Management

Synthesizing the literature, the main factors contributing to successful SCM include seven components of interconnection: information exchange, goal congruence, decision synchronisation, incentive alignment, resources sharing, communication and joint knowledge creation (Parody, Viloria, & Gonzalez, 2017). Since these seven components are interrelated, this research groups them into three broader categories: resources, communication/information sharing between supply chain entities, and culture. Research has shown that these factors add value to supply chains by reducing costs and response time, leveraging resources and improving innovation (Parody et al., 2017).

3.4.2.1 Resources

Several articles have identified the disproportionate power held by large companies in supply chain activities due to their relatively higher expert knowledge levels and greater financial resources (Norrman & Jansson, 2004; Wisner, Tan, & Leong, 2015). This can be contrasted with SMEs with their generally limited human and financial resources, lack of formal structures and processes (Ritchie & Brindley, 2000), and focus on day-to-day business rather than long-term objectives and strategic decisions (Seidel et al., 2009). As a result, SMEs find it more difficult to effectively manage and interact with their supply chains. According to Stock and Boyer (2001) SCM functions best if resources are shared, underlining the relevance of collaboration for SCM.

3.4.2.2 Communication/Information Sharing between supply chain entities

"Communication is the contact and the process of message transmission between the partners of the supply chain in terms of frequency, direction, mode and strategy influence" (Parody et al., 2017). Communication between supply chain entities is important to align incentives, goals and priorities of the individual companies that collaborate in the supply chain (Gardiner, 2010). If supply chain entities have misaligned incentives, goals and priorities, then it can be very hard to keep up a good relationship and effective communication in the supply chain (Gardiner, 2010; Gustavsson, Cederberg, Sonesson, Van Otterdijk, & Meybeck, 2011). In particular, it is important to communicate customer needs back up the supply chain so that every supply chain entity can adapt processes accordingly and create the best possible added-value product for the customer (Fiala, 2005). At the same time, it is important to ensure two-way communication, which means each supply chain entity proactively communicates with other supply chain partners both up and down the supply chain, to ensure feedback, information and knowledge is shared effectively (Knemeyer, 2009). According to Parody et al., (2017), communication can be evaluated by looking at the following five characteristics. The company and customers of the supply chain:

- Have frequent contact.
- Have an open bidirectional communication.
- Maintain informal communication.
- Have different channels of communication
- Influence the decisions of each one through the dialogue or debate.

Apart from sharing existing information, supply chain entities should also team up to create knowledge (Sarkis, Zhu, & Lai, 2011).

3.4.2.3 Culture

SCM can be a key competitive advance for organisations and supply chains, if cooperation between supply chain entities is done in a way where organisations not just focus on their individual improvements and opportunities, but also think outside of their own boundaries, viewing improvements more holistically from one end of the supply chain to the other (Frohlich & Westbrook, 2001). In order to embed this open-minded approach, it is crucial to have leadership teams in place that encourage this way of thinking and a culture of collaboration (Kache & Seuring, 2014). Trust between supply chain entities creates momentum and supports suppliers to share innovative ideas with other supply chain entities (Gold, 2010; Hoejmose, Brammer, & Millington, 2012; Sharfman, Shaft, & Anex, 2009). Trust is important when supply chain entities collaborate as it facilitates commitment and emergence of a common vision of participants (Gold, 2010). Trust grows between supply chain entities when they successfully collaborate together (Christopher, 2016; Ojha, Shockley, & Acharya, 2016).

3.4.3 Factors Affecting Uptake of Life Cycle Management in SMEs

The identified characteristics of SMEs (Section 3.2) and SCM factors (Section 4.2) affecting the uptake of LCM can be summarised as:

1. SMEs: the characteristics that affect the effectiveness of environmental management (including LCM) implementation by SMEs include owner/manager influence, environmental culture, resources availability, future orientation, knowledge of environmental issues, market requirements, geographical

separation of production and consumption, and awareness of own environmental impacts (Section 3.2).

2. SCM: the factors that influence the effectiveness of SCM include resources, communication/information sharing between supply chain partners and culture (Section 3.4.2).

Mortimer (2011) provides a model for organisational change for sustainability and associated adoption factors. The model has four categories, which include the individual, the organisation, the organisational field (supply chain) and the broader environment (e.g. market, government). On this basis, the characteristics and factors identified in this research that can potentially act as enablers or barriers for LCM uptake can be condensed into four views (Figure 3-2).

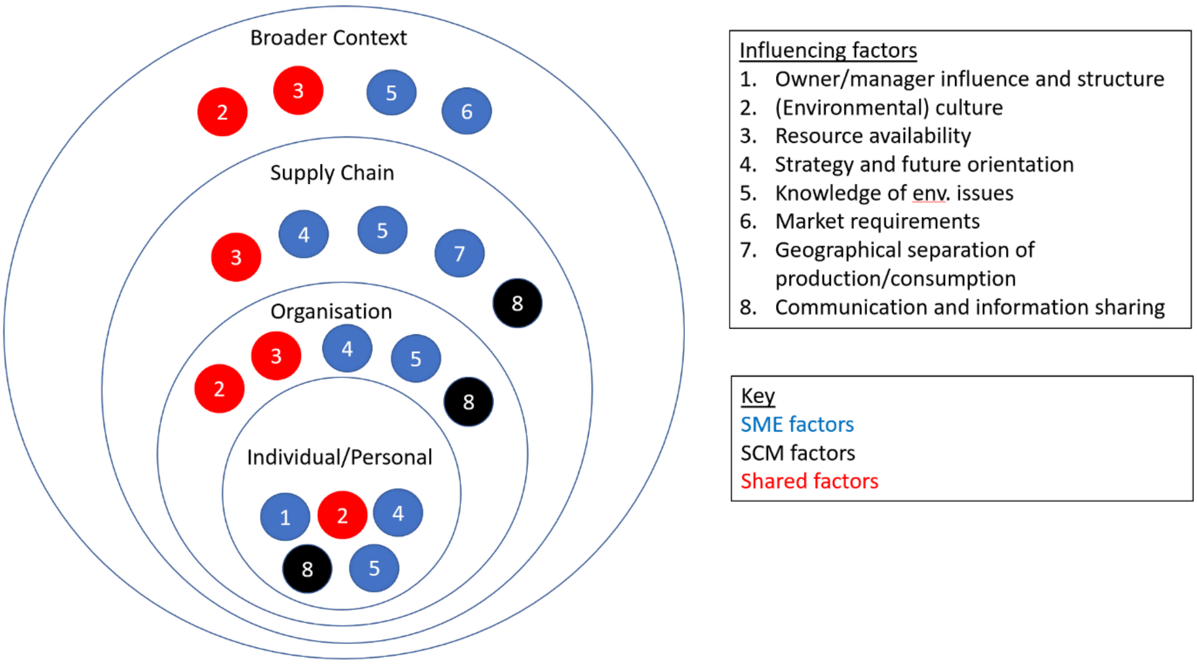

Figure 3-2: Enablers and barriers to successful LCM uptake based on four views

Figure 3-2 summarises the different lenses that can be applied depending on the position and/or view of the stakeholder. Some factors are present in multiple views whereas others are specific to a particular group. This approach can provide the basis for understanding and addressing relevant issues at the appropriate level. For example, certain enablers and barriers can be influenced at the individual or organisation level whereas it can be more efficient and effective to address other issues at the level of the industry sector or broader context.

3.5 The Sector-Based Approach as a Way of Increasing the Uptake of LCM in SMEs

The previous sections provided a summary of the factors that affect the successful implementation of LCM initiatives in SMEs. The challenges are often related to internal characteristics of the SMEs themselves, but some are also due to external factors arising along the supply chains and due to the broader context in which SMEs are situated.

Based on their situation it is argued that SMEs find it challenging to implement LCM initiatives by themselves. To drive effective and meaningful change at scale, it may be beneficial to use a sector-based approach. This section investigates the use of a sector-based approach as a way of overcoming both the internal and external barriers to facilitate more effective implementation of LCM amongst SMEs.

The section provides a definition for the term “sector-based approach” (Section 3.5.1), which is then followed by New Zealand and international examples of sector-based approaches (Section 3.5.2). Finally, the benefits and shortcomings of a sector-based LCM approach – as opposed to individual organisations pursuing their own LCM programmes are discussed (Section 3.5.3 and 3.5.4).

3.5.1 Defining Sector-Based LCM Approaches

There is very little published research on sector-based approaches for environmental management that addresses both vertical and horizontal cooperation within sectors. Indeed, Seuring (2011) in his work on Green Supply Chain Management (GSCM), highlights this lack of research on reducing environmental impacts using sector-wide initiatives and calls “on the imagination of other researchers to develop new research projects and hypotheses” to drive sustainable SCM further. For the three guides to LCM uptake discussed in Section 3.2.2, the focus is on the individual organisation rather than uptake across an industry sector. Also, the guides focus on providing guidance and ideas on areas of improvement to reduce environmental impacts and how to support management decisions that facilitate LCM uptake within the organisation, as opposed to addressing the underlying key factors that must be in place to facilitate LCM uptake. However, there are some examples of sector-based environmental management approaches, and a selection are reviewed in Section 3.5.2.

The lack of definition means there is no commonly used basis that can be used to determine the elements which constitute an industry sector-based approach. This gap needs to be filled in order to provide a common foundation for researchers and practitioners to design and implement an industry sector-based approach for LCM. In this paper, we adopt a working definition of an industry sector-based approach to LCM as: ”a planned and systematic programme driven centrally by a sector body or other relevant accepted and knowledgeable organisation, covering both horizontal and vertical supply chain organisations that has the goal of continually improving the collective life cycle environmental performance of the industry sector".

Based on this definition, a sector-based LCM approach is envisaged as having several key requirements. Firstly, it must be a planned and systematic programme as opposed to ad hoc, discrete or one-off initiatives. The programme should be driven by a relevant, focal organisation which has relationships and trust with stakeholders as well as the appropriate industry sector and LCM specific knowledge. An industry sector-based approach must be concerned with the supply chain of a product or a service, i.e. the organisations that are vertically linked in a supply chain to produce a particular product or service (for example, the grower, post-harvest operator, distributor, and retailer in the kiwifruit supply chain). An industry sector-based LCM approach also needs to include the horizontal links between organisations in an industry sector i.e. the organisations that are in the same life cycle stage (for example, kiwifruit growers in the kiwifruit supply chain). Finally, the focus is on the environmental life cycle improvement of the industry sector's overall performance ideally based on an understanding of the hotspots and taking into account the need to avoid shifting the burden.

3.5.2 Examples of Sector-Based Approaches

This section provides examples of initiatives using sector-based approaches in New Zealand and around the world. The New Zealand initiatives are the Greenhouse Gas Footprinting Strategy and Sustainable Winegrowing New Zealand (SWNZ), and the overseas initiatives are the Australian Dairy Industry Sustainability Framework and the European Plastic and Steel Sector programmes. Each initiative is explained briefly, in particular highlighting whether it meets the requirements for a sector-based LCM approach as identified in Section 3.5.1. The European Plastics and Steel Sector programmes are included, even though they are not primary sector initiatives, because they are two of the most established and longest-running environmental LCM programmes.

3.5.2.1 Greenhouse Gas Footprinting Strategy of Ministry for Primary Industries (New Zealand)

In 2006, the Ministry of Foreign Affairs and Trade identified an emerging threat to New Zealand's primary exports due to the popularity of the "food miles" concept that advocated consumption of more locally grown food (Landcare Research; Saunders & Barber, 2006). That created the need to respond to increasing pressure in key export markets for carbon footprint information of primary products.

In response, the New Zealand Government developed the Greenhouse Gas Footprinting Strategy, a programme that worked with 70% of primary industry exports (Landcare

Research) including the kiwifruit (Mithraratne, McLaren, & Barber, 2008), pipfruit (Hume et al., 2009), wine (Greenhalgh S. et al., 2008) and berryfruit (Hume & Coelho, 2010) sectors. The projects involved undertaking carbon footprint studies of products in each sector and developing standardised ways for measuring and managing greenhouse gas emissions across the life cycle of these agricultural products (Ministry for Primary Industries, 2011). The results of the studies were intended to provide a basis for defining improvement projects for each of the industry sectors.

The Greenhouse Gas Footprinting Strategy did not meet all three requirements of the definition for a sector-based LCM approach. It did not actively encourage and facilitate the horizontal and vertical cooperation between supply chain partners. It was not a programme that put ongoing processes and strategies in place to foster exchange of ideas and knowledge between entities in the supply chain. However, it did generate an extensive body of knowledge about the environmental performance of the different industry sectors as carbon footprint studies were undertaken covering each life cycle stage of the different industry sectors. To further this programme, it would be important to put processes in place to encourage active communication between the entities up and down the supply chain as well as communication between organisations at the same point in the supply chain, to exchange ideas, knowledge and experiences about implementation of LCM initiatives.

3.5.2.2 Sustainable Winegrowing New Zealand

The SWNZ programme was introduced in 2002 with the aim of reducing environmental impacts occurring during viticulture and winemaking (NZ Wine, 2015). An important driver for the programme was the increasing demand by customers for environmental credentials, as well as the justification of the “clean and green” image of New Zealand (Garnevska, McLaren, & Hiroki, 2014). The SWNZ programme uses a scorecard approach to monitor the environmental performance of activities including irrigation, weed control, soil management, fertilisers, and pest and disease management (Hughey, Tait, & O'Connell, 2005, NZ Wine, 2015; Marshall, Akoorie, Hamann, & Sinha, 2010). It also provides a platform for technology transfer through networking events and information on the website, so vineyards and winegrowers can keep up to date regarding new technology and its implementation and use and use it as a forum to exchange knowledge and ideas. SWNZ also incorporates an audit structure to ensure compliance with market expectations.

The SWNZ programme is a sector-based approach as it provides a shared environmental management system for both grape growers and wine makers in New Zealand i.e. it involves both horizontal and vertical entities in the supply chain of wine through a coordinated initiative. All of the organisations can make use of this programme and use it to reduce their environmental impacts. Since many vineyards and wineries take part in the programme, environmental improvements can be realised on a large scale and benefit the whole industry sector. Therefore, it can be regarded as a sector-based approach.

3.5.2.3 Australian Dairy Industry Sustainability Framework

The Australian Dairy Industry Sustainability Framework was established in 2012 by the Australian Dairy Industry Council to enhance livelihoods across the industry, improve community and animal wellbeing, and reduce environmental impacts (Australia, 2014). It is managed by an industry Steering Committee and supported by Dairy Australia (Dairy Australia, 2017). Recently, the focus has been expanded from 11 targets and 41 performance measures to also include other challenges that the industry faces. Improvements include environmental enhancements such as waste to landfill reductions, as well as trade agreements that benefit the farmers and allow for better competitiveness and profitability as well as health and safety indicators. The targets and performance indicators are reviewed and updated on a regular basis to ensure that the framework responds to the industry's challenges.

Currently, the framework supports the industry in understanding the common issues and areas for improvement, as well as areas where further collaboration, research and knowledge sharing is required. It also provides a basis for discussion with other global dairy industry organisation. The Australian dairy industry wants to share their information and insights with global partners and thereby speed up the research for improvement actions (Dairy Sustainability Framework, 2016).

However, missing elements in this approach are the facilitation of communication and information sharing between supply chain partners in this industry. This could include information sharing amongst farmers, and amongst dairy manufacturers, as well as knowledge sharing and information sharing between these two supply chain entities. Additionally, since farmers and organisations need to become members of the framework, there may be a lack of representative data as most likely only proactive farmers/organisations will invest in becoming members (Dairy Sustainability Framework, 2016).

3.5.2.4 European Plastics Sector

PlasticsEurope supports the use of LCA to calculate and assess environmental impacts associated with a product, process or service (PlasticsEurope). The first Eco-profile-reports, which include LCA results, were published in 1993 and comprise environmental information about processes operated by members of PlasticsEurope. During the last two decades, more than 70 Eco-profile reports were made freely available through PlasticsEurope. Additionally, in 2006 PlasticsEurope started a complementary

Environmental Product Declaration (EPD) programme. Together, Eco-profiles and EPDs cover a large number of polymers that are widely used in engineering plastics and several common plastics conversion processes (PlasticsEurope). Through the publication of average data, PlasticsEurope ensures that there are scientifically sound data in the public domain for use in LCAs without compromising confidentiality. Moreover, the published data serve as environmental benchmarks for other companies.

The initiative by the European Plastics sector qualifies as a sector-based approach as organisations at the same life cycle stage, i.e. plastic producers, share information and knowledge about the environmental performance of their business practices.

3.5.2.5 European Steel Sector

The European Steel Association, called EUROFER, was established in 1976 with the aim to improve cooperation between steel companies and steel federations throughout the European Union. It supports the development of the European steel industry and represents the common interests of its members. The EUROFER Sustainability for Steel Construction Products Committee (ESSCPC) is a committee with a key focus on sustainability and corporate responsibility. As a part of its role, the ESSCPC develops, manages and promotes a certification system (called the Mark) related to sustainability and corporate responsibility in the steel construction products sector. Companies producing steel products for the construction sector can get certified with regards to the requirements for sustainability aspects and get granted the Mark (Sustainable Steel, 2015).

The initiative by the European Steel sector qualifies as a sector-based approach as members share common goals towards sustainability improvements in their sector. They have a certification system in place to ensure third-party audits.

3.5.3 Benefits of Sector-Based Approaches to LCM

Based upon the examples in the previous section, a number of benefits can be identified that are associated with a sector-based approach to LCM as opposed to organisations individually implementing LCM. They include economies of scale for LCM research to support implementation, ease of administration, streamlined collection and management of data, improved reputation of the product, knowledge sharing, and creating momentum for LCM.

Economies of scale for LCM research to support implementation refers to the cost and results of LCM studies being shared amongst many organisations who carry out similar activities in a specific sector. This benefit of sector-based LCM addresses the resource availability factor identified in Section 3.4, and was shown to be present in all five case studies above. For example, the Greenhouse Gas Footprinting Strategy involved undertaking one LCA study on behalf of all the organisations in each sector and including data ranges where activities varied across different organisations (e.g. quantities of fertilizer, irrigation activities and use of refrigerants). It was not necessary to carry out a separate LCA for each organisation in the supply chain because averages and ranges were sufficient to identify environmental hotspots for the sector. **Ease of administration** is a benefit of using a sector-based approach. SWNZ, for example, implemented one framework applicable to all growers in the wine sector and managed it centrally through New Zealand Winegrowers. This meant that individual growers did not have to develop their own strategies and key objectives, and reporting systems. It can also be easier to monitor, audit, and certify organisations in a sector when there is a common system. In industry sectors with a small number of players, in particular, this is usually easier than in sectors with a high degree of diversity or a large number of players (Schmidt, Helme, Lee, & Houdashelt, 2008). The accompanying **collection and management of data** is also streamlined when using a centralised system, and this facilitates an industry sector to more accurately communicate and market its generic environmental credentials (Schmidt et al., 2008). Related to this, if the majority of companies from any one life cycle stage act together to reduce the environmental impacts associated with their activities and their supply chains, it is likely that the subsequent **improved reputation of the product** will benefit the entire industry sector rather than individual companies. Implementation of sector-based LCM will help to counteract the increasing focus on sustainability “weak links” in supply chains (Luckman, 2012). For New Zealand, this approach can be particularly important in order to reinforce the country’s “clean and green” image and to improve positioning of New Zealand products in overseas marketplace (Brown & Stone, 2007; Gnoth, 2002). Thus, a sector-based approach can more effectively address the factors identified in Section 3.4 regarding meeting market requirements, geographical separation of production and consumption, trust between supply chain entities, and communication/information sharing between supply chain partners. Finally, sector-based approaches facilitate **knowledge sharing** and experiences (thus addressing the knowledge of environmental issues, awareness of own environmental issues, and future orientation factors identified in Section 3.4). For example, all New Zealand wine growers have access to a network of knowledge around environmental management implementation and strategies to reduce environmental impacts effectively in their operations. SWNZ acts as a platform for knowledge exchange and transfer, through access to an online platform for all SWNZ members. This has the potential to **create momentum** that increases participation in LCM. If an individual organisation at one life cycle stage sees another organisation implementing LCM, this can build confidence that LCM works or competitiveness that can motivate that other organisation to implement LCM (Bradley, Baumert, Childs, Herzog, & Pershing, 2007). This is one way of gaining support from owner/managers and developing an environmental culture, identified as relevant factors for LCM implementation in Section 3.4.

3.5.4 Disadvantages of Sector-Based Approaches to LCM

The disadvantages of implementing a sector-based approach to LCM as opposed to individual organisations implementing LCM include loss of first-mover advantage, and time-consuming cooperation processes.

If an organisation makes improvements to its processes and environmental performance in cooperation with other supply chain entities in its sector, it **loses the first mover advantage**. Its efforts will not result in the organisation differentiating itself from its competitors in the same industry sector. However, on the other hand, proactive companies that drive sector-based change in an industry sector are likely to be more advanced than their competitors and thus benefit from a reputation for being proactive in change management. The New Zealand wine industry shows that this first mover advantage is not necessarily lost when a sector-based approach is implemented. Certain individual wineries and vineyards have implemented additional LCM initiatives and thereby built a reputation of being particularly proactive in the area of LCM. For example, Yealands and Villa Maria are winemakers that regularly win awards for their success in reducing environmental impacts (Villa Maria, 2013; Yealands Family Wines, 2014).

Sector-based approaches require the supply chain entities/players to work together, exchange knowledge and ideas, and discuss initiatives to increase uptake of environmental activities. In particular, in long and complex supply chains, it can be hard to agree on approaches for LCM implementation at a sector-level. This can make sector-based LCM a **time-consuming process**. However, this time commitment needs to be balanced against the time that would be taken for an individual company to develop its own LCM programme without the economies of scale associated with developing a sector-wide programme.

3.5.5 Summary of the Effectiveness of Using a Sector-Based Approach for LCM

Based on the discussions in Sections 3.5.3 and 3.5.4, the sector-based approach seems to be a viable and practical way to implement LCM in organisations. In particular, supply chains that have a large number of SMEs and that operate in the same economic sector, can potentially benefit from this approach. Since these SMEs have similar day-to-day activities, and inputs and outputs, the sector-based approach allows them to share information in order to identify environmental impacts as well as improvement opportunities and learn from each other’s experiences. If the sector has strong communication tools in place, this can lead to momentum which facilitates other organisations in the sector to take up LCM initiatives, leading to an improvement in the overall sector's performance, which subsequently has a positive effect on the sector's reputation, consumer perceptions about the sector, and overall environmental performance.

3.6 Conclusions

The development of a sector-based LCM programme can facilitate overcoming the barriers that many SMEs face when implementing LCM. A sector-based approach allows SMEs to share resources and collectively benefit from the results. For example, they may share the cost for consultants to undertake LCAs that will help the sector identify areas for improvements. Additionally, the SMEs can share knowledge and expertise, and can develop and implement strategies together, which may lead to greater momentum, more regular updates and improvements, and subsequently a better reputation of the product/service.

This chapter has presented a summary of the SME and SCM literature research culminating in the identified eight factors that can act as either enablers or barriers for individual SMEs considering uptake of LCM. The factors are owner/manager influence, culture, resources, strategy, knowledge, market requirements, geography and communication.

Further research is needed to identify where different companies and sectors are situated vis-a-vis whether each factor is acting as an enabler or barrier to uptake of LCM. A capability maturity model will be developed that can be used by individual organisations and industry sectors to evaluate their maturity with respect to the eight influencing factors. Once this is done, LCM programmes can be developed that are tailored to maintain and strengthen the enablers, and address the barriers, for the different companies in a sector.

Future research will focus on the development of collaboration tools such as a cloud-based platform to facilitate effective LCM at the industry sector level by providing solutions to the barriers identified in this research.

3.7 References

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STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

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(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

4 A QUANTITATIVE STUDY ON LCM EXPERIENCES IN THE NEW ZEALAND KIWIFRUIT INDUSTRY

Chapter 1 provided a review and evaluation of SME characteristics and the barriers and enablers to the uptake of LCM. It included an evaluation of sector-based approaches as a means to exchange knowledge between supply chain partners and within organisations to facilitate LCM. Chapter 4 follows with a case study of the New Zealand kiwifruit sector conducted to validate the factors identified in Chapter 3 and verify the benefits of adopting a sector-based approach for LCM implementation in primary industries.

Section 4.1 summarises the purpose of the quantitative study in the context of the PhD research. Section 4.2 provides an introduction to the kiwifruit sector in New Zealand to provide background about its history, industry structure and global market position. Section 4.3 presents an overview of existing environmental and sustainability initiatives in the New Zealand kiwifruit sector. Section 4.4 follows with a discussion of the choice of research method for the case study and Section 4.5 presents the results of the research and discusses this in the context of the outcomes of Chapter 1.

My contribution to this manuscript was as the main author. I conducted the literature review and designed and carried out the online survey and wrote up the results. My supervisors provided feedback on the survey design as well as the write up of the results, and feedback on the writing and structure of paper, as well as the presentation of the visual results in the graphs.

After formatting it to meet the journal requirements, the aim is to submit this manuscript for publication in the Journal "Sustainability".

Abstract

The focus of this paper is to offer insights into the New Zealand kiwifruit industry and their activities in the area of environmental management. Findings from an online survey of New Zealand kiwifruit growers provide learnings in relation to current environmental initiatives undertaken in the sector. This includes a summary of the importance of environmental initiatives for individual growers as well as the industry as a whole, a presentation of existing initiatives and the associated enablers and barriers and lastly the means of communicating practices amongst growers as well as other stakeholders in the supply chain, specifically post-harvest operators and the industry body Zespri. In this research, it was identified that kiwifruit growers are already implementing a wide range of environmental initiatives, such as reducing office and orchard waste, as well as water, electricity, fuel, fertiliser and pesticides in additional to

initiatives to enhance biodiversity. It became clear that organic growers are in general more proactive than contemporary growers when it comes to these initiatives.

It is suggested to strengthen the network between kiwifruit growers and other supply chain partners, such as post-harvest operators and Zespri, in order to capture and share knowledge more easily. At this stage, the results show that the growers share their knowledge about environmental practices via face to face meetings. Although they state that the frequency and method of communication amongst stakeholders is set up in a satisfying and beneficial way, the researchers noted that it could be more efficient. The suggestion is to increase the number of growers that get access to this knowledge by setting up an online platform to share knowledge and experiences, so other growers can benefit from those as well. This would enhance the environmental performance of the kiwifruit industry and thereby improve the industry's image even further thereby enhancing their competitive advantage in the global market.

Keywords: New Zealand Kiwifruit Industry, Sustainability, Quantitative Research, Online Survey, Uptake of Environmental Initiatives.

4.1 Introduction

New Zealand has a reputation and image for being "clean and green". In order to maintain and reinforce this reputation in global markets, there is a need to drive continuous improvement in environmental performance and implement effective approaches to demonstrate environmental credentials. LCM is an approach that allows incorporation of sustainability in organisations and industry sectors by sharing responsibility across the entire supply chain, form raw material extraction to end of life of the product (Seidel-Sterzik, McLaren, & Garnevska, 2018). Thereby, all areas of a product's life cycle can be improved from an environmental view point, which results in a better performance of the final product.

As New Zealand is an exporting country and the economy relies heavily on primary products, it is appropriate to focus on this sector, and this chapter addresses environmental management in the primary sector, and in the kiwifruit sector in particular. It builds on previous research by Seidel-Sterzik et al. (2018) which identified the main factors influencing successful LCM uptake as: The factors are owner/manager influence, culture, resources, strategy, knowledge, market requirements, geography and communication. Each of these factors can act as a barrier or enabler, depending on the day-to-day practices of individual organisations. The purpose of this study was to:

- Identify the life cycle based environmental initiatives that have been implemented by New Zealand kiwifruit growers.

- Determine whether the factors identified by Seidel-Sterzik et al. (2018) are enablers or barriers to LCM uptake amongst these New Zealand kiwifruit growers.
- Understand the relationships between the different stakeholders in the kiwifruit supply chain in order to evaluate the potential for a sector-based approach to LCM uptake.

This chapter provides background information on the industry sector and its environmental initiatives in the New Zealand kiwifruit industry (Section 4.2 and Section 4.3). Section 4.4 outlines the methods used for the research. Section 4.5 summarises the results and discussion. Further details and visual representations of the results can be found in the Appendix.

4.2 Background to the Kiwifruit Sector in New Zealand

Zespri is the single desk exporter with the exclusive rights to export and market New Zealand kiwifruit overseas (excluding Australia) (Kilgour, Saunders, Scrimgeour, & Zellman, 2008). Growers typically liaise with post-harvest operators, who pack, store and deliver kiwifruit to Zespri markets on the growers' behalf.

In 2013, kiwifruit exports were valued at $934 million. In the same year, kiwifruit was exported to 53 countries. The largest export markets for New Zealand kiwifruit in 2013 were Japan ($262m), EU central distribution ($187.4m), China ($107.3m) and Taiwan ($81.5m). These markets accounted for 76.4% of total 2013 kiwifruit exports. The most common kiwifruit variety was Zespri green (7982ha), followed by Zespri Organic Green (5,508 ha), Zespri Gold and Organic Gold ('Hort 16A') (10,213 ha), Zespri SunGold ('Zesy002'/Gold3) and Organic SunGold (Gold 3) (174 ha), Zespri Charm ('Zesy003'/Gold 9) (193 ha), Zespri Sweet Green ('Zesh004' Green 14) (135 ha) (Horticulture New Zealand, 2013).

4.3 Life cycle based environmental initiatives in the New Zealand kiwifruit industry

A number of the New Zealand Crown Research Institutes as well as other researchers have already conducted technical studies of greenhouse gas emissions as well as water consumption associated with cultivation of kiwifruit in New Zealand. This section gives a brief overview of the studies and results that focus particularly on New Zealand kiwifruit growers.

The carbon footprinting project was a part of the New Zealand government's 'Greenhouse Gas Footprinting Strategy' with the goal to calculate a sector-specific carbon footprint for the New Zealand kiwifruit (exported to Europe) and, based on the results, develop ideas for reducing the carbon footprint of the industry sector. The project was carried out between February and August in 2008, by Landcare Research in collaboration with AgriLINK New Zealand, HortResearch and Massey University. It was undertaken for Zespri International and the Ministry for Agriculture and Forestry. Data were acquired through surveys on orchard and post-harvest operator level. The results are split into the different life cycle stages of the kiwifruit production, and the researchers distinguished between green, organic green and gold kiwifruit. Furthermore, the researchers provide a list of recommendations on how to decrease the carbon footprint in each of the areas of the kiwifruit production (Mithraratne, Barber, & McLaren, 2010).

Another study was undertaken by Müller, Holmes, Deurer, and Clothier (2015) on “Eco-efficiency as a sustainability measure for kiwifruit production in New Zealand”. The study investigated sustainable kiwifruit production in the Bay of Plenty, New Zealand, and considered the orchards’ environmental and economic performance. Müller et al. (2015) used the concept of eco-efficiency (first introduced by Sturm and Schaltegger (1989); they also distinguished between organic and contemporary growers. One key result of the study was that differences in results occur if the analysis is area-based or mass-based. If the mass-based carbon footprint is applied, it’s slightly more positive outcome towards contemporary production. However, the area-based carbon footprint leads to results that favour organic production. Organic kiwifruit yielded premium prices in the market, which led to a higher net added value, in spite of lower yields and the comparable greenhouse gas emissions from fuel use and N-related emissions for the two management systems. These results highlight that eco-efficiency is closely related to market prices and economic outcomes (Müller et al., 2015).

The aim of the water footprint project was to study the freshwater consumption (water footprint) of the green kiwifruit supply chain. This was undertaken in response to the increased awareness of consumers about the freshwater consumption of businesses and products, and related impacts on the environment (Hume & Coelho, 2010). The purpose of the study was to compare the results of the Water Footprint Network (WFN) method compared the LCA method. Both methods use a life cycle perspective. The researchers state that it is difficult to say definitely which method is better at describing the environmental impacts of freshwater consumption. They suggest a larger number of case studies and the provision of data specific for water footprint calculations. Often, both methods share the same secondary data sources. It is also highlighted that the WFN results might be the better communication tool for stakeholders like consumers. For example, a water footprint of 421 l per green kiwifruit is easier to understand by the lay person than LCA results.

The Agriculture Research Group on Sustainability (ARGOS) undertook a study to evaluate the soil of kiwifruit orchards in 2004. Soil quality was chosen as an important indicator as it is fundamental for sustaining production and livelihoods, as well as maintaining diverse and abundant ecological communities on orchards and ensuring health in the kiwifruit sector (Monks & MacLeod, 2013). One results of the study was that orchards managed under an organic system support enhanced biodiversity and soil quality relative to those managed under contemporary orchard management. Furthermore, reduction of frequency and toxicity of pesticide applications within kiwifruit orchards not only addresses consumers' concerns about adverse health impacts of spray residue on fruit in the international markets, but also alleviates adverse impacts on biodiversity (Monks & MacLeod, 2013).

To sum up, a number of studies on the environmental sustainability of kiwifruit have been undertaken over the last 15 years. This has facilitated maturing of the methodologies. This is important as it then ensures that there is a commonly used standard that describes the specific boundaries and methodology for conducting an LCA-related study in the New Zealand kiwifruit sector. It is important to make sure that methods are internationally recognised in order for the studies where the methods were used to be credible. However, it is clear that the studies so far have mainly focused on actual environmental impacts of the New Zealand kiwifruit sector, and recommendations for improvements. There has not been any detailed research on how to implement environmental improvements effectively.

4.4 Method

Online surveys were chosen as a method to verify whether the barriers and enablers to successful LCM uptake identified in the literature were applicable in the New Zealand kiwifruit sector. An advantage of this method is the fact that participants can fill in the survey in their own time and it is less intrusive than a telephone or face-to-face interview (Denscombe, 2010). Online surveys reduce bias as the researcher is not in the same room and answers are all confidential. Therefore, the participants of the online survey do not feel pressured to answer the questions in a certain way and the researcher's own opinions do not influence the participants. There are no verbal or visual cues to influence the respondent (Denscombe, 2010) as gestures and other body language are not applicable with written questionnaires.

To get insights into practices and perceptions around LCM it was important to include kiwifruit growers from across different regions of New Zealand. The online surveys were a useful tool to accomplish that in an effective manner within the time and resource constraints of the research.

Given that Zespri, the industry body for the kiwifruit sector, provides an online portal with information and tools for growers, it was assumed that the vast majority of kiwifruit growers have access to the internet. Furthermore, most people are familiar with online surveys and therefore this method does not make people apprehensive towards it (Denscombe, 2010).

The online survey was undertaken by using a survey software tool called Qualtrics. It allows the researcher to enter questions of different types (e.g. yes/no questions, multiple choice questions, open ended questions, etc.) and send the link to survey participants. Survey participants can then open the survey and answer the questions at their time of convenience. Altogether, 85 kiwifruit growers responded to the survey. Since there are around 2600 kiwifruit growers in New Zealand, the researcher is aware that 85 responses from kiwifruit growers is not a representative number. However, the aim of the online survey was to verify or otherwise the findings from the literature research in Chapter 3. The literature research in Chapter 3 is based on international references and it was important to identify if those applied in the New Zealand primary industry context. The results from the online survey showed that the literature findings do apply in New Zealand as well, and out of the 85 responses there was no response that gave the researcher the impression that there were any additional details or barriers that might come to the surface if more people responded. The researcher also undertook face to face interviews with stakeholders in the kiwifruit industry which would shed light on additional factors, if there were any. The researcher therefore decided that although 85 responses are not a representative number that allows for a detailed statistical analysis, it is a sufficient number to achieve the goal of the survey, and confirm or otherwise the findings from the literature. The additional time and resources spent to get more responses would most likely not lead to any additional findings for this research.

The link to the online survey was made available on the website that Zespri uses, called the Canopy website, to communicate to growers. Since this is a key communication tool used by Zespri to get in touch with the growers in New Zealand, it can be assumed that most growers have access to the internet, to the website, and would have the chance to access the link to the online survey. However, it is important to highlight that people took part in the survey on a voluntary basis, and since participants proactively chose to take part or not, there is an element of self-selection included which might have favoured participants that are interested, and therefore potentially quite proactive in the area of environmental management.

The survey was undertaken in March and April 2013.

The researcher used a statistics software tool called SPSS to process the survey responses. It was important to clean the data first and delete surveys that were submitted without any response to any of the questions. Furthermore, the categorical variables were checked to make sure that only possible responses appeared in SPSS.

Where this was not the case, the researcher consulted the original questionnaire to confirm what the response for that particular question was.

Additionally, it was important to check for missing cases. If there are a lot of missing cases it needs to be checked if there are errors in entering the data (e.g. in the wrong columns).

Continuous variables also need checking. For example, it is crucial to check maximum and minimum values to see if they are realistic and make sense. One question, for example, asked participants to enter the number of years that they have been working in the New Zealand kiwifruit sector. It is important to check that those numbers are realistic, as typos can occur when the participants enter data, and they have the potential to ruin the average for this question.

The responses were grouped into organic and contemporary growers, in order to identify any differences between these two groups. The primary data was analysed using *IBM SPSS Statistics (version 20)*.

4.5 Results and Discussion

This section provides a summary of the key findings of the quantitative study undertaken amongst New Zealand kiwifruit growers.

The questionnaire can be found in Appendix 1 of this thesis.

4.5.1 Characteristics of the participants

Over half of the participants were 61 years old or older. The results are the same for organic and contemporary growers. Most of the respondents classified themselves as being from a NZ European/European background.

On average, the participants have been working in the industry for 22.8 years. 87% of the participants are also the owner of the company that they are working for, 31% were Operations Manager, 26% were Environmental Manager, 22% were Health and Safety Manager; and 20% held the role of Quality Manager in their company (

Table 4.1). This can total to more than 100% as participants had the chance to tick more than one applicable answer. Particularly in SMEs, where job descriptions are not as clearly described in the contract, employees tend to take on tasks from a variety of different areas and could therefore have several roles.

All the organic participants were the owner of their companies, compared to 84.1% of contemporary growers. Moreover, 36.4% of the participants from organic companies had the role of Environmental Manager, compared to 20.6% contemporary growers.

Table 4.1: Position in the company

Position	Contemporary growers	Organic growers	All responses	Frequency (all responses)
Owner	84.1%	100%	88.2%	75
Operations Manager	33.3%	27.3%	31.8%	27
Environmental Manager	20.6%	36.4%	24.7%	21
Health and Safety Manager	19.1%	31.8%	22.4%	19
Quality Manager	17.5%	27.3%	20%	17
Other, please specify:	11.1%	9.1%	10.6%	9

Regarding qualifications, about half of the participants had agricultural or horticultural qualifications (Table 4.2). Over two thirds of organic growers (68.2%) held agricultural/ horticultural qualifications, compared to 44.4% of contemporary growers.

Table 4.2: Responses about agricultural/ horticultural qualifications (all participants)

Agricult./hort. qualification	Contemporary growers	Organic growers	All responses	Frequency (all responses)
Yes	44.4%	68.2%	50.6%	43
No	55.6%	31.8%	49.4%	42
Total	100%	100%	100%	85

4.5.2 Company characteristics

A majority of participants were from the Bay of Plenty (60%). 14.4% of participants have orchards located in the Northland, 10% in Auckland and 15.6% in other regions in New Zealand, including Gisborne, Waikato and Opotiki/ East Coast. None of the participants had orchards located on the South Island.

76.5% of the businesses were family owned, 5.9% represent a syndicate, 1.2% a Māori trust and 1.2% a lease. 16% of the participants ticked "others" and some of them specified that their business is a Trust, NZ Trust, Family Trust or they are sole traders.

Participants were asked to provide the total size of their kiwifruit orchards in ha, categorised into contemporary green, contemporary gold, organic green and organic gold kiwifruit. Many kiwifruit growers live on their orchard, but the question requested details of the orchard size only related to the land producing kiwifruit. As shown in Table 4.3, organic production occurred on a relatively small proportion of the land, and was dominated by green kiwifruit production whereas slightly more gold than green kiwifruit was cultivated by contemporary growers.

Table 4.3: Total orchard size

	Contemporary kiwifruit	Organic kiwifruit
Green	651ha	140ha
Gold	793ha	30ha
Total	1444ha	170ha

The average number of full-time employees for all responses was 2.55 (ranging from zero to 32). The values differed for organic and contemporary growers: On average, contemporary growers had 3.03 full time employees compared to 1.18 full time employees in organic businesses. Contemporary businesses employed between zero and 32 full time staff, compared to maximum six full time staff in organic businesses.

As shown in

Table 4.4, for approximalety one third of the participants kiwifruit production represented 100% of their income, and for another third of the participants it provided a significant part of their income (80-100% of their income). None of the participants received less than 25% of their income from kiwifruit production.

The results differed when comparing organic and contemporary growers: for 45.46% of the organic growers the income through sales of kiwifruit contributed to 100% to their total income, whereas this was only the case for 30.65% contemporary growers. For none of the organic grower it contributed less than 50% to their total income.

Table 4.4: Contribution of sales of kiwifruit to total income

Answer	Contemporary growers	Organic growers	All responses	Frequency (all responses)
100% of total income	30.7%	45.5%	34.1%	29
80-99% of total income	33.9%	27.3%	33.0%	28
50-79% of total income	24.2%	22.7%	23.5%	20
25-49% of total income	11.2%	4.5%	9.4%	8
Less than 24% of total income	0%	0%	0%	0
Total	100%	100%	100%	85

31.8% of the participants produced other horticulture products, including avocado (52% of the growers producing other horticulture products), citrus (9%), apple (9%), and a small amount of corn, peaches, feijoa, honey, peaches and herbs.

Only 16.5% of all participants were involved in producing non-horticultural products, which mainly included production of beef (53% of them), and an insignificant amount of dairy, tree crop, pigs, donkey and deer velvet.

4.5.3 Current environmental initiatives

All participants indicated that they had implemented at least one environmental initiative.

4.5.3.1 Responsibility for environmental initiatives

Table 4.5 shows who in the company is responsible for environmental initiatives. Participants were able to choose more than one answer to this question. The reason for this is that particularly in SMEs employees typically have several roles. This is particularly due to the fact that these companies have limited financial resources and would not be able to employ one person only for environmental issues, another person for quality, for health and safety, etc. Therefore, participants were able to tick several answers to this question and this is the reason why the total would add up to more than 100%. The percentage is calculated based on the total of responses of each particular role.

The results revealed that the owner of the company had a significant influence in driving LCM. In 84.7% of the answers it was the owner who pushed environmental initiatives in kiwifruit growing businesses. Only 11.8% of the participants ticked “Environmental Manager” as the one who implements environmental initiatives. The reason for that could be that some orchards have not established the role of Environmental Managers. Only one of the participants ticked “no one”.

As shown in Table 4.5, the results do not differ significantly when splitting the responses into organic and contemporary growers. In the majority of the cases, the owner had a significant influence on the implementation of environmental initiatives. In 86.4% of organic businesses, and 84.1% of contemporary businesses, the owner was involved in implementing these initiatives. However, more organic companies had environmental managers (18.2% compared to 9.5%).

Table 4.5: Person implementing environmental initiatives on the orchard

Role	Contemporary growers	Organic growers	All responses	Frequency (all responses)
Owner	84.1%	86.4%	84.7%	72
Principal Orchard Operator	31.7%	22.3%	30.6%	26
Health and Safety Manager	6.3%	13.6%	8.2%	7
Environmental Manager	9.5%	18.2%	11.8%	10
No one	1.6%	0%	1.2%	1
Other, please specify:	4.8%	0%	3.5%	3

In most companies the owner was not just the one suggesting the environmental initiatives, but also mainly involved in their implementation (72.9%). The results differ between organic and contemporary growers; in 90.1% of organic companies the owner played a key role in the uptake of environmental initiatives, compared to 67.7% of contemporary growers.

4.5.3.2 Environmental initiatives implemented on the orchards

This section sought to understand what environmental initiatives the businesses put in place in order to reduce their environmental impacts. Growers were asked if they have implemented the following environmental initiatives on their orchard, or if they used to take actions regarding those in the past:

- Reduce/ reuse/ recycle office waste
- Reduce waste arising on the orchard
- Reduce water consumption
- Reduce electricity consumption
- Reduce fuel consumption
- Reduce fertiliser use
- Reduce pesticide use
- Encourage biodiversity.

More than half of the orchards that took part in the survey had undertaken at least one action for each of the initiatives. The number of organic growers that implemented the different environmental initiatives on orchards was always higher than the number of contemporary growers.

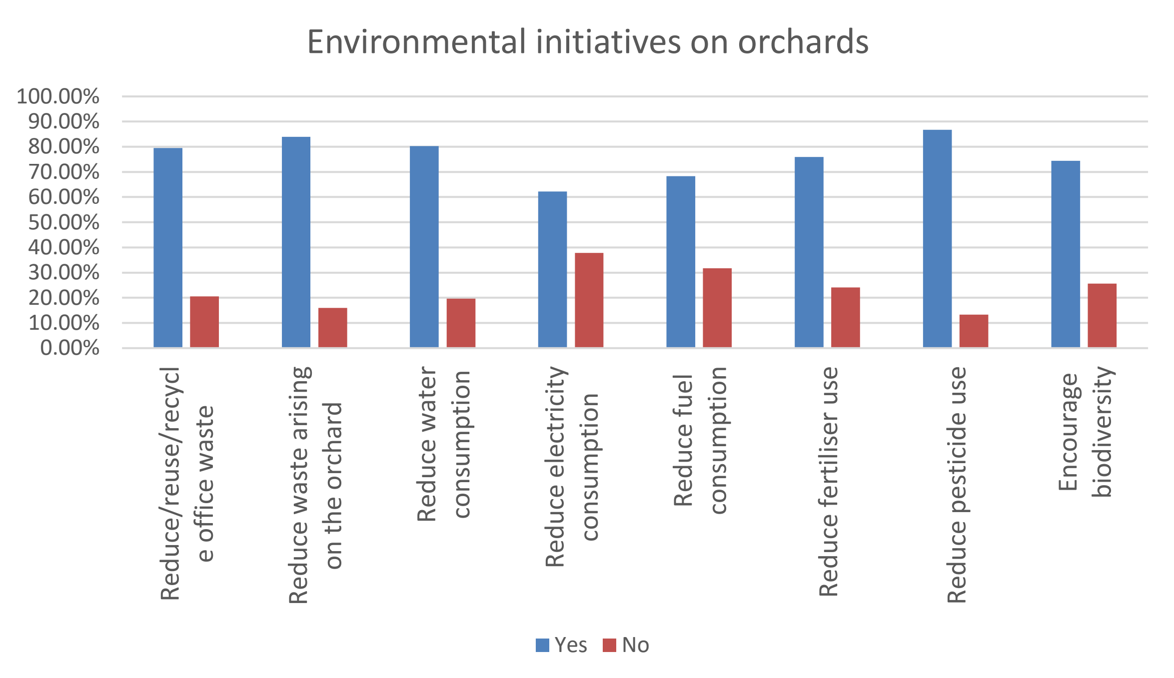


Figure 4-1: Environmental initiatives on orchards

As it can be seen in Figure 4-1 only 20% of the participants did not actively put actions in place to reduce/reuse/recycle office waste related to their orchard activities. Almost all organic growers (91%) and three quarters of the contemporary growers responded positively to this statement.

More organic growers (96%) than contemporary growers (80%) had implemented actions to reduce waste on orchards. These actions include “reduce use of any materials transported to site” as well as “reduce[d] deliveries to orchard”. “Composting” as well as “mulching prunnings back into soil” were mentioned by growers in the comments section after that question. One grower mentioned “composting of dairy waste and pine processing by products into fertiliser and soil conditioners” as an activity to actively improve the environmental performance of the orchard.

According the interviewees, water consumption in the Bay of Plenty was not very high due to the ideal climate and sufficient rain for kiwifruit orchards in the region. Therefore, most growers in this region did not have to irrigate the orchard.

62.2% of the participants proactively reduced their electricity consumption. Electricity consumption mainly occurs in the office due to the use of computers/laptops and the internet as well as lights in the office/shed. It is also used for irrigation, if this is required on the orchard.

A slightly higher percentage of organic growers (77.3%) than contemporary growers (65%) had measures in place to reduce fuel consumption on their orchard. Fuel consumption occurs due to vehicles that need to be used in order to apply sprays (such as fertiliser and pesticides) and compost, but also to clip the grass between the plants. It is in the growers' interests to reduce that as it is a cost for them if they use more than required. Organic growers tried to avoid mowing the lawn on a regular basis. They believed that the plants growing there enhance biodiversity and are beneficial for a healthy kiwifruit orchard. They also mentioned that particularly the Bay of Plenty is an area which is nearly a monoculture of kiwifruit orchards. Therefore, it was important to plant other crops and allow weeds, flowers and grass to grow between the kiwifruit vines. Thereby, they significantly reduced fuel since they mow less often.

75.9% of the participants actively reduced the use of fertiliser on their orchards per area. There is a difference when comparing organic and contemporary kiwifruit orchards: 81.8% of organic growers and 73.8% of contemporary growers proactively reduced the use of fertiliser on their orchard.

86.7% of the surveyed kiwifruit growers put actions in place to reduce the use of pesticides. All organic growers and 82% of contemporary growers reduced use of pesticides on their kiwifruit orchards prior to the Psa outbreak. However, the use of pesticides had increased due to the outbreak of the Psa kiwifruit vine disease in 2010. Particularly the growers in the Bay of Plenty were affected, as the region can be described as a kiwifruit monoculture. The Psa disease spread quickly and has affected a number of growers. In order to protect healthy vines from the disease, growers reported they had increased the use of pesticides in order to protect their orchards and ensure survival. Organic growers mentioned particularly the "use of copper" and the "need to reduce that in order to protect and enhance biodiversity and vine resistance". Copper has been widely used in order to protect plants from Psa, but growers were concerned about the increase of that chemical in their soils.

74.4% of kiwifruit growers promoted protection and enhancement of biodiversity. Almost all organic growers (95.5%) and only two thirds of contemporary growers actively protected and enhanced biodiversity on their orchard. Encouraging biodiversity relates to initiatives such as planting native trees and tree lucerns to encourage native birds and other animals on the orchard but also allowing grass and flowers to grow between kiwifruit vines. Growers specifically mentioned restorative planting of natives on non-producing land, fencing native bush areas and waterways, pest control in bush areas (possums, rats, rosellas and rabbits) as well as soil biodiversity. They also included clean-up of water bodies, retention of wetlands as well as leaving areas for animals to breed in safety. Growers also mentioned in the online survey that they have beehives for pollination. One grower taking part in the online survey also mentioned "transforming the orchard from contemporary to organic" in order to reduce environmental impacts.

Other initiatives that contemporary growers intend to implement in the future include: solar panel if cost effective, composting and worm farms, more planting as well as bird habitat, plantation of wild insects to assist pollination, no chemical pest control, always fine tuning current initiatives, more efficient irrigation system and controls, and reducing weed spraying by using alternative techniques.

The large majority, 93.2% of the participants of the online survey, did not receive any external funding that supported them in implementing the initiatives.

This question was important because companies might be more likely to implement change if they get financial support from external parties, such as governments. Moreover, change is usually a process that is not easy to implement in companies, and it requires financial, technical as well as human resources. As mentioned earlier, most of the participants are involved in SMEs and these are typically characterised by very limited resources. It is therefore on one side surprising and very proactive that such a high percentage of kiwifruit growers have implemented environmental initiatives; on the other side, these initiatives can be classified as actions with immediate financial benefits. Most of them result in immediate cost savings for the growers, such as fuel reduction and reduction of fertilisers and pesticides. However, reducing fertiliser and pesticides does increase the risk of producing less kiwifruit or having a crop of different quality, which would then clearly result in a financial loss for the grower, since the payment system rewards growers that produce a certain size and quality of fruit.

4.5.3.3 Drivers to implement environmental initiatives

All participants gave an indication about their drivers to implement environmental initiatives. As it can be seen in Figure 4-2, the most significant driver for LCM implementation for NZ kiwifruit growers were personal belief of owner/manager (77.6%) and alignment with business values (41.2%). Other notable drivers for the businesses were cost efficiency (34.1%) as well as future (28.2%) and current market requirements (25.9%).

There are some differences in terms of drivers between organic and conventional growers. 90.9% of the owner/managers in organic companies pushed the implementation of environmental initiatives, compared to 73% of owners/managers in conventional kiwifruit orchards.

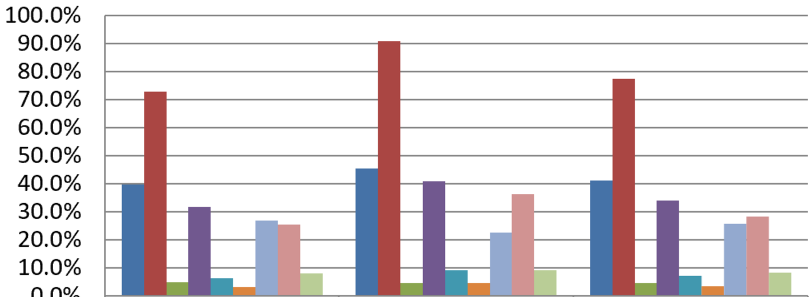
Additionally, more organic growers (40.9%) than conventional growers (31.7%) experienced cost benefits through uptake of environmental initiatives. This was an unexpected result, as organic growers often spent more money on certification, however, this might be outweighed by the fact that they spray less fertiliser and pesticides.

Another different attitude between organic and conventional growers was the power of future market requirements: 36.4% of organic growers thought that future market requirements will push them to become more environmentally friendly and put systems in place to prove that; compared to 25.4% of conventional growers.

However, more conventional growers (27%) saw current market requirements as a driver to implement environmental initiatives (compared to 22.7% of organic growers).

Both groups believed that pressure from the local community as well as staff were minor drivers. Many businesses don't have full-time staff employed (or only one to two people), which explains why staff might not be a significant driver to convince companies to take up environmental initiatives.

Other drivers mentioned by the participants of the online survey include "research study on this orchard showed resistance to sprays being used, so stopped all fungicides", "add value to property", "staff and own health reasons", "better use of waste", "become a sustainable business" as well as "EuroGap" and "GlobalGap". The two latter refer to current market requirements by European countries.



	Contemporary growers	Organic growers	All responses
Aligns with business values	39.7%	45.5%	41.2%
Personal belief of owner/ manager	73.0%	90.9%	77.6%
Initiated by staff	4.8%	4.5%	4.7%
Cost efficiency	31.7%	40.9%	34.1%
Other growers in the region have successfully implemented them	6.3%	9.1%	7.1%
Pressure from local community	3.2%	4.5%	3.5%
Current market requirements	27.0%	22.7%	25.9%
Future market requirements	25.4%	36.4%	28.2%
Other	7.9%	9.1%	8.2%

Figure 4-2: Drivers for implementation of environmental initiatives

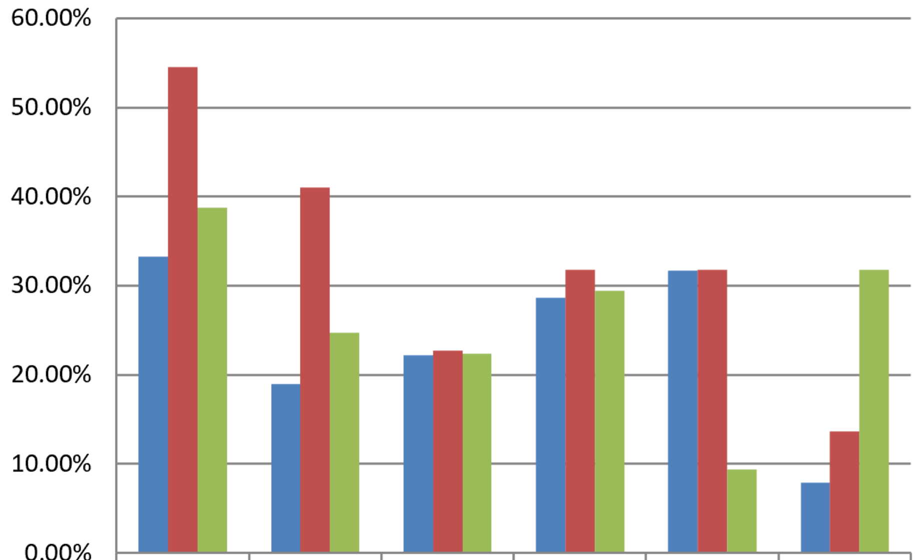
4.5.3.4 Resources to implement environmental initiatives

The implementation of environmental initiatives on a kiwifruit orchard requires knowledge and resources. That includes knowledge about different environmental initiatives and their benefits and applicability on an orchard. It not only requires the 'knowledge' resource, but also financial and staff resources to initiate change and actively implement those changes. 38.8% of participants used internal company resources. 29.4% of the participants used the support of Zespri and 24.7% worked together with other growers. 22.4% of the participants drew upon external consultants (Figure 4-3).

There are significant differences comparing responses from organic and contemporary growers. Although for both groups internal company resources are the most widely used resource when it comes to implementation of environmental initiatives, more than half of the organic growers (54.5%) used internal company resources, compared to 33.3% of contemporary growers. This might be due to the fact that organic growers receive education through their certification process. They learn how to work with pesticides, herbicides and fertilisers that are less harmful to the environment and their overall attitude towards the environment is different. Therefore, they can use their own knowledge or share with their business partner or employees when it comes to implementation of environmental initiatives. Contemporary growers might be less aware of what environmental initiatives they could implement and how to, so they need to support their internal knowledge with other sources.

Organic growers also communicate more with other growers about environmental initiatives. 41% of organic growers compared to 19% of contemporary growers share knowledge about environmental initiatives. Again, this can be due to the certification process that organic growers go through and the associated meetings organised by the organic growers to discuss current issues.

Organic growers mentioned BioGro as a resource that helped them understand what and how they can implement LCM in their business successfully. Also, advice from family, experience through horticulture education as well as literature helped them to understand how to implement environmental initiatives. These responses do not vary too much from the ones from contemporary growers, who mentioned books and literature as well as horticulture magazines as resources. Also, councils provided them with support.



	Internal company resources	Other growers	External consultants	Zespri	Don't know	Other, please specify:
Contemporary growers	33.30%	19%	22.20%	28.60%	31.70%	7.90%
Organic growers	54.50%	41%	22.70%	31.80%	31.80%	13.60%
All responses	38.80%	24.70%	22.40%	29.40%	9.40%	31.80%

Figure 4-3: Resources for implementation of environmental initiatives

4.5.3.5 Benefits experienced through implementation of environmental initiatives

Participants were asked to select the benefits experienced through implementation of environmental initiatives from the list provided in the survey; in addition, they could add other benefits under an "Other" category. More than 40% of participants mentioned cost savings and orchard gate returns as benefits of implementing environmental initiatives. The third most common benefit was improved company culture (27% of participants). Benefits listed under the "Other" category included "grower satisfaction and pride in producing a top product", "improved relationships with family", "enhancing natural features of environment", "improved relationships with apiarist", "better environment to work in", "increased biodiversity and erosion control", "improved property" as well as "better for the planet and future generations".

4.5.4 Facilitators of implementation of environmental projects in the industry

Survey participants were asked about specific factors that make environmental initiatives easier: the particular industry structure (single kiwifruit marketing desk), the culture of the industry, the existing networks within the industry and the long distance to the markets.

The majority of participants agreed/strongly agreed (80.2%) that the industry structure was beneficial in facilitating the uptake of environmental initiatives by the entire NZ kiwifruit industry. There were no significant differences between organic and contemporary growers.

Again, most of the participants agree (44.7%) or strongly agree (22.4%) that the culture in the NZ kiwifruit industry makes it easy to take up environmental initiatives in the industry.

The results differed when comparing organic and contemporary growers. 74.6% of the contemporary growers (strongly) agreed that the culture in the industry has a positive impact on implementing LCM industry-wide. Only 47.6% of organic growers (strongly) agreed with that statement, and 23.8% (strongly) disagreed, compared to 10.9% of the contemporary growers who disagreed.

Meetings with organic growers have highlighted that they felt left out and not included in industry-wide decisions. They often felt neglected and have the impression they are "treated differently compared to the contemporary growers". Organic growers therefore have a network where they regularly meet to discuss industry issues, but also specific issues relating to organic practices. They "feel like a subgroup within the whole industry".

Most NZ kiwifruit is exported to markets that are a long distance away from the place of production, such as Japan, Europe and the US. This can create a challenge when it comes to uptake of environmental initiatives on an industry-wide scale. As the consumer is one of the important drivers to implement activities to reduce negative impacts on the environment, the long distance to the consumer can reduce the pressure coming from them.

According to the participants of the online survey, more than half of the participants did not agree with this statement (18.4% strongly disagreed and 40.8% disagreed).

The participants of the online survey were asked about their experiences with the implementation about environmental initiatives.

37.9% of the participants did not (strongly) agree with the statement that environmental initiatives require many staff resources.

None of the organic growers agreed with the statement that implementation of environmental initiatives requires many staff resources. However, 22.2% of contemporary growers agreed.

Over a third of the participants (35.1% disagreed and 2.7% strongly disagreed) did not think that specialist knowledge is required for the implementation of environmental initiatives on their orchard, whereas the same number of participants (36.5%) (strongly) agreed with the statement.

Again, around one third (31.1%) disagreed and 2.7% strongly disagreed with the statement that environmental initiatives are time consuming, whereas 37.9% (strongly) agreed with it.

39.2% of the survey participants disagreed, and 6.8% strongly disagree with the statement that it is difficult to get started. 27% agree, and only 1.4% strongly agrees.

Most organic growers (60%) (strongly) disagreed with the statement, whereas only 33.3% of contemporary growers disagreed and 7.4% strongly disagree. Only 15% of contemporary growers agree with the statement, compared to 31.5% of contemporary growers who agree and 1.9% of contemporary growers who strongly agree with it.

52.6% of the participants agreed and 18.4% strongly agreed that environmental initiatives are important for their business. Only 2.6% strongly disagreed and 5.3% disagreed with that statement.

45.9% of the participants agreed and 4.1% strongly agreed that it is possible to measure benefits resulting from successful implementation of environmental initiatives.

21.6% of the participants agreed and 9.5% strongly agreed that implementation of environmental initiative requires much paperwork.

35.2% of participants (strongly) disagreed with the statement that the implementation of environmental initiatives requires special equipment, 28.4% (strongly) agreed and 37.8% neither agree nor disagree.

58.1% agreed and 9.5% strongly agreed that the culture in their company facilitates the uptake of environmental initiatives.

A high percentage (54.1%) agreed that networks with external parties are a facilitator of uptake of environmental initiatives.

Kiwifruit growers need to purchase equipment such as fertilisers, pesticides and herbicides, as well as compost to run the orchard. According to the online survey, 68.8% of them participants consider the environmental performance of the suppliers. 90.5% of the organic growers; and 60.7% of the contemporary growers consider the environmental performance of their suppliers.

28.6%% of the organic growers, and 27.7% of contemporary growers planned to implement further environmental initiatives on their orchard within the next year.

They specified these initiatives in the comments section, which include “avoid use of copper and any other products against Psa, that may destroy biodiversity and/ or vine resistance" (response from an organic grower), "composting/ worm farm, solar panel if cost effective", "improved recycling", "improved quarantine measures", "more planting", "bird habitat", "plant wild insect-attracting plants to assist pollination", "energy and water resourcing improvement, e.g. install solar panels, water tanks", "non-chemical pest controls", "encouraging native re-establishment", "reduction of fertiliser" as well as "reduce weed spraying by using alternative techniques". One respondent mentioned "we are packer as well as grower; the business is chasing the more holistic values of sustainability rather than just the environmental area". Others also mention "2-tier farming", "always fine tuning what we do and open to new initiatives" and "whatever is required".

4.5.5 Importance of environmental performance for the business in the future

Participants were asked how important they think the environmental performance will be for their business in the next five years.

45.9% of the participants believed that the environmental performance will be as important as it is now for their business in the next five years. Importance of environmental performance for the industry in the future

A similar question was asked but referring to the importance of environmental performance for the NZ kiwifruit industry in the next 5 years.

A quarter (25.3%) of all participants believed the environmental performance will be much more important, and over half the participants (56%) thought it will be more important for the kiwifruit industry in the next five years.

42.9% of organic growers, compared to 18.5% of contemporary growers, believed that the environmental performance of the industry will be much more important and more important in the next five years.

None of the organic growers saw a decline of the importance of environmental initiatives for the industry, compared to 3.9% of contemporary growers.

4.5.6 Communication

This section of the survey sheds light on the medium used to communicate with supply chain partners (other growers, post-harvest operators and Zespri) as well as the frequency of communication. Participants also provided information about their satisfaction with the medium and frequency.

Most growers (47.4%) used informal ways of communication such as coffee breaks. Notice boards (11.3%), regularly scheduled catch up meetings (9.3%) as well as formal training sessions (9.3%) were not very common means of communication.

The results regarding informal communication were very similar for both organic and contemporary growers. However, only a small number of organic growers developed formal training sessions (3.6%) and weekly or monthly catch-up meetings (11.6%) compared to contemporary growers. Notice boards were more common amongst organic growers (17.9%) compared to 8.7% in companies that grow contemporary fruit.

30% of the growers explained these responses in the comments field by mentioning that there are no other employees. One respondent mentioned "sharing resource material and actively seeking employee initiatives". Other comments include "field days", "education" and "verbally". Growers mostly communicated via field days (74.1%). Other important means that facilitated communication between growers are personal communication via phone (65.9%) and email (55.3%) as well as "chatting over the fence" (60%), which means communication with neighbours and growers in the region. Most kiwifruit growers happily share their practices as well as success stories with other growers in the industry and help them to achieve best practice.

According to the survey, 63.2% of participants were satisfied and 10.5% were very satisfied with the media used for communication between growers. 74% of the survey participants state that they communicate at least once a month, and 21% at least once every three months with other growers.

Communication between growers and post-harvest operators was mainly facilitated by personal communication via phone (81.2%) and email (71.8%), email newsletters (50.6%) and field days (61.2%). The printed newsletter provided by the post-harvest operator was a mean of communication that 50.6% of the growers use. Other means of communication between growers and their post-harvest operators included "board meetings", "hosting industry visitors", "social events", "consultation", "face-to-face meetings" and "post-harvest website". Personal communication via phone and email, field days and email newsletter are the most widely used means of communication between organic and contemporary growers and their post-harvest operators. 63.2% of the participants were satisfied and 28.9% were very satisfied with the media being used for communication between growers and post-harvest operators. 88.2% of the survey participants communicated with their post-harvest operator at least once a month outside of harvest season. 50.6% of the participants were satisfied and 27.1% were very satisfied with the frequency of communication between growers and their post-harvest operators.

The main media to communicate between Zespri and the growers was the Canopy website (75.3%) which is a website facilitated by Zespri and only available to growers via password login. The Zespri website (55.3%), email newsletters (45.9%) and printed newsletters (50.6%) were well-adopted means of 'one-way communication'. Other means taken up in the industry were personal communication via email (49.4%) and phone (48.2%) and again, field days (57.6%).

Once again, the means of communication were very similar between organic growers and Zespri, and contemporary growers and Zespri. The Canopy-Website was the most widely used way to communicate with Zespri (81.8% of organic growers, and 73% of contemporary growers use it). The results were also similar regarding personal communication via email and phone. However, 68.2% of organic growers used the printed newsletter, whereas only 44.4% of contemporary growers adopted it as a way to communicate with Zespri. Other ways of communication between the growers and Zespri include “hosting industry visitors”, “social events” as well as “industry meetings”.

55.3% of the growers are satisfied and 21.1% were very satisfied with the media being used for communication between growers and Zespri.

The online survey in the New Zealand kiwifruit industry shows that the commonly agreed on barriers and enablers which were identified in Chapter 3 apply in this context as well. The survey allowed the researchers to understand the kiwifruit industry, including its specific structure and relationships between the different players, including the growers, post-harvest operators and Zespri.

Zespri is the key driver and pushes growers to meet the expectations of the export markets. However, there are individual growers, such as the group of organic growers, who often move beyond those expectations, especially in the area of biodiversity, to improve the environmental performance on their orchards. There are also a number of ad-hoc LCM initiatives, such as supplier evaluations. These are not driven and standardised by Zespri, which means each organisation sets up their own criteria and processes for those, if they decide to do it.

4.6 Conclusion and future research

The online survey was able to confirm that the enablers and barriers to successful LCM uptake identified in the literature by Seidel-Sterzik et al. (2018) were applicable amongst New Zealand kiwifruit growers. The questions in the online survey related to the different enablers and barriers from the literature, and the responses showed that the participants in the kiwifruit industry considered those when putting actions in place to improve their environmental performance. The study also helped to understand the dynamic between the growers, post-harvest operators and Zespri.

The insights into the New Zealand kiwifruit industry showed that in particular the structure of the industry, as well as the tools used to communicate and the frequency of communication between the various stakeholders, provide a useful basis for setting up a sector-based approach in that particular industry sector. As defined in Section 3.5.1, a sector-based approach is “a planned and systematic programme driven centrally by a sector body or other relevant accepted and knowledgeable organisation, covering both horizontal and vertical supply chain organisations that has the goal of continually improving the collective environmental performance of the industry sector". In the New Zealand kiwifruit industry, Zespri represents that sector body that is accepted by other stakeholders as the organisation that collects information and distributes it to the relevant stakeholders, so they can adjust to present and future market requirements. It is also the organisation that ensures that the New Zealand kiwifruit stays competitive in the global market place, considering a wide range of consumer and market criteria, amongst those environmental performance. The goal for the industry sector is to continually improve their environmental performance, and as shown in Section 4.5.6 about communication in the sector, horizontal and vertical communication is facilitated.

The findings show that a sector-based approach can be a very efficient and effective way forward for the industry in order to improve their environmental performance and thereby strengthen their position in the New Zealand and global market. There is a strong relationship amongst growers and networks are already in place which facilitate learning from each other. There is also a culture of sharing knowledge.

By improving their current performance, it might be possible to strengthen the sector's performance even more. This could be done by combining each stakeholder's effort by sharing data, and providing a platform with shared goals, aggregated industry data and short- and long-term actions. A platform for sharing information might be a way to share information that has been shared in face to face communication with the wider community and allow more growers to benefit from the findings and practices of individuals.

If there was a way to see the industry's data (for example data on energy or pesticide use), the individual could then see how they perform compared to the average of the industry, and how, when they enter their data, the overall performance of the industry sector changes. This could be a way to create momentum, especially in industry sectors where stakeholders are not in such close proximity as they are in the New Zealand kiwifruit industry.

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STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Helene Seidel-Sterzik
Name/title of Primary Supervisor:	Prof. Sarah McLaren
Name of Research Output and full reference:	
A Quantitative Study on LCM Experiences in the New Zealand Kiwifruit Industry	
In which Chapter is the Manuscript /Published work:	Chapter 4
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
candidate: structured the paper, prepared and carried out the online survey, analysed the results, wrote the paper supervisors: feedback on survey design&on presentation of results, proof reading	
For manuscripts intended for publication please indicate target journal:	
Sustainability	
Candidate's Signature:	Helene Seidel-Sterzik Digitally signed by Helene Seidel-Sterzik Date: 2020.03.28 12:50:16 +13'00'
Date:	
Primary Supervisor's Signature:	Sarah McLaren Digitally signed by Sarah McLaren Date: 2020.04.01 09:39:02 +13'00'
Date:	1st April 2020

(This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis)

5 A CAPABILITY MATURITY MODEL FOR LIFE CYCLE MANAGEMENT AT THE INDUSTRY SECTOR LEVEL

This chapter presents the LCM Uptake Evaluation Framework (LUEF), which is a framework for assessing the factors influencing the uptake of LCM by industry sectors. It allows organisations as well as industry sectors to evaluate their maturity on their journey of effective implementation of LCM. The LUEF can be used to identify a baseline in terms of LCM performance and measure an organisation or industry sector against it on a regular basis.

There are seven factors against which organisations and industry sectors can benchmark themselves. The factors were identified in the research presented in Chapter 1. Maturity scales were developed for each of the seven factors.

The chapter begins with a summary of the factors based on three bodies of knowledge: LCM, SME characteristics and SCM (Section 5.1). Section 5.2 describes the methods used for identifying and developing the maturity scales. Both literature review and the results of a series of semi-structured interviews were used to develop these maturity scales. The resulting LUEF is presented in Section 5.3.

The following sections have been published as a journal paper "Seidel-Sterzik, H., McLaren, J.S., and Garnevska., E. A Capability Maturity Model for Life Cycle Management at the Industry Sector Level. Sustainability 2018; https://doi-org.ezproxy.massey.ac.nz/10.3390/su10072496".

My contribution to the paper was as the main author. I carried out the literature research, as well as the design and conduct of the interviews with the various kiwifruit growers and post-harvest operators. I also developed the framework and the maturity scales for each factor of the framework. My supervisors provided me with feedback and support on the structure of the paper, and additional literature resources to be included where appropriate. They also contributed by editing and proofreading the paper and providing ideas and feedback on the framework itself.

Abstract

One approach to incorporate environmental sustainability in organisations is the implementation of Life Cycle Management (LCM). LCM is a comprehensive and integrated approach for measuring and managing environmental impacts. Successful sector-wide uptake of LCM has the potential to enable the environmental impacts associated with an industry sector to be efficiently measured and managed in a continual improvement process.

There is an opportunity for the New Zealand primary sector to strengthen its competitiveness in the global marketplace by demonstrating the environmental credentials of its products and supporting the country's "green and clean" image. Previous research has identified the barriers and enablers to successful LCM uptake by New Zealand primary sector SMEs in a sector-based context. This chapter builds on that foundation and presents a Life Cycle Management Uptake Evaluation Framework (LUEF) that allows both individual organisations and industry sectors to identify the key factors affecting successful LCM uptake and assess their level of maturity for each factor. The key factors used in this study are structure, culture, resource availability, LCM strategy, knowledge, market requirements and communication.

The study employed a qualitative methodology and used face-to-face interviews with different stakeholders in the value chain for the New Zealand kiwifruit sector to inform the development of the framework. In the framework, each factor is represented as a maturity scale to allow organisations as well as industry sectors to assess their position on the scale. This will help them to create a baseline assessment, both for themselves as an organisation, as well as on an industry sector level. The baseline assessment will allow them to identify areas for improvements, which can be tracked over time by checking the progress on the scales in the individual areas. It can also be used as a communication tool for stakeholders in the supply chain (e.g. growers, post-harvest operators and staff from industry boards). These stakeholders can use the tool to measure and compare performance, including evaluating their own performance against the industry average, as well as performance of the industry sector over time. This is useful to engage these stakeholders and demonstrate that changes (such as reducing carbon footprints) have a positive impact and lead to progress (as well as highlighting any actions that need to be reviewed and adjusted).

Keywords: Sector-Based Approach (SBA), Capability Maturity Model, LCM Uptake, Small and Medium Sized Enterprise (SME), Primary Industry

5.1 Introduction

Environmental problems and wider sustainability questions have become a shared concern for governments, industries and consumers in New Zealand and worldwide. Consequently, many organisations have implemented environmental sustainability initiatives into their business activities (Dowell & Muthulingam, 2017; Hsu, Tan, & Mohamad Zailani, 2016). Research over the last few decades has suggested that organisations should also consider the role of their supply chain partners when addressing the environmental impacts of their products and services in order to remain competitive (Fernando & Saththasivam, 2017; Rajeev, Pati, Padhi, & Govindan, 2017; Sharma, 2016). However, not all organisations find it easy to address environmental impacts associated with their supply chains. This is particularly the case for SMEs as highlighted by Mandl & Dorr (2007). SMEs face challenges in implementing environmental initiatives due to their specific characteristics, such as limited support from owner/managers, limited resources and lack of awareness of their own environmental impacts (Seidel-Sterzik, McLaren, & Garnevska, 2018). Therefore, SMEs should not be treated as smaller versions of large organisations. Many New Zealand businesses in the primary sector are in this SME category, and moreover are an integral part to the New Zealand economy as over 70% of New Zealand's exports come from primary industries (Ministry for Primary Industries, 2017).

One approach to implementing environmental sustainability is the use of Life Cycle Management (LCM). LCM is the application of Life Cycle Thinking (LCT) to business practice, with the aim of managing the total life cycle of an organisation's products and services to move towards more sustainable consumption and production systems. According to the United Nations Environment Programme (UNEP), "LCM has been defined as the application of LCT in modern business practice" (UNEP, 2006).

A research study was previously undertaken to identify the specific enablers and barriers faced by SMEs in implementation of LCM (Seidel-Sterzik et al., 2018). The research drew on the SME, SCM and LCM literature to identify relevant enablers and barriers. The factors that could act as enablers or barriers were identified as: owner/manager influence, culture, resources, strategy, knowledge, market requirements, geography and communication. It was concluded that a sector-based approach is preferable for implementing LCM in primary industry sectors that have large numbers of SMEs. The advantages of sector-based approaches include economies of scale for LCM research to support implementation, ease of administration, streamlined collection and management of data, improved reputation of the product, knowledge sharing and creating momentum for LCM (Bradley, Baumert, Childs, Herzog, & Pershing, 2007; Schmidt, Helme, Lee, & Houdashelt, 2008; Seidel-Sterzik et al., 2018).

Building on that study, this research used the concept of capability models to develop an LUEF using the identified factors. The factors identified for the LUEF can either act as enablers towards LCM uptake by the organisation or industry sector, or can act as a barrier, if they have not been established and implemented sufficiently. Capability models assess the capability of organisations against sets of complex or multifaceted (complex) criteria (Dinsmore, 1998). They raise awareness and create a shared reference point, as well as providing guidance for the development of action plans and supporting the ongoing monitoring of progress (Silvius & Schipper, 2010). Shared reference points are important to ensure that all involved parties use the same way of measuring and comparing performance.

The method used for the research is explained in Section 5.2, and Section 5.3 presents the resulting maturity scales for the different factors. Section 5.4 briefly outlines how the LUEF can be used in future.

5.2 Methods

The LUEF was developed to comprise a maturity scale for each factor that can be used to assess either an individual organisation or a wider industry sector. This has several purposes. Firstly, it allows an organisation/sector to develop a baseline for measuring progress and identifying future projects to improve the performance. Secondly, the maturity scales can be used to compare organisations with each other and identify laggards who can then be targeted for improvements. Thirdly, maturity scales can be used as a tool for communication internally to staff in order to show them how their actions changed the organisation's performance, and externally to stakeholders to report on progress and future plans and goals.

In this research, firstly a prototype maturity scale was developed for each factor based on a literature review. The literature review was done by using relevant key words to find applicable research articles.

Then a series of interviews were undertaken with stakeholders in the New Zealand kiwifruit supply chain to understand how each factor might act as an enabler or barrier for different stakeholders, and to inform refining of the maturity scales. The LUEF consists of the following elements: structure, culture, resource availability, LCM strategy, knowledge, market requirements and communication (Seidel-Sterzik et al., 2018).

The stakeholder groups identified for the interviews were Zespri, kiwifruit growers, and post-harvest operators. The Zespri Group Ltd. is the industry organisation for the New Zealand kiwifruit sector; it is recognised as the single desk exporter with exclusive rights to export and market New Zealand kiwifruit overseas (excluding Australia) (Kilgour, Saunders, Scrimgeour, & Zellman, 2008). Zespri sells directly and indirectly through various collaborative marketing agreements. Growers typically do not contract directly to Zespri but to a post-harvest operator, which packs and delivers the fruit to Zespri markets on the growers' behalf. Each post-harvest operator runs a pool system for grower payments received from Zespri, from which they deduct packing and cool storage fees (Grant Thornton New Zealand, 2011) and then pay the growers. There are approximately 2600 kiwifruit growers and about 13 post-harvest operators in New Zealand (NZKGI, 2018).

For the study, convenient sampling was used and 23 stakeholders in the kiwifruit supply chain participated. These comprised two staff members employed by the industry body Zespri, twelve growers, and nine post-harvest operators. The interviews were conducted in 2013, in the Bay of Plenty, the main kiwifruit growing region in New Zealand. The growers were the owners of the businesses in all cases, and the representatives of the post-harvest operators were either Production Managers or Environmental Managers. A more detailed analysis of the kiwifruit study can be found in Sterzik et al. (in preparation). In this paper, relevant quotes from the interviews and observations are provided in Boxes to illustrate the points made in the text about the different factors.

Semi-structured interviews were used as a research method to gather qualitative data relating to the implementation of LCM initiatives in the New Zealand kiwifruit sector. Interviews, especially unstructured or semi-structured interviews, offer considerable researcher flexibility. By directly posing questions to relevant stakeholders of the industry, large amounts of relevant information about the different experiences can be acquired. Qualitative research through in-depth interviews results in more detailed data than what is available through other data collection methods such as online surveys. The use of semi-structured interviews was appropriate to supplement and extend knowledge about the culture, structure and technology transfer processes within the New Zealand kiwifruit sector as well as enablers and barriers to LCM uptake. Moreover, it provides a more relaxed atmosphere in which to collect information and people often feel more comfortable having a conversation as opposed to filling out a survey (Woods, 2011). The method enables the researcher to ask spontaneous questions and allow the participants to express themselves. This method also allows questions to flow naturally, based on information provided by the participants. The partial pre-planning of the questions still allows for replication of the interview with others. A limitation of this method is that interviewers could be biased and consequently leads to inaccurate results (Woods, 2011). That can be reduced by avoiding judgement of their answers. In addition, the researcher is from a university and is not a stakeholder in the kiwifruit sector. Moreover, yes/no-questions and leading questions were avoided to allow the respondent to provide the information that reflected and justified his or her opinion. The language and terms used during the interviews was chosen to be easily understood by participants, and complicated or confusing questions were avoided.

There are different means of analysing semi-structured interviews. One way is to record and then transcribe the interviews. However, Denscombe (2010) highlights that “the amount of the raw data that needs to be transcribed will depend on the use to which the data is being put. If the contents of an interview are being used for the factual information they provide, for example, as part of a “descriptive account” then the researcher can be quite selective; transcription might only be needed for the purpose of small extracts that can be used as “quotes” to illustrate particular points when writing up the findings”. He further explains that “if the researcher is looking for the underlying structure of the talk or the implied meanings of a discussion, the audio recordings will need to be transcribed quite extensively […]” (Denscombe, 2010). However, the interviews were conducted to obtain information about what different stakeholders did with regards to LCM uptake, what experiences they had and what projects they might take up in the future. Therefore, as the interviews were about facts and not about underlying assumptions or perceptions, it was not deemed necessary to transcribe the entire interviews. Rather, it was more important to obtain quotes to highlight the stakeholders' activities in LCM uptake and their opinions about specific issues.

Emails were sent out, addressed to the person responsible for sustainability or, in cases where no role of this nature existed, to the owner or CEO of the organisation. The email explained the purpose of the study and requested to arrange meetings between the researcher and the individual stakeholders. It also indicated the expected duration of the interview. In cases where the kiwifruit stakeholders did not reply, the email was followed up with a phone call.

At the beginning of each interview the researcher provided an introduction to the research and the purpose of the interview was explained. The researcher explained that the information would be treated as confidential and the participants acknowledged that they were comfortable with the interview being electronically recorded. The interview was divided into five parts:

1. Personal information: This includes information about the participant's background and education, particularly for how long they had been involved in the kiwifruit industry, and if they had a degree in horticulture.
2. Company information: This section includes information about the company, such as the age and the size of the orchard, as well as details about other products that they produce.
3. Processes: This section gave insights into how the business is run and how jobs and roles are divided between employees.
4. LCM projects: This section provided insights into environmental practices on the orchards, such as fuel saving, reduction of pesticide use, etc.
5. Supply chain: In this section participants talked about the communication and networking with other growers, their post-harvest operators, Zespri and external research organisations.

5.3 Development of the LCM Uptake Evaluation Framework

This section presents the LUEF which is a maturity model based on the factors influencing the uptake of LCM. A maturity model allows the users to find out how mature an organisation or industry sector is in regard to specific criteria. The purpose of this maturity model is to assess the level of maturity against the seven factors in relation to LCM for the individual organisation, as well as on a sector level.

As introduced in Section 5.1, Capability Maturity Models (CMMs) are a practical means to represent the capability of organisations against complex or multifaceted criteria (Dinsmore, 1998). Kolk and Mauser (2002) reviewed the literature on organisational sustainability and environmental management maturity models; they found that the models use between three and five maturity phases. Generally, the maturity models of environmental management in organisations refer to organisations transitioning from a 'defensive', 'ad hoc' or 'compliance' phase to an 'integrated', 'optimised' or 'visionary' maturity level (Kolk and Mauser 2002). Cagnin, Loveridge and Butler (2010) developed a five-phase organisational sustainability maturity model. The researchers presented the criteria for the various phases of the model based on the key activities and competences of the organisation (Cagnin et al., 2010). They argue that if an optimised sustainability maturity is to be achieved, it must be aligned to a common strategy and shared approach amongst stakeholders in a wider 'sustainability net'. The 'sustainability net' includes the organisation, its customers, supply chain, partners and interested stakeholders within society.

The LUEF maturity model in this research has been developed based on findings from the literature on enablers and barriers to the uptake of LCM and other environmental management practices and informed by interviews with stakeholders in the New Zealand kiwifruit sector. A diagrammatic representation of the model is shown in Figure 5-1; it consists of the seven enabler/barrier factors identified in previous research, and five maturity levels. A five-point Likert Scale was chosen for the maturity levels which range from "defensive" through to "optimised". This provides the user with enough distinction between the different maturity levels, and yet not too many levels which would make it hard to distinguish between adjacent maturity levels.

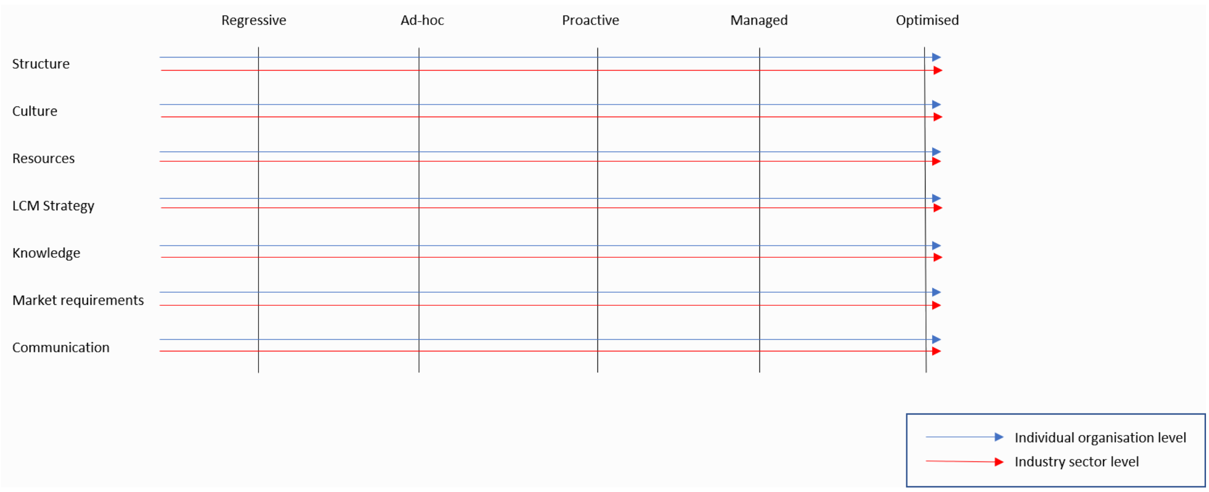

Figure 5-1: Diagrammatic representation of the Life Cycle Management Uptake Evaluation Framework (LUEF)

The following subsections provide an overview of the seven factors used in the LUEF. Each section starts with a short description of the factor, and then describes how the maturity scale was developed based on literature and insights from the kiwifruit study. It should be noted that in these sections, the phrase "Life Cycle Management" is used as an umbrella term to describe all environmental management initiatives, including those that are just concerned with the company's on-site activities.

5.3.1 Structure

The structural characteristics of an organisation as well as the wider industry sector can act as an enabler or barrier to the uptake of LCM (Grekova, Calantone, Bremmers, Trienekens, & Omta, 2016). Structure includes the arrangement of entities within an organisation as well as along the supply chain, and their relationships to one another with respect to flow of information and resources (Chandra & Kumar, 2000; Tatoglu et al., 2016). It therefore determines (to a large extent) the allocation of tasks, methods of reporting and information sharing, coordination, control and interaction (Benzer, Charns, Hamdan, & Afable, 2017). Moreover, it affects innovation and the implementation of change (such as LCM uptake) as it has a large influence on the linkages between individuals and their activities, as well as knowledge transfer amongst collaborative entities (Klievink, Bharosa, & Tan, 2016).

Organisations can decide whether to use the existing organisational structure or an extended structure to manage LCM initiatives (Epstein & Buhovac, 2014). When using the existing structure, responsibilities for LCM are allocated to staff in addition to their existing functional responsibilities. In the case of an extended structure, one or more new resources or functional entities are specifically allocated to LCM e.g. an Environmental Manager position may be created. In either case, a critical success factor is the power and influence of the human resource responsible for managing LCM to affect decisions in the organisation (Roome, 1992). It is important for the Environmental Manager (or equivalent) to have 'a seat at the table' or direct access to the owner or CEO for successful integration of LCM into decisions and processes of the organisation (Epstein & Buhovac, 2014). The allocation of responsibility and influence regarding LCM implementation was therefore used to develop the maturity scale in Table 5.1.

It should also be noted that the optimal structure for an organisation and an industry sector depends on multiple factors such as the external environment, the size of the organisation, and the existence of specific business strategies (McShane, Olekalns, & Travaglione, 2009). External factors are, for example, determined by whether the environment is stable or dynamic, complex or simple, and diverse or integrated. There is therefore a strong connection between organisational structure and other internal influencing factors presented in this chapter such as culture, resource availability, strategy and communication (McShane et al., 2009).

At the individual organisation level, a low level of maturity is represented by situations where no structures or processes are in place to facilitate improvements in LCM performance.

An optimised level of maturity involves having dedicated resources allocated to LCM and where processes and structures exist to ensure continual improvement. Similarly, at the industry sector level there may initially be no formal structure in place to improve or promote sector level LCM. As the sector becomes more mature, structures are put in place culminating in formal LCM programmes and sector-specific standards used by industry stakeholders. Table 5.1 provides a summary of the LUEF scale for structure relating to LCM and Box 1 summarises the findings from the kiwifruit industry.

Table 5.1: Proposed maturity scale to assess the effectiveness of organisational and sector level structure for LCM uptake

Maturity scale	Individual organisation level	Industry sector level
1–Regressive	No roles and responsibilities related to LCM initiatives.	No formal structure or responsibility for LCM exists.
2–Ad hoc	Staff are sporadically encouraged to take part in LCM initiatives.	Industry level policy and commitment to the environment.
3–Proactive	All staff encouraged to participate in LCM initiatives.	Dedicated role at the sector level to coordinate and drive LCM.
4–Managed	Development of dedicated roles and/or responsibilities for LCM or environmental management.	Formal programme exists to coordinate and drive LCM at the sector level.
5–Optimised	Responsibility for LCM or environmental management lies with decision makers such as the owner or roles who report directly to them.	Comprehensive industry wide framework for assessing and verifying sector stakeholders against sector specific standards.

Box 1. Structure examples in the kiwifruit sector

During the interviews with kiwifruit growers, it became apparent that, due to the small size of most kiwifruit orchards in New Zealand, hierarchies in these organisations are flat and reporting processes are therefore very informal. In most cases, the owner makes all the decisions but is also involved in undertaking day-to-day operations. The post-harvest operators are larger organisations and have more distinct job descriptions for each employee, but the hierarchies are also relatively flat, and the owner/manager is usually still closely involved in the day-to-day operations.

At the sector level, Zespri has considerable influence over both the post-harvest operators and the growers. For example, growers as well as post-harvest operators receive a book of requirements that they need to fulfil in order to supply Zespri with kiwifruit. The growers and post-harvest operators recognise that this system managed by Zespri is helpful in keeping the industry competitive as indicated in this statement by a grower: *"That [system] is very useful and gives a lot of market power as opposed to every individual grower trying to sell their kiwifruit"*.

5.3.2 Culture

Culture is a very important criterion that influences the successful uptake of LCM within an organisation and also within a sector (Biondi, Iraldo, & Meredith, 2002). One frequently cited definition of culture has been provided by Schein (1985) who describes culture as a “pattern of shared basic assumptions that the group has learned as it solved its problems of external adaption and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems”. Pizzirani et al. (2014) stated “generally, culture is referred to as an emergent grouping of beliefs, knowledge, practices, values, ideas, language and worldviews within a social group; each of these elements affects the social group’s ongoing attitude and behavior”.

Organisational culture is often cited as the primary reason for the failure of implementing organisational change programmes. Researchers have suggested that, while the tools, techniques and change strategies may be present, failure occurs because the fundamental culture of the organization remains the same (Cameron & Quinn, 2011). Linnenluecke et al. (2010) suggest that “the successful implementation of culture change for corporate sustainability might be largely dependent on the values and ideological underpinnings of an organisation’s culture and that these in turn affect how corporate sustainability is implemented as well as the results”.

According to the literature, it is important that there is organisation-wide consensus among employees around a set of shared assumptions, values and beliefs (Martin, 2002). This creates consistency in perceptions, unity of purpose and action (Zammuto, 2005). Many researchers also agree with the idea that strong cultures enhance coordination and control, increase motivation and goal alignment, and subsequently lead to better performance (Deal & Kennedy, 2000). The same can be assumed for industry sectors.

In the context of this research, then, it is important to have an environmental culture. According to Dodge (1997), it is the role of organisational leaders (aka managers) to foster a strong and highly integrative sustainability-oriented organisational culture; this can unite members and foster a sense of identity and commitment to common environmental goals and aspirations (Crane, 1995; Dodge, 1997; Hoffman, 1993; Welford, 1995).

Throughout the organisation, culture is created and maintained through the organisational ‘grapevine’ and is supported through frequent opportunities for interaction, so employees and organisational leaders can share stories and re-enact rituals. Organisation magazines and other media can further strengthen culture by communicating values and beliefs (Ashforth & Mael, 1989). Environmental culture can also be reinforced in meetings by putting environmental issues onto the agenda on a regular basis and discussing ideas, initiatives, etc. Based on these aspects, Table 5.2 provides a summary of the proposed LUEF scale for culture for both individual organisations and industry sectors. Box 2 summarises the findings from the kiwifruit industry.

Table 5.2: Proposed maturity scale for organisations and industry sectors on LCM culture

Maturity scale	Individual organisation level	Industry sector level
1–Regressive	No shared language, vision or approach to LCM activities.	No shared language, vision or approach to LCM activities.
2–Ad hoc	Some visible elements of an LCM culture are apparent in the organisation.	Some visible elements of an LCM culture are apparent in the industry sector.
3–Proactive	Employees are actively encouraged to improve the organisation's LCM performance.	The industry sector actively encourages the supply chain partners to contribute ideas for LCM improvements and activities to enhance the sector's environmental performance.
4–Managed	The organisation has LCM embedded into its culture.	The industry sector has LCM embedded into its culture.
5–Optimised	The organisation promotes an LCM culture outside its own organisational boundaries.	The industry sector promotes an LCM culture outside its own sector boundaries.

Box 2. Culture examples in the kiwifruit sector

In the New Zealand kiwifruit industry, a Zespri staff member commented that the implementation of sustainability initiatives by one post-harvest operator not only resulted in financial savings, *"but they also have been able to enhance their culture in that time when there is great stress on the industry by having a strong sustainability focus"*. In this case, the staff member recognised that there was a relationship between sustainability and culture in that organisation.

Some quotes from postharvest operators illustrate how an environmental culture can be encouraged:

"After we've introduced noticeboards and meetings to provide staff with information on our environmental initiatives, they understand what carbon footprint, biodiversity and so on mean a lot better."

"The noticeboards are used to share ideas around environmental improvements. If we take them up, we mention that in meetings, and if we don't we also explain why to keep encouraging everyone to share ideas. We don't just want to ignore them."

"We like to celebrate our successes and share the benefits with our staff. For example, we have built a big new recreational area where they can spend their breaks. This was possible from the savings we made through energy efficiency projects."

5.3.3 Resource availability

The availability of financial, human and technical resources impacts the success of LCM at the organisation and sector level (Stadtler & Lin, 2017). Lack of any of those resources presents significant barriers for individual organisations to take up LCM initiatives, but also prevents collaboration to facilitate sector-wide LCM uptake. All three types of resources are closely related and dependent on each other (Stadtler & Lin, 2017).

In the context of LCM initiatives, there are organisations that only make resources available for LCM initiatives if legally required to do so, or because they will experience non-tariff barriers in their marketplaces if they are not active in LCM. This can be due to limited resource availability in the organisation as well as limited awareness around LCM initiatives (Stadtler & Lin, 2017). The same applies to industry sectors. Some industry sectors do not invest resources into the development of LCM programmes unless there is significant external pressure.

On the other hand, organisations that are proactive when it comes to LCM implementation make resources available for LCM projects. This can include human resources to manage environmental projects, such as reduction of packaging material or energy efficiency, but also financial and technical resources to implement change (Stadtler & Lin, 2017). This also applies to industry sectors that are proactive and support their stakeholders in taking up LCM projects. They make resources available to research, educate and facilitate industry level improvements.

More mature organisations and industry sectors, at the "managed" level, will have ongoing LCM initiatives in place, and environmental management plays a key role in their operations. Ongoing investments can include creating the role of "Environmental Manager" in an organisation. At an industry sector level, Environmental Managers are also beneficial to ensure projects serve different stakeholder groups.

Therefore, at the individual organisation level, the maturity ranges from a situation where no resources are made available for the implementation of LCM through to a mature stage where there are appropriate financial, technical and human resources available to support the integration of LCM into all aspects of the organisation as well as for knowledge sharing within the wider community. Similarly, at the industry sector level, resource availability relating to LCM progresses from being non-existent to providing resources for industry stakeholders to collaborate to improve sector level performance. Based on these aspects, Table 5.3 provides a summary of the proposed LUEF scale for resource availability for both individual organisations and industry sectors. Box 3 summarises the findings from the kiwifruit industry.

Table 5.3: Proposed maturity scale for organisations and industry sectors on resource availability for LCM initiatives

Maturity scale	Individual organisation level	Industry sector level
1–Regressive	No or limited resources are made available for the implementation of LCM.	No or limited resources made available on an industry sector level to investigate more environmentally friendly options for the stakeholders.
2–Ad hoc	Resources are made available sporadically for LCM initiatives that are required to be implemented to meet market standards or legislation.	Resources are made available for LCM projects that are required in order to operate in a certain market and/or comply with legal requirements.
3–Proactive	Resources are proactively made available for LCM projects.	Resources proactively put in place to work on LCM improvements.
4–Managed	Ongoing resources are available to ensure LCM initiatives can be implemented on a regular basis.	Ongoing resources are available to ensure LCM initiatives can be implemented on a regular basis.
5–Optimised	Appropriate financial, technical and human resources are available to support integration of LCM into all aspects of the organisation as well as for knowledge sharing within the wider supply chain.	Appropriate financial, technical and human resources are available to support integration of LCM into all aspects of the organisation as well as for knowledge sharing within the wider supply chain.

Box 3. Resource availability examples in the kiwifruit sector

In the kiwifruit sector, from 2010 until quite recently, the New Zealand kiwifruit industry has struggled with the kiwifruit disease *Pseudomonas syringae pv. actinidia* (Psa), a bacterium that can cause the death of the kiwifruit vine. Since it is carried by airborne spores, it can easily be spread by rain, strong winds, animals and humans. Growers as well as other industry stakeholder such as postharvest operators, Zespri and Kiwifruit Vine Health (KVH), together with research organisations like Plant and Food Research, focused their resources on finding ways to stop the disease as well as helping growers to overcome the burdens they are faced with once their vines are affected. As a Zespri staff member noted, *"We don't have any budgets. […] and right now there is no interest in the industry […] because they are all fighting this disease"*. Therefore, during this time the industry body was not able to initiate further LCM projects across the kiwifruit supply chain.

The interviewed organic kiwifruit growers said that the increased cost due to, for example, lower yields, is outweighed by the premium prices they get for their fruit from Zespri. Therefore, financial resources were not considered an overriding barrier for the organic growers that took part in the interviews.

Some post-harvest organisations have implemented sustainability projects. That is driven by employees and managers, and the overall perception that sustainability is important for the business and the environment. One example about how sustainability leads to financial benefits for an organisation is highlighted in the following quote from Zespri about a post-harvest operator:

"In the [times] of the major disease epidemic […], there has been a reduction of staff at Zespri, there has been a reduction of staff at the packhouses and the orchard management companies. In that environment, [one of the packhouse groups] had been able to appoint two new people for sustainability; because they partnered sustainability initiatives with a lean manufacturing approach. And they found they were able to make significant cost savings, which have allowed them to appoint these two new people."

This initiative led to a range of benefits for the organisation and thereby created the momentum amongst senior management and employees that led to continuous implementation and focus on LCM projects.

5.3.4 LCM strategy

Environmental strategies are characterised by a "trajectory in the strategies' goals, practices, priorities and underlying mindsets" (Stadtler & Lin, 2017). This definition can be extended to LCM strategy, which means that an LCM strategy sets out the goals and associated actions, priorities and underlying values.

Most researchers conceptualise environmental strategy as a continuum between reactive and proactive strategy (Stadtler & Lin, 2017). For example, Hart (1997) distinguishes the nuances between proactive strategies in terms of incremental pollution prevention and radical, transformative sustainable development. Pollution prevention implies the improvement of existing processes and products whereas strategies of sustainable development entail greater strategic and operational shifts and prompt firms to challenge essential assumptions that underlie their business models (Dyllick & Muff, 2016).

The literature identifies proactive environmental strategies as approaches that involve collaborative and inclusive features, such as partnerships with universities, exchanging, sharing or co-developing environmental knowledge, policies, products, technologies or business models (Wassmer, Paquin, & Sharma, 2014). This applies at the organisational level, where organisations cooperate with other partners to integrate LCM strategies but also on a sector level, where the industry sector cooperates with other organisations to embed and improve the LCM strategy.

Strategic commitment to LCM at an organisational and sector level usually starts with the development of an environmental policy. However, this does not mean that the organisation or the industry sector will necessarily take active steps to reducing environmental impacts. Organisations and industry sectors that are more proactive, undertake research to guide development of an LCM-oriented strategy; this may involve undertaking streamlined LCAs or other research to identify environmental hotspots to guide prioritisation of activities to reduce environmental impacts both internally and in the wider supply chain. Once the LCM strategy has been developed, a focused programme of actions is developed; this should be responsive to changes and trends in markets, political climate, etc. (UNEP/ SETAC Life Cycle Initiative, 2005). Table 5.4 provides a summary of the proposed LUEF scale for LCM strategy for individual organisations and industry sectors based on evidence of increasing commitment to an LCM strategy. Box 4 summarises the findings from the kiwifruit industry.

Table 5.4: Proposed maturity scale for organisations and industry sectors on LCM Strategy

Maturity scale	Individual organisation level	Industry sector level
1–Regressive	The organisation does not have an LCM strategy.	The industry sector does not have a sector-wide LCM strategy.
2–Ad hoc	High level commitment by the organisation to LCM.	High level commitment by the industry sector to LCM.
3–Proactive	Identify relevant criteria for the organisation's LCM strategy.	Identify relevant criteria for the sector-wide LCM strategy.
4–Managed	Continuously improving and communicating the LCM strategy within the organisation.	Continuously improving and communicating the LCM strategy to relevant stakeholders.
5–Optimised	LCM strategy is integrated into all aspects of the organisation's decisions.	LCM strategy is integrated into all aspects of the industry sector's decisions.

Box 4. LCM strategy examples in the kiwifruit sector

Interview responses from the kiwifruit study indicated that *"Zespri is mainly doing research into markets and future requirements, including proactively identifying better and more sustainable practices*". Zespri then passes on that information to stakeholders in the industry. On a grower and post-harvest operator level, the focus on future environmental practices is divided. Some growers simply rely on information from Zespri, as shown by this kiwifruit grower: *"We get this big catalogue from Zespri with all the information we have to do. They have done their research. It's this big folder here."*

Other growers proactively work with Zespri or research institutes to identify better practices and solutions; for example, one kiwifruit grower explained, *"We work with Zespri and Plant & Food to improve biodiversity on the orchard."*

The interviews with Zespri staff showed that their experience with growers is that they usually have a defensive approach towards sustainability. For example, one Zespri staff member commented, *"without the market signals, the growers will say, 'I don't really want to know about this and I will wait until it stops me from selling my fruit.'"*

5.3.5 Knowledge

The level of knowledge of LCM can have a significant impact on the uptake of LCM at both the individual organisation as well as industry sector levels. Murillo-Luna et al. (2011) conducted a study which concluded that lack of environmental knowledge presents one of the main barriers for SMEs in the uptake of improvement practices (Murillo-Luna, Garcés-Ayerbe, & Rivera-Torres, 2011). In particular, the limited knowledge amongst owners and senior managers of SMEs is relevant because they make most of the decisions about their organisations (Seidel et al., 2009).

The lack of knowledge about LCM also plays a role at the industry sector level. If no organisation within the sector sees environmental sustainability as a risk or opportunity, then the sector-wide uptake of LCM is unlikely. To overcome this lack of engagement, LCM information should be made relevant to the specific industry as well as being in a form that can be disseminated and absorbed by sector stakeholders who are not yet knowledgeable about LCM.

Cohen et al. (1990) divide knowledge management into three components: acquisition, assimilation and exploitation of knowledge. Zahra et al. (2002) define four components for knowledge management: acquisition, assimilation, transformation, and exploitation of knowledge (Zahra & George, 2002). Heeley (1997) explicitly highlights that there is an external and internal factor to acquiring knowledge. The researcher uses the phrase absorptive capacity to describe an organisation's ability to acquire external knowledge and disseminate it within an organisation (Heeley, 1997). Sung et al. (2000) acknowledge the importance of acquiring knowledge but also dissemination of knowledge about environmental sustainability within an organisation and its role in the supply chain.

Dissemination of knowledge in the organisation is concerned with the flow and absorption of knowledge which occurs when knowledge that exists internal or external to the organisation, is learned by individuals within the organisation (Peri, 2005).

Nonaka and Takeushi (1995) and Nonaka (2005) explain that knowledge flows in organisations and is absorbed through the conversion and interaction between its tacit and explicit components. *Tacit knowledge* is based on experience, thinking and feelings, is contextual and is composed of both cognitive and technical components. The cognitive components refer to mental models, maps, beliefs, paradigms and viewpoints, while the technical components refer to specific contextual know-how and skills. In order to learn tacit knowledge, interaction as well as trust is required. Examples of tacit knowledge include: riding a bike, being able to speak a language, or hitting a nail with a hammer. On the other hand, *explicit knowledge* is codified, articulated and communicated using symbols. Explicit knowledge is either object- or rule-based. Explicit knowledge about environmental sustainability is object-based when codified in words, numbers, formulas, or made tangible as equipment, documents and written procedures or models. It is regarded as rule-based when it is encoded as rules, routines or standards (Popadiuk & Choo, 2006). Examples of explicit knowledge include the information found in books as well as images or formulas.

A key organisational characteristic that aids the knowledge conversion process is organisational integration. It has been suggested that integration is a construct with structural and cultural dimensions (Lemon & Sahota, 2004). The structural dimension (interaction) refers to the formally coordinated activities between functional departments; it includes meetings, memoranda and flow of standard documentation. The cultural dimension (collaboration) represents the more unstructured affective nature of interdepartmental relationships and emphasizes continuity of relationship between departments rather than just transactions.

At the individual organisational level, knowledge maturity progresses from a stage in which few, if any, individuals are able to make the link between the organisation's activities and its environmental impacts, to a stage where the organisational structures and processes are influenced by new knowledge, and mechanisms are in place to disseminate knowledge internally as well as with and between sector stakeholders. Similarly, at the industry sector level, knowledge maturity begins with a situation where no industry-specific LCM knowledge exists and progresses to a stage where case studies and best practice research underpinned by LCA are shared via sector-based programmes. Table 5.5 provides a summary of the proposed LUEF scale for knowledge for individual organisations and industry sectors. Box 5 summarises the findings from the kiwifruit industry.

Table 5.5: Maturity scale for organisations and industry sectors in relation to LCM knowledge

Maturity scale	Individual organisation level	Industry sector level
1–Regressive	Few, if any, staff understand the importance of LCM for the business. Any knowledge does not result in any action and it does not influence any processes or procedures.	Staff in the industry sector has no specific knowledge about LCM that is relevant to the sector.
2–Ad hoc	Tacit knowledge has been acquired by some staff and/or decision maker(s). Some staff take actions to reduce environmental impacts. However, these people do not actively teach others about the actions and the associated benefits.	Basic environmental knowledge exists within the staff at the sector body of the industry sector.
3–Proactive	Explicit knowledge has been acquired by staff and/or decision maker(s). Set procedures are employed to act on any newly acquired knowledge, and to ensure that existing knowledge is passed on to new employees.	Responsible people in the industry sector proactively seeks and acquires knowledge relating to environmental management and LCM through relationships with stakeholders, and policies and procedures that support knowledge management in the area of LCM.
4–Managed	Knowledge of LCM is integrated into the organisation in the form of structures, responsibilities and processes to manage responses to new knowledge.	Staff in the industry sector organisation have in-depth and specific knowledge of LCM associated with the industry as well as relevant market conditions such as customer and legislative requirements.
5–Optimised	Dissemination of LCM knowledge to the wider supply chain. The organisation is not	Staff in the industry sector actively disseminate LCM knowledge to industry

	only learning and sharing knowledge internally but also managing knowledge about LCM with other up- and downstream supply chain partners.	stakeholders, and process exist to continually expand the expertise via close collaboration with research organisations and other relevant parties.

Box 5. Knowledge examples in the kiwifruit sector

In this research, the interviews with Zespri staff highlighted that the organisation is aware of the environmental impacts associated with kiwifruit and the necessity to manage and reduce these to stay competitive. Therefore, a range of projects have been conducted in the past to identify the impacts associated with the entire kiwifruit supply chain e.g. a carbon footprint study and a water footprint study for the industry (Hume, 2011; Zespri, 2011).

Zespri also conducted an extensive evaluation of the international marketplace which highlighted the LCM issues relevant to the industry (Mowat, 2014). It was apparent during the interviews with Zespri staff that, as the marketer of kiwifruit, the organisation was aware of the laws and trends in overseas markets and acknowledged the importance for the New Zealand operations to ensure these are met. For example, one staff member commented, *"We have been able to communicate our carbon footprint. […] But once you go down this route of creating a sustainability update, because you have got customers who are developing their strategies looking for case studies, they are looking for innovators in their supply base and so it's important for us to be seen as an innovator to be innovated by them. […] and you are helping them understanding how to set their priorities."*

Based on the interviews with the growers, knowledge about LCM and environmental sustainability issues and trends does not seem to be evenly distributed. The interviewed organic growers in general knew about the environmental and health impacts of certain practices and had adjusted their operations to meet the requirements of BioGro (organic certification). Contemporary growers, on the other hand, tended to have the perception that their environmental impacts could be neglected; they thought that the little impact they had was not worth mentioning compared to the harm that other businesses caused to the environment.

5.3.6 Market requirements

In order to stay competitive, organisations must identify emerging market requirements and proactively implement initiatives to meet or even exceed those requirements. This may reduce future costs since the organisation will be able to meet requirements once they are legally enforced, and can avoid penalties, as well as increasing its competitiveness (Font, Garay, & Jones, 2016). However, this proactive implementation will not take place when organisations are not aware of emerging market requirements, and of the advantages that meeting and exceeding these requirements can bring to their organisation or the industry sector (Font et al., 2016).

The spectrum for market requirement ranges from not being prepared to meet new market requirements, through to integrating market requirements into the strategy and researching future trends and communicating these across the industry (Manganari, Dimara, & Theotokis, 2016; Martínez García de Leaniz, Herrero Crespo, & Gómez López, 2017). Manganari et al. (2016) and Martinez García de Leaniz et al. (2017) believe that implementing sustainability is expensive and complex. These beliefs and motivations result in a shallow eco-friendly behaviour, where LCM initiatives are taken to make cost savings (Manganari et al., 2016). In order to integrate market requirements into the business planning, organisations communicate and share their knowledge and findings about market requirements with other supply chain partners horizontally and vertically (Ross, 2016). That helps them to develop actions and LCM strategies together to meet and exceed requirements and improves their competitive advantage. Industry sectors set up technology platforms to support sharing and communicating trends about market requirements (Ross, 2016). Additionally, they interact with players in the market, such as supermarkets, to influence future market requirements and trends.

Therefore, at the individual organisation level, the maturity of meeting market understandings and requirements progresses from a situation where there is a lack of information on market requirements through to a mature stage where there are ongoing initiatives with other supply chain partners to identify emerging LCM trends in the market. Similarly, at the industry sector level, knowledge about market requirements relating to LCM progresses from being non-existent to providing the means and opportunities for industry stakeholders to collaborate to improve sector level LCM performance. Based on these aspects,

Table 5.6 provides a summary of the proposed LUEF scale for market requirements for both individual organisations and industry sectors. Box 6 summarises the findings from the kiwifruit industry.

Table 5.6: Proposed maturity scale for organisations and industry sectors on market requirements

Maturity scale	Individual organisation level	Industry sector level
1–Regressive	The organisation lacks information on market requirements and opportunities for LCM initiatives.	The industry sector lacks information on market requirements and opportunities for LCM initiatives.
2–Ad hoc	The organisation identifies and meets emerging legal market requirements.	The industry sector identifies and meets legal and market requirements and communicates these to stakeholders when appropriate.
3–Proactive	Market requirements are addressed beyond legal pressure, but the organisation only takes initiatives that provide immediate financial returns.	The industry sector proactively researches and identifies future market requirements and trends. These are communicated to the supply chain together with implementation suggestions.
4–Managed	Market requirements are managed by researching potential future trends and actively implementing LCM initiatives to prepare for future changes (even when the short-	The industry sector actively researches future market trends to prepare the supply chain for future changes.

	term financial returns are not apparent).	
5–Optimised	Ongoing initiatives with other supply chain partners to identify and meet emerging environmental trends in the market.	The industry sector establishes a platform which allows communication of existing and future market trends within the supply chain, but also actively works with players in their markets to influence future market requirements.

Box 6. Market requirement examples in the kiwifruit sector

In the kiwifruit industry, one of Zespri's roles is to identify market trends and requirements. The simple structure of the kiwifruit sector allows all growers and post-harvest operators to benefit from Zespri's research provided it is communicated effectively. This is an efficient way of gaining information, and at the time of the interviews the participants did not see a need for change.

An example of Zespri successfully meeting an emerging market requirement was the implementation of the KiwiGreen programme; this programme provides growers with information about pests in kiwifruit orchards, and how to monitor and control them (Zespri Group Limited, 2018). Key elements of the KiwiGreen programme include: monitoring pest populations to decide on timing of spray applications, preferred use of 'soft' chemicals wherever possible (to promote biological control), risk assessment, canopy management to minimise disease, and operating a continuous improvement programme (Growing Futures, 2014). The development of the KiwiGreen programme was driven by the development of stricter environmental standards in Italian markets and enabled New Zealand to continue to supply to that export market.

An example at the postharvest level of market requirements affecting operations is the development of kiwifruit juice production activity at one postharvest facility. As a staff member described, *"We researched waste reduction options and are now able to use kiwifruits, which are not meeting the export requirements, to make juice and sell it in local markets."*

5.3.7 Communication

Effective communication is recognised as a key factor affecting the uptake of LCM at both the individual organisation as well as industry sector level. Communication refers to the process by which information is transmitted and understood between two or more people or entities (McShane & Travaglione, 2009).

In the context of environmental management, one of the key themes that emerges in the literature on communication is the progression from one-way to two-way communication (Liebowitz & Frank, 2016; McQuail & Windahl, 2015). One-way communication transfers information from the sender to the receiver only, whereas two-way communication allows the receiver of the information to provide feedback. This factor is relevant within an individual organisation as well as at an industry sector level.

Another communication aspect relevant at the organisation and industry sector level is the importance of both formal and informal communication**.** Formal communication is planned whereas informal communication is ad hoc. Formal communication involves deliberate control of information that flows through predefined channels in the organizational hierarchy (for example, through meetings and distribution of printed notices) or industry sector (for example, field days or networking events). Informal communication involves exchange of experiences and ideas between staff members or industry stakeholders (Lai, 2016; Manuti, Pastore, Scardigno, Giancaspro, & Morciano, 2015). At the individual organisation level, informal communication can be facilitated by effective workspace design and workplace routines (McShane & Travaglione, 2009) whereas regular industry networking events can support sector level communication between stakeholders.

Knowledge sharing of LCM is where organisations communicate with other organisations at the same level in the supply chain and/or with supply chain partners up- and downstream in the supply chain (Cai, Goh, de Souza, & Li, 2013). Knowledge sharing between organisations is associated with a higher maturity level since it facilitates other organisations in the supply chain to improve their environmental performance and to exchange ideas and experiences thereby helping make the implementation of sector-wide LCM easier (Dou, Zhu, & Sarkis, 2017; Lee, Klassen, Furlan, & Vinelli, 2014). At the industry sector level, technology platforms can support effective knowledge sharing and communication between sector stakeholders.

Therefore, at the individual organisation level, the maturity of communication progresses from a situation where LCM is not addressed by staff at all through to a mature stage where there are mechanisms in place, such as planned meetings, to support the effective exchange of ideas and management of LCM projects. Similarly, at the industry sector level, communication relating to LCM progresses from being non-existent to providing the means and opportunities for industry stakeholders to collaborate to improve sector level performance. Based on these aspects, Table 5.7 provides a summary of the proposed LUEF scale for Communication for both individual organisations and industry sectors. Box 7 summarises the findings from the kiwifruit industry.

Table 5.7: Proposed maturity scale for organisations and industry sectors on communication relating to LCM

Maturity scale	Individual organisation level	Industry sector level
1–Regressive	No communication about environmental issues in the organisation.	No or limited industry sector communication relating to LCM.
2–Ad hoc	One-way communication about environmental topics to staff.	Basic one-way communication to industry stakeholders around sustainability.
3–Proactive	Informal communication about LCM is encouraged amongst staff members and internal stakeholders.	Opportunities are created for two-way communication for shared learning around LCM.
4–Managed	Regular, planned meetings and communication dedicated to LCM.	Communication of 'best practice' and industry specific guidelines relating to LCM.
5–Optimised	Active communication and collaboration on LCM with other industry sector stakeholders.	Collaboration processes in place such as technology platforms to facilitate knowledge management, communication and improvement of industry sector LCM performance.

Box 7. Communication examples in the kiwifruit sector

On informal communication, one kiwifruit grower commented that *"we use noticeboards in the common areas to share our successes. For example, we share tips around reducing energy at work and also at home. People really enjoy those tips and make changes in their private lives as well"*. The idea of using noticeboards was also mentioned by a postharvest operator who noted that *"noticeboards allow our staff to carpool and people can share when they come in to work, and if anyone wants a ride with them to reduce carbon emissions"*.

Another post-harvest operator highlighted that *"shifts are scheduled in a way that people can have breaks together, in designated areas which we just renovated. We want people to have a place to relax and refresh".*

An additional example of LCM communication of LCM within postharvest operators is *"we have monthly environmental management meeting which include the Green Team, as well as upper level management".*

To sum up the results from the kiwifruit interviews, it can be said that the monopoly structure is perceived as beneficial by growers and post-harvest operators as well as Zespri, and it facilitates implementation of processes that lead to efficient distribution of kiwifruit in overseas markets. Moreover, it facilitates communication back up the supply chain about market trends such as the growing importance of environmental performance. The specific structure of the New Zealand kiwifruit supply chain means that Zespri has influential power over the growers and packhouses and can therefore push LCM implementation in the kiwifruit supply chain in New Zealand.

The culture in the industry is characterised by trust, honesty and effective communication. That is useful in order to implement LCM based on a sector-based approach, since open and honest communication and exchange of experiences and ideas are key for this approach. Communication could still be improved, in particular between research institutes and Zespri, but also between Zespri and growers/post-harvest operators in order to make better use of research results.

However, the kiwifruit sector lacks sufficient resources in order to effectively implement LCM sector-wide – although financial resources were available before the outbreak of Psa. Moreover, technical resources are not sufficient in order to communicate research findings from previous studies to growers and post-harvest operators to build a foundation for the development of LCM objectives. At the moment, the limited resources are a barrier for the industry to implement LCM sector-wide and lack of appropriate technical resources has led to insufficient evaluation of previous projects.

The industry recognises the need to move towards more environmentally friendly practices, based on market research undertaken by Zespri. Some growers (in particular the organic growers) and post-harvest operators are convinced that there is a need to be more sustainable and implement LCM projects. Therefore, the industry sector can use the market requirements and their knowledge about the importance of environmental issues in the future as enablers for LCM uptake.

At the moment, the industry is experiencing trade-offs between two different objectives for the industry: managing the Psa crisis and focusing on the sustainability agenda in order to stay competitive. Since Psa is threatening the existence of some orchards, more financial resources are being allocated towards this objective. More research to support LCM implementation is unlikely to be prioritised until Psa is managed successfully.

Also, the separation from consumers means that it is more difficult to convince defensive kiwifruit growers to take up LCM initiatives. Finding mechanisms for these growers to be more aware of market trends regarding sustainability could help to overcome this barrier.

The kiwifruit sector has established networks for communication with external partners that support the identification of environmental improvement areas through scientific research. Networks within the industry are also established, for example, between growers through field days.

5.4 Conclusion

A sector-based approach has been suggested to overcome the barriers to LCM uptake identified by Seidel-Sterzik et al. (2018). Sector-based approaches allow organisations to share research results, facilitate administration and streamline data collection and management, contribute to improving the reputation of a product/service, facilitate knowledge sharing, and create momentum amongst involved parties.

The LUEF described in this chapter is based on the enablers and barriers faced by organisations during the uptake of LCM as originally identified by Seidel-Sterzik et al. (2018).

Both an organisation and an industry sector can be evaluated separately on a scale from one to five for each of the enabler/barrier factors. Once evaluated, an organisation will have a better understanding of its strengths and weaknesses, and areas for improvement. Thus, the LUEF can be used as a benchmarking tool to compare progress over time, but also to compare performance amongst supply chain partners. Additionally, it can be used to communicate progress, as well as future strategies to relevant stakeholders.

The framework is set up in a visual way and allows interested parties to quickly appraise the organisation and sector. Details and specific actions can then be described further in reports. Furthermore, the visual representation allows stakeholders to easily compare each other's performances, compare to the industry sector performance, and compare the results with previous years to identify if actions have had positive results, or if they need to be adjusted and changed.

The selected criteria have purposely been developed to be generic so they can be adapted by industry sectors in particular countries to suit their individual context. This is an opportunity for industry sectors to adapt the levels with examples that apply to the sector at the particular time, and thereby support the users in making less subjective evaluations of their performance.

Future research should focus on the use of the LUEF in industry sectors as an evaluation tool to inform development of targeted environmental improvement programmes. Potentially the framework can then be incorporated into cloud-based software to support the effective ongoing management of sector-based Life Cycle Management for different industries.

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STATEMENT OF CONTRIBUTION
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We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Helene Seidel-Sterzik
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A CAPABILITY MATURITY MODEL FOR LIFE CYCLE MANAGEMENT AT THE INDUSTRY SECTOR LEVEL	
In which Chapter is the Manuscript /Published work:	Chapter 5
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	85
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
- candidate undertook the literature research and the interviews, wrote the paper, including the maturity scales, diagrams - received feedback on the structure of the paper and additional literature where	
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Date:	20th November 2019
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Date:	21st November 2019

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6 AN INFORMATION TECHNOLOGY PLATFORM TO FACILITATE A SECTOR-BASED APPROACH FOR LIFE CYCLE MANAGEMENT IN THE PRIMARY INDUSTRY

This chapter summarises the investigation of Information Technology (IT) platforms to facilitate a sector-based approach for LCM in the primary industry.

Chapter 1 established that SMEs face particular challenges when it comes to implementing LCM, and that a sector-based approach has the potential to provide individual industry sector supply chain partners with advantages and support in making effective changes to their practices. Chapter 4 summarised a quantitative study in the New Zealand kiwifruit industry, to identify if the findings from the literature were applicable in the New Zealand context. It was found that some of the factors identified in the literature were barriers in the New Zealand kiwifruit industry when it came to effective uptake of LCM. Other factors were enablers as they were already addressed by the industry body or individual stakeholders. Communication, in particular, was a factor that was acting as an enabler: communication in the New Zealand kiwifruit industry is between individuals, often face-to-face, through field days, conversations between growers, or between growers and their post-harvest operators. However, this face-to-face communication is not considered easily repeatable or scalable across an industry sector.

One potential solution identified by several of the interviewees in the kiwifruit case study was the use of an IT platform that allows individual organisations in the sector to share and benchmark their LCM activities. Ideally this would support individuals in participating at the point in time that suits their day-to-day activities. Chapter 6 investigates the requirements and characteristics for an IT platform that can be used in this way to effectively measure and manage LCM in primary industry sectors.

Section 6.1 outlines the context for use of an LCM-oriented IT tool and Section 6.2 summarises the literature on information systems for LCM. Section 6.3 provides examples of existing IT platforms that aim to support LCM programmes and analyses their strengths and shortcomings, and Section 6.4 describes the requirements for an IT platform for LCM in primary industry sectors. Section 6.5 describes how an IT platform was set up and piloted in the aquaculture industry in New Zealand, and the challenges are assessed in Section 6.5.4. Conclusions and areas for future research are summarised in Section 6.6.

My contribution to the manuscript was as the main author. I carried out the literature research, as well as the case study with the New Zealand Aquaculture. I also set up and configured the IT platform for the New Zealand Aquaculture Industry. My supervisors *provided me with feedback and support on the structure of the paper, and additional literature resources to be included where appropriate. They also contributed by proofreading and providing ideas and feedback on the approach of the case study itself.*

At this stage, this chapter is unpublished. After formatting it to meet the journal requirements, the aim is to publish it in "The Journal of Strategic Information Systems".

Abstract

Primary sector organisations struggle to implement a life cycle approach to reducing their environmental impacts. Additionally, it is challenging and resource-intensive to capture accurate data relating to the environmental performance of an industry sector. Previous research suggests that a collaborative, sector-based approach has the potential to support individual organisations to make progress by utilising shared resources and knowledge thereby minimising the need for 'reinventing the wheel'. In this context, an information technology platform can be used for knowledge exchange and data capture in support of a sector-based approach.

This chapter investigates the required characteristics of an information technology platform to support LCM implementation in the primary industry from the perspectives of growers, industry sector bodies and third-party verification organisations. These characteristics are developed based on a review of previous research into software and information systems for environmental management and Life Cycle Assessment (LCA), and a case study of the New Zealand aquaculture industry. The chapter concludes with an evaluation of the pilot implementation of an IT platform in the aquaculture industry, and an analysis of future requirements in this fast-evolving research area.

Keywords: IT platform, primary industry sector, sector-based approach, LCM, sustainability

6.1 Introduction

The implementation of LCM has thus far been studied predominantly at the level of individual organisations. However, Seidel-Sterzik, McLaren, and Garnevska (2018) suggest using a sector-based approach to implement LCM in primary industries. Primary industries are often composed of many small organisations. For example, in the New Zealand horticulture industry, which is made up of 22 product groups, approximately 10% of growers make up 90% of the industry production output and a large proportion of the remaining growers have an annual sales turnover of less than $100,000 (De Silva & Forbes, 2016). The researchers argue that a sector-based approach utilising modern information systems platforms could help industry sectors to overcome the barriers to LCM uptake and facilitate implementation on a wider scale, with benefits for the entire supply chain (Seidel-Sterzik et al., 2018).

A key challenge for primary industry sectors is the lack of LCM knowledge and experience among growers and other stakeholders (Seidel-Sterzik et al., 2018). Indeed, effective knowledge exchange, both internally in an individual organization and horizontally as well as vertically within the supply chain, has been identified as critical to support learning and implementation of best practice in LCM and sustainability (Beske, Land, & Seuring, 2014; Testa, Nucci, Iraldo, Appolloni, & Daddi, 2017). Sector-based approaches can support small organisations to share knowledge about environmental impacts and practices which avoids the need for them to individually invest time and resources in research to identify best practices (Seidel-Sterzik et al., 2018).

At the same time, LCA studies – which inform development of LCM programmes - are often limited by gaps in inventory data due to the cost and complexity of collecting and maintaining data (Hellweg & i Canals, 2014). Regular reporting of environmental performance data at the industry level provides an essential source of knowledge for industry stakeholders in relation to LCM uptake in the sector. Additionally, it enables individual farmers to benchmark their sustainability performance against other sector participants or the industry average and best practice to guide their decision making (Van Passel, Nevens, Mathijs, & Van Huylenbroeck, 2007). One-off data capture from stakeholders in an industry sector does not provide insights into a sector's LCM performance nor does it provide reliable data to guide decision making in individual farms, hotspot analysis, stakeholder communication and labelling (Notarnicola, Tassielli, Renzulli, & Giudice, 2015). Therefore, a critical step is to ensure that data are captured year on year in order to record changes and to enable the adjustment of strategies accordingly (Xing, Qian, & Zaman, 2016). It is not surprising, then, that one of the key challenges to LCM uptake in the primary sector is the lack of reliable and up-to-date inventory data on agricultural products and processes (Notarnicola et al., 2015).

The collection of data in relation to the LCM performance of organisations can be very time consuming and costly due to the use of manual approaches (Xing et al. 2016), and there is concern that a lack of resources and capacity to provide data for LCAs leads to a lower quality of analysis (Moreno et al., 2015). Conducting the surveys or data collection for LCM often requires participants to submit their data in a specific timeframe. For example, Sustainable Winegrowing NZ, a certification and auditing system developed for the New Zealand wine industry, requires participants to submit their data by the end of June, although records continue to come in after this date and therefore analysis often does not take place until November (Barber et al., 2014). That shows that it is important for organisations to be able to submit their data for a specified time period in their own time (Xing et al., 2016).

Another challenge inhibiting the success of LCM uptake in primary industries is that once data has been captured, a lack of independent verification of the data can mean that the results of the assessment of the industry LCM performance are less credible than they could be (England & White, 2009; Notarnicola et al., 2015; Witczak et al., 2014). Given the financial constraints of small businesses in primary sectors, verification or third-party auditing of the data needs to be cost effective and scalable from a resource perspective for this to be feasible (Koehler-Munro, Courchesne, Aung Moe, Goddard, & Kryzanowski, 2014; Testa et al., 2017).

The above challenges suggest that primary industry sectors may benefit from an Information Technology (IT) platform that supports LCM knowledge exchange about best practices between stakeholders in the supply chain as well as facilitating the capture and verification of relevant data to support reporting of environmental credentials (Moreno et al., 2015). Yet, according to Palacin-Silva, Seffah, and Porras (2017) "today smallholder agriculture and their communities (as opposed to the industrial-scale farming concerns) are strikingly underserved by modern IT". Given the challenges that SMEs face in implementing LCM (Seidel-Sterzik et al., 2018), it is important that these new technologies are inexpensive for users, and are accessible as well as easy to use for the key industry stakeholders (Palacin-Silva et al., 2017).

IT has been shown to enable collaboration among supply chain partners and support the development of business capabilities across the supply chain that help them increase profit and confer them with competitive advantage (Dao, Langella, & Carbo, 2011). The critical role of IT in sustainability was first alluded to by Klassen and Whybark (1999). From a sustainability perspective, IT can support firms in standardising, monitoring, capturing and utilising economic, environmental and social data associated with business activities (Melville, 2010). IT could also improve information flows among supply chain partners (Banker, Bardhan, & Asdemir, 2006) that facilitate increased stakeholder participation in the management of operations, increase employee engagement in environmental matters, develop and facilitate cross-functional collaboration, and monitor internal and external performance in both financial and environmental terms (Banker, Bardhan, Chang, & Lin, 2006).

This chapter therefore aims to contribute to the theoretical and practical knowledge of utilising IT for supporting LCM implementation in primary industry sectors. It begins with a review of the literature on IT in the context of supporting environmental management. Several examples of existing IT applications utilised by primary industries to facilitate environmental initiatives are assessed for their effectiveness in supporting overcoming the barriers of a sector-based approach for LCM. The literature review and insights drawn from previous research in the study of sector-based approaches for LCM, are then used as a basis to identify the required characteristics for an IT platform to facilitate a sector-based approach to LCM. This is followed by a study of the development, and critical evaluation, of an LCM IT platform which is piloted in the aquaculture industry in New Zealand. The chapter concludes with a summary of the contributions and future potential for development of IT platforms to support sector-based approaches to LCM in primary industries.

6.2 Information Technology Systems for LCM

Research in the context of using software to support sustainability initiatives, began in early 2000 (Melville, 2010). In software engineering research, IT is concerned with the study of technological systems in interaction with social systems. It is therefore an important area when considering mechanisms for supporting implementation of environmental sustainability initiatives (Lee, 2010, 2015). IT researchers are aiming to further understand how IT can be used to address the significant global challenges associated with sustainability (Dao et al., 2011; Melville, 2010; Shevchuk & Oinas-Kukkonen, 2016) and Elliot and Webster (2017) state that the uptake of IT has the potential to play a fundamental role in providing solutions to global sustainability and environmental management challenges.

Initially, the sustainability concepts applied in software development focused on reducing first-order, direct effects of the software system on its environment such as improving energy efficiency and emissions caused by the required hardware and infrastructure, etc. (Penzenstadler, Raturi, Richardson, & Tomlinson, 2014). More recently, software has also been developed to reduce the second-order indirect impacts that are influenced by software systems such as changes to consumer resource usage and behaviour (Penzenstadler et al., 2014). Sustainability in the context of software engineering can therefore be considered in two ways: environmental improvement of the information systems themselves ('greening of IT') and influencing environmental improvement through IT ('greening by IT'). Taken together, this research area is described as 'green IT'.

According to Lee (2010) existing research predominantly focuses on green IT at the level of the organisation and more research is required at the sector level. Xing et al. (2016) highlight the importance of IT in supporting collaboration amongst supply chain members within an industry sector in the context of LCM and in capturing LCA data. Penzenstadler et al. (2014) argue that sociotechnical IT systems are among the most powerful tools created by humans and that, by understanding the requirements of such systems, there is significant potential for them to enable social well-being and support sustainability.

Schroeder, Minocha, and Schneider (2010) define social software as "applications and services that facilitate collective action and social interaction online with rich exchange of multimedia information and evolution of aggregate knowledge". They also highlight that web-based tools allow users to create and share dynamic content, which is formed in collaborative way and can therefore facilitate the learning process. Discussion boards and blogs were the early types of social software, followed by wikis and social media applications, which became popular in the early 2000s. Discussion boards allow users to exchange knowledge and experiences, but also facilitate knowledge distribution by authorised parties (Pena-Shaff & Nicholls, 2004). Additionally, social software allows users to make contacts and form social relationships (Ellison, Steinfield, & Lampe, 2007). Those tools have gained widespread acceptance in social, educational and business contexts (Schroeder et al., 2010).

Although many farming and agriculture decision support systems have been developed, the existing solutions have not been taken up widely by industry stakeholders. According to Krintz et al. (2016) the reasons include concerns related to cost, data privacy, security and control. Costs were related to maintaining and enhancing the software as well as the fees to access and use tools; Krintz et al. (2016) highlight that farmers find it costly to transfer data onto cloud-based software solutions using expensive and low bandwidth network links. On top of that, some vendors increase licensing fees year by year, which is beyond the users' control and, since it is not always easy to get data out of the system, it is difficult for users to move to a different vendor. Regarding data privacy, security and control, growers are concerned about sharing private information and relinquishing ownership and control of their data to the software vendors. Krintz et al. (2016) state that centralised IT platforms make growers vulnerable to security breaches, data loss and interruptions; many farmers don't feel comfortable sharing their data because they perceive it as 'giving away' sources of competitive advantage. An additional issue can be data analysis, if users input information and the system doesn't allow them to present it in a meaningful way.

In their review of a range of sustainability tools for assessment at the farm level, de Olde et al 2016, found that tool developers make assumptions, for example around which indicators to select, and how to measure, compare and aggregate the indicators (De Olde, Oudshoorn, Sørensen, Bokkers, & De Boer, 2016). A disparity between the value judgements and assumptions made by tool developers and farmers can result from insufficient involvement of end users during the development of a tool, and is considered as a reason for the limited adoption of sustainability assessment tools in farming practice (De Olde et al., 2016). Literature on the adoption of tools by farmers highlights the significance of the perceived relevance of the tool (De Olde et al., 2016): farmers stop using tools when they don't see sufficient value for action resulting from their output.

In summary, IT has been recognised as a potential means to support sustainability and LCM implementation across supply chains and industry sectors. IT provides the potential to capture data across independent and related entities and could therefore aid in closing the gap in LCA data in primary industries. Additionally, collaboration tools of IT systems provide capabilities that could support LCM knowledge exchange amongst industry stakeholders, thereby reducing resource barriers experienced by individual supply chain entities. However, in order for IT to provide a viable solution to the LCM challenges experienced by primary industries, cost, data privacy, security and control challenges need to be addressed in the design and development of IT platforms. In addition, engaging with the stakeholders in the design and development of the systems in crucial to ensure effective adoption of the IT system among end users.

6.3 IT platforms to support sector-based LCM programmes

In New Zealand and Australia, a range of software tools are available to support individual farmers in primary industry sectors. These applications include a land and environment tool developed by the Beef and Lamb NZ industry body (Synge, Mackay, & Palmer, 2013), the DairySAT (Dairy Self-Assessment Tool) environmental tool for the Australian dairy industry and the WiSE software tool for the New Zealand wine industry. Additionally, other software tools such as SmartFarm have been developed globally to support sustainability and LCM in the agricultural sector (Krintz et al., 2016).

The majority of these tools have been developed for use by individual farmers and therefore many of the requirements for an IT platform to support a sector-based LCM programme identified in the previous section are not met. For example, the Beef and Lamb NZ environmental tool provides guidelines for individual farmers to improve their own performance but does not capture data to provide industry level metrics or collaboration potential.

In this review of platforms, the purpose is not to identify and assess the capabilities of all of the IT systems used for environmental management and sustainability. Rather, three leading IT systems used in LCM have been evaluated: SmartFarm, WiSE and DairySAT.

6.3.1 SmartFarm

SmartFarm was developed in the United States to enable SME farmers and other agricultural stakeholders to use analytics to improve environmental sustainability and efficiencies in food production. SmartFarm integrates environmental sensor technologies into an on-premise, private cloud-based software (Krintz et al., 2016). It was developed to enhance information outputs about increasing yields, profitability and animal welfare.

The software is provided at no cost and thereby addresses the issue of limited financial resources that SME farmers face. Since the software is open source to researchers and software developers, new sustainability science and engineering in areas related to agriculture, agronomics, bio-resource and agriculture engineering can be developed in the form of ‘apps’. SmartFarm connects data from external cloud sources (weather predictions, state and national datasets, etc) with farm-local statistics. The result is an interface into which custom analytics applications can be integrated. The IT platform predicts and visualises data and according to Krintz et al. (2016), allows farmers to have full control over the privacy, security and sharing of their farm data.

To counterbalance the issue of data connectivity, SmartFarm provides growers with a hybrid, distributed architecture (hardware and software) allowing them to use an on-farm appliance. A built-in algorithm provides the growers with decision support and if internet is available, SmartFarm can download data analytics and visualisation applications. Thereby, SmartFarm runs with or without internet. (Krintz et al., 2016) highlight that the system ensures that no private data is leaked and provides robustness and security via its 'black-box' design.

In summary, in comparing the SmartFarm software against the factors highlighted in the previous section the following conclusions can be made:

- Cost: SmartFarm is available at no cost to farmers which is a key consideration in the uptake of IT by small primary sector organisations. However, farmers need to purchase additional apps to ensure they can collect and analyse relevant data for their industry. The setup of SmartFarm cannot be configured to suit individual growers' or industry sectors' needs and therefore would present initial development cost barriers and ongoing maintenance issues for individual sector bodies.
- Security and data privacy: The SmartFarm tool addresses security and privacy concerns by providing the IT system as an on-farm hosted solution. However, this approach means that each individual farmer's instance of the software operates in isolation and SmartFarm therefore does not allow growers and industry stakeholders to communicate and collaborate, nor does it support the aggregation of environmental data for individual farm benchmarking against industry metrics. Additionally, the maintenance of the IT would require resource intensive upgrades to individual on premise software installations.

Given the above, SmartFarm therefore appears to suit individual organisations to track their own performance. However, it lacks the potential to support a sector-based approach to LCM in primary industries.

6.3.2 The New Zealand Sustainability Dashboard and Wine Industry Sustainability Engine

Sustainable Winegrowing New Zealand (SWNZ) has worked with the New Zealand Sustainability Dashboard (NZSD) project to develop the Wine Industry Sustainability Engine (WiSE) sustainability assessment tool. The WiSE online assessment and reporting software incorporates annual scorecard records of energy and water use by SWNZ members. The tool intends to provide fast feedback to growers and support in reducing reporting and monitoring costs (Barber et al., 2014; Rosin, Legun, Campbell, & Sautier, 2017b)

Before the WiSE tool was developed a previous version of the software ("Muddy boots") was in place for the SWNZ programme. Wine growers have judged the SWNZ programme based on the software as it was the main interface between the grower and the industry body. The original software was difficult to use and required significant manual intervention. In addition to this, the software vendor was difficult to deal with and reluctant to make changes to the software based on feedback. In this basis, changes to the WiSE software included simplifications and reductions to audit questions, basing the certification criteria on international standards, and introducing WiSE online sustainability dashboard. Given that the software interface is a key component to the grower's experience SWNZ auditing, updates to the software aimed to improve the programme and also mitigate negative impressions to 'compulsory' certification.

In addition to providing an assessment and reporting function, the WiSE tool was developed to provide a "hub for learning to become more sustainable". It intends to create a platform for linking past data sources to existing decision support software applications so that growers can be alerted when their environmental key performance indicators are approaching 'amber' or 'red' alert thresholds.

The WiSE tool was primarily developed to assist growers with management of the large amounts of available information and with their subsequent management decisions. The tool also aims to support growers in meeting their requirements for market and regulatory reporting. The overall objectives are to reduce monitoring and compliance costs, enhance reputation with consumers, secure market access and garner support from wider New Zealand society by verification and regular reporting of standardised sustainability criteria (Rosin et al., 2017b).

The development of the WiSE audit and reporting tool shows the potential for the use of IT to facilitate industry sector collaboration around sustainability and environmental performance reporting. However a key barrier identified in this case study was the reluctance of participants in the sector to willingly submit control of their data (Rosin, Campbell, & Reid, 2017a). The wine industry is strongly competitive, individualized and independent, and compliance with the audit involves a collective enterprise to gain recognition for New Zealand wine industry as a whole. Individual organisations were hesitant to provide information that could affect their competitive advantage and "diminish the mystery" of winemaking.

(Rosin et al., 2017a) describe that some users of the tool see it as nothing more than a compliance tool and a "necessary evil" rather than an effective means to align with best practice, let alone sustainability, in the sector or in their operation. Other users believe that the main impacts of the WiSE tool are benefits to SWNZ in terms of controlling practice in the sector as well as to the larger winemakers wishing to control their contract growers.

In comparing the WiSE tool with the factors summarised in the previous section, the following conclusions can be made:

- Security, privacy of data and control: Wine industry stakeholders are highly competitive and there appears to be a concern relating to data privacy and a reluctance to publish competitive data in the WiSE tool.
- Collaboration: The WiSE software was able to support the collection of data across the New Zealand wine industry however the perception of users is that the system was not valuable to them has affected the benefits of this tool for LCM. Stakeholders were not consulted in the development of the original software programme, however the updated WiSE interface has incorporated feedback to improve usability.

Given the above, it is considered fundamental to engage sector stakeholders in the design and development of the IT platform to ensure functional requirements are aligned with the needs of the end user.

6.3.3 DairySAT

The DairySAT tool is an environmental management self-assessment and action planning tool developed for the Australian dairy industry. DairySAT was developed to enable individual farmers and industry stakeholders to understand their environmental performance and benchmark themselves in comparison to industry averages relating to relevant sustainability indicators.

The initial concept of the DairySAT came from Gippsland (Australia) dairy farmers in the early 2000's who understood the need to be proactive in addressing environmental concerns. The online software tool has continually evolved with the support of Government funding based on input from farmers as well as industry and technical experts across Australia (Lampland, 2012). DairySAT underwent a complete technical and functional review in 2013 and the upgraded web version was released in 2014.

DairySAT covers 10 key topic area that are relevant to the dairying industry: Soils, Fertilisers, Effluent Management, Irrigation, Greenhouse Gas Emissions, Biodiversity, Energy and Water in the Dairy, Pests and Weeds, Chemicals, and Farm Waste.

Data submitted into the DairySAT software is not shared at an individual farm or business level. All personal identifying information is kept confidential and not used for any purpose. Data captured relating to the practices at a farm level is confidential and general data trends are collected anonymously. Aggregated data collection occurs at a regional and national level to support the demonstration of continual improvement in practices in the Australian dairy industry.

A review of the use of DairySAT found that farmers were unlikely to continue autonomous participation in the DairySAT EMS program without external facilitation and co-ordination or the threat of increased regulation and enforcement (Cary & Roberts, 2009). For the majority of farmers, on-going participation was likely to require continual extension and industry support or government subsidy due to the perceived insufficient privately-captured benefit (Lampland, 2012). In other words, participation and use of the DairySAT tool did not directly link back to consumers or markets for dairy products and the commercial benefit perceived by farmers was therefore limited. The study found that the discipline and resources required for more formal credentialing and auditing did not appear to be attractive to participating dairy farmers.

In summary, when comparing the DairySAT software tool to the factors outlined in the previous section the following conclusions can be drawn:

- <u>Cost</u>: The DairySAT tool is available to farmers at no financial cost due to being funded by the Australian federal Government and incentives are provided to farmers to encourage use.
- <u>Security and data privacy:</u> The DairySAT software satisfies the important requirement of data security without compromising the ability to bench-mark performance and make available best practice guidelines to stakeholders.

However, the key shortcoming highlighted in the reviews of the DairySAT tool is the inability to ensure ongoing use and adoption by the industry. It has been recognised that increasing use is unlikely to be achieved without the backing of dairy companies who are in a potentially strong position to influence their suppliers.

6.4 Requirements for an IT platform for LCM in primary industry sectors

Requirements engineering is an important field in software and IT development. It is complex and interdisciplinary in nature and is fundamentally important for development success (Penzenstadler, 2014). “Requirements Engineering is the branch of software engineering concerned with the real-world goals for, functions of, and constraints on software systems. It is also concerned with the relationship of these factors to precise specifications of software behaviour, and to their evolution over time and across software families” (Zave, 1997).

Section 6.3 summarised examples of existing applications of IT software in the LCM field highlighting the extent to which they address the key success factors identified in 6.2. In addition to considerations in the literature, previous research in this study has identified several key barriers that have the potential to limit the effectiveness of an LCM or sustainability programme at an individual company and industry sector level (Seidel-

Sterzik et al., 2018). These challenges include financial resource limitations, lack of knowledge of LCM and gaps in communication and information sharing.

The review of existing IT platforms for LCM highlighted the importance of providing a cost effective or free solution to farmers. However, in the case of SmartFarm, maintenance to the individually hosted IT systems would provide future cost barriers and restrict collaboration. In the case of the WiSE tool, individual farmers were reluctant to submit their data to a collaborative system as they felt their competitive data may not be secure. The DairySAT and WiSE cases both highlighted the challenges associated with the uptake and ongoing use of the tools by farmers due to the time commitment compared to the perceived value obtained.

Based on the review of the literature, the factors identified previously in this PhD study as well as an assessment of three existing LCM software applications used in the primary industry, Table 6.1 presents an overview of the key factors that need to be considered in the design and implementation of an IT platform for LCM according to the different key stakeholders that may use such a system.

Table 6.1: Summary of relevant factors that need to be considered in the design of a sector-based LCM platform

Stakeholder	Factor	High level requirements	Required Functionality
Farmer/company	Cost and complexity of data collection	Simple and streamlined capture of data	• SmartForms to capture LCM data periodically • Ability to upload evidence such as documents and photographs • Fields adjust depending on input of data into previous fields • Notifications for new reporting periods and reminders when data has not been submitted in time • Simple and intuitive user interface ensuring minimal training is required • Help files accessible to end users
	Benchmarking	Compare company result with relevant indicators and sector average	• Data aggregation from the entire sector to be visible at appropriate levels • Charting/reporting capability
	Lack of knowledge and experience	Access industry LCM strategy, objectives and 'best practice' guidelines	• Display strategy with associated objectives • Commenting and feedback capability for two-way communication • Display text and multi-media content • Access legislative compliance requirements

	Credibility of claims and market understanding	Option for third party auditing of data	• Ability for farmer to 'opt in' to having their data audited by a third party • Self-assessment questions based on international standards relevant to industry sector.
	Lack of resources	Affordable	• No or minimum maintenance cost • Minimum training cost • Individual small businesses in the supply chain should incur little or no cost to utilise the system
	Data privacy and competitiveness	Data security	• Organisations do not access each other's data • Robust permissions framework enabling effective management of viewing, editing, notification and task allocations
	Accessibility and maintenance costs	Cloud based system	• Live update of data • System updates don't require changes to individually hosted applications • Updates to the platform and content should be immediately available without the need for costly and inefficient maintenance • Stakeholders require access any time and from any location
Industry sector body	Complexity of data collection	Industry level reporting	• Aggregated data displayed in charts • Dashboards to filter, export and evaluate trends

	Lack of knowledge	Develop, update and disseminate LCM strategy and objectives	• Ability to create and edit content relating to the LCM strategy including text, photos, videos, graphical strategy representation etc. • Share standardised 'good practice' guidelines for LCM
	Cost of administration	Notifications	• Notifications about completed audits • Notifications about farmers/companies' feedback
	Cost of development	Configurable without needing to build a sector specific solution	• Ability to configure the software to align with the specific sector requirements based on a generic template
Customers and public	Market understanding	View data	• Integration of platform with website to display 'live' data or reports for a specific period • View achieved targets and upcoming goals and objectives
3rd party auditor	Credibility of claims	Verification of data submitted by farmers	• Auditor gets notified once data input is completed • The ability to access (but not edit) and assess self-assessment records of farmers • Commenting functionality • Scoring system to provide feedback to farmers on performance

6.5 Pilot implementation of the LCM IT platform in the aquaculture industry in New Zealand

At the time of the research AQNZ sought a New Zealand provider of web-based risk and environmental management systems. The aim was to "develop a user-friendly online tool for operator self-assessments, AQNZ administration and individual as well as across-industry reporting of general trends". A suitable partner for the development of the IT platform was chosen (ecoPortal) and I, as the PhD researcher and also an employee of ecoPortal, had the opportunity to be involved in the design and development of the software for AQNZ.

The chosen software vendor, ecoPortal, had previously developed an IT platform to support *individual organisations* in designing, implementing, and maintaining internal environmental and sustainability management programmes. However, for the software to be effective in achieving the needs of the New Zealand aquaculture industry, it needed further development to support a *sector-based* approach and this was undertaken (and led by myself) based on the requirements identified in Table 6.1.

6.5.1 Introduction to the New Zealand Aquaculture industry

The aquaculture industry is the fastest growing animal protein producing sector in New Zealand. Approximately 66% of New Zealand's aquaculture production is exported, to 77 different countries (Aquaculture New Zealand, 2015). In 2011, the sector generated over $400 million in revenue, and during the following year the sector employed over 3000 people. It has a target of reaching $1 billion in sales by 2025 and is therefore a significant contributor to the New Zealand economy.

According to a survey in 2014, 68% of New Zealanders agree that aquaculture contributes positively to New Zealand's green and clean image, and 91% of participants agree that New Zealand should look for opportunities to sustainably grow the aquaculture industry (Aquaculture New Zealand, 2015).

Currently, New Zealand produces over 100,000 tons of products related to aquaculture activities with mussels, oysters and salmon being key product categories. To produce premium products, it is essential to ensure a high standard of water quality. Balancing financial growth with ecological sustainability entails ensuring that the growth of the industry takes place within acceptable environmental limits and respects the values of waterways and the marine environment. It is crucial for the aquaculture industry to be able to operate in a clean, healthy marine environment to be able to provide high quality export products (Aquaculture New Zealand, 2015).

The Aquaculture New Zealand (AQNZ) industry sector body was formed in 2007 as a single voice for the New Zealand aquaculture sector to protect the current industry, while enhancing its profitability and providing leadership to facilitate transformational growth (Aquaculture New Zealand, 2015). AQNZ is funded through an industry levy and it aims to bring together the memberships of the individual species bodies, which include the New Zealand Mussel Industry Council, the New Zealand Salmon Farmers Association and the New Zealand Oyster Industry Association.

The main role of AQNZ is to support the implementation of sector-wide strategies, which have the aim of growing the sector sustainably. For successful development and sector-wide implementation of the strategies, active participation and communication from all participants is crucial. Through the wide involvement of stakeholders, it can be ensured that the strategies are commercially viable, and market driven. Strategies are therefore prepared in conjunction with participants from all sectors of the seafood industry, iwi, Government ministries, researchers and NGOs.

At the time of this research, the New Zealand aquaculture industry was working towards creating a structured and repeatable process to enable farmers to access ‘best practice’ guidelines to continually improve their environmental and sustainability performance, capture industry data via a self-assessment to gain an understanding of overall performance; and allow individual organisations to be audited by a third party against the industry sustainability framework to verify the responses from the self-assessment.

The structure of the aquaculture industry in New Zealand as well as the documented commitment of the industry body to enhancing the environmental and sustainability performance using a sector-based approach meant that the aquaculture industry provided a suitable case study for piloting an IT platform to facilitate LCM in the primary industry.

The following sections provide an overview of the New Zealand aquaculture industry in relation to environmental sustainability as well as of the design, development and implementation of an IT platform to support the uptake of an LCM strategy within the three key sectors.

6.5.2 Aquaculture industry sustainability strategy

The New Zealand aquaculture industry launched the A+ Sustainability Framework in September 2015; “[…] a world class sustainable management framework which enables the New Zealand aquaculture industry to better engage with […] communities and continuously improve […] environmental practices while strengthening global demand for […] seafood” (A+ New Zealand Sustainable Aquaculture, 2018).

The A+ Sustainability Framework aims to support the identification and implementation of best management practices (Aquaculture New Zealand, 2015). It focuses on the following seven areas (also shown in Figure 6-1):

- **Ecology**: recognition of the value of the rich biodiversity of the New Zealand marine environment and the need for its protection. In addition, the industry is aware of its interactions with the environment and concerns of the wider community.
- **Water quality**: a key component of environmental health that the aquaculture industry depends upon is water quality. The industry needs to maintain clean water by avoiding the discharge of marine debris and contaminants.
- **Waste:** the reduction and recycling of waste to avoid contamination of the waterways and surrounding environment is a key element of the strategy.
- **Resources**: efficient use of resources allows the industry to reduce risk and increase the resilience of the environment that it operates in. Placing a value on ecosystem services from the perspective of all users also provides a platform from which policy makers can better plan for sustainable use of the environment.
- **Food safety**: throughout the supply chain, from raw materials to final product, food safety is a key sustainability focus. Issues of food safety and traceability are addressed to the highest standard to reassure consumers that they are receiving the best quality products.
- **Iwi participation**: industry and farm operations should be designed and operated to have regard to sites of special significance to Iwi and on traditional harvesting practices of Mahinga Kai.
- **Community**: all farm operations should be designed and operated to co-exist with the local community and to minimise negative impacts to the local community and coastal marine users.

The A+ Sustainability Framework takes a life cycle approach in the sense that it includes focus on the supply chain and waste management. However, packaging and transport within New Zealand as well as international shipping are not within the scope of the strategy. The A+ Sustainability Framework emanated through a holistic programme to standardise and advance environmental management across the New Zealand aquaculture industry and provide practical tools to increase the sustainability of sector. A range of stakeholders were involved in the development of the A+ Sustainability Framework to ensure that the interests of the key people in the industry were represented accurately, and that environmental, social and business aspects were considered. The key stakeholders included marine farmers, industry stakeholders, AQNZ, species representative organisations, regional associations, delivery centres, central and local government agencies, Maori/Iwi, environmental groups, suppliers, contractors, customers, employees and communities (Aquaculture New Zealand, 2015). The framework has been adapted and applied separately to each of the main species of the aquaculture industry: green shell mussels, pacific oysters and salmon.

Ecology	Biodiversity	Biosecurity	Wildlife
	Benthic Effects		
Water Quality	Discharges	Pollution	Hydraulic Impacts
Waste	Waste Audit	Marine Farm Debris	Recycling
	Zero Waste		
Resources	Farm Structures	Energy	Ecosystem Services
Food Safety	Health & Hygiene	Traceability	
Iwi Participation	Iwi Participation		
Community	Navigation	Communication	Visual Impacts
	Noise & Odour	Employee Welfare	

Figure 6-1 The high level AQNZ A+ Sustainability Framework

6.5.3 Implementing an IT platform to support LCM uptake in the NZ aquaculture industry

In the context of the project, I provided the aquaculture industry with guidance and support relating to integrating requirements to support a sector-based LCM approach into the configuration of the IT platform for the needs of the industry stakeholders. In this role, I was in the position to capture feedback from participants in the study and critically evaluate the extent in which the IT platform for AQNZ met the requirements identified in the literature.

The pilot implementation of the IT platform involved the following elements:

1. <u>IT platform requirements analysis:</u>
   The aim of this stage was to consolidate the foundation of knowledge in relation to the requirements for an IT platform for LCM and the specific considerations of the sustainability programme for AQNZ and its sector participants. This was based around three key areas: stakeholders, requirements, and functionality (Table 6.1).
2. <u>Aquaculture industry configuration:</u>
   This stage involved setting up AQNZ's A+ sustainability programme on the software platform, including:
   - Creation of the AQNZ A+ instance on the IT platform
   - Creation of the visual representation of the sustainability strategies to support communication with stakeholders

- Configuration of the self-assessment templates to align with the industry's A+ sustainability framework
- Development of dashboards and report templates based on AQNZ's and sector participant data requirements
- Creation of user login structure and permissions groups based on stakeholder roles and workflow requirements to support privacy and security.

3. <u>Pilot study with industry stakeholders:</u>

   A pilot study of the IT platform for LCM was conducted with key New Zealand aquaculture sector stakeholders across the three species (salmon, oysters and mussel). The intent of the pilot was to gain qualitative feedback and insights on usability and other considerations to optimise the end user experience once the platform was rolled out to the wider industry.

   Feedback was captured from stakeholders based on interactions during training sessions and workshops with the industry body, as well as information gathered during the pilot study with farmers. I also conducted face-to-face training sessions with the auditors to ensure they knew how to use the tool in the future.

The stakeholders of the project included the AQNZ industry organisation, farmers, customers and consumers, general public and 3rd party auditing organisations. Each of the stakeholders have different access levels to the platform and need to see different types of data. This is relevant for the setup of permissions for each of those stakeholder groups to ensure data security and confidentiality. Additionally, the provision of unnecessary permissions often leads to 'information overload' and a cluttered user interface, so it was important to carefully consider access levels and permissions for each of the stakeholder groups.

The stakeholders participating in the pilot included companies that either own or manage aquaculture farms as well as industry body stakeholders. For the salmon industry three companies participated in the pilot representing 15 farms in total (3, 5 and 7 farms respectively). In the mussel sector, two companies participated in the pilot representing 89 farms (83 and 6 farms respectively). Two companies from the oyster sector were involved in the pilot representing 59 farms (53 and 6 respectively).

The IT LCM platform functionality included the ability to visually display the A+ sustainability strategy with associated best practice guidelines and data capturing capability to assess the industry performance. The strategy visualisation served the purpose of creating a shared understanding of the industry goals, while the best practice guidelines and environmental codes of practice provide farmers with industry specific learnings that can be implemented without "the need to reinvent the wheel". Data capture via self-assessment templates allow farmers to input data to facilitate individual farmer/company benchmarking and produce industry-wide key performance indicators. Additional information included links to relevant legislation and policies and case studies that could be shared with the sector stakeholders (Figure 6-2).

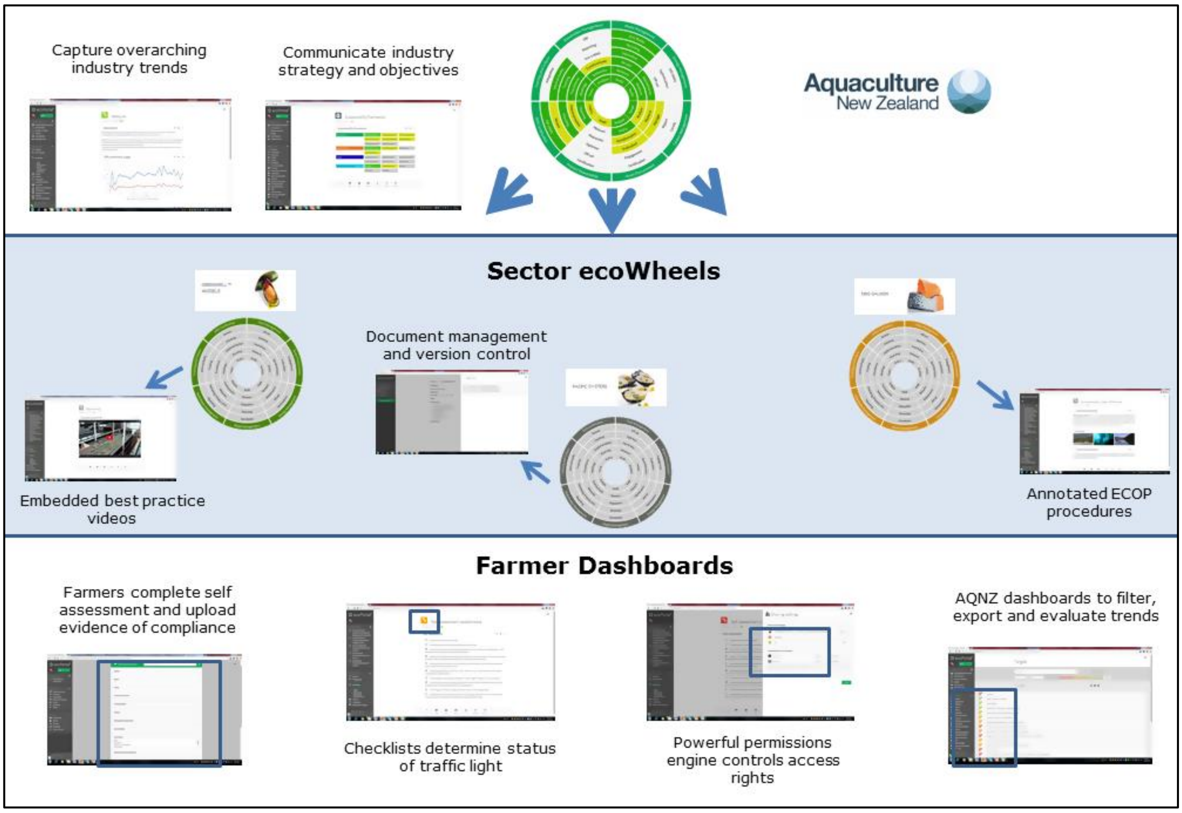

Figure 6-2: Translation of the A+ sustainability strategy into the LCM IT platform (AQNZ, 2015)

Farmers and companies of the salmon, oyster and mussel sectors have access to the sector specific sustainability frameworks and associated environmental codes of practice (Figure 6-3). By 'drilling down' into the various elements of the framework, users are presented with relevant content with the objective of providing an understanding of the legislation and 'good practice' requirements. Users have the ability to comment and engage in conversations on the various aspects of the frameworks and associated good practice guidelines, thereby allowing stakeholders across the sector to learn from each other, share ideas and collaborate where appropriate.

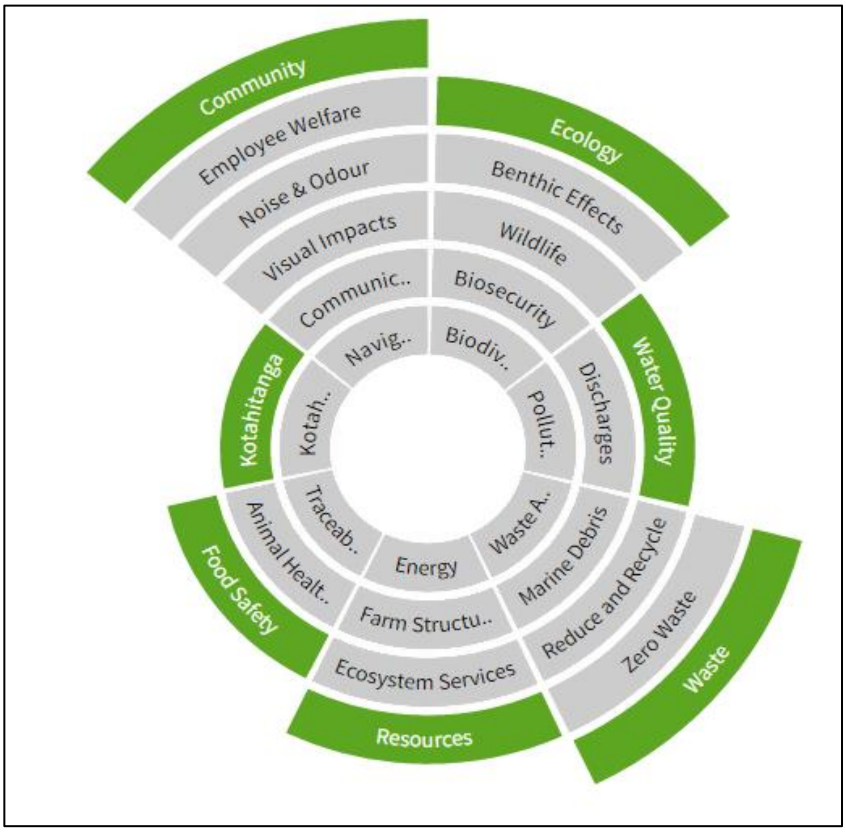

Figure 6-3: Example of the green shell mussel sector strategy used as an entry point to the good practice guidelines (AQNZ, 2015)

The purpose of the farmer self-assessment element of the IT platform is to allow the farmers to assess themselves against the seven focus areas of the A+ sustainability framework as well as provide data to AQNZ for industry performance benchmarking (Figure 6-4). Each company that agreed to be involved in the A+ sustainability programme is invited to the IT platform and is requested to complete the assessment as well as upload associated records/content as evidence. Should a company have multiple aquaculture farms, they are required to complete the assessment individually for each of them.

A key design consideration for the IT platform was whether the self-assessments should display an evaluation or judgement of the actual environmental performance of the farmer or merely the status of completion of the assessment. After considering the maturity of sustainability in the industry, a decision was made by the stakeholders involved in the design to display the completion status of each section of the framework self-assessment only so as not to demotivate participants in the pilot project (Figure 6-4). There was potential for this aspect to be adjusted in the future once the platform was established and users had gained confidence over time.

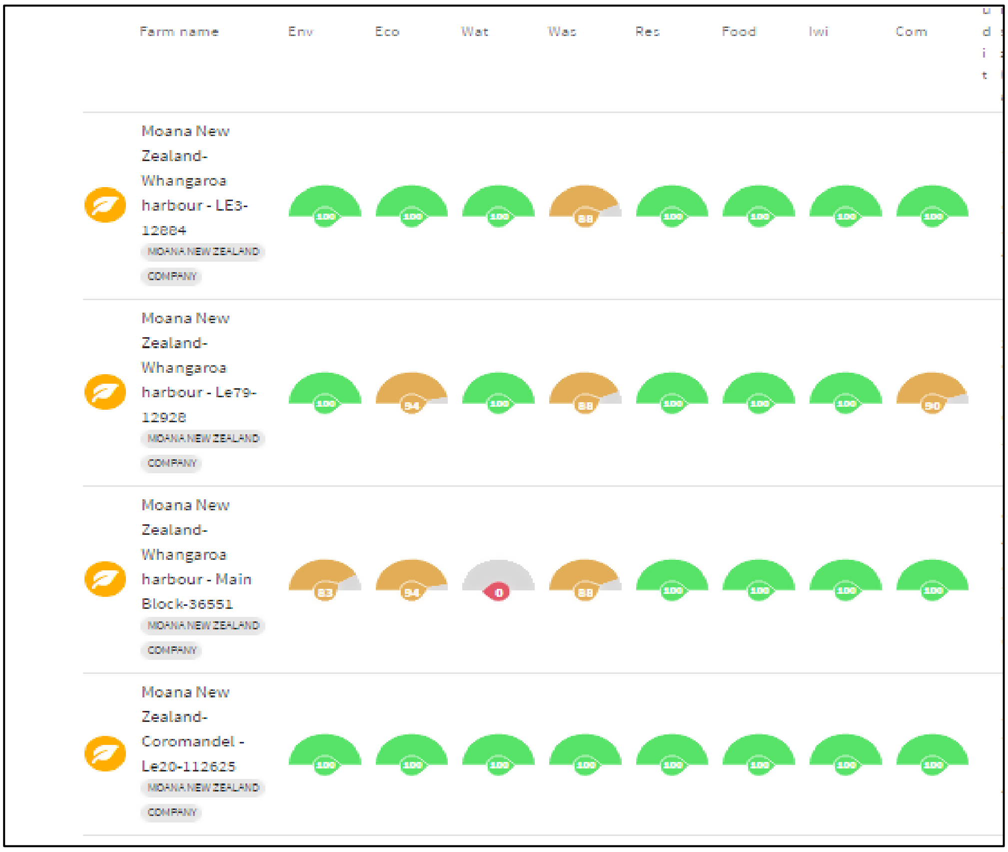

Figure 6-4: Company dashboard to display self-assessment status of farms against the various elements of the A+ framework (AQNZ, 2015)

Each aquaculture species (pacific oysters, green shell mussels and king salmon) has an individual sector specific self-assessment with questions relating to the seven focus areas of the A+ sustainability framework (Figure 6-5). The self-assessment dynamically adjusts to suit the input of data into previous fields. In this way, users are not prompted to complete unnecessary and time-consuming entries that are not relevant based on their context.

Each of the companies trialled the self-assessment across a range of their farms in various locations. In several cases, companies involved in the pilot had farms across more than one species. The company representatives completing the self-assessment pilot were either the business owner or they had a role with responsibility for environmental compliance such as the Product Manager, Chief Operating Officer, On-Water Manager, Environmental Manager and the Site Manager.

A finding from the pilot was that companies managing multiple farms needed to consider the scope of their operations to be included in each self-assessment. In other words, should a company complete one self-assessment for their entire organisation (one for each farm in each geographic location) or a self-assessment for each resource consent that they held (which usually covered more than one farm). This design consideration has significant implications given the time required to complete the questions in the self-assessment. Importantly, there can be differences in the responses for one farm owned by a company compared to another farm owned and managed by the same company. As a result of this feedback, the decision was made by AQNZ to group farms covered under the same resource consent into one self-assessment to reduce the administrative burden on the user.

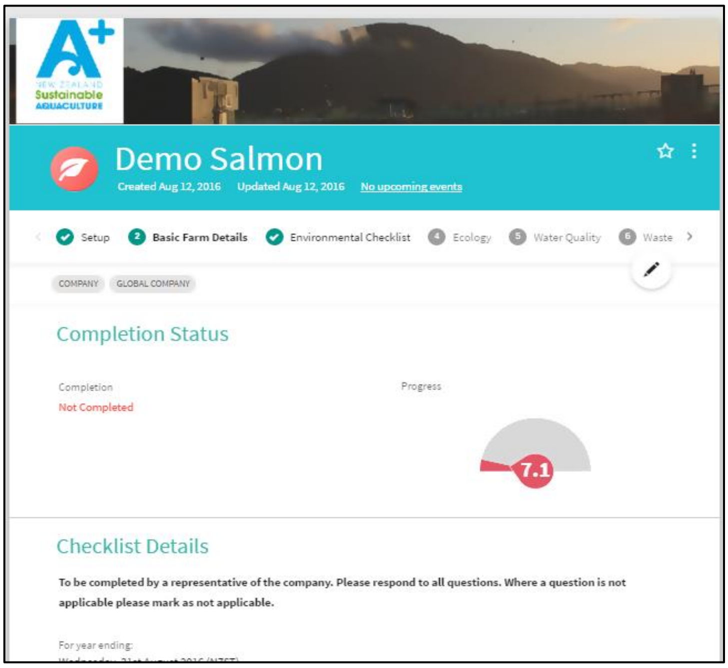

Figure 6-5: A+ farmer self-assessment input example for a king salmon farmer

A key identified requirement of an effective sector-based LCM programme is reporting of performance data at the individual and sector level. As identified in the review of existing software systems, companies are reluctant to share data due to a fear that this may dilute their competitive advantage. For this reason, companies accessing the AQNZ IT platform only have access to their own self-assessment results, however they can access aggregated industry data which enables benchmarking against the average scores of the entire sector (Figure 6-6). This approach enables confidentiality of information (no individual company or farm is identified in the aggregated data) while supporting and driving improved performance via sharing of best practice approaches.

Figure 6-6: Sector performance reporting dashboard (AQNZ, 2015)

A key requirement of an effective LCM programme is to ensure credibility of the data provided by industry stakeholders. It is important for data to be independently verified to ensure that farmers do not simply see the completion of the input as a compliance or “tick-box” activity. The IT platform was designed to allow 3rd party auditors to access the responses and associated evidence of farmers who have completed their self-assessment. Notifications are generated to the auditor once the farmer has completed the self-assessment and opted into the verification.

6.5.4 Challenges and future development

During the development and roll out of the IT LCM platform in the aquaculture industry, feedback was gathered from the key stakeholders including AQNZ, farmers and auditors. The primary challenges identified by these stakeholders in the implementation of the LCM IT platform in the aquaculture industry included ongoing maintenance, speed of implementation, accessibility and cost.

The IT LCM platform for the aquaculture industry was configured to ensure it suited their specific needs. This included requirements around permissions and visibility (for example which stakeholder group can access certain data, who can edit the different pieces of information, and who cannot etc.) for privacy and security reasons. Additionally, the setup of notifications that need to go to specific individuals and user groups, together with reminders and escalations.

To ensure the system suits the industry, terminology and data fields in the self-assessments were adjusted. This is a key aspect that is required for individual industry sectors to ensure it is relevant for their context and to facilitate the uptake of the software. As with all changes, there are always stakeholders who can be classified as the 'late movers' and there are various reasons for the late uptake of the change, or their resistance to the change.

Since the LCM IT platform has been configured to the specific needs of the requirements and structure of the aquaculture industry, this means that there is an ongoing element of maintenance required. For example, the industry body may need to adjust self-assessment templates which would have to be adjusted in the LCM IT platform. Additionally, changes to the structure of the industry sector might have implications on permissions, notifications, reminders and escalations, and need to be adjusted accordingly.

Depending on the contract between the industry sector and the LCM IT platform provider, these changes are most likely incurring some form of cost which needs to be considered by the stakeholders.

As mentioned earlier, the LCM IT platform was configured specifically to the needs of the stakeholders of the aquaculture industry. This requires communication and sharing of knowledge and specific requirements between the stakeholders of the aquaculture industry as well as the LCM IT platform provider. The industry thus needs to set up a project team which can communicate the different needs of the various stakeholders, and these needs do then have to be communicated to the LCM IT platform provider. This is most likely a process which includes several feedback loops and stages. Therefore, it is important to consider that the speed, at which all the detailed information is provided, as well as the availability of the configurators, and the complexity of the configuration, are crucial factors in determining the speed of the implementation and launch of the LCM IT platform for an industry sector.

The ease of use of a software system in any context is critical to facilitate uptake and gain maximum value from the solution. For an IT LCM platform, end users need to be able to interact with the system without requiring extensive, costly and time-consuming training. An intuitive system ensures that users do not get frustrated and maximises the chance of stakeholders utilising the tool on an on-going basis. Therefore, the design of the user interface and alignment of the system with commonly used social media platforms are key elements to consider when creating an LCM platform for industry sectors.

Customers and the public need to understand the environmental impacts of the sector to allow them to make informed purchasing decisions. This can be achieved via an IT platform that provides access to updated, aggregated data of the environmental performance of the sector in relation to the sector LCM strategy and specific environmental 'hot spots'. To mitigate competitive and privacy concerns, the platform needs to ensure that the responses and data submitted by individual organisations that is made public are aggregated to ensure that the specific performance of specific companies is not revealed.

Although most people in New Zealand have access to the internet, this is not always a given for people that work in remote areas. The challenge for the farmers in the aquaculture industry was that the farmers did not always have access to internet (via computer, smartphone or any other device) when they were on the job. This meant that they could only access the LCM IT platform when they were back in areas with internet access. They were therefore not always able to update their information and data immediately, or access information provided by the industry body on the job.

6.6 Conclusions and future research

There is a growing global need to support primary industry sectors to improve their sustainability performance. Individual farmers often lack the resources from a technical, financial and knowledge perspective to effectively make progress, and an industry sector approach to facilitate LCM has been suggested to facilitate efficient use of resources and support knowledge transfer amongst stakeholders. IT and software technology have the potential to facilitate such a sector-based approach by providing the functionality to allow collaboration across organisations in a sector as well as supporting collection of inventory data which has been documented as a key gap and concern for LCA researchers and practitioners.

The critical success factors and associated functional requirements of an IT platform were identified based on a review literature and assessment of three relevant existing software applications. Key considerations included ease of use, data security, ability to benchmark, maintenance and development costs, industry relevance, credibility of claims and the ability to support collaboration and dissemination of good practice.

The aquaculture industry in New Zealand is an example of an industry that is proactively seeking to enhance the collective environmental sustainability and LCM performance of the stakeholders across the three main species of mussels, oysters and salmon. The aquaculture industry was selected as a case study due to its structure and proactive commitment to improving its environmental sustainability performance.

An IT platform was designed and configured to align with the requirements for sector-based LCM software identified in the research as well as the specific needs of the AQNZ A+ sustainability programme. The platform included a range of functional requirements to support the industry sector's sustainability programme. These functional requirements included: a visualisation of the strategy framework, a self-assessment questionnaire, dashboards and reports, permissions frameworks as well as workflows to support third party auditing.

A key learning from the design and implementation of the IT platform was the ongoing challenge with funding for such systems. The AQNZ A+ programme and the development and licencing of the IT platform were funded using support from the Ministry for Primary Industries (MPI) Sustainable Farming Fund. This meant that farmers did not have to pay for the development of the platform or the ongoing use. This being said, it is acknowledged that the funding from MPI is not ongoing and the aquaculture industry and others in the future will need to find ways to support the maintenance and licencing of LCM IT platforms that don't rely on Government support.

Future research and practical development work should focus on evolution of the platform so that it can be easily configured to other industry sectors. As a result of the case study, it was also identified that usability should be a future focus to ensure minimal training is required by end users and to maximise their time available for actually enacting LCM programmes and associated environmental improvements.

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DRC 16

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STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Helene Seidel-Sterzik
Name/title of Primary Supervisor:	Prof. Sarah McLaren
Name of Research Output and full reference:	
An Information Technology Platform to Facilitate a Sector-Based Approach for Life Cycle Management in the Primary Industry	
In which Chapter is the Manuscript /Published work:	Chapter 6
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	90
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Candidate: literature research, case study work, writing up the paper. Supervisors: proof reading, feedback on structure of the paper	
For manuscripts intended for publication please indicate target journal:	
The Journal of Strategic Information Systems	
Candidate's Signature:	Helene Seidel-Sterzik Digitally signed by Helene Seidel-Sterzik Date: 2020.03.28 13:03:14 +13'00'
Date:	
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7 DISCUSSION AND CONCLUSIONS

7.1 Introduction

This section provides a concluding discussion on the contributions, implications and limitations of the research conducted in this PhD project. This research had the overall aim of investigating the development of a sector-based approach to support LCM uptake in an industry sector. A summary of the four main phases of the research is shown in Figure 7-1.

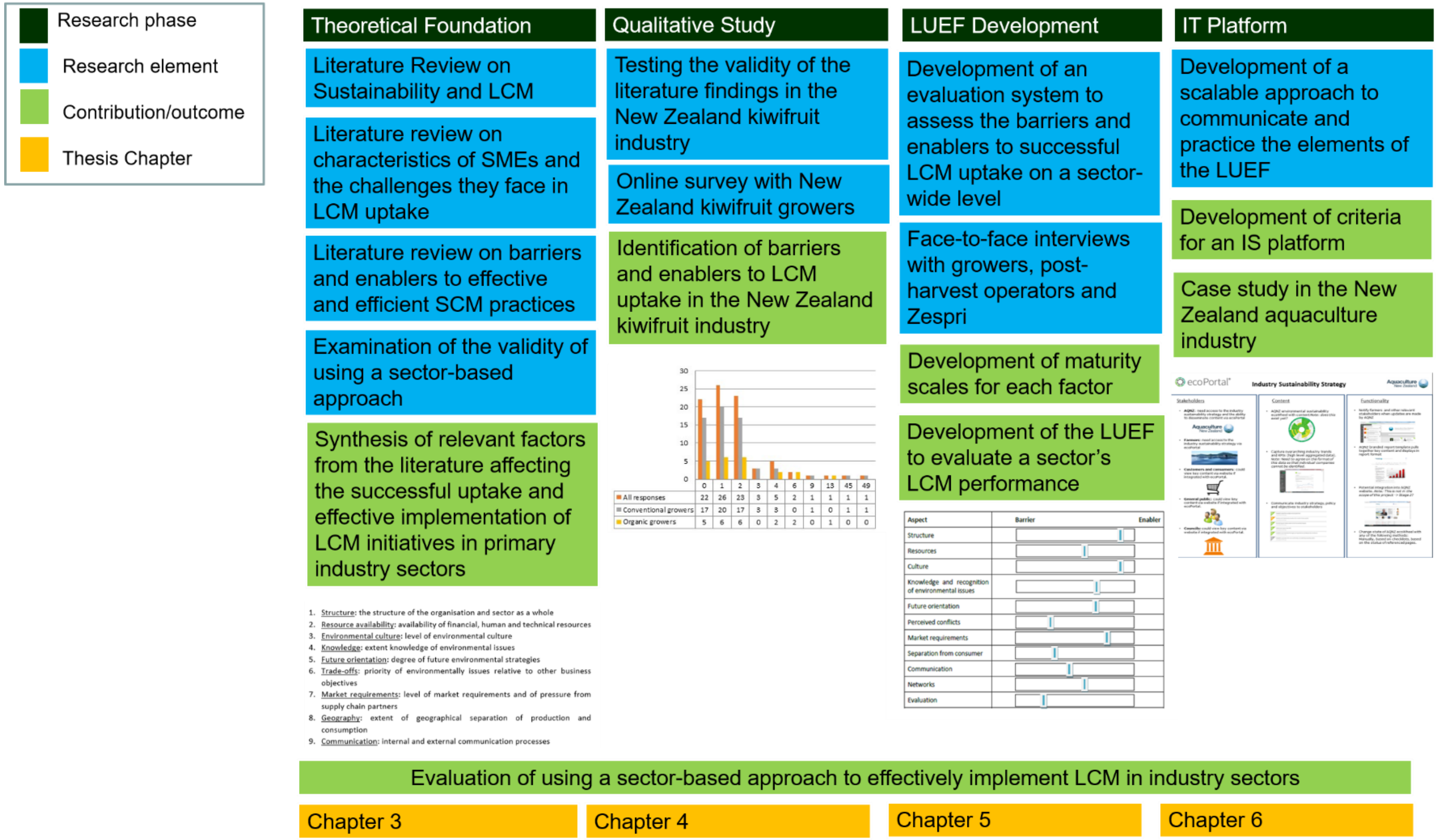

Figure 7-1: Overview of the research elements and outcomes of this PhD research

7.2 Review of Objectives

The research investigated the enablers and barriers to successful LCM uptake within industry sectors and tested their validity in a case study of the New Zealand kiwifruit sector. The research continued with the development of an LCM Uptake Evaluation Framework (LUEF) that can be used to benchmark capabilities and support LCM uptake in industry sectors. Having identified communication and knowledge sharing as a specific barrier to improving a sector's environmental performance, the development of an IT platform was identified as a possible solution and tested in a case study of the New Zealand aquaculture sector. Table 7.1 to

provide a summary of the four research objectives and the contributions that the researcher made in each of those areas.

Objective 1 of this PhD was to build the theoretical foundation for the research. It was identified that the research areas of sustainability, LCM, SMEs and SCM are closely related and need to be considered when identifying enablers and barriers towards successful LCM uptake in primary industry sectors. It was also important to research the relevance of LCM in a New Zealand context. The contributions include a synthesis of relevant factors from the literature affecting the successful uptake and implementation of LCM initiatives in primary industry sectors. As part of Objective 1, the specific characteristics of SMEs were identified, and they explain why SMEs face unique challenges towards LCM uptake. Additionally, the research identified the barriers and enablers to efficient SCM management practices. Due to the nature of primary industries, it was identified that a sector-based approach is a possibility to implement LCM initiatives with effective results for the individual organisations as well as the industry. Based on that understanding, the term 'sector-based approach' was defined.

Objective 2 had the goal of identifying the specific enablers and barriers to LCM implementation in the New Zealand kiwifruit sector. It focuses on the linkages between supply chain partners and the associated barriers for the entire sector to improve the sector's environmental performance. The research takes into consideration the New Zealand part of the product life cycle stages only and overseas activities (such as international transport and sale) are not included. It deals with the key stakeholders; which in the case of the study included growers, postharvest operators and the industry body Zespri. The contributions include the documentation of key insights of LCM in the New Zealand kiwifruit supply chain.

Objective 3 was to formalise the approach by which organisations and industry sectors can benchmark their current LCM performance and improve going forward. The contributions include the development of a framework with key factors to evaluate barriers and enablers towards successful LCM uptake. It included the development of maturity scales for each factor on the framework, as well as interviews with kiwifruit growers, post-harvest operators and Zespri in order to verify the suggested maturity scales.

Objective 4 was to develop an IT platform to support LCM within primary industry sectors. The contributions related to this objective include research into existing IT platforms and how they facilitate LCM uptake. Based on that, it was possible to develop the criteria for an LCM platform, and then set one up for the New Zealand aquaculture industry.

During the literature review it was established that companies in general face difficulties implementing LCM initiatives successfully into their operations (Section 3.3.2). Therefore, the problem of LCM uptake can be described as general in character which could apply to any organisation or product supply chain. The specific challenges faced by the individual organisations and supply chains could vary according to certain circumstances which are investigated in this research.

This does not limit the value of the research findings; the hurdles that the kiwifruit and aquaculture sectors are facing are relatively universal as it can be seen from the literature review and are thus relevant for other primary industry sectors. Consequently, the LUEF for sector-wide uptake of LCM is not specific, but applicable to as many instances as possible. This means that while the research draws from data gathered in the kiwifruit industry sector, the results can be generalised for primary industry sectors that implement LCM initiatives. Additionally, the development of the IT platform uses findings from the literature (Section 6.3) as well as the insights gained from the quantitative and qualitative studies in the New Zealand kiwifruit industry (Section 4.5 and 5.3).

Table 7.1: Contributions to Objective 1

Objective 1		**Contributions**
Name	***Development of a theoretical understanding of LCM including identification of factors to successful LCM uptake in organisations and industry sectors***	***Synthesis of relevant factors from the literature affecting the successful uptake and effective implementation of LCM initiatives in primary industry sectors***
Research steps	• Literature review on the growing importance of sustainability and the associated need for LCM implementation and tools, including barriers and enablers for uptake *(Section 1.2.1 and Section 1.2.2, Section 1.2.3 and Section 1.3).* • Literature review on characteristics of SMEs and the challenges they face in LCM uptake *(Section 3.3).* • Literature review on barriers and enablers to effective and efficient SCM practices *(Section 3.4).* • Examination of the validity of using a sector-based approach – including review of existing examples of implementation of LCM at the sector level *(Section 3.5).*	• Literature review on characteristics of SMEs and the challenges they face in LCM uptake *(Section 3.3).* • Literature review on barriers and enablers to effective and efficient SCM practices *(Section 3.4).* • Examination of the validity of using a sector-based approach – including review of existing examples of implementation of LCM at the sector level *(Section 3.5).* • Definition of the terminology “Sector-Based Approach” *(Section 3.5).*

Table 7.2: Contributions to Objective 2

Objective 2		**Contributions**
Name	***Identification of enablers and barriers to LCM implementation in the New Zealand kiwifruit sector.***	***Documentation of key insights of LCM in the New Zealand kiwifruit supply chain***
Research steps	• Testing the validity of the factors identified in the literature review in a pilot study in the New Zealand kiwifruit sector with different supply chain stakeholders (*Chapter 4).*	• Testing the validity of the factors identified in the literature review in a pilot study in the New Zealand kiwifruit sector with different growers using a different methodology *(Section 4.5).*

Table 7.3: Contributions to Objective 3

Objective 3		**Contributions**
Name	***Framework Development***	***Development of the LCM Uptake Evaluation Framework (LUEF) to evaluate the maturity of an industry sector regarding LCM practices. This includes the development of a framework with key factors to evaluate barriers and enablers towards successful LCM uptake for the industry sector as well as maturity scales for each of the factors.***
Research steps	• Development of an evaluation system to assess the barriers and enablers to successful LCM uptake on a sector-wide level *(Chapter 5).* • Use of the LUEF to evaluate different supply chain stakeholders in the New Zealand kiwifruit sector through face-to-face interviews and an online survey *(Chapter 5).*	• Development of a framework for assessment of barriers and enablers to LCM uptake in companies and industry sectors *(Section 5.3)*. • Development of maturity scales for each factor on the framework *(Section 5.3)*. • Interviews with kiwifruit growers, post-harvest operators and Zespri, the industry body to identify and verify the suggested maturity scales *(Section 5.3)*.

Table 7.4: Contributions to Objective 4

Objective 4		**Contributions**
Name	***Development of an IT platform***	
Research steps	• Literature research on IT platforms *(Section 6.2).* • Literature research on IT platforms for industry sectors *(Section 6.3).* • Identification of key characteristics of effective IT platforms for primary industry sectors *(Section 6.4).* • Case study *(Section 6.5).*	• Research on existing IT platforms used to facilitate LCM uptake in industries *(Section 6.3).* • Development of the criteria for the IT platform *(Section 6.4).* • Development of an IT platform for the New Zealand aquaculture industry *(Section 6.5).*

7.3 Limitations of the Research

The following sections addresses limitations of the research. All research methods have their own limitations and in order to interpret the results, compare them with other studies or replicate the study, it is necessary to be aware of these limitations.

7.3.1 Sample size

There are some limitations in this research that could be addressed in future research. The development of the LUEF involved literature, as well as the kiwifruit case study. Although a mixed method approach was applied, which included qualitative and quantitative research, there are still limitations as only one primary industry sector, the New Zealand kiwifruit sector, was looked at. Future research could incorporate further sectors to test if the LUEF applies there as well, or if other enablers/barriers should be added to the list. Also, over time the descriptions of the maturity scales might become outdated and need updating.

Similarly, the IT platform was developed and set up in cooperation with one industry sector, which is the New Zealand aquaculture industry. Future research into the benefits of utilising software to support LCM uptake in primary industry sectors would benefit from further case studies in other sectors.

7.3.2 Bias

As outlined in Section 2.2, another limitation is bias. Since the researcher undertook the semi-structured interviews, it is possible that participants answer the questions in a way that they think is expected, instead of what they would say if it was not a face to face interview. It could also be the case that they misunderstand the question or have other reasons to skew their responses. The researcher tried to mitigate those issues by making sure questions were easily understood, the interviews happened in an environment that was comfortable for the participants and issues can be raised and discussed. The mixed method approach was also a way to counterbalance the shortcomings of one approach.

An additional area of potential bias was that the researcher was employed to deliver the IT platform for the aquaculture industry. That means the data that was received by the aquaculture industry was not independently verified and the opinions and feedback provided by the aquaculture industry might not reflect the concerns of other industry sectors. The researcher tried to counterbalance that by including literature into the development of the IT platform to get other researchers' experience and results incorporated. Also, self-reported data contains the potential of selective memory, where only specific experiences are remembered, and certain events have the potential to be unintentionally misrepresented. It was important for the researcher to be aware of those potential limitations in order to actively avoid them.

7.4 Implications for Practice

This research has led to the development of a novel approach to progressing the implementation of LCM in primary industry sectors. Since the LUEF was developed, there has been considerable interest amongst sustainability stakeholders in New Zealand and beyond. This includes industry boards, representatives of the Ministry for Primary Industries, growers and post-harvest operators, as well as researchers in the international community.

Industry boards have been introduced to the LUEF and the idea of using IT platforms to monitor and improve the environmental performance of industry participants. They see the use of these tools as a potentially effective means to engage and communicate with their stakeholders. Documentation and recording of assessments could also be conducted by the industry body and the third-party auditors from off-site, saving time and money for their participants. Subsequently, on-site auditing of operational aspects of the system can then be conducted as normal.

Additionally, the development of the IT platform which can be used for any primary industry sector is a novel outcome of this research. It will allow primary industry sectors across the globe to effectively improve the environmental performance of individual stakeholders as well as the entire industry sector.

7.5 Recommendations for Future Research

In Chapter 4, it was mentioned that 85 responses from the online survey are not sufficient to provide a detailed analysis about the kiwifruit growers in regards to their stance towards environmental initiatives and the actions they take. It might be a very useful and interesting project to carry out an online survey with a representative number of respondents in order to be able to do a statistical analysis in this area.

Future research should focus on the evaluation of the wider implementation of the LUEF in other industry sectors, as well as other geographical areas. The development of the generic LUEF will allow the framework to be implemented in a range of different contexts. In doing so, the limitations of this research in terms of the limited research sample for the qualitative elements of the research can be addressed.

Additionally, future research should also investigate the applicability of the LUEF for very large organisations, as well as multinational organisations. So far, the case studies focused on activities in one country (New Zealand) as opposed to supply chains that include a range of countries.

The same recommendations apply to the IT platform. This has been tested in the aquaculture industry; however, it would be valuable to develop it for other industry sectors in New Zealand and beyond.

Since LCM and environmental management systems are often integrated with other risk management solutions, such as health and safety as well as quality/food safety, it might be advantageous to identify if the LUEF can be used or adapted to suit an industry sector that has the desire of aligning those different systems and identifying improvement ideas for several areas of risk management.

8 APPENDIX

The appendix presents the online questionnaire that was sent out to the New Zealand kiwifruit growers, relating to Chapter 4.

Dear Kiwifruit Growers,

I am doing a PhD at Massey University and want to find out what orchardists think about environmental initiatives on their orchard and in the industry.

In April this year, I have already had the opportunity to talk to a small number of growers and packhouses in the industry. I really enjoyed my interaction with the kiwifruit industry and the insights I got. I am now very interested in taking the opportunity and getting some broader feedback from you. Therefore, I would like to encourage you to contribute to this research and take part in a survey. The survey contains questions about your kiwifruit orchard(s) and personal opinion regarding environmental initiatives.

No individual or organisation names will be made public and all collected information is confidential. Indeed, although you have received this email through Zespri, we want to assure you that the individual survey results will only be available to me and not to Zespri.

This survey is best answered by the owner/manager of the business.

Please click on the following link to complete the survey, which takes approximately **15 minutes**.

Thank you in advance for your cooperation.

If you have any questions about the project or the survey please don't hesitate to contact me directly: H.Sterzik@massey.ac.nz.

I would be happy to give you further details about the research.

Best regards,

Helene Sterzik

The researcher named above is responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you wish to raise with someone other than the researchers, please contact Professor John O'Neill, Director (Research Ethics), telephone 06 350 5249, e-mail humanethics@massey.ac.nz.

Q1.1 What is your age?

❍ < 31
❍ 31-40
❍ 41-50
❍ 51-60
❍ 61-70
❍ 71 and over

Q1.2 What is your ethnic background?

❍ NZ Māori
❍ NZ European/ European
❍ Pacific Islands
❍ Asian
❍ Other, please specify: ____________________

Q1.3 For how many years have you been working in the NZ kiwifruit industry?

Q1.4 For how many years have you managed, owned or been associated with your current business?

Q1.5 What is your position in the business? (please select all that apply to you)

❑ Owner
❑ Operations Manager
❑ Environmental Manager
❑ Health and Safety Manager
❑ Quality Manager
❑ Other, please specify: ____________________

Q1.6 What is the highest level of education you have completed?

❍ Secondary School
❍ Tertiary Education

Q1.7 Do you have any agricultural or horticultural qualifications?

- ❍ Yes
- ❍ No

Q2.1 In what region(s) does your business have orchard(s)? (please select all that apply to you)

- ❑ Northland
- ❑ Auckland
- ❑ Katikati
- ❑ Tauranga
- ❑ Te Puke
- ❑ Whakatane
- ❑ Waikato
- ❑ Opotiki/East Coast
- ❑ Gisborne
- ❑ Hawke's Bay
- ❑ Nelson
- ❑ Other, please specify: ____________________

Q2.2 For how many years has your business been operating?

Q2.3 What type of ownership is your business?

- ❍ Family owned
- ❍ Lease of kiwifruit orchard(s)
- ❍ Māori trust
- ❍ Syndicate
- ❍ Other, please specify: ____________________

Q2.4 Please can you provide the total orchard size in ha for the following kiwifruit products you produce:

Contemporary green (including new green varieties) Conventional gold (including new gold varieties) Organic green Organic gold	

Q2.5 How many people are directly employed in your business?

Full time: Part time: Seasonal workers:	

Q2.6 Do you use any contractors to undertake work on your orchard?

- ❍ Yes
- ❍ No

Q3.1 Does your company produce any other horticultural products?

- ❍ Yes, please list the products you produce: _____________________
- ❍ No

Q3.2 Does your company produce any other agricultural products?

- ❍ Yes, please list the products you produce: _____________________
- ❍ No

Q3.3 How much does your income from total sales of kiwifruit contribute to the overall income from your business? Please provide an approximate number in percentage.

Q4.1 Who in your business is responsible for strategies related to environmental initiatives? (please select all that apply)

- ❑ Owner
- ❑ Principal Orchard Operator
- ❑ Health and Safety Manager
- ❑ Environmental Manager
- ❑ No one
- ❑ Other, please specify: _____________________

Q4.2 How many people employed in your business are actively involved in environmental initiatives?

Q4.3 Has your business implemented practices to:

	Yes	No	Not anymore	Don't know
Reduce/ reuse/ recycle office waste?	❍	❍	❍	❍
Reduce waste arising on the orchard?	❍	❍	❍	❍
Reduce water consumption?	❍	❍	❍	❍
Reduce electricity consumption?	❍	❍	❍	❍
Reduce fuel consumption?	❍	❍	❍	❍
Reduce fertiliser use?	❍	❍	❍	❍
Reduce pesticide use?	❍	❍	❍	❍
Encourage biodiversity?	❍	❍	❍	❍

Q4.4 Are there any other environmental practices (apart from the above) that your business has implemented?

❍ Yes, please specify: ______________________

❍ No

Q4.5 When did your current company implement the first environmental initiative? Please type in the year in the box below.

Q4.6 Have you received any external funding to implement environmental initiative(s)?

❍ Yes
❍ No
❍ Don't know

Q4.7 Why did you implement the initiative(s)? (please select all that apply)

❑ Aligns with business values
❑ Personal belief of owner/ manager
❑ Initiated by staff
❑ Cost efficiency
❑ Other growers in the region have successfully implemented them
❑ Pressure from local community
❑ Current market requirements
❑ Future market signals
❑ Other, please specify: ____________________
❑ Don't know

Q4.8 Where did you get the information that helped you to implement the initiative(s)? (please select all that apply to you)

❑ Internal company resources
❑ Other growers
❑ External consultant
❑ Zespri
❑ Other, please specify: ____________________
❑ Don't know

Q4.9 What benefits have accrued to the business by implementing the initiative(s)? (please select all that apply to your business)

- ❑ Improved orchard gate return
- ❑ Cost savings
- ❑ Improved communication within the company
- ❑ Improved company culture
- ❑ Improved relationship with our post-harvest operator
- ❑ Improved relationship with suppliers (e.g. fertiliser supplier)
- ❑ Other, please specify: ____________________
- ❑ None

Q4.10 Who is/was actively involved in implementing and managing any environmental initiative(s) in your business? (please select all that apply to your business)

- ❑ Owner
- ❑ Management
- ❑ Employees
- ❑ Seasonal workers
- ❑ Contractors
- ❑ Suppliers
- ❑ Other, please specify: ____________________

Q4.11 How do/did you communicate with employees in your business about any environmental initiative(s)? (please select all that apply to your business)

- ❑ Weekly or monthly catch-up meetings
- ❑ Informal communication (e.g. during coffee breaks)
- ❑ Formal training sessions
- ❑ Notice boards
- ❑ Other, please specify: ____________________

Q4.12 Do you intend to implement other environmental initiatives in your business in the next year?

- ❍ Yes, please specify which one(s) you intend to implement: ____________________
- ❍ No

Q4.13 To what extent do you agree with the following sentences about environmental initiatives:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
They require many staff resources.	❍	❍	❍	❍	❍
They require much specialist knowledge.	❍	❍	❍	❍	❍
They are time-consuming.	❍	❍	❍	❍	❍
It is difficult to get started.	❍	❍	❍	❍	❍
They are seen as important for our business.	❍	❍	❍	❍	❍
There is a way of measuring benefits.	❍	❍	❍	❍	❍
They require much paperwork.	❍	❍	❍	❍	❍
They require special equipment.	❍	❍	❍	❍	❍
The culture in our business makes it easy to implement environmental initiatives.	❍	❍	❍	❍	❍

Networks with external parties help to implement environmental initiatives.	❍	❍	❍	❍	❍

Q4.14 In your opinion, what might make it easier for kiwifruit growers to implement environmental initiatives?

Q4.15 When purchasing supplies for the orchard(s) do you consider the environmental performance of your suppliers and/or contractors (e.g. environmental policy, environmental certifications for their fertiliser products, etc.)?

❍ Yes
❍ No

Q5.1 How strongly do you agree with the following statements?

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
The single kiwifruit marketing desk (i.e. Zespri), facilitates improved environmental performance in the kiwifruit industry.	❍	❍	❍	❍	❍
The culture of the NZ kiwifruit industry makes it easy to improve the industry's environmental performance.	❍	❍	❍	❍	❍
Existing networks within the NZ kiwifruit industry make it easy to improve the industry's environmental performance.	❍	❍	❍	❍	❍

The long distance to markets and the separation from end consumers make it hard for the NZ kiwifruit industry to improve its environmental performance.	❍	❍	❍	❍	❍

Q5.2 What do you think could be done to improve uptake of environmental initiatives in the NZ kiwifruit industry?

Q6.1 How do you communicate with: please select all that apply)

	Zespri website	Canopy website	Email newsletter	Printed newsletter	Personal communication via email	Personal communication via phone	Field days	Chatting 'over the fence'	Other
Other growers	❑	❑	❑	❑	❑	❑	❑	❑	❑
Your post-harvest operator	❑	❑	❑	❑	❑	❑	❑	❑	❑
Zespri	❑	❑	❑	❑	❑	❑	❑	❑	❑

Q52 What other media do you use to communicate with other growers?

Q53 What other media do you use to communicate with your post-harvest operator?

Q54 What other media do you use to communicate with Zespri?

Q6.2 How satisfied are you with the type(s) of communication between you and...?

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Other growers	❍	❍	❍	❍	❍
Your post-harvest operator	❍	❍	❍	❍	❍
Zespri	❍	❍	❍	❍	❍

Q6.3 How often does some form of communication take place between you and...?

	At least once a month	At least once every three months	At least once every six months	At least once a year	Less than once a year
Other growers	❍	❍	❍	❍	❍
Your post-harvest operator (out of harvest season)	❍	❍	❍	❍	❍
Zespri	❍	❍	❍	❍	❍

Q6.4 How satisfied are you with the frequency of communication between you and...?

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Other growers	❍	❍	❍	❍	❍
Your post-harvest operator	❍	❍	❍	❍	❍
Zespri	❍	❍	❍	❍	❍

Q55 How satisfied are you with....

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
the level of involvement Zespri allows you to have when they change market requirements that you have to comply with?	❍	❍	❍	❍	❍
the support Zespri provides to make necessary changes to comply with new market requirements?	❍	❍	❍	❍	❍

Q7.1 Thinking about the future of your business, in the next 5 years, environmental performance will become:

❍ Much more important
❍ More important
❍ As important as it is now
❍ Less important
❍ Much less important

Q7.2 Thinking about the future of the New Zealand kiwifruit industry, in the next 5 years, environmental performance will become:

- ❍ Much more important
- ❍ More important
- ❍ As important as it is now
- ❍ Less important
- ❍ Much less important

Q7.3 Are there any comments you may wish to add to the survey: